pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Pennsylvania's
Priority Climate Action Plan

March 1, 2024

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Disclaimer and Acknowledgements

The Pennsylvania Department of Environmental Protection (DEP) developed the Commonwealth of Pennsylvania's Priority Climate Action Plan (PCAP) to meet the requirements of the US Environmental Protection Agency's (EPA) Climate Pollution Reduction Grant (CPRG) program. The CPRG program provides funding to states, local governments, tribes, and territories to develop and implement plans for reducing greenhouse gas (GHG) emissions and other harmful air pollution.

The Pennsylvania PCAP includes GHG reduction measures that reflect the Commonwealth's priorities as they relate to implementation funding opportunities through the CPRG program, many of which are in line with existing state climate, energy and transportation goals, plans, actions, and programs. Specifics of each measure provided in the PCAP (e.g., key implementers, implementation activities and milestones) are meant to be informative but are not exhaustive of all specifics of or opportunities to implement a given measure.

Pennsylvania's PCAP was coordinated by staff from the Pennsylvania DEP and informed by interested parties across the state.

DEP would like to thank the technical experts, state agency staff, local government staff, and other interested parties who provided their ideas and time to support this PCAP. DEP would also like to acknowledge the contributions of ICF and Rocky Mountain Institute (RMI).

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Acronyms

ACEEE	American Council for an Energy-Efficient Economy
ACF	Advanced Clean Fleets
AEO	Annual Energy Outlook
AEPS	Alternative Energy Portfolio Standard
AFIG	Alternative Fuels Incentive Grant
AFV	Alternative Fuel Vehicle
AGF	American Gas Foundation
APCA	Air Pollution Control Act
BAU	Business as usual
BEPS	Building Energy Performance Standard
BEV	Battery electric vehicle
BIL	Bipartisan Infrastructure Law
BMP	Best management practices
CAEJC	Climate Action for Environmental Justice Communities
CAP	Climate Action Plan
CCAP	Comprehensive Climate Action Plan
CCUS	Carbon capture, utilization, and storage
CDFI	Community Development Financial Institutions
CEJST	Climate & Economic Justice Screening Tool
CEPP	Clean Energy Program Plan
CFA	Commonwealth Financing Authority
CMAQ	Congestion Mitigation and Air Quality
CPRG	Climate Pollution Reduction Grant
DCED	Department of Community and Economic Development
DCNR	Department of Conservation and Natural Resources
DEP	Department of Environmental Protection
DER	Distributed Energy Resources
DOE	Department of Energy
DOT	Department of Transportation
DVRPC	Delaware Valley Regional Planning Commission
EE&C	Energy Efficiency & Conservation
EIA	Energy Information Administration
EIR	Energy Infrastructure Reinvestment
EJ	Environmental Justice
EPA	Environmental Protection Agency
EPS	Energy Policy Simulator
ERA	Empowering Rural America
EV	Electric vehicle
FCEV	Fuel cell electric vehicles
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GELF	Green Energy Loan Fund
GGRF	Greenhouse Gas Reduction Fund
GHG	Greenhouse gas
GWP	Global Warming Potential
IA	Impacts assessment
ICE	Internal combustion engine
ICEV	Internal combustion engine vehicle
IPM	Integrated Planning Model
IPP	Independent Power Producers
IRA	Inflation Reduction Act
IRS	Internal Revenue Service
L&I	Labor and Industry
LCAP	Local Climate Action Program
LCFS	Low carbon fuel standard
LDV	Light-duty vehicles
LIDAC	Low-income and disadvantaged community
LRTP	Long Range Transportation Plan
LULUCF	Land-use, land-use change, and forestry
LVPC	Lehigh Valley Planning Commission
MHDV	Medium- and heavy-duty vehicles
MOU	Memorandum of understanding
MPO	Metropolitan and Rural Planning Organizations
MSA	Metropolitan Statistical Area
NEVI	National Electric Vehicle Infrastructure
NREL	National Renewable Energy Laboratory
ODS	Ozone-depleting substances
PEDA	Pennsylvania Energy Development Authority
PennDOT	Pennsylvania Department of Transportation
PFBC	Pennsylvania Fish and Boat Commission
PHEV	Plug-in-hybrid-electric vehicles
RET	Retrofit
RFI	Request for Information
RGGI	Regional Greenhouse Gas Initiative
RMI	Rocky Mountain Institute
RNG	Renewable Natural Gas
ROB	Replace on burnout
RPO	Rural Planning Organization
SEFI	State Energy Financing Institution
SIT	State Inventory Tool
SPC	Southwest Pennsylvania Commission
STBG	Surface Transportation Block Grant
USDA	US Department of Agriculture
VMT	Vehicle miles traveled
VOC	Volatile organic compounds
ZEV	Zero Emission Vehicles

1 Introduction

The Pennsylvania Department of Environmental Protection (DEP) developed this Priority Climate Action Plan (PCAP) to meet the requirements of the US Environmental Protection Agency's (EPA) Climate Pollution Reduction Grant (CPRG) program. The CPRG program provides funding to states, local governments, tribes, and territories to develop and implement plans for reducing greenhouse gas (GHG) emissions and other harmful air pollution.

As the lead organization for CPRG planning deliverables, DEP was awarded a CPRG planning grant in June 2023 and partially used those funds to develop this PCAP. The funds will also be used to develop a Comprehensive Climate Action Plan (CCAP) by mid-2025, which will serve as a comprehensive update to this PCAP.

The Allentown-Bethlehem-Easton, PA-NJ Metropolitan Statistical Area (MSA), the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA, and the Pittsburgh, PA MSA also received CPRG planning grants. DEP coordinated closely with the Lehigh Valley Planning Commission (LVPC), Delaware Valley Regional Planning Commission (DVRPC), and the Southwest Pennsylvania Commission (SPC) as the lead organizations responsible for the MSAs' CPRG plans, to align priorities within the state to jointly engage with interested parties across Pennsylvania.

PCAP Definitions

- **Greenhouse Gas (GHG):** The air pollutants carbon dioxide, hydrofluorocarbons, methane, nitrous oxide, perfluorocarbons, and sulfur hexafluoride.
- **GHG Inventory:** A list of emission sources and sinks and the associated emissions quantified using standard methods.
- **GHG Reduction Measure:** Policies, programs, actions, or projects that reduce GHG emissions or enhance carbon removal. Measures that enhance "carbon removal" are those that increase the removal of carbon dioxide from the atmosphere through, for example, the uptake of carbon and storage in soils, vegetation, and forests.
- **Co-Benefits:** Positive effects beyond the stated goal of a GHG reduction measure (e.g., improved public health outcomes, economic benefits, increased climate resilience).
- **Low Income Disadvantaged Community (LIDACs):** Communities with residents that have low incomes, limited access to resources, and disproportionate exposure to environmental or climate burdens.

1.1 CPRG Program Overview

The Inflation Reduction Act (IRA), signed into law on August 16, 2022, directs federal funding to reduce carbon emissions, lower healthcare costs, fund the Internal Revenue Service (IRS), and improve taxpayer compliance. The IRA contains provisions that directly or indirectly address issues related to climate change, including reduction of GHG emissions and promotion of adaptation and resilience to climate change impacts.[1]

The CPRG program, authorized under Section 60114 of the IRA, provides $5 billion in grants to states, local governments, tribes, and territories to develop and implement plans for reducing GHG emissions and other harmful air pollution. The program consists of two phases: planning and implementation. The planning phase provides $250 million in noncompetitive planning grants for state and local agencies to develop PCAPs and CCAPs aimed at reducing GHG emissions and providing other benefits to communities. The implementation phase provides $4.6 billion for competitive implementation grants to eligible applicants to implement GHG reduction measures identified in a PCAP developed under a CPRG planning grant.[2]

[1] CRS. "Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change," October 3, 2022. https://crsreports.congress.gov/product/pdf/R/R47262.

[2] US EPA. "Climate Pollution Reduction Grants." January 18, 2023. https://www.epa.gov/inflation-reduction-act/climate-pollution-reduction-grants.

1.2 PCAP Purpose, Scope, and Overview

Pennsylvania's PCAP identifies cost-effective, ready-to-implement GHG reduction measures that will significantly lower GHG and provide other benefits to the Commonwealth, especially in low-wealth communities, minoritized communities, and communities impacted by environmental justice concerns (also referred to as low-income and disadvantaged communities, or LIDACs in this document in alignment with EPA's CPRG guidelines). Table 1 summarizes the required information for a PCAP, per CPRG guidance, and the location of that information in Pennsylvania's PCAP.[3]

A measure being included within a PCAP is a pre-requisite for agencies and organizations within an MSA or state to compete for implementation grant funding in the second phase of the CPRG program. Accordingly, the measures identified in this PCAP are designed to be broad enough to encompass regional and local priorities for addressing climate pollution. The PCAP also serves as a starting point for the CCAP.

Table 1: PCAP Requirements and Documentation

PCAP Requirement	Requirement Notes and Document Location
GHG Inventory	• Section 2.1
GHG Reduction Targets	• Section 2.2.1
Priority Quantified GHG Reduction Measures	• Priority GHG reduction measures, including the following measures - Section 4 – an estimate of the quantifiable GHG emissions reductions – key implementing agency or agencies – implementation schedule and milestones – expected geographic location if applicable – identification of relevant funding sources – metrics for tracking progress – a review of the statutory or regulatory authority to implement the measure (and a schedule and milestones for key entities to obtain it if not existing). • Details of GHG reduction quantification methods are in Appendix B.
Benefits Analysis	• Qualitative discussion of the expected co-benefits associated with PCAP GHG reduction measures - Section 4.1 • For information by measure in combination with LIDAC Benefits - Section 4.5
Review of Authority to Implement	• Section 4.5
Low Income Disadvantaged Communities Benefits Analysis	• Specific climate impacts or risks to which LIDACs are vulnerable – Section 3.2 • LIDACs that will be affected by the GHG reduction measures in the PCAP – Section 3 and Appendix A • Census block group IDs for affected LIDACs and PCAP measures – Section 3 and Appendix A

[3] US EPA. "Climate Pollution Reduction Grants Program: Formula Grants for Planning," March 1, 2023. https://www.epa.gov/system/files/documents/2023-02/EPA%20CPRG%20Planning%20Grants%20Program%20Guidance%20for%20States-Municipalities-Air%20Agencies%2003-01-2023.pdf.

	• Qualitative discussion of the expected benefits to LIDACs associated with PCAP GHG reduction measures – Section 4.5 for information by measure • Overview of planned and/or ongoing engagement with representatives and residents of LIDACs to inform PCAP and CCAP development and implementation – Section 1.3.1
Workforce Planning Analysis	• Overview of workforce development activities that are needed to implement the priority measures in the PCAP – Section 4.4 and summarized within industrial measures in Section 4.5

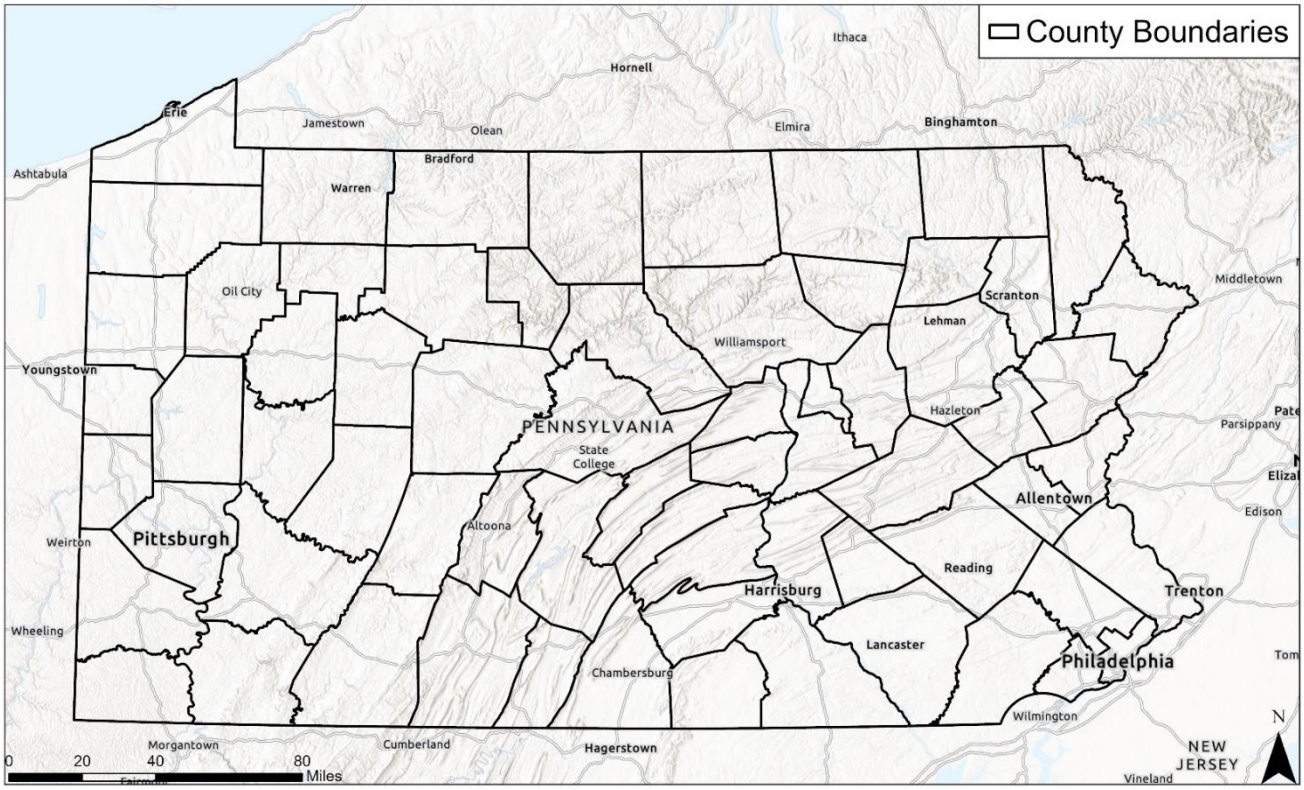
1.2.1 Relationship to Pennsylvania Climate Action Plan Update

As mandated by the Pennsylvania Climate Change Act (Act 70 0f 2008), DEP is required to produce a Climate Action Plan (CAP) every three years that identifies GHG emissions and sequestration trends; evaluates cost-effective strategies for reducing or offsetting GHG emissions from various sectors in the Commonwealth; identifies costs, benefits and co-benefits of those strategies; and makes recommendations to the General Assembly of legislative changes necessary to implement the plan. To meet these requirements, the 2024 CAP is currently being developed in coordination with this PCAP. Pennsylvania's PCAP draws upon the Act 70-required CAP for much of the required analysis, and outlines Commonwealth priorities for the deployment of funds that may be received from the IRA-funded CPRG implementation grant.

1.2.2 Geographic Scope

This PCAP covers the entirety of the Commonwealth of Pennsylvania (Figure 1, including the Allentown-Bethlehem-Easton, PA-NJ MSA, the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA, and the Pittsburgh, PA MSA).

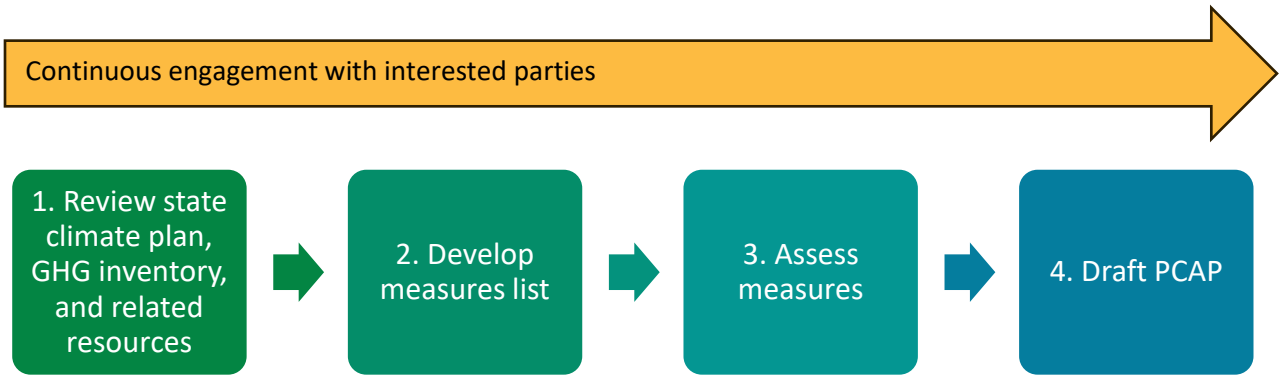
Figure 1: State of Pennsylvania with County Boundaries



1.3 Approach to PCAP Development

To develop the PCAP, DEP followed the approach outlined below.

Figure 2: PCAP Development Process



Step 1. DEP reviewed the 2021 CAP,[4] draft 2024 CAP, the Department of Conservation and Natural Resources' (DCNR) Climate Adaptation and Mitigation Plan,[5] and other existing plans, reports, and resources (e.g., EPA Quantified Climate Actions Measure Directory[6]). DEP also finalized the annual Pennsylvania Greenhouse Gas Emissions Report in December 2023. This inventory (see Section 2.1) was also reviewed to identify PCAP measures by targeting the largest sources of Pennsylvania's GHG emissions.

Steps 2 and 3. DEP compiled a list of measures based upon Step 1 and engagements with interested parties. DEP first sorted concepts by sector. Each measure was assessed in line with PCAP requirements, such as primary actor, authority to implement, quantified GHG reductions, and other information. After review, measures were developed by consolidating similar and related concepts into groups to form the broader reduction measures identified in this PCAP. To prioritize measures, each draft measure was briefly assessed for implementation readiness, GHG reductions, and benefits (particularly for LIDACs). The measure list was also cross checked with priorities as outlined in the Pennsylvania 2021 CAP and draft 2024 CAP updates.

Step 4. DEP prepared this PCAP using information from existing plans and reports, new analysis where information did not exist, and input from interested parties. Along with measure-specific information, DEP assessed other required information for the PCAP in this step, such as identifying LIDACs using EPA's EJScreen and the Pennsylvania Environmental Justice Mapping and Screening tool (PennEnviroScreen)[7]. The PCAP appendices provide information on the GHG quantification methods and LIDAC identification.

Continuous Engagement. Throughout the development of the PCAP, DEP conducted outreach activities for interested parties to educate participants, solicit input, and synthesize priority project and action ideas into the PCAP. These activities built on the extensive outreach DEP already has been conducting related to climate change, energy, and environmental justice. The PCAP engagement activities occurred across multiple modalities to enable maximum participation (i.e., virtual, in-person, via written feedback), and included additional elements to increase accessibility and inclusion for individuals living in communities impacted by environmental justice concerns such as:

- Developed website content for PCAP meeting materials and process updates;
- Provided meeting materials in multiple languages, where appropriate;
- Ensured Americans with Disabilities Act accessibility and accommodations for meetings;

[4] DEP. "2021 Climate Action Plan." 2021. https://www.dep.pa.gov/Citizens/climate/Pages/PA-Climate-Action-Plan.aspx

[5] DCNR. "Climate Change Adaptation and Mitigation Plan." 2018. https://www.dcnr.pa.gov/conservation/climatechange/Pages/default.aspx

[6] EPA. "Quantified Climate Action Measures Directory." 2023. https://www.epa.gov/statelocalenergy/quantified-climate-action-measures-directory

[7] PennEnviroScreen (pa.gov)

- Partnered with "ambassador" organizations, such as municipal governments, local non-profits, and community action groups, to site and promote meetings; and
- Solicited community input to inform meeting agendas.

Further information on key participating entities and the engagement process is in Section 1.3.1.

1.3.1 Engagement with Interested Parties

DEP engaged interested parties from state government, local and regional governments, industry, the public, and LIDAC related and representative groups through virtual workshops, working group meetings, and surveys to solicit feedback on PCAP measure development. Through these engagements, interested parties provided useful feedback to help shape priority measures for inclusion in the PCAP. DEP intends to continue these engagements throughout the CPRG process.

Intergovernmental and Intragovernmental

DEP coordinated CPRG at the state-level through a cross-agency working group with representatives from over 25 agencies and departments across the state. This cross-agency working group met on September 5, 2023 to discuss the cross-government intersection of climate change impacts, mitigation, and resilience. The working group convened again on October 31, 2023 to discuss priority GHG reduction measures and program design considerations for an industrial decarbonization program.

DEP participated in regular working group and advisory sessions with the three MSAs who received planning grants within the state (LVPC, DVRPC, and SPC). DEP continually coordinated with these MSAs as their PCAPs and the Commonwealth's PCAP were developed. Additionally, these efforts encouraged interested parties within these communities to reach out to the leading entities to collaborate on regional projects.

To reach local governments, DEP leveraged its existing Local Climate Action Program (LCAP)[8] as well as connections with local government associations such as Pennsylvania Association of Boroughs, Pennsylvania State Association of Township Supervisors, and the County Commissioners Association of Pennsylvania. DEP hosted a virtual session on December 11, 2023 with 51 local and Pennsylvania regional government partners to provide an overview of the CPRG program and solicit feedback on priorities for inclusion in the PCAP. After the meeting, DEP continued outreach with local governments through DEP's existing networks to ensure local governments' priorities are captured within the statewide PCAP measures. DEP is continuing follow-up discussions with local government representatives regarding their CPRG priorities, and potential Implementation Grant applications. Examples of local governments that participated in these outreach meetings and provided priority GHG reduction project ideas include: Catawissa Township, Chambersburg, Lewis Township, Lewisburg Borough, Lower Merion Township, Mansfield, Millvale, Philadelphia, Scranton, SEDA Council of Governments, Tioga County, Shamokin, and many others. DEP held a second virtual meeting with local government representatives on February 15, 2024 to discuss priority climate measures and analyses included in this PCAP.

DEP also participated in monthly working groups led by New Jersey to coordinate efforts with other Mid-Atlantic states and coordinated with Maryland and West Virginia to learn about their approach to PCAP development and their potential priority measures.

Industrial Sector and Other Interested Parties

To engage with industry, DEP hosted a virtual session on November 28, 2023 with 53 industry, manufacturing, and utility sector representatives to provide an overview of the CPRG program and solicit feedback on priorities for inclusion in the PCAP. DEP subsequently released a Request for Information (RFI) on December 30, 2023 to continue to gather feedback on potential program design for an Industrial Decarbonization program that DEP hopes to fund with a CPRG Implementation Grant. The RFI closed on January 29, 2024 and received a total of 39 responses from 24 businesses

[8] DEP. "Local Climate Action Program." https://www.dep.pa.gov/Citizens/climate/LocalClimateAction/Pages/Local-Climate-Action.aspx

and organizations and 15 individuals. Respondents included academic and research organizations, business advocacy groups, civic organizations, the United State Climate Alliance (US Climate Alliance), environmental advocacy groups, trade associations, natural gas utilities, and industrial and technology companies. Respondents expressed interest in ensuring that benefits of the program were prioritized to low-wealth, disadvantaged, and energy-burdened communities. They also encouraged flexibility in program design and structure and supporting peer-learning and technical assistance around the application process to increase accessibility to the program. Respondents also expressed interest in ensuring that the program adequately addresses the needs of small businesses.

Community Engagement

DEP created its Climate Action for Environmental Justice Communities (CAEJC) Program to identify and support strategic actions to help Pennsylvania's communities impacted by environmental justice concerns adapt to climate change while striving to lower GHG emissions, with measures that reduce risk and capitalize on potential opportunities to strengthen local economies. In spring 2023, DEP engaged with Pennsylvanians in seven communities across the Commonwealth including Meadville, Pittsburgh, Scranton, Reading, Harrisburg, Norristown, and Philadelphia. This engagement took the form of in-person open discussions with community members, where participants shared their experiences with climate change and other environmental issues, and insights on climate mitigation and adaptation actions that could be directly beneficial to their communities. A public survey was also developed as part of the CAEJC Program to solicit feedback on statewide climate priorities. Results of this engagement effort were published in a June 2023 report.[9]

DEP expanded on the community engagement of the CAEJC Program to conduct specific outreach to guide the development of this PCAP. There is significant overlap in the areas that DEP identifies as environmental justice areas in Pennsylvania and the areas identified by EPA as LIDACs through its EJScreen tool. In December 2023, DEP held four workshops across the Commonwealth (Clairton – December 4, Williamsport – December 6, Hazelton – December 7, and Wysox – December 12), and one virtual session (December 14) to solicit community feedback on priorities for the PCAP. Workshop locations were selected to build on existing learnings from and expand the reach of DEP's successful CAEJC program. DEP targeted outreach in areas that were identified in EJScreen and PennEnviroScreen as LIDACs or EJ areas, and in communities which have been impacted by industrial activities. Through these sessions, 177 individuals were reached (73 in-person attendees and 104 virtual attendees) and DEP identified community priorities around weatherization, public and active transportation, and air pollution from industrial sites.

[9] Pennsylvania Climate Action: Strategies for Environmental Justice Communities (2003) files.dep.state.pa.us/Energy/Office of Energy and Technology/OETDPortalFiles/ClimateChange/2023-06-27_PA_DEP_Final_Report_HI_RES.pdf

2 Pennsylvania Climate Work and Context

2.1 GHG Inventory

Pennsylvania's GHG inventory provides data on GHG emissions in the state from 2005 to 2020 and tracks progress toward the GHG emission-reduction targets.[10] In 2020, gross GHG emissions were 238.74 million metric tons of carbon dioxide equivalent ($MMTCO_2e$), and net GHG emissions in 2020 were 213.94 $MMTCO_2e$. Pennsylvania is on track to meet the 2025 GHG emissions reduction goal of 26% as required in Executive Order 2019-01. Pennsylvania has already reduced net emissions by 25.9% from the 2005 baseline. However, this achievement is likely fleeting and not durable, as the temporary impacts from the COVID-19 pandemic on the economy, rather than new policy implementation, appear to be a main driver of the decrease of GHG emissions in data year 2020.

2.1.1 Methodology

Pennsylvania's GHG inventory reflects CO_2-equivalent GHG emission totals using 100-year Global Warming Potential (GWP) values from the Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5).[11] The inventory was developed using data from US EPA's State Inventory Tool (SIT) and US EPA's Inventory of US Greenhouse Gas Emissions and Sinks by State report, which disaggregates the national inventory emissions to the state level. The GHG inventory methodology is consistent over time so that past and present inventories can be compared.

EPA's SIT consists of sector-specific estimation modules to calculate GHG emissions, using reputable data gathered by federal agencies and other sources. Pennsylvania's GHG inventory was primarily produced using the default activity data included in each SIT module, with supplemental data included for categories that can be estimated in SIT but do not have default data. To supplement the SIT, additional data for several emissions sources were obtained from the US EPA's Inventory of US Greenhouse Gas Emissions and Sinks by State report.

Pennsylvania used data from EPA's state level disaggregates for the following sectors: natural gas and oil sector (abandoned oil and gas wells), forestry and land uses (carbon stocks from Land Converted to Settlements, Wetlands Remaining Wetlands, Land Converted to Wetlands), industrial processes (ferroalloy production, zinc production, carbon dioxide consumption, N_2O from product uses, glass production, lead production, carbide production and consumption), and solid waste (composting and anaerobic digestion at biogas facilities). Because the emissions source categories obtained from the US Inventory by state disaggregation are not estimated within SIT, there is no double-counting, and these additional categories can be directly added to emissions results estimated by the SIT. Note that uncertainty is inherent in all emissions estimates due to incomplete data, proxied or scaled data, and the use of average emissions factors. Certain sectors carry greater uncertainty than other sectors because of these challenges.

2.1.2 Results

The latest GHG inventory results for 2020 include GHG emissions from the electric power, transportation, industrial, residential and commercial buildings, agriculture, waste management, and land-use, land-use change, and forestry (LULUCF) sectors.

Pennsylvania's gross GHG emissions[12] were 238.74 $MMTCO_2e$ and net GHG emissions were 213.94 $MMTCO_2e$ in 2020. Figure 3 shows the breakdown of Pennsylvania's GHG emissions in millions of metric tons of carbon dioxide equivalent ($MMTCO_2e$) in 2020 by economic sector.

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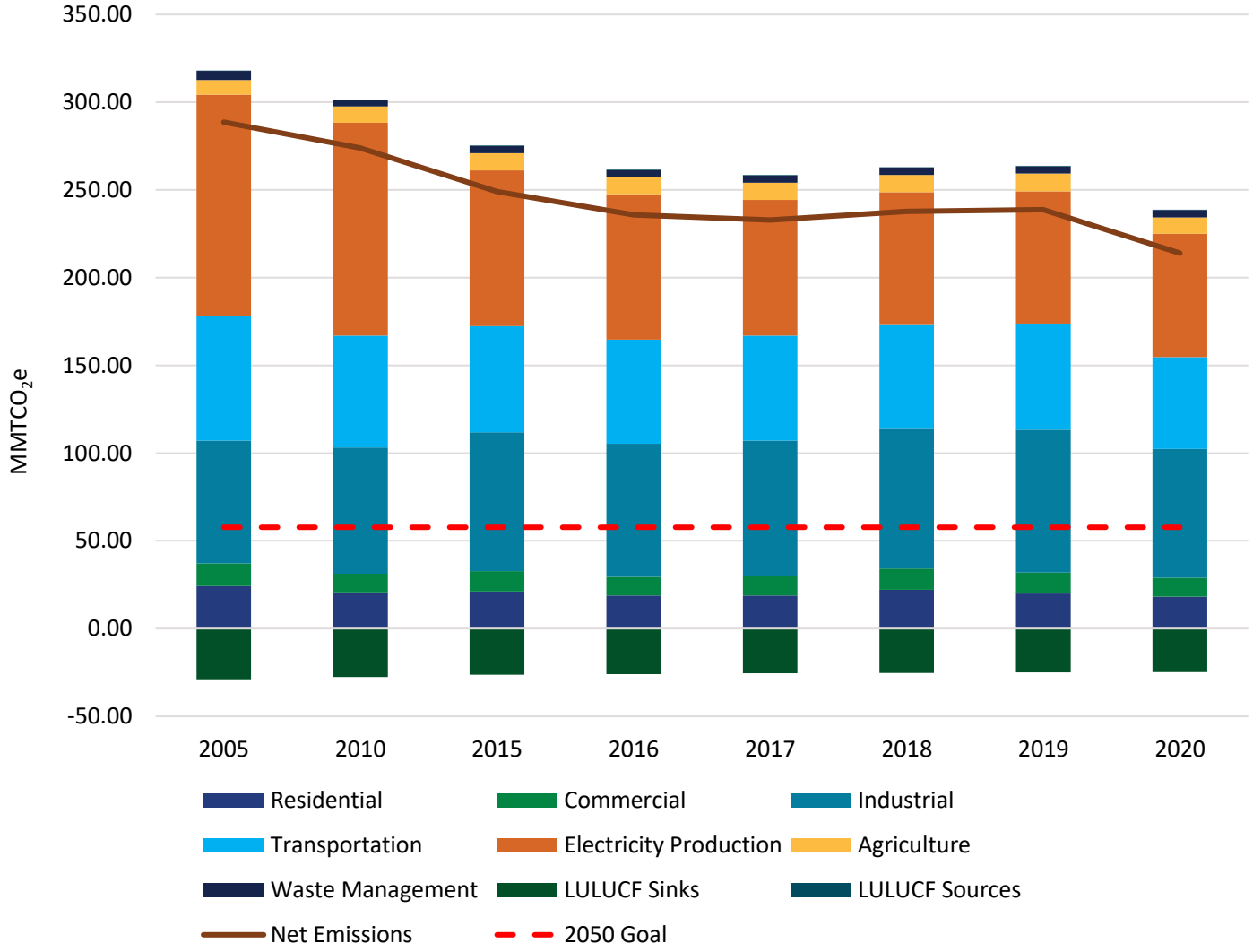
[10] The latest GHG inventory for Pennsylvania is available online here: https://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/ClimateChange/FINAL_2023_GHG_Inventory_Report_12.13.23.pdf

[11] IPCC, 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* https://www.ipcc.ch/report/ar5/syr/ .

[12] Gross GHG emissions are the sum of all GHG emitting sectors. This sum does not include carbon sinks, such as the Land Use, Land Change, and Forestry Sector.

Figure 3: GHG Emissions by Sector ($MMTCO_2e$)



The largest source of GHG emissions in Pennsylvania in 2020 was emissions from the industrial sector, which emitted 73.56 $MMTCO_2e$, or 31 percent, of gross GHG emissions. Electricity generation was the second largest contributor of GHG emissions, accounting for 70.22 $MMTCO_2e$, or 29 percent of gross emissions. GHG emissions from transportation in Pennsylvania represent the third largest contributor of GHG emissions, accounting for 52.25 $MMTCO_2e$, or 22 percent of gross emissions. Residential buildings produced 18.14 $MMTCO_2e$ (8 percent) and commercial buildings produced 10.76 $MMTCO_2e$ (5 percent). The agriculture sector produced 9.37 $MMTCO_2e$ (4 percent), and waste management produced 4.25 $MMTCO_2e$ (2 percent). Pennsylvania's forestry and land use sector was a net carbon sink, absorbing 24.79 $MMTCO_2e$ in 2020. Table 2 and Table 3 show emissions by subsector and emissions by gas.

Table 2: GHG Emissions by Sector ($MMTCO_2e$)

Sector / Emission Sources ($MMTCO_2e$)	2005	2010	2015	2016	2017	2018	2019	2020
Residential	**24.25**	**20.58**	**21.15**	**18.81**	**18.86**	**22.07**	**19.91**	**18.14**
Commercial	**12.98**	**10.63**	**11.53**	**10.66**	**10.94**	**12.22**	**11.97**	**10.76**
Industrial	**69.97**	**72.00**	**79.25**	**75.86**	**77.35**	**79.62**	**81.48**	**73.56**

Combustion of Fossil Fuels	32.05	29.04	37.68	35.50	36.33	38.24	37.96	32.89
Industrial Process	14.18	13.61	13.33	13.17	12.85	12.64	13.13	12.86
Coal Mining and Abandoned Mines	11.56	14.27	12.06	11.15	12.05	12.58	14.13	11.62
Natural Gas and Oil Systems	12.18	15.07	16.18	16.05	16.12	16.15	16.27	16.20
Transportation	**70.84**	**63.74**	**60.41**	**59.33**	**59.83**	**59.66**	**60.55**	**52.25**
Petroleum	67.66	60.11	57.34	56.46	56.81	56.53	57.19	49.17
Natural Gas	1.71	2.63	2.42	2.25	2.45	2.59	2.79	2.62
Non-CO_2 Emissions	1.46	1.01	0.66	0.62	0.58	0.54	0.58	0.46
Electricity Production	**126.31**	**121.35**	**88.87**	**82.91**	**77.30**	**75.10**	**75.30**	**70.22**
Coal	117.14	106.95	63.98	54.87	47.99	44.77	38.07	24.53
Petroleum	4.20	0.51	0.45	0.25	0.22	0.58	0.16	0.08
Natural Gas	4.43	13.39	24.14	27.52	28.84	29.52	36.86	45.46
Non-CO_2 Emissions	0.55	0.50	0.31	0.27	0.24	0.23	0.21	0.15
Agriculture	**8.23**	**9.25**	**9.81**	**9.70**	**9.81**	**9.89**	**10.06**	**9.37**
Enteric Fermentation	3.68	3.75	3.74	3.84	3.91	3.92	3.71	3.57
Manure Management	1.72	1.99	2.26	2.36	2.32	2.41	2.41	2.35
Agricultural Soil Management	2.79	3.10	3.69	3.32	3.38	3.40	3.73	3.24
Liming of Soils	0.03	0.38	0.08	0.16	0.15	0.11	0.15	0.15
Urea Fertilization	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.06
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry and Land Use	**0.09**	**0.12**	**0.22**	**0.28**	**0.23**	**0.21**	**0.19**	**0.19**
Non-CO_2 Emissions	0.09	0.12	0.22	0.28	0.23	0.21	0.19	0.19
Waste Management	**5.35**	**3.88**	**4.07**	**4.10**	**4.13**	**4.23**	**4.23**	**4.25**
Solid Waste and Combustion	3.70	2.16	2.32	2.35	2.36	2.46	2.47	2.47
Waste Water	1.64	1.72	1.75	1.75	1.77	1.76	1.76	1.78
Total Statewide Gross Emissions (Prod.)	**318.01**	**301.55**	**275.31**	**261.65**	**258.46**	**262.98**	**263.68**	**238.74**
Change relative to 2005		*-5.2%*	*-13.4%*	*-17.7%*	*-18.7%*	*-17.3%*	*-17.1%*	*-24.9%*
Forestry and Land Use Carbon Flux	**-29.38**	**-27.63**	**-26.25**	**-25.90**	**-25.55**	**-25.26**	**-24.91**	**-24.79**
Total Statewide Net Emissions (Prod w/ Sinks)	**288.63**	**273.93**	**249.06**	**235.75**	**232.91**	**237.73**	**238.77**	**213.94**
Change relative to 2005		*-5.1%*	*-13.7%*	*-18.3%*	*-19.3%*	*-17.6%*	*-17.3%*	*-25.9%*

Table 3: GHG Emissions by Gas ($MMTCO_2e$)

Emissions ($MMTCO_2e$)	2005	2010	2015	2016	2017	2018	2019	2020
Gross CO_2	275.81	253.57	228.16	215.82	211.65	215.48	214.34	192.83
Net CO_2	246.43	225.95	201.91	189.92	186.11	190.22	189.43	168.03
CO_2 from Fossil Fuel Combustion	263.90	243.28	218.00	205.72	201.85	205.83	204.27	183.08
Industrial Processes	10.28	8.47	8.42	8.24	7.93	7.71	8.09	7.75
Waste	1.58	1.43	1.61	1.67	1.68	1.78	1.78	1.78
Agriculture	0.05	0.40	0.12	0.19	0.20	0.16	0.21	0.22
LULUCF	-29.38	-27.63	-26.25	-25.90	-25.55	-25.26	-24.91	-24.79
Natural Gas and Oil Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	32.53	37.24	36.49	35.60	36.58	37.28	38.69	35.88
Stationary Combustion	0.39	0.44	0.53	0.46	0.46	0.53	0.50	0.44
Mobile Combustion	0.14	0.10	0.07	0.07	0.07	0.06	0.07	0.06
Coal Mining	11.56	14.27	12.06	11.15	12.05	12.58	14.13	11.62
Natural Gas and Oil Systems	12.17	15.07	16.18	16.05	16.11	16.15	16.27	16.20
Agriculture	4.87	5.22	5.43	5.61	5.65	5.74	5.54	5.34
LULUCF	0.05	0.08	0.15	0.20	0.16	0.14	0.12	0.12
Waste	2.04	0.68	0.67	0.65	0.65	0.66	0.66	0.67
Wastewater	1.30	1.38	1.41	1.41	1.43	1.42	1.41	1.44
Industrial Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	5.92	5.74	5.91	5.45	5.45	5.44	5.75	5.07
Stationary Combustion	0.68	0.62	0.47	0.41	0.38	0.38	0.34	0.27
Mobile Combustion	1.32	0.91	0.59	0.55	0.51	0.48	0.51	0.40
Industrial Processes	0.16	0.15	0.15	0.15	0.15	0.15	0.14	0.15
Agriculture	3.31	3.62	4.25	3.90	3.96	3.99	4.32	3.82
LULUCF	0.03	0.04	0.07	0.08	0.07	0.07	0.07	0.07
Waste	0.09	0.06	0.04	0.03	0.03	0.03	0.03	0.03
Wastewater	0.34	0.34	0.34	0.34	0.34	0.35	0.34	0.34
HFC, PFC, SF_6 and NF_3 Emissions	3.74	4.99	4.75	4.78	4.77	4.79	4.89	4.95
Industrial Processes	3.74	4.99	4.75	4.78	4.77	4.79	4.89	4.95
Indirect CO_2 from Electricity Consumption*	89.46	84.58	64.65	59.36	55.83	55.72	52.80	46.68
Gross Emissions	**318.01**	**301.55**	**275.31**	**261.65**	**258.46**	**262.98**	**263.68**	**238.74**
Sinks	**-29.38**	**-27.63**	**-26.25**	**-25.90**	**-25.55**	**-25.26**	**-24.91**	**-24.79**
Net Emissions (Sources and Sinks)	**288.63**	**273.93**	**249.06**	**235.75**	**232.91**	**237.73**	**238.77**	**213.94**

* Emissions from Electricity Consumption are not included in totals in order to avoid double counting with Fossil Fuel Combustion estimates.

Note: Totals shown here are slightly different than totals shown in Table 2 due to differences in accounting and rounding.

Table 4 shows changes in emissions from 2005 to 2020 and 2019 to 2020. Overall, emissions decreased by 24.95 MMTCO2e or 10.4 percent from 2019 levels. Between 2005 and 2020, electricity production emissions decreased by 44.4 percent. This is mainly a result of coal being replaced by increased natural gas generation (and to a smaller extent renewables such as wind and solar) and energy efficiency improvements, due in part to Act 129.[13] Coal-based electricity generation decreased from 60 percent of Pennsylvania's total electricity in 2005 to 10 percent in 2020. In 2020, natural gas-based electricity generation was the largest source of electricity in Pennsylvania, providing 52.5 percent of all electricity. Gas-based electricity generation surpassed nuclear-based electricity generation in 2019.

Although industrial sector emissions decreased by 9.7 percent from 2019 to 2020, this likely resulted from COVID-19 related disruptions. Overall, industrial emissions have increased 5.1 percent since 2005, and are likely to return to pre-COVID levels in upcoming years. This increase in emissions coincides with an increase in manufacturing Gross State Product of 49 percent from 2007 to 2022.[14] Pennsylvania's economy largely consists of industrial activity compared to other states. Industries in Pennsylvania with high levels of emissions include cement manufacturing, iron and steel production, process heating using fossil fuels, and various industrial processes requiring the utilization of ozone-depleting substances (ODS) substitutes.

Transportation emissions decreased by 26 percent since 2005, mainly due to increased fuel efficiency and a growing proportion of alternative fuel vehicles. Emissions from residential and commercial buildings have decreased by 25.2 and 17.1 percent respectively since 2005. This decrease is likely a result of switching to lower emitting fuels for heating, and energy efficiency improvements resulting from the greater availability and cost effectiveness of energy efficiency technologies.

Like the industrial sector, the agriculture sector emissions decreased from 2019 to 2020, despite a 13.8 percent increase in emissions from 2005 to 2020. Net carbon sequestration from forestry and land use decreased 15.6 percent since 2005, and emissions from waste management decreased 20.5 percent since 2005.

[13] Act 129 | PA PUC

[14] NEPIRC 2023. Pennsylvania Manufacturing Industry Report 2023.

Table 4: Summary of Key Emissions Trends

	2020 Emissions		% Change from 2019		% Change from 2005
Residential	18.14	↓	-8.9%	↓	-25.2%
Commercial	10.76	↓	-10.1%	↓	-17.1%
Industrial	73.56	↓	-9.7%	↑	5.1%
Transportation	52.25	↓	-13.7%	↓	-26.2%
Electricity Production	70.22	↓	-6.8%	↓	-44.4%
Agricultural	9.37	↓	-6.9%	↑	13.8%
Waste Management	4.25	↑	0.6%	↓	-20.5%
Forestry and Land Use Non-CO_2 Emissions	0.19	↓	-0.1%	↑	110.6%
Total Gross Emissions	**238.74**	↓	**-9.5%**	↓	**-24.9%**
Forestry and Land Use Net Carbon Flux	-24.79	↓	-0.5%	↓	-15.6%
Total Net Emissions	**213.94**	↓	**-10.4%**	↓	**-25.9%**

Table Key: ↓ = Decrease in emissions; ↑ = Increase in emissions

2.1.3 COVID-19 Pandemic Impacts

Pennsylvania has almost met its 2025 goal of a 26 percent reduction in GHG emissions from 2005 levels. However, the impact of the COVID-19 pandemic on emissions data, particularly in the transportation sector, may have contributed to a portion of this decrease. Recent energy generation, use, and emissions indicators point to potential increases in emissions in 2021 to 2023 compared to values reported in the 2020 inventory as the economy has rebounded from the pandemic. Pennsylvania's CCAP, due in summer of 2025, will include an updated GHG inventory showing data years 2005 through 2021.

2.2 Existing State Goals, Plans, Policies, and Programs

2.2.1 Pennsylvania Climate Change Act and Emissions Reductions Goals

The Pennsylvania Climate Change Act of 2008 requires DEP to compile an annual GHG inventory for Pennsylvania's GHG emissions, to develop a voluntary GHG registry, and to develop a CAP and impacts assessment and update them every three years.

Executive Order 2019-01 established a Pennsylvania climate goal of a 26% reduction in net GHG emissions statewide by 2025 and an 80% reduction by 2050, from 2005 levels. It also reestablished the GreenGov Council to assist state agencies in incorporating environmentally sustainable practices into policy and planning decisions.

In 2019, Pennsylvania joined the US Climate Alliance [15], a bipartisan coalition of governors aiming to advance high-impact climate action. Emissions reductions goals of the US Climate Alliance include:

- Reducing collective net GHG emissions at least 26-28% by 2025 and 50-52% by 2030, both below 2005 levels.
- Collectively achieving overall net-zero GHG emissions as soon as practicable, and no later than 2050.

[15] United States Climate Alliance

2.2.2 Pennsylvania Act 70 Climate Action Plan and Climate Impacts Assessment

As required by the Climate Change Act of 2008, DEP and the Climate Change Advisory Committee produce and submit to the governor a CAP that:

- Identifies GHG emissions and sequestration trends.
- Evaluates cost-effective strategies to reduce or offset GHG emissions.
- Evaluates the costs, benefits, and co-benefits of the recommended reduction strategies.
- Recommends legislative changes necessary to implement the CAP.

This plan is updated every three years with the most recent publication in 2021. The 2021 plan outlines a pathway to reducing GHG emissions by 26 percent in 2025 and 80 percent in 2050 through 18 strategies across economic sectors supported by quantitative modeling to verify the emission reduction estimates. Developed in parallel with the CAP is the climate impacts assessment which identifies current climate hazards impacting Pennsylvania and projects how those impacts will change under several climate change scenarios.

Both the CAP and IA are currently being updated for a 2024 release and have been used to help inform the measures included in this PCAP.

2.2.3 Local Climate Action Program (LCAP)

DEP launched LCAP to help local governments lead by example on critical climate change mitigation actions. LCAP provides free technical and personnel assistance to local governments for planning efforts to reduce GHG emissions and address climate change. As of 2023, LCAP has trained 64 cities, townships, boroughs, counties, and regional organizations, representing approximately 440 municipalities across the Commonwealth. LCAPs have helped Pennsylvania municipalities take mitigation actions and plan for more, with many planned actions included in this PCAP where municipalities are ready to implement. The LCAP has been a crucial program for connecting state-level climate planning and goals with local leaders and jurisdictions to catalyze climate action.

2.2.4 Other Commonwealth Climate Efforts

DCNR's Climate Change Adaptation and Mitigation Plan[16]

DCNR aims to utilize the Department's 2.2 million acres of state forests, 121 state parks, and 15 million acres of private forest land to mitigate atmospheric carbon as well as ensure that the Commonwealth's public lands remain resilient and able to adapt to climate change. DCNR seeks to be a leader in climate-smart land management and green infrastructure development. The plan provides a look at current and projects climate change impacts, and the actions taken by DCNR to address these vulnerabilities.

Pennsylvania Fish and Boat Commission (PFBC) Climate Action Plan[17]

This plan identifies climate change issues anticipated to impact PFBC's trust species (i.e., fish, amphibians, reptiles, freshwater mussels, crayfishes, other aquatic invertebrates), their habitats, the angling and boating public, and other assets. From these issues, the plan provides goals, strategies, and actions to build resilience and support adaptative actions. In the development process, the PFBC CAP Team broadly considered "fish" as all PFBC's trust species (see Legal Authority below). Thus, goals, strategies, and action items are made in this context.

[16] elibrary.dcnr.pa.gov/GetDocument?docId=1743769&DocName=Climate_Change_Adaptation_Plan_Final_Aug2018.pdf

[17] PFBC (Pennsylvania Fish and Boat Commission). 2022. Pennsylvania Fish and Boat Commission Climate Action Plan: Strategies for Enhancing Climate Adaptation and Resilience to Protect, Conserve, and Enhance Pennsylvania's Aquatic Resources and Support Anglers and Boaters, Version 2022-1.0. Harrisburg, Pennsylvania.

Pennsylvania Department of Transportation's (PennDOT) Extreme Weather Vulnerability Study[18]

To help prepare for future extreme weather, PennDOT conducted an Extreme Weather Vulnerability Study, which analyzed past PennDOT flooding-related data, traffic volumes, federal and national weather and flooding resources, and more. It also identified roadways susceptible to flooding based on that data.

The study also projected potential future flooding vulnerabilities in Allegheny, Delaware, and Lycoming counties. The completed study was shared with planning partners, PEMA, federal highway officials, and department staff for reference in maintenance and project work, and to complement the data PennDOT already uses in planning future projects. The next phase of the study will identify potential mitigation strategies to use on projects in Allegheny and Delaware counties, made possible with state and federal matching funds.

Pennsylvania Department of Health (PA DOH) Efforts

PA DOH is working to protect Pennsylvanians from the health impacts of a changing climate.

PA DOH considers work around a changing climate, Environmental Justice (EJ), and health equity to all be intertwined. Some groups have been disproportionately affected by environmental conditions, and PA DOH work must commit to assisting these communities. These groups include those living in EJ areas, as defined by DEP, but also those living in rural areas, and those who do not have the same access to basic needs, such as shelter, healthy food, clean water, schooling, employment.

PA DOH has an internal workgroup comprised of individuals from across various program areas and offices within the department, that meets monthly to discuss the latest information on a changing climate, sustainability, and environmental health topics. This group will help facilitate climate and health prioritization and planning across the department and identify additional external partners for collaborative work.

The latest version of the State Health Improvement Plan[19] includes an environmental health goal, with objectives related to improving air quality, decreasing heat-related hospitalizations, and testing more children for lead. These objectives will be met by various capacity-building, surveillance, and outreach strategies to improve environmental health in Pennsylvania.

PA DOH also has an Environmental Justice Strategic Plan, which lays out internal and external strategies on how the department intends to commit to those living in EJ areas and improve their health and representation in the department's work. Staff from the Division of Environmental Health Epidemiology, Bureau of Emergency Preparedness and Response, Office of Health Equity, and the Policy Office are leading these efforts, including implementing an equity-informed climate work plan which addresses how a changing climate is affecting health. PA DOH has published a document[20] detailing how different changing climate threats are impacting public health. This document also provides information on departmental programs that are working to address these issues and identifies disproportionately affected populations. Part of the work plan includes strengthening their coalition of partners working in the climate space.

[18] Extreme Weather Vulnerability Study (arcgis.com)

[19] SHIP_2023-2028.pdf (pa.gov)

[20] Public Health Impacts of Climate Change Threats in Pennsylvania.pdf

3 LIDACs and Pennsylvania Environmental Justice Areas

LIDACs are defined by EPA as communities with low incomes, limited access to resources, and disproportionate exposure to environmental or climate burdens. To identify these communities, CPRG planning guidance references federal tools, including the EPA's EJScreen, which uses a series of environmental and socioeconomic indices like income, air quality, and race. Figure 4 displays LIDACs in Pennsylvania based on EPA's EJScreen.

Through a robust public engagement process[21], Pennsylvania revised its own definition for environmental justice areas, and in 2023 published its updated dataset, PennEnviroScreen, displayed in Figure 5. The PennEnviroScreen tool is updated annually and utilizes Pollution Burden and Population Characteristics data to identify Environmental Justice Areas. By presenting PennEnviroScreen Composite Score percentiles, pinpointing EJ Areas (block groups at the 80th percentile or higher), and detailing individual indicators, the framework aims to enhance public engagement in the permitting process for proposed facilities, promoting a more equitable environmental landscape.[22] This tool provides unique insight into the state of Pennsylvania as it considers indicators specific to the state, like proximity to coal mines and abandoned oil and gas wells, that have significant impacts on local communities but are not considered by EJScreen. Nevertheless, there is a significant overlap between these two data sets.

According to EJScreen, 32% of the state population is designated as residing in an environmental justice area. Philadelphia County has a population of 77% in environmental justice areas, and Allegheny and Lancaster County have an environmental justice population of 34%. Montgomery and Bucks County each have an environmental justice population of 10%. A full list of the Census Block IDs that are identified as environmental justice areas in the Commonwealth is included in Appendix A. Figure 5 shows EJ areas designated by PennEnviroScreen in the state. Like EJScreen, PennEnviroScreen's data indicates that Philadelphia has the highest number of people residing in EJ areas in the Commonwealth.

Throughout the remainder of this report, the terms LIDAC and environmental justice areas, DEP's preferred terminology, are used interchangeably.

[21] EJ Policy Revision (pa.gov)

[22] PADEP. PennEnviroScreen. 2023. https://www.dep.pa.gov/PublicParticipation/OfficeofEnvironmentalJustice/Pages/PA-Environmental-Justice-Areas.aspx

Figure 4: EJScreen LIDACs in Pennsylvania

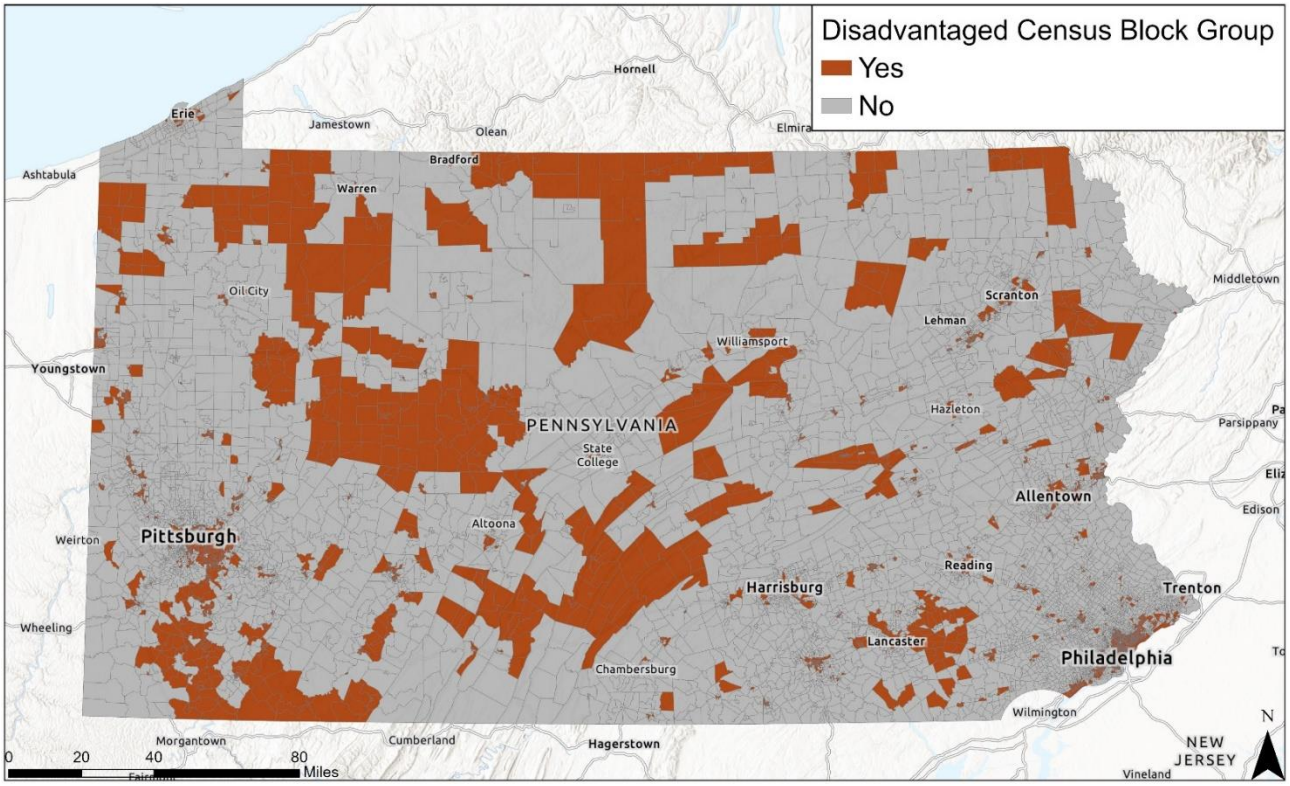
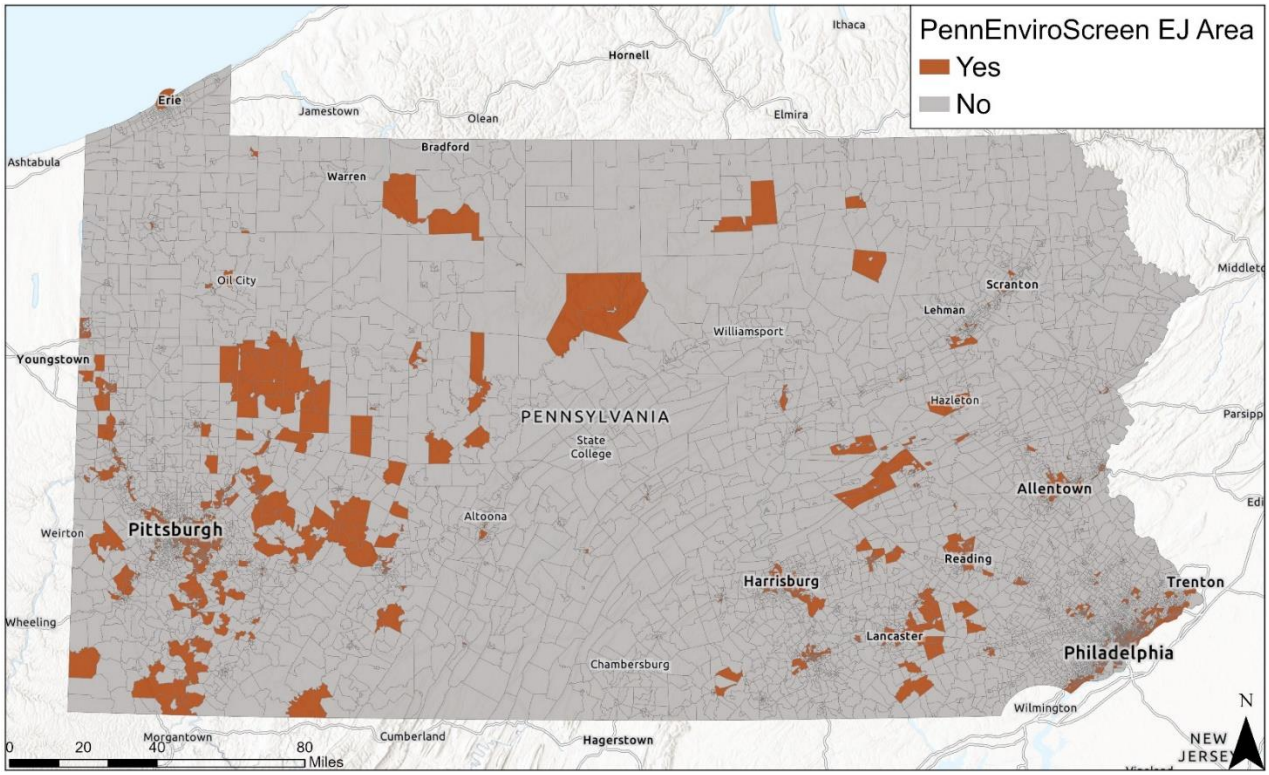


Figure 5: PennEnviroScreen EJ Areas in Pennsylvania



3.2 Climate Risks to Pennsylvania's LIDACs

Climate change will not affect all Pennsylvanians equally. Low-wealth and minoritized communities are expected to experience the most severe impacts of climate change, but they are also the least able to prepare for and respond to these impacts due to a lack of resources and socio-political power.

Within Pennsylvania, the most prevalent climate hazards are extreme precipitation events, extreme heat, landslides, sea level rise, severe tropical and extra-tropical cyclones, and drought, all of which will disproportionately burden LIDAC communities.

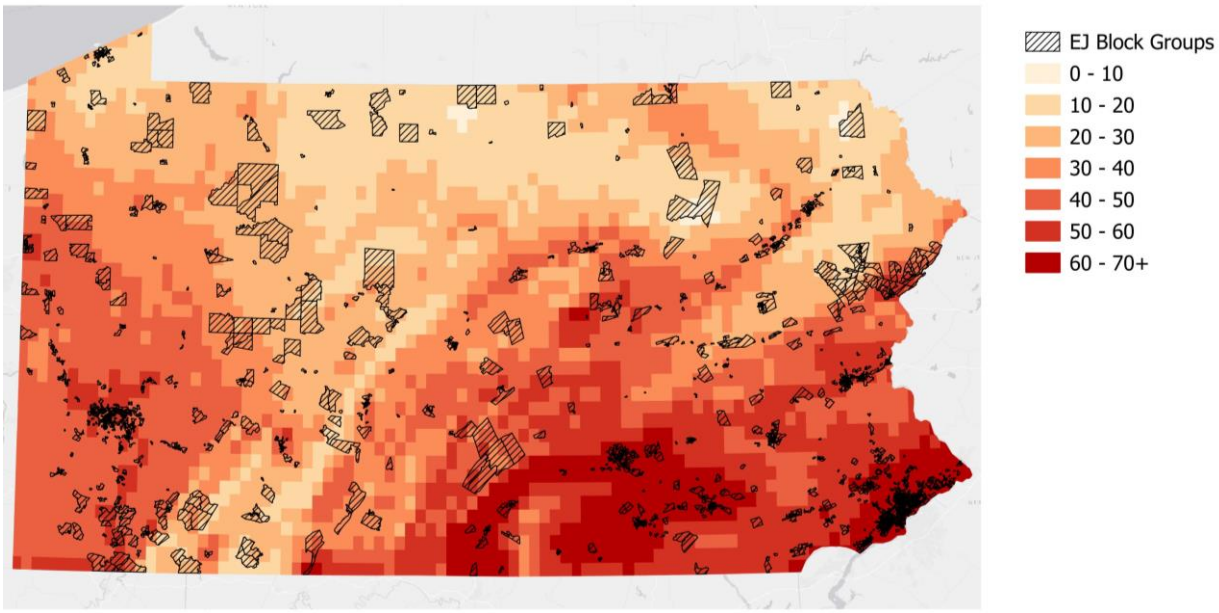
Extreme Heat

Between the years 1971 and 2000, Pennsylvania experienced an average annual daily temperature of about 48.3°F. By 2050, this is projected to rise by at least 6.7°F, and up to 10.4°F, by 2100. Additionally, heat waves will increase in frequency and severity. The baseline length for Pennsylvania is 2.3 days; this could rise to 8.8 days by 2050 and 19.3 days by 2100.[23] Exposure to extreme heat can cause heat exhaustion, heat stroke, and can contribute to deaths from a range of cardiovascular diseases such as heart attacks and strokes. Older adults, young children, people of color, outdoor workers, those with poorer health, and low-income individuals are more at risk of heat-related death. Additionally, higher temperatures will lead to increased energy demand and higher energy costs.[9] Individuals belonging to LIDACs will be less able to afford these increased costs, thus exacerbating heat-related health risks.[24]

Pennsylvania's designated EJ areas[25] are expected to be almost twice as exposed to extreme heat as the general Pennsylvania population (see Figure 6). Despite EJ populations constituting less than a third of Pennsylvania's population, more than half of those exposed are in EJ areas. Additionally, heat projections may be underestimated in cities, where urban heat island effects enhance temperatures. In fact, average surface temperatures are up to 22°F hotter in certain neighborhoods than others; these neighborhoods have higher minority and low-income residents. LIDAC populations may lack access to air conditioning, shaded outside areas, cooling centers, and healthcare.[26]

[23] Pennsylvania Department of Environmental Protection. 2024. Pennsylvania: Climate Action Plan Update.
[24] EPA, 2023. Climate Change and Heat Islands. https://www.epa.gov/heatislands/climate-change-and-heat-islands#:~:text=When%20people%20are%20exposed%20to%20extreme%20heat%2C%20they,attacks%2C%20strokes%2C%20and%20other%20forms%20of%20cardiovascular%20disease .
[25] Pennsylvania Department of Environmental Protection. Environmental Justice Map (accessed November 7, 2023). https://gis.dep.pa.gov/PennEnviroScreen/
[26] Pennsylvania Department of Environmental Protection. 2021. Pennsylvania Climate Impacts Assessment 2021. https://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/Climate%20Change%20Advisory%20Committee/2021/2-23-21/2021_Impacts_Assessment_Final_2-09-21_clean.pdf

Figure 6. Projected annual number of days with temperatures over 90°F in 2050, with EJ block groups



Extreme Precipitation and Inland Flooding

Extreme precipitation events are projected to increase in Pennsylvania due to climate change, as are annual precipitation levels. The frequency and severity of precipitation events will likely increase throughout the century.[27] This will cause more intense flooding, harming primarily households without homeowners or renters insurance or that cannot afford the necessary infrastructure repairs. In addition to flooding, heavy precipitation can cause landslides, which can further damage infrastructure.[28] Flooding can also impact human health by increasing mold production and exposure to waterborne diseases, particularly affecting those in poor living conditions and lacking access to safe and reliable drinking water.[29]

EJ populations are also disproportionately located in high-risk flood zones compared to Pennsylvania overall. About 5.5% of Pennsylvania land is located in FEMA 100-year floodplains and 5.8% in 500-year floodplains, while 6.5% of EJ areas are located in 100-year floodplains and 7.1% in 500-year floodplains. A history of development practices has placed low-income and minority communities in these higher flood-risk areas. The poorest populations often have less flood protection infrastructure, investment in stormwater management, insurance, and adaptation options available to them.[30]

Landslides

Extreme precipitation events can also increase the risk of landslides, which disproportionately impact EJ areas. EJ areas experience landslides at 1.17 times the risk of the statewide average. Furthermore, they are less able to deal with the

[27] Pennsylvania Department of Environmental Protection. 2024. Pennsylvania: Climate Action Plan Update.
[28] EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003. www.epa.gov/cira/social-vulnerability-report
[29] EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003. www.epa.gov/cira/social-vulnerability-report
[30] Pennsylvania Department of Environmental Protection. 2021. Pennsylvania Climate Impacts Assessment 2021. https://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/Climate%20Change%20Advisory%20Committee/2021/2-23-21/2021_Impacts_Assessment_Final_2-09-21_clean.pdf

devastating effects of these events. EJ communities often lack homeowners' insurance coverage for landslide damage, cannot afford the cost of repairs, and are located in areas less targeted for infrastructure repairs.[31]

Sea Level Rise

Pennsylvania has a small 56-mile coastline along the Delaware estuary, concentrated in the Philadelphia area. While Philadelphia saw approximately eight days of tidal flooding in a year early this decade, it is likely to see 74 days of tidal flooding by mid-century.[32] Higher sea-level exposes more of Pennsylvania's population to flooding. Coastal EJ areas in Pennsylvania are not disproportionately exposed to sea level rise-driven flooding. However, certain populations may be disproportionately vulnerable to or impacted by this hazard. For example, many flooding inequities prevalent in urban areas often place low-income people and communities of color at higher risk.[33] Those who live in economically distressed communities or in sub-standard housing may have a greater sensitivity to flooding. Affordable housing units have been found to face much higher risk from Sea Level Rise than standard housing in Pennsylvania.[34] They may experience greater impacts from Sea Level Rise related flooding and be less able to recover as a result of limited access to resources.

Severe Tropical and Extra-Tropical Cyclones

Many of the same impacts described under Heavy Precipitation and Inland Flooding apply to cyclone events. Cyclones will threaten those in low-lying areas, as these extreme storm events exacerbate flooding. EJ areas are slightly over-represented in FEMA 500-year floodplains compared to the state average (1.2 times as exposed). Affordable housing is also expected to see a 792% increase in exposure to coastal flood. This is the largest predicted increase in affordable housing exposure for any coastal state.[35]

Beyond being slightly over-represented in terms of exposure, communities with a high percentage of low-income individuals are more at-risk of facing serious consequences after an extreme storm. Low-income households are more likely to lack the resources to recover quickly from an extreme cyclone, and to reside in substandard housing, which increases the risk of mold, mildew, poor indoor air quality, and damage after intense rain and wind during storms.[36,37] Similarly, areas with a high percentage of low-income individuals are more likely to have less climate-resilient infrastructure.[38]

Drought

Despite higher annual rainfall totals, the increasing number of extreme precipitation events will also be punctuated by an increasing number of consecutive dry days, leading to drought.[39] Drought can contribute to water scarcity and cause major food insecurity or threaten farming livelihoods. Food insecurity leads to hikes in food prices and potentially civil unrest and mass migration. All these impacts will be felt most strongly by minority and low-income communities.[40]

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[31] Pennsylvania Department of Environmental Protection. 2021. Pennsylvania Climate Impacts Assessment 2021. https://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/Climate%20Change%20Advisory%20Committee/2021/2-23-21/2021_Impacts_Assessment_Final_2-09-21_clean.pdf

[32] "Projected Flooding | Flooding Analysis Tool," NASA Sea Level Change Team, n.d., https://sealevel.nasa.gov/flooding-analysis-tool/projected-flooding.

[33] U.S. Water Alliance. 2020. "Water Rising: Equitable Approaches to Urban Planning."

[34] Buchanan, Maya K, Scott Kulp, Lara Cushing, Rachel Morello-Frosch, Todd Nedwick, and Benjamin Strauss. "Sea Level Rise and Coastal Flooding Threaten Affordable Housing." Environmental Research Letters 15, no. 12 (December 1, 2020): 124020. https://doi.org/10.1088/1748-9326/abb266.

[35] Buchanan, Maya K, Scott Kulp, Lara Cushing, Rachel Morello-Frosch, Todd Nedwick, and Benjamin Strauss. "Sea Level Rise and Coastal Flooding Threaten Affordable Housing." Environmental Research Letters 15, no. 12 (December 1, 2020): 124020. https://doi.org/10.1088/1748-9326/abb266 .

[36] Urban Sustainability Directors Network (USDN) and Raimi Associates. 2017. "Equitable Community-driven Climate Preparedness Planning." 46. https://www.usdn.org/uploads/cms/documents/usdn_guide_to_equitable_community-driven_climate_preparedness-_high_res.pdf

[37] Clifton, R., Majumder, B., and Kelly, C. 2020. "Equitable and Just Hurricane and Disaster Preparedness Amid COVID-19." *Center for American Progress.* https://www.americanprogress.org/issues/green/reports/2020/09/30/490964/equitable-just-hurricane-disaster-preparedness-amid-covid-19/

[38] Clifton, Majumder and Kelly. 2020. Preparedness.

[39] Pennsylvania Department of Environmental Protection. 2024. Pennsylvania: Climate Action Plan Update.

[40] Bolster, C.H., R. Mitchell, A. Kitts, A. Campbell, M. Cosh, T.L. Farrigan, A.J. Franzluebbers, D.L. Hoover, V.L. Jin, D.E. Peck, M.R. Schmer, and M.D. Smith, 2023: Ch. 11. Agriculture, food systems, and rural communities. In: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH11 .

4 Priority Climate Action Measures

DEP's priority GHG reduction measures target the industrial, buildings, transportation, power, LULUCF, agricultural, and waste sectors. These measures are designed not only to directly reduce GHG emissions and improve air quality, but provide other benefits to improve public health, create safer and more reliable infrastructure, provide workforce development opportunities, and reduce costs for Pennsylvanians, particularly for people living in areas impacted by environmental justice issues. A list of PCAP Measures is outlined initially in Table 5.

Table 5: PCAP Measures List

Measure	Sector(s)
1. Industrial Electrification, Efficiency, and Process Emissions	Industrial
2. Low Carbon Fuels	Industrial
3. On-Site Renewable Energy	Industrial/Buildings
4. Carbon Capture Utilization and Storage	Industrial/LULUCF
5. Fugitive Emissions Reduction	Industrial/Agricultural/Waste
6. Net-Zero Electricity Grid	Power
7. Building Electrification and Efficiency	Buildings
8. Electric and Alternative Fuel Vehicles	Transportation
9. Public and Active Transportation	Transportation

4.1 Benefits and Co-Benefits Analysis

The initiatives outlined in the PCAP will contribute to achieving local, state, and national climate objectives while reducing co-pollutants, such as criteria air pollutants and hazardous air pollutants, that adversely affect Pennsylvania and its environment. Decreasing fossil fuel (i.e., coal, natural gas, petroleum, propane) use in buildings, vehicles, and electric power generation, in addition to more clean and efficient industrial practices, will lower emissions and generate environmental, public health, and socioeconomic advantages. In the short term, the reduction of co-pollutants will enhance both indoor and outdoor air quality, diminishing hazardous air pollutants, toxins, and other harmful substances. The immediate alleviation of these pollutants can positively impact the physical and economic well-being of communities. In the long run, the reduction of GHGs will mitigate the impacts of climate change. The pollutants reduced by the following PCAP measures are outlined in Table 6.

Table 6: Air Pollutants and GHGs Reduced by PCAP Measures

Type of Pollutant	Categories of Related Measures
Carbon Monoxide (CO)	Industry, Buildings, Transportation, Grid
Methane	Industry, Buildings, Transportation, Grid, Waste
Sulfur dioxide	Industry, Buildings, Transportation, Grid
Nitrogen Oxides	Industry, Buildings, Transportation, Grid
Carbon Dioxide	Industry, Buildings, Transportation, Grid, Waste
Volatile Organic Compounds	Industry, Transportation
Sulfur Hexafluoride	Industry, Buildings, Grid
Particulate Matter (e.g., PM2.5)	Industry, Buildings, Transportation, Grid
Heavy Metals	Industry, Buildings, Transportation, Grid
Nitrous Oxide	Industry, Transportation, Grid
Hydrocarbons	Industry, Transportation
Other hazardous air pollutants and air toxics	Industry, Transportation, Grid

These co-pollutants are also described throughout the PCAP Measures section. The co-benefits, detailed below, impact all communities where programs and projects related to the PCAP measures may be implemented.

4.1.1 Public Health Benefits

Reducing GHG and co-pollutant emissions has and will continue to have profound implications for public health of Pennsylvanians. The combustion of fossil fuels contributes to outdoor and indoor air pollution which, in turn, poses significant health risks. In the United States, roughly 87% of people's lives are spent indoors, so indoor exposure to combustion pollutants, such as natural gas for cooktops or heating, has the potential for substantial health effects.[41] In instances of long-term exposure, these health effects can include premature mortality, adverse birth outcomes, cognitive decline, and gastrointestinal inflammatory disease. Short term exposure can lead to asthma and respiratory symptoms.[42]

Furthermore, the adverse health impacts extend to climate impacts such as extreme heat events. Nearly two-thirds of the US population resides in areas susceptible to health risks related to extreme heat, including heat-related illnesses and cardiovascular conditions. See Section 3.2 for more information on climate-related risks, particularly for LIDACs.

4.1.2 Socioeconomic Benefits

The implementation of the priority GHG reduction measures in Pennsylvania's PCAP can bring significant socioeconomic advantages to Pennsylvanians, especially among people living in communities impacted by environmental justice issues. One major shift will be increased high-quality energy related jobs to the state as it builds renewable energy infrastructure and expands on energy efficiency efforts. The development of clean energy technologies, such as solar installations and electric vehicle (EV) charging infrastructure, necessitates skilled individuals proficient in installing and maintaining such hardware. The 2023 Pennsylvania Energy Efficiency Workforce Needs report[43] projects that demand for energy efficiency

[41] U.S. EPA. 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, DC.

[42] Health Effects Institute. 2020. *Health Effects Institute Annual Report 2020: Valuing Science Informing Decisions.* https://www.healtheffects.org/system/files/hei-annual-report-2020.pdf

[43] PA DEP. 2023. Pennsylvania Energy Efficiency Workforce Needs https://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/2023_Energy_Report/PA%20EE%20Workforce%20Needs%20Report%20Final.pdf

and building electrification workers including heating, air conditioning, and refrigeration mechanics and construction and building inspectors will see a significant increase over the next decade. Offering clean energy job training, especially within environmental justice areas, both supports resilient and clean infrastructure and generates economic opportunities.

Clean energy can be developed to improve grid resilience (e.g., through battery storage), reducing the risk of blackouts and promoting energy independence.[44] Consequently, these investments mitigate the economic and physical impact of extreme weather events.

GHG emissions contribute to more frequent and severe extreme weather events, resulting in substantial financial costs and economic impacts. Long-term reduction of GHG emissions can mitigate these events, such as extreme precipitation and storms, while preventing associated costs like increased insurance premiums, expenses for repairing structural damage, and losses in crops and natural resources. The reduction of extreme weather events also alleviates costs related to medical bills and premature deaths. In 2022 alone, the US faced 18 extreme weather and climate events costing over $1 billion, making the reduction of these costs crucial for individual, community, and overall economic well-being.[45]

Electrifying and decarbonizing energy end-use sectors and enhancing efficiency through properly designed measure implementation can offer financial relief to individuals and businesses, especially for low-wealth and minoritized residents. Energy efficiency retrofits will reduce overall household energy use, therefore lowering energy bills. This reduction in energy cost burden eases financial stress for households and businesses, allowing resources to be redirected to better individual economic situations and stimulate the economy.

Additionally, the PCAP measures promote and require public education, community engagement, and social inclusion. Implementing measures such as enhanced multimodal and public transit options fosters social capital, encourages community engagement, and contributes to the overall socioeconomic well-being of the Commonwealth.

4.2 LIDAC Benefits

The PCAP measures provide a range of benefits to LIDAC communities including:

- **Reduced Indoor Air Pollution:** Reductions in co-pollutants (e.g., GHGs, particulate matter, hazardous air pollutants) result in enhanced public health outcomes, including declines in illnesses and premature mortality associated with indoor air pollution.[46]
- **Reduced Outside Air Pollution:** Enhanced public health outcomes stemming from reductions in co-pollutants (e.g., GHGs, particulate matter, hazardous air pollutants) result in enhanced public health outcomes, including declines in illnesses and premature mortality associated with outdoor air pollution.[47]
- **Increased Resilience to Climate Change:** Strengthened resilience to climate change events from measures that reduce GHGs and offer climate adaptation co-benefits. GHG emissions are linked to global warming and climate change, so reducing emissions lowers the likelihood of climate events (e.g., extreme heat) and associated risks (e.g., heat-related illness).[48]
- **Increased Employment Opportunities and Workforce Development:** Establishment of high-quality employment opportunities and workforce development initiatives in LIDAC communities, prioritizing access to the clean workforce and economy for LIDAC workers and small businesses, in accordance with Justice40 guidance.

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[44] Stout, S., Hotchkiss, E., Lee, N., Holm, A., & Day, M. (2018). *Distributed Energy Planning for Climate Resilience.* NREL. https://www.nrel.gov/docs/fy18osti/71310.pdf

[45] Smith, A. 2023. *2022 U.S. billion-dollar weather and climate disasters in historical context.* NOAA. https://www.climate.gov/news-features/blogs/beyond-data/2022-us-billion-dollar-weather-and-climate-disasters-historical

[46] U.S. EPA. 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, DC.

[47] Health Effects Institute. 2020. Health Effects Institute Annual Report 2020: Valuing Science Informing Decisions. https://www.healtheffects.org/system/files/hei-annual-report-2020.pdf

[48] Vaidyanathan, A. Malilay, J., Schramm, P., and Saha, S. 2020. Heat-Related Deaths — United States, 2004–2018. MMWR Morb Mortal Wkly Rep 2020; 69:729-734.

- **Increased Energy Security:** Bolstered energy security through enhancements in energy efficiency and the adoption of more resilient energy generation technologies.
- **Enhanced Quality of Space:** Increased comfort and quality of space, such as a safer, healthier home or workplace due to reduced indoor air pollution.
- **Improved Access to Climate Change Resources:** Provide easier access to climate change-related resources, education, job trainings, and services.
- **Increased Accessibility to Transit and Active Transportation:** Expanded access to public transit and alternative transportation methods (e.g., increased frequency in transit routes, improved sidewalks or bike lanes).
- **Less Noise Disturbance:** Less noise pollution (e.g., from vehicle traffic) due to a decrease in single-occupancy vehicles on the road.
- **Increased Climate Change Awareness:** More purposeful community engagement and enhanced public awareness of climate-related projects and their outcomes.
- **Expanded Community Networks:** Greater social capital that arises when communities can enjoy public spaces safely (i.e., without air pollution), have greater access to public resources (e.g., information, transportation), and overall live healthier lives with improved socioeconomic wellbeing.
- **Energy Efficiency Cost Savings:** Cost savings from energy efficiency as a smaller portion of income is allocated to electricity and heating bills.[49]
- **Electric Vehicle Cost Savings:** Cost savings associated with the transition from ICE vehicles to EVs due to lower vehicle fuel and maintenance cost.[50]

Table 7 shows the associated LIDAC benefits for each measure. Details of LIDAC benefits for each measure are described in Section 4.5.

[49] U.S. DOE. 2019. Low-Income Household Energy Burden Varies Among States — Efficiency Can Help In All of Them. Energy.gov. https://www.energy.gov/sites/prod/files/2019/01/f58/WIP-Energy-Burden_final.pdf

[50] U.S. DOE. 2022. Saving Money with Electric Vehicles. https://www.energy.gov/energysaver/articles/saving-money-electric-vehicles

Table 7. LIDAC Benefits by Measure

LIDAC Benefits from GHG Emissions Reductions	Industrial Electrification, Efficiency, and Process Emissions	Low Carbon Fuels	On-Site Renewable Energy	Carbon Capture Utilization and Storage	Fugitive Emissions Reductions	Net-Zero Electricity Grid	Building Electrification and Efficiency	Electric and Alternative Fuel Vehicles	Public and Active Transportation
Reduced Indoor Air Pollution			✓			✓	✓		
Reduced Outside Air Pollution	✓	✓	✓	✓	✓	✓	✓	✓	✓
Increased Resilience to Climate Change	✓	✓	✓	✓	✓	✓	✓	✓	✓
Increased Employment Opportunities and Workforce Development	✓	✓	✓	✓	✓	✓	✓	✓	✓
Increased Energy Security	✓	✓	✓			✓	✓	✓	✓
Enhance Quality of Space			✓				✓		
Improved Access to Climate Change Resources	✓	✓	✓	✓	✓	✓	✓	✓	✓
Increased Accessibility to Transit and Active Transportation								✓	✓
Less Noise Disturbance								✓	✓
Increased Climate Change Awareness	✓	✓	✓	✓	✓	✓	✓	✓	✓
Expanded Community Networks	✓	✓	✓	✓	✓	✓	✓	✓	✓
Energy Efficiency Cost Savings	✓		✓		✓		✓	✓	
Electric Vehicle Cost Savings								✓	

4.3 Implementation Schedule

Table 8 depicts a proposed timeline for implementation of the PCAP measures.

Table 8: Proposed Timeline

Milestone	Timeframe
2024	
Deliver final PCAP to EPA, which includes interested party input on measures	March 1, 2024
Identify key actions to take under each measure	Throughout 2024
2025	
Coordinate resources across jurisdictions and take initial actions across the PCAP measures	Early 2025
Estimate GHG emissions reductions measure actions	Early 2025
Estimate LIDAC benefits from measure actions	Early 2025
Deliver final CCAP to EPA	Mid 2025
2026	
Continue implementing measure actions	Early 2026
Implement pilot programs and short-term strategies for GHG reductions	Mid 2026
Secure approval and budget for ongoing GHG reductions	Mid-late 2026
2027	
Deliver Status Report to EPA	Mid 2027
Continue to implement measures and reduce GHGs; Track progress across the state	2027 onward

4.4 Workforce Planning Analysis

4.4.1 Labor Demand and Priority Occupations

The CPRG calls for grantees to reduce climate pollution while building the clean energy economy in a way that benefits all Americans, provides new workforce training opportunities, and effectively addresses environmental injustices in low-wealth and minoritized communities. This PCAP includes a preliminary analysis of workforce development activities needed to implement the plan's priority measures, with emphasis on industrial measures. To analyze the local workforce in preparation for these priority industrial measures, it is vital to take multiple factors into account, including examining the structure of the current workforce and the workforce required to implement the measures, anticipated supply of labor appropriate to the measures, inventory of workforce education and training resources to shape and meet the demand for labor and skills gaps, and how workforce measures can benefit the communities that need the most help.

There are approximately ten priority occupations that will be in-demand as a result of the implementation of the industrial measures, and these occupations are likely to see some of the greatest increase in demand. Due to the nature of these occupations' specialized skills, the shortage of these workers would hinder the successful implementation of the plan's priority measures. The priority occupations with descriptions of their primary roles are listed below.

- **Electricians** install, maintain, and repair electrical wiring, equipment, and fixtures.
- **Heating, Air Conditioning, and Refrigeration (HVAC/R) Mechanics and Installers** install or repair heating, central air conditioning, HVAC, or refrigeration systems, including oil burners, hot-air furnaces, and heating stoves.
- **Pipelayers, Plumbers, Pipefitters, and Steamfitters** assemble, install, alter, and repair pipelines or pipe systems that carry water, steam, air, or other liquids or gases.
- **Construction Laborers** perform tasks involving physical labor at construction sites.
- **Carpenters** construct, erect, install, or repair structures and fixtures made of wood and comparable materials, such as concrete forms; building frameworks, including partitions, joists, studding, and rafters; and wood stairways, window and door frames, and hardwood floors.
- **Boilermakers** construct, assemble, maintain, and repair stationary steam boilers and boiler house auxiliaries.

- **Construction Equipment Operators** operate one or several types of power construction equipment, such as motor graders, bulldozers, scrapers, compressors, pumps, derricks, shovels, tractors, or front-end loaders to excavate, move, and grade earth, erect structures, or pour concrete or other hard surface pavement.
- **Insulation Workers** apply insulating materials to pipes, ductwork, or other mechanical systems in order to help control and maintain temperature.
- **Industrial Machinery Installation, Repair, and Maintenance Workers** repair, install, adjust, or maintain industrial production and processing machinery or refinery and pipeline distribution systems.
- **Welding, Soldering, and Brazing Workers** use hand-welding, flame-cutting, hand-soldering, or brazing equipment to weld or join metal components or to fill holes, indentations, or seams of fabricated metal products.

Based on the typical attributes of these jobs including wages, benefits, training needed, unionization rates, and access to training pathways, the increase in demand for these occupations provides a significant opportunity to create and maintain good jobs throughout Pennsylvania as the industrial sector decarbonizes. By focusing workforce development investments and programs in support of these occupations, Pennsylvania and its residents can maximize the funding resources available and streamline engagement with critical stakeholders.

More than 210,000 workers are employed within the ten priority occupations in Pennsylvania. Construction Laborers (51,300 jobs) and Carpenters (35,500) make up the largest share of priority occupation workers, while Insulation Workers and Boilermakers account for fewer than 1,500 jobs each across the state. Six of the ten priority occupations (carpenters; electricians; plumbers, pipefitters, and steamfitters; construction laborers; boilermakers; and insulation workers) have location quotients—or concentration of those jobs—lower than the national average. That means that although these occupations are crucial to supporting the implementation of the priority measures, many of them are found in lower concentrations in Pennsylvania than the broader United States, which could worsen shortages as the demand for these workers increases.

4.4.2 Considerations for Meeting Demand

Hiring Difficulty

With unemployment near all-time lows, stories of hiring difficulty across industries have become more commonplace. In fact, the 2023 US Energy and Employment Report found that 59% of non-union construction firms in clean energy reported it was very difficult to find new workers, while only 31% of union signatory or Project Labor Agreement firms reported the same level of difficulty.[51] The energy sector in Pennsylvania is no different; two-thirds of non-labor signatory firms reported it was 'very difficult' to find workers compared to 28% of labor signatory firms. In fact, 44% of labor signatories reported no challenges finding talent at all.

Key Skills

The ten priority occupations overwhelmingly do not require workers with a four year degree. In fact, between 85% and 95% of workers in each of the priority occupations do not have a four year degree, compared to 58% of all workers throughout the Pennsylvania economy. This data makes it clear that these occupations do not have extensive educational requirements or barriers. The priority occupations also have many shared top knowledge attributes, skills, and abilities. For example, nine out of ten priority occupations require 'Mechanical' knowledge, and eight out of ten priority occupations have 'Critical Thinking' as a top skill. The similarities in knowledge attributes, skills, and abilities means that pre-apprenticeship and other career entry programs can support many of these occupations simultaneously without the need to specialize curriculum.

Economic Opportunity for LIDACs

Residents within LIDAC communities have far fewer economic opportunities than their non-disadvantaged neighbors; the unemployment rate is nearly twice as high, the labor force participation rate is five percentage-points lower, and

[51] https://www.energy.gov/sites/default/files/2023-06/2023%20USEER%20REPORT-v2.pdf

household income is nearly half as high (Table 9). The severity of the discrepancy highlights the historic lack of investment and opportunity flowing into these communities and reflects both a need and an opportunity for these communities. Greater effort and resources are needed to attract and access the greater share of potential job seekers that live within disadvantaged communities. Offering wraparound support services to job seekers can increase retention and completion rates of training programs and help individuals segue into their new careers.

Table 9. Economic Opportunity for Disadvantaged Communities in Pennsylvania

	Unemployment Rate	Labor Force Participation Rate	Household Income
Non-Disadvantaged Communities	4.4%	64.2%	$108,245
Disadvantaged Communities	9.0%	59.4%	$58,200

4.5 Priority GHG Reduction Measures

The Pennsylvania PCAP incorporates GHG reduction measures aligned with the Commonwealth's priorities to pursue funding opportunities under the CPRG program. Pennsylvania's PCAP GHG reduction measures encompass a broad range of project, program, and idea submissions from the state government, local authorities, regional planning agencies, individuals living in communities impacted by environmental justice issues, and other interested parties received by the Pennsylvania CPRG team. The details of each measure, such as key implementers, implementation activities, and milestones, are intended to be informative but are not exhaustive of all opportunities to implement a given measure.

Notably, Pennsylvania acknowledges the potential far-reaching impact of leveraging the IRA tax incentives. While the clean technology adoption and utilization decisions are decentralized across the Commonwealth's many residents and businesses, Pennsylvania can play a role in informing and engaging the public of the available opportunities, easing access to those opportunities with streamlined and simplified application requirements and technical support, and developing data-driven, targeted complementary policies to increase uptake economywide. The Commonwealth is exploring the potential of a centralized resource to coordinate and facilitate this streamlining and engagement, versus embedding these functions directly in their relevant measures and programs.

The measures in this document highlight the Commonwealth's priorities, with a specific focus on opportunities within the industrial sector, where emissions have been growing and where there has been a smaller emphasis on programs, policies, and projects to reduce emissions. Six of the nine PCAP measures have potential to reduce emissions in the industrial sector (Industrial Electrification, Efficiency, and Process Emissions; Low Carbon Fuels; On-Site Renewable Energy; Carbon Capture, Use and Storage; Fugitive Emissions Reduction; and Net-Zero Electricity Grid.)

4.5.1 Industrial Electrification, Efficiency, and Process Emissions

GHG Measure Description

Pennsylvania is home to a range of industrial operations for processing raw materials and finished products with significant diversity. While industrial processes vary significantly across types of industry (including iron and steel, bulk chemical processes, pulp and paper and other industrial work), nearly all industrial processes have opportunities to enhance their thermal or electrical efficiency. With opportunities from the IRA, some industrial operations can be cost-effectively decarbonized through electrification tools from heat pumps for low to medium temperature ranges to thermal storage for high temperature processes, and by changing industrial processes that generate GHG emissions. Electrification's suitability might differ by use case, and such efforts are well complemented by further changes to chemical processes, production techniques to reduce process emissions, and/or carbon capture, utilization, and storage (CCUS). This measure complements the advancement of CCUS and hydrogen/hub infrastructure (more details in the *CCUS* and *Low Carbon Fuels* measures) which includes exploring the expansion of the current offtake profiles of hydrogen hubs to include heavy industry, particularly steel, chemicals and fertilizer/ammonia production, and establishing regulations.

This measure will be supported by national and DEP programs to enhance energy efficiency, deploy electrification, and reduce process emissions in industrial facilities throughout the Commonwealth. Additionally, pilots of new technologies to reduce emissions from hard-to-decarbonize industrial processes is a key activity of this measure. Finally, studies to identify phase-down and phase-out pathways for fossil-reliant industries that cannot be defossilized, as well as exploring

regulatory standards or financial disincentives that can complement public investments and encourage private investments into technology and equipment changes, would effectively leverage the strategies proposed in this measure to reduce industrial emissions in Pennsylvania.

Deploying industrial electrification, efficiency and reducing process emissions can take many forms including:

- Supporting education on industrial decarbonization opportunities (electrification, efficiency and process emissions reduction).
- Funding industrial decarbonization.
- Using financing tools to expand industrial decarbonization.
- Encouraging and providing incentives for industrial decarbonization.
- Conducting comprehensive planning efforts in deploying hydrogen and/or biomethane projects (both production and use) in industrial applications, with a goal to support the project development and implementation of projects.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory Sector: Industrial
- Cumulative Reductions from 2025-2030: 20.1 MMT CO_2e
- Cumulative Reductions from 2025-2050: 265.4 MMT CO_2e

Summary of GHG reduction calculations approach

Industrial emissions reductions from thermal efficiency gains were modeled using EPA's Flight Facility-level GHG Emissions Data, Greenhouse Gas Reporting Program[52] and the US Department of Energy (DOE) Industrial Decarbonization Roadmap[53] data to identify thermal efficiency potentials for each industry type and the resulting emissions compared to the business as usual (BAU) case.

Industrial process emissions reductions were estimated using the Energy Policy Simulator (EPS) for Pennsylvania, a model maintained by Energy Innovation and RMI. Strategies estimated using the EPS include methane destruction and capture, fluorinated gas equipment retrofits, cement clinker substitution, N2O abatement, and material efficiency. The rate of implementation of these strategies is commensurate with meeting 2030 and 2050 targets, and technological readiness.

More detail on the methodology for thermal efficiency emissions reductions, how the EPS works and the inputs can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

- **Pennsylvania Energy Development Authority (PEDA):** PEDA is Pennsylvania's State Energy Financing Institution (SEFI) under Title 17, and as the PA Energy Accelerator Program/Pennsylvania's Green Bank. PEDA assists in the deployment of low-carbon solutions for the industrial sector through financial mechanisms , and has applied for the EPA Solar for All funding opportunity.
- **Pennsylvania Department of Community and Economic Development (DCED) and Commonwealth Financing Authority (CFA):** Provides financing opportunities for various energy projects including solar, geothermal, and wind energy.
- **Pennsylvania Department of Labor and Industry (L&I):** Partners in the development of a clean energy workforce.
- **State and Federal Government:** Can support new technologies, update regulations, and incentivize investments. They can enable pilot projects by updating regulations or through permitting. This can enable the use of technologies for which a clear regulatory process does not yet exist.

[52] https://ghgdata.epa.gov/ghgp/main.do?site_preference=normal

[53] DOE. "Industrial Decarbonization Roadmap." 2022. https://www.energy.gov/industrial-technologies/doe-industrial-decarbonization-roadmap

- **Industry and trade groups:** Industry and trade groups may implement electricity and gas efficiency, electrification, or process improvement projects, share best practices, and build and disseminate resources for companies and other industrial bodies to become more efficient and decarbonized. Partnering with industry and trade groups enables efficiency and decarbonization planning that is tailored to subsectors with unique needs.
- **Utilities:** Gas and electric utilities provide crucial support for efficiency programs and provide energy to support industrial operations.
- **C-PACE Administrators:** Regional or local partners that have provided assistance to industry in implementing efficiency measures and have strong connections to decision-makers in the industrial space.

Progress to Date and Future Activities and Milestones

Progress in industrial decarbonization has mainly been targeted at industrial efficiency through participation in DOE's Better Plants Challenge and DEP's Energy Efficiency, Environment, and Economics (E4) Initiative. Actions outlined in the Pennsylvania Clean Energy Program Plan (CEPP)[54] have been taken to decarbonize the industrial sector including:

- Clean energy financing through Green Energy Loan Fund (GELF).
- Deployment of assistance for clean and resilient microgrids for industrial entities.
- Development of a training incentive program with L&I to train new clean energy workers.
- Dedication of DOE State Energy Program Funds provided to Pennsylvania for over 10 years to conduct industrial energy assessments. This program is currently expanding with Bipartisan Infrastructure Law funding.

Future activities that will support this measure include, but are not limited to:

- Funding and providing technical assistance to industrial partners through the in-development Reducing Industrial Sector Emissions in Pennsylvania (RISE PA) grant program.
- Building best practices, and legal frameworks to facilitate and structure the growing CCUS and hydrogen infrastructure adjacent to industrial decarbonization proposed within this measure.
- Clean energy workforce analysis (building off the PA DEP 2022 energy and clean energy employment reports[55]), training, and development.
    - Train workers to employ energy management systems, conduct scoping audits, and prepare industry to utilize technology to manage and reduce emissions.
    - Partner with state universities and post-secondary institutions to provide training, apprenticeship, and educational programs to support the growing hydrogen and carbon capture infrastructure.
    - Support coal and coke communities that may suffer employment loss as demand for thermal and metallurgical coal decreases.
- Accelerate the deployment of energy efficiency solutions in existing facilities.
    - Energy efficiency actions can include heat exchange efficiency, novel and existing efficient technologies, combined heat and power, and waste heat recovery. Analysis of emissions reduction potential for each industry and facility would be beneficial to ensure significant capital is not spent on efficiency improvements with limited emissions reductions, as large investments in existing fossil-based facilities with limited emissions reductions will create carbon lock-in.
    - Provide incentives for energy management or demand response actions.
- Electrify industrial processes and equipment for low- and mid-temperature processes. Decarbonization of the electric grid (see the *Net-Zero Electricity Grid measure*) will increase the impact of electrified industrial processes and equipment.
    - Heat electrification methods can include: heat pumps for low-medium temperature ranges (<200C), thermal storage for high-temperature ranges (>200C) that apply for most heavy industrial processes from

[54] DEP. "Clean Energy Program Plan: Priorities in Renewable Energy and Energy Efficiency, Security, and Workforce Development." 2022. https://greenport.pa.gov/elibrary//GetDocument?docId=4852828&DocName=CLEAN%20ENERGY%20PROGRAM%20PLAN%202023-2025.PDF%20%3cspan%20style%3D%22color:green%3b%22%3e%3c/span%3e%20%3cspan%20style%3D%22color:blue%3b%22%3e%28NEW%29%3c/span%3e

[55] https://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/2022_Energy_Report/2022_PA_CEER_3.4vw.pdf

steel, cement, chemicals and refining, as well as novel electrochemical based methods (e.g. electrified chemical separation processes).
    - Create analysis to assess rate and tariff design in partnership with the Pennsylvania Public Utility Commission to establish, if necessary, affordable industrial user rates that properly values flexible loads while ensuring equitable outcomes (including avoiding cost shifts) for Pennsylvania residents.
    - Leverage federal funding opportunities such as the Energy Infrastructure Reinvestment (EIR) funds to fund coal conversion projects that combine thermal storage's ability to integrate renewables and on-site thermal equipment (such as steam turbines), with heat as an output for industrial off-takers.
- Invest in large scale industrial decarbonization projects.
    - Support first of its kind industrial projects through grants, offtake agreements, and other incentives (including demand-side incentives).
    - Streamline permitting processes for industrial decarbonization projects while maintaining proper safety considerations and requiring community consent or engagement as a key part of project approval processes.
    - Increase funding to leverage PEDA's status as Pennsylvania's State Energy Financing Institution (SEFI) under Title 17 and leverage DOE Loan Program Office funds to act as a credit backstop for industrial decarbonization projects, similar to the US Department of Agriculture's (USDA) Empowering Rural America (New ERA) program, to ensure projects are able to attract private financing.
    - Transition existing steel assets away from coal-based production and towards cleaner technologies (electrolysis, direct reduction paired with carbon capture, hydrogen or electric arc furnaces).
    - Create a long-term phase down and phase out of petroleum and natural gas production, refining, processing and end-use industrial activities in conjunction with labor and community representatives.
- Reduce embodied carbon from alternative material use, sustainable regional supply chain hubs, and industrial clusters. Lower-carbon materials can be used in the development of lower-carbon industrial markets.
    - Material efficiency can be achieved in the industrial sector by "lightweighting" products, designing products for longer use, utilizing more sustainable materials, and increasing reuse and recycling.
    - Support increased usage of low carbon supplementary cementitious materials such as calcined clays, fly ash, slag, natural pozzolans, and others.
    - Explore and pilot ordinary Portland cement alternatives through relevant subsidies and pilot projects.
    - Support state level buy-clean initiatives to help grow demand for low-carbon construction materials (steel and cement).
    - Adopt product-specific, third-party verified environmental products declarations to identify and prioritize lower-carbon petrochemical materials such as insulation and carpeting material in state public procurement initiatives, while incentivizing bio-based materials as a long-term transition goal for procurement.
- Perform an analysis, cost estimation, and provide general technical support of the industrial sector, targeted subsectors, or specific project sites to identify what technologies, financing approaches, and projects should be a focus of industrial decarbonization programs and what it would cost to implement them.
- Implement an industrial emissions standard to ensure alignment and industry compliance with state decarbonization goals. Investments in monitoring equipment (GHG emissions and other air pollution) within facility fence lines would aid in emission transparency, as well as meet long-standing community concerns about toxic industrial emissions.

The actions that will be most effective in decarbonizing one industrial sector may vary greatly from another. Under this measure, actions to decarbonize the industrial sector must be flexible to allow for the most impactful actions to be deployed for each industry.

Authority to Implement

The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the Air Pollution Control Act (APCA) or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs. Alternatively, industrial partners have the authority to

implement energy efficiency, electrification, and process emission reduction projects. DEP has the authority to administer programs that provide funding to incentivize industrial decarbonization efforts. If industrial decarbonization mandates are pursued, there is precedent in Act 129, but any new legislation would have to go through the same process.

Geographic Coverage

This measure is applicable to the entire state of Pennsylvania.

Funding Sources

- 48C Federal Tax Credit
- US Department of Energy (US DOE) - State Energy Program
- US DOE - Energy Efficiency Revolving Loan Fund Capitalization Grant Program
- US DOE - Energy Efficiency and Conservation Block Grant
- Federal Highway Administration - Carbon Reduction Program
- US Department of Housing and Urban Development - Green and Resilient Retrofit Program
- US EPA - Greenhouse Gas Reduction Fund (GGRF)
- PA DEP – GELF, PEDA
- PA DEP - Alternative Fuels Incentive Grants and Rebates

LIDAC Benefits and Co-Benefits

Benefits to LIDACs in Pennsylvania may include improved air quality, especially in fence line communities where localized air pollution can be reduced. This can lead to improved public health outcomes in highly industrialized communities. For example, a recent American Council for an Energy-Efficient Economy (ACEEE) study notes that children living near industrial sites have a much higher likelihood of being diagnosed with asthma.[56] Through implementing this measure, this likelihood and other risks will be reduced for fence line communities. This was a priority identified in CAEJC outreach in EJ areas. Reducing the amount of fossil fuels used in industry can also result in improved safety and working conditions for industrial employees.

The equity considerations and associated LIDAC vary depending on the technologies and specific strategies involved in facilitating industrial decarbonization.

Iron and steelmaking, in addition to upstream coke production and coal preparation, are sources of considerable local environmental pollutants (NOx, SOx, PM2.5, PM10, hazardous air pollutants). Removing coal from production methods and transitioning to direct reduced iron and electric arc furnace steelmaking (DRI-EAF) can help to reduce these pollutants in addition to GHG emissions.

Workforce Planning Analysis

Industrial decarbonization and improved efficiency offers a strong path forward for both high-quality employment and climate goals. Heavy industry is a heavily unionized sector that requires well-trained and skilled workers to complete complex jobs safely, and decarbonizing industry will require many such workers. The implementation of this priority measure is expected to increase the creation of jobs within the following occupations:

- Carpenters
- Heating, Air Conditioning, and Refrigeration Mechanics and Installers
- Electricians
- Plumbers, Pipefitters, and Steamfitters
- Construction Laborers
- Boilermakers
- Construction Equipment Operators

[56] ACEEE. “Funded Strategically, Industrial Decarbonization Can Cut Pollution in Disadvantaged Communities. December 2023. https://www.aceee.org/blog-post/2023/12/funded-strategically-industrial-decarbonization-can-cut-pollution-disadvantaged.

- Insulation Workers
- Industrial Machinery Installation, Repair, and Maintenance Workers
- Welding, Soldering, and Brazing Workers

Metrics

Potential metrics to track progress for this measure include:

- Number of and types of industrial decarbonization projects completed.
- Energy savings from projects (kWh for electricity, kBTU for gas).
- GHG and other harmful pollutants' emissions reductions ($MMTCO_2e$ or by gas for some process emissions).
- Number of quality jobs created.
- Mitigation of environmental justice impacts, which can be measured by recognized DOE or EPA tools such as Climate & Economic Justice Screening Tool (CEJST), Environmental Justice Screening and Mapping Tool (EJScreen), and/or PennEnviroScreen.

4.5.2 Low Carbon Fuels

GHG Measure Description

Incentivizing and increasing the production and use of low-carbon fuels will be imperative to reduce the Commonwealth's industrial sector emissions.

Through this measure, Pennsylvania will further explore the production and deployment of clean fuels used in heavy industries, particularly in cases where electrification poses a significant challenge. The industrial sector is uniquely positioned to use alternative gaseous fuels such as hydrogen and biomethane as a substitute for fossil gas. This measure aims to increase the production and use of both fuel types as a way of reducing net emissions. Further incentivizing market development of low carbon fuels will be key to decarbonizing the fuel supply of heavy industry.

The dedicated use of hydrogen could take place in hubs of industrial operations or other use cases where the fuel is either burned or run through a fuel cell to generate needed power. Hydrogen production is expected to increase in Pennsylvania, particularly through the Appalachian Regional Clean Hydrogen Hub (ARCH2) and the Mid-Atlantic Clean Hydrogen Hub (MACH2) efforts, two projects that were awarded funding by the DOE, that will provide a total of almost $1.7 billion to expand production and use of hydrogen throughout Pennsylvania and other participating hub states.[57] When produced using carbon-free energy sources, like wind or solar power, hydrogen is a zero-carbon fuel that can reduce emissions when replacing fossil fuels. Where renewable energy is not available, hydrogen can be produced with natural gas and paired with CCUS technologies to reduce the net emissions resulting from production.

Biomethane from sources including animal manure, food waste, landfill gas, water resources recovery facilities, agricultural residue, energy crops, forestry residue, and municipal solid waste, helps to capture GHGs that would be emitted into the atmosphere as part of the natural carbon cycle. Biomethane development from animal waste also has the dual benefit of increased nutrient management and can lead to positive impacts on odor and can improve nutrient efficiencies.

Deploying low carbon fuels in Pennsylvania can take many forms including:

- Supporting education on hydrogen and biomethane, how it is generated and its uses.
- Developing and scaling feedstocks of biomethane production throughout the Commonwealth.
- Developing low carbon fuels standard whereby a certain amount of gas used by facilities would need to come from low-carbon sources.
- Using clean energy financing tools to expand fuel use and production facilities.
- Encouraging and providing incentives for the use of hydrogen and biomethane in industrial operations.
- Revising or supporting local governments to amend rules that might limit the production or use of hydrogen and biomethane.
- Conducting comprehensive planning efforts in deploying hydrogen and/or biomethane projects (both production and use) in industrial applications, with a goal to support the project development and implementation of projects.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory Sector: Industrial
- Cumulative Reductions from 2025-2030: 20.0 $MMTCO_2e$
- Cumulative Reductions from 2025-2050: 284.1 $MMTCO_2e$

Summary of GHG reduction calculations approach

GHG reduction associated with the use of hydrogen fuels was modeled through switching natural gas fuel to hydrogen fuel in the built environment, transportation, and power generation sectors. EPA Motor Vehicle Emissions Simulator

[57] DOE. "Regional Clean Hydrogen Hubs Selections for Award Negotiations." https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations

(MOVES3) was used to model transportation section transitions while a proprietary market model was used to project the growth of hydrogen in the building sector. Integrated Planning Model (IPM) was used for hydrogen consumption in the power sector. Emissions associated with hydrogen consumption was calculated based on the projected percentage of blue, green, and pink hydrogen based upon assumed changes in the Pennsylvania energy generation mix.

GHG reduction associated with the use of biomethane was based on the 2019 American Gas Foundation evaluation for feedstock options for biomethane in Pennsylvania to determine the potential for replacing natural gas usage with biomethane usage where biomethane is a carbon neutral fuel.

Additional detail on these methodologies can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

- **Industrial energy consumers:** Most end users in the hydrogen economy will be in hard-to-electrify sectors like industrial and power sectors, but there may be additional transport uses from heavy-duty trucking, public transport buses, garbage trucks, and other heavy-duty maintenance vehicles. Transportation uses of low-carbon fuels are outlined in the *Electric and Alternative Fuel Vehicles* measure.
- **Industry (fuel producers and transporters):** Industry will manufacture new technologies to enable the use of hydrogen fuels such as fuel cells, electrolyzer producers, refueling stations for hydrogen-powered vehicles, pipelines, and more. Industry will also develop hydrogen delivery infrastructure such as pipelines, liquefaction plants, liquid tankers, dispensers, and more.
- **Inspectors and regulators:** Inspectors and regulators will play a role in reviewing new low-carbon fuel infrastructure, detecting leaks, and more.
- **Companies and farms running feedstock operations:** Suppliers of biomethane feedstocks, including farms, waste management facilities and land management entities would need to work to develop projects to store and transport feedstocks.

Progress to Date and Future Activities and Milestones

To support further production and deployment of clean fuels for heavy industries, Pennsylvania has passed a Hydrogen and Natural Gas Tax Credit for the purchase of hydrogen or natural gas from a Regional Clean Hydrogen Hub in Pennsylvania. Pennsylvania is poised to be an early leader in hydrogen production through the ARCH2 and MACH2 hydrogen hub awards, to expand production and use of hydrogen throughout Pennsylvania and other participating hub states. Other complementary policies that may be explored for this measure include:

- A production tax credit for sustainable aviation and or maritime fuels that aligns with federal requirements for incentive-qualifying fuels.
- Incentivization for the offtake of hydrogen into priority sectors, which includes heavy transportation vehicles including aircraft, ocean-going vessels, hydrogen powered forklifts, and other offroad vehicles, as well as industries that cannot or should not be electrified for a variety of reasons like cement production, steel and aluminum smelting, and chemical refining.
- Permit streamlining and standardization for clean fuel production facilities and offtake infrastructure like pipelines and fueling stations.

Authority to Implement

DEP recognizes that electric utilities and hydrogen fueling network partners will be key players in incentivizing the market adoption of these technologies. The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the APCA or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs.

Any new policies would need to be passed as legislation through Pennsylvania's legislature and signed by the Governor. Passage of a low carbon fuel standard (LCFS), incentives for low carbon fuels, streamlined permitting, or other supportive

concepts would empower DEP and other relevant agencies to work together to design and implement the specifics of the LCFS program.

Geographic Coverage

This measure is applicable to the entire state of Pennsylvania.

Funding Sources

- US DOE - Industrial Efficiency and Decarbonization Funding Opportunity Announcement
- US DOE - Hydrogen Hubs

LIDAC Benefits and Co-Benefits

The development of hydrogen technology may result in the creation of jobs. Pennsylvania can work with the ARCH2 and MACH2 clean energy hubs to facilitate the equitable distribution of these jobs.[58] Additionally, when evaluating which sectors or uses of hydrogen are most viable, costs should be considered, to emphasize uses that are most cost effective and do not place undue financial or tax burden on communities impacted by environmental justice issues. New biomethane projects may result in the creation of job opportunities as well as new revenue streams, which can benefit small businesses, farms, and local communities.

To maximize emissions reductions, hydrogen must be produced with the lowest carbon intensities possible, through either electrolysis using zero-carbon electricity or through adding CCUS technologies to other production processes, such as steam methane reforming of natural gas. Zero emission sources such as solar, wind or nuclear energy are used to produce hydrogen will reduce emissions from CO_2 and other GHGs associated with unabated fossil fuel-fired electricity generating sources. In addition to GHGs, reducing the volume of natural gas combustion also reduces criteria pollutant emissions such as NOx, SOx, $PM_{2.5}$, and VOCs that are ground-level ozone precursors.

While hydrogen fuels can reduce net GHG emissions and the emissions of other air pollutants such as VOCs, the combustion of hydrogen fuel, when done in the presence of air, can still lead to the generation of nitrous oxides, which can contribute to community air pollution and negative health impacts. When used in fuel cells, hydrogen does not generate these nitrous oxides, leading to air quality benefits.

Workforce Planning Analysis

When deploying novel technologies like hydrogen hubs, it can be difficult to know if a workforce is ready. Fortunately, in Pennsylvania, there is a significant workforce that is already prepared to meet the technical specifications for these new technologies. The transition to low carbon fuels offers a strong path forward for both high-quality employment and climate goals. The implementation of this priority measure is expected to increase the creation of jobs within the following occupations:

- Carpenters
- Heating, Air Conditioning, and Refrigeration Mechanics and Installers
- Electricians
- Plumbers, Pipefitters, and Steamfitters
- Construction Laborers
- Boilermakers
- Construction Equipment Operators
- Insulation Workers
- Industrial Machinery Installation, Repair, and Maintenance Workers
- Welding, Soldering, and Brazing Workers

[58] Governor Josh Shapiro: Pennsylvania the Only State to Secure Two Regional Clean Hydrogen Hub Projects - PA Department of Community & Economic Development

Metrics

Potential metrics to track progress for this measure include:

- GHG and other harmful pollutants' emissions reductions.
- Number of quality jobs created.
- Mitigation of environmental justice impacts, which can be measured by EJScreen and/or PennEnviroScreen.
- Number of hydrogen fuel stations, hydrogen production facilities or biomethane facilities
- Amount of hydrogen and biomethane produced and used in Pennsylvania.

4.5.3 On-Site Renewable Energy

GHG Measure Description

Developing on-site renewable energy and energy storage systems for residential, commercial, and industrial properties will be critical to bolstering clean electricity sources across the Commonwealth. The most common source of on-site renewable energy will be solar photovoltaics, which can be developed on all types of buildings, from single-family homes and shopping centers to school and local government buildings. However, on-site renewable energy development can also include small wind turbines (especially in more rural or industrial areas), micro-hydropower, or geothermal technologies. On-site renewables and energy storage play an important part in the decarbonizing of the electrical grid because they expand the magnitude of renewable energy sources while contributing to a more decentralized, and thus less vulnerable, energy grid system. Developing on-site renewable energy can also lower energy costs for property owners and their tenants.

Deploying renewable energy in Pennsylvania can take many forms including:

- Installing distributed generation on properties, such as rooftop solar systems, and battery storage systems.
- Using renewable energy certificates or other clean energy financing tools to expand onsite clean energy such as solar and storage.
- Encouraging and providing incentives for the use of solar panels and energy storage systems on existing buildings and in the construction of new buildings.
- Providing incentives to homeowners and home builders on completing electrification-ready upgrades when doing other work (e.g., panel upgrades to be prepared for a future heat pump or electric appliance) and steps to make buildings ready for charging infrastructure.
- Revising or supporting local governments to amend rules such as local zoning or permitting to encourage better adoption of solar and energy storage projects.
- Conducting comprehensive planning efforts in deploying solar and storage projects in buildings, with a goal to support the project development and implementation of projects.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory Sector: Residential, Commercial, and Industrial, Electricity Consumption
- Cumulative Reductions from 2025-2030: 1.7 $MMTCO_2e$
- Cumulative Reductions from 2025-2050: 15.4 $MMTCO_2e$

Summary of GHG reduction calculations approach

Emissions reductions from renewable energy were projected through the forecasted adoption of rooftop solar systems in Pennsylvania. Total technical potential for rooftop solar was aggregated from city and county level data and the most aggressive 2050 adoption scenario from National Renewable Energy Laboratory's (NREL) storage futures study was applied to this potential. PJM's 2023 load forecast was used to determine existing capacity. NREL's annual technology baseline was used to determine avoided emissions due to solar. More detail on this methodology including full assumptions and data sources can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

- **Pennsylvania Public Utility Commission, Utilities, and Energy Suppliers:** Participation and approval by these groups and their regulators is critical for renewable energy implementors. They manage interconnection rules (for both energy generation and storage) and have the ability to streamline renewable energy development.
- **Local Governments:** Local governments and their supporting agencies can streamline the permitting and development of energy generation and storage projects. Local zoning laws (especially those prohibiting structures above certain heights, therefore wind turbines), can be major barriers to renewable energy development in the residential and commercial sector.
- **Energy generation and storage installers**: There will continue to be a growing demand for a skilled energy generation and storage installation workforce.
- **Private sector and building owners:** Property owners and tenants must participate in developing small-scale renewable energy operations to reap the financial and environmental benefits of their investments.

Progress to Date and Future Activities and Milestones

Pennsylvania has a long history of supporting renewable energy, and specifically on-site renewable energy through a range of programs. In the past, the following actions have been taken:

- The Pennsylvania DEP developed Finding Pennsylvania's Solar Future[59], a comprehensive solar deployment plan, through a statewide partnership of experts who have collaborated to identify strategies, including grid-scale solar and smaller, distributed systems (such as rooftop installations), that can increase solar-powered electricity development.
- Pennsylvania's Alternative Energy Portfolio Standard (AEPS), originally passed in 2004 requires that electric distribution companies and electric generation suppliers include a specific percentage of electricity from alternative resources, including onsite solar, in the generation that they sell to Pennsylvania customers. This program provides additional incentives for renewable energy sources.

More recently, the Commonwealth has pursued funding for EPA's Solar for All program as part of the GGRF and has pursued projects and sought to lead by example in renewable energy adoption by prioritizing installing on-site renewable energy projects on public buildings and land.

In the future, the Commonwealth and local government partners can continue to support on-site renewable energy by bolstering a range of programs that educate consumers, connect them with programs and incentives for renewable energy development, or through direct funding of projects. Financing programs can connect developers with local, state, and federal incentives for renewable energy development and seek to develop replicable models for deployment. Pennsylvania can also use funding to subsidize the installation and interconnection of renewable energy projects on residential, commercial, and industrial properties.

Finally, Pennsylvania could pursue a range of legislative updates:

- Reforming the existing tier 1 and solar credits established by Pennsylvania's Alternative Energy Portfolio Standards Act (2005) to require 30% of electricity to come from renewable energy sources by 2030 and further support renewable energy to align with the strategy to achieve a carbon-free grid by 2050. The recommendation could also include a carveout for on-site renewable energy projects.
- Authorizing community solar in the Commonwealth to allow households within a geographic area to subscribe to and share electricity from a project in exchange for a credit on their electricity bill from the power produced by the project. Community solar is a well-suited option for Pennsylvania households who do not have access to solar because they rent, live in multi-tenant buildings or have physical restrictions on their rooftops that make them unable to host a system.

[59] Pennsylvania's Solar Future Plan (pa.gov)

- Encouraging or incentivizing localities across the state to reconsider zoning laws that prevent renewable energy development in residential, commercial, and industrial areas.

Authority to Implement

The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the APCA or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs. The Commonwealth can support the development of renewable energy under its authority to streamline permitting and siting processes, and collaborate with utility regulatory agencies to make improvements to the interconnection process. The Commonwealth can also support investments in transmission and distribution grids to ensure sufficient capacity to meet demand from an increasing number of energy providers. Pennsylvania will need to work in partnership with utilities and local governments to approve, design, and interconnect these projects.

Geographic Coverage

This measure is relevant to the entire state of Pennsylvania.

Funding Sources

- US DOE - Energy Efficiency and Conservation Block Grant
- EPA - GGRF, Solar for All
- Production Tax Credit for Electricity Renewables
- Energy Credit for Solar & Wind Facilities Placed in Service in Connection with Low-Income Communities
- Clean Electricity Production/Investment Tax Credits

LIDAC Benefits and Co-Benefits

On-site renewable energy development is a property improvement that can support both renter and owner-occupied properties. Community-scale solar can be supported at community centers or rental properties, given legislative updates. The range of different ways to install solar (purchase, financed, power purchase agreements, leases) provide varied opportunities to enable solar development without placing undue burden on individuals living or working in environmental justice areas. Ensuring that savings realized by renewable energy installations on rental properties can be passed on to tenants, especially in energy burdened renting communities, is vitally important. Renewable energy generation and storage development can also create job opportunities for communities in need. Additionally, program administrators can prioritize a local workforce and create partnerships with high schools in EJ areas or training programs. In addition to these benefits, reducing overall emissions from fossil fuel combustion will reduce air pollution and improve environmental justice outcomes for low-wealth and minoritized communities.

Workforce Planning Analysis

When installing renewable energy and energy storage technologies, the primary workforce will be electricians and construction laborers for onsite systems. Pennsylvania already has a significant workforce that is prepared to install these technologies. However, significant growth will be needed, especially for electricians. The transition to onsite renewable energy offers a strong path forward for both high-quality employment and climate goals. The implementation of this priority measure is expected to increase the creation of jobs within the following occupations:

- Electricians
- Construction Laborers

Metrics

Potential metrics to track progress for this measure include:

- Number of on-site renewable energy installations, across Pennsylvania and in LIDACs
- Capacity of on-site renewable energy installations, across Pennsylvania and in LIDACs

Number of quality jobs created.

4.5.4 Carbon Capture Utilization and Storage

GHG Measure Description

This measure aims to reduce GHG emissions through point source CCUS and natural-land based storage and sequestration efforts.

CCUS can be used in both the industrial and the power sectors to decarbonize in hard-to-abate sectors. In the industrial sector, CCUS is helpful where electrification, low carbon fuels, and efficiency are insufficient to achieve deep decarbonization, and in the power sector, where CCUS can provide reliability for a net zero grid by helping fossil fuel-powered generating plants continue operating. Power sector CCUS is included in the *Net-Zero Electricity Grid* measure elsewhere in this document.

Point source capture of CO_2 from industrial sector emissions for utilization or storage provides a key opportunity to reduce GHG emissions. Efforts should be focused on heavy industry applications that currently lack viable low-carbon alternatives including cement and chemicals manufacturing (4.9 MT CO_2 annually[29]). Additionally, capture and storage of non-fossil CO_2 is one of the most mature and scalable non-nature-based carbon dioxide removal technologies, and utilization of this CO_2 is required as a critical feedstock for some harder to electrify applications (chemicals/plastics) or synfuels (e.g. aviation). Between its waste, pulp & paper, and ethanol facilities, the Commonwealth has approximately 3.1 MT CO_2 per year of biogenic CO_2 available for utilization/storage. According to the Great Plains Institute's report on implementing Carbon Capture and Storage[60] in the state:

- Pennsylvania has the estimated capacity to store roughly 2.4 billion metric tons of CO_2 through geologic storage.[61]
- The 47 facilities in Pennsylvania that qualify for the IRA's 45Q tax credit are responsible for ~85% of the state's industrial and power sector emissions.
- There are 22 facilities that have been identified as potentially economically feasible candidates for near-term CCUS.

Improving agricultural and land-based management practices are imperative in the Commonwealth's decarbonization efforts. Carbon dioxide can be captured and stored through carbon sinks such as trees, soils, biomass, and oceans. Strategies to increase the sequestration of CO_2 by using these sinks include reforestation and afforestation, enhanced soil carbon uptake and increased soil health, biochar or compost application to soils, and more. Pennsylvania has significant potential for these opportunities because it is estimated that forests cover 16.6 million acres of land[62], and agriculture covers 7.3 million acres in the Commonwealth as of 2022.[63]

Actions under this measure will prioritize funding, policies, and programs that support the deployment of point source capture and geological storage of carbon as well as support for forest, agriculture, and other land-based management strategies. Deploying CCUS in Pennsylvania can take many forms including:

- Installing point source capture on existing or new industrial facilities.
- Developing new geological storage facilities.
- Using clean energy financing tools to expand point source capture, geological storage, or natural land-management strategies.
- Encouraging and providing incentives for point source capture, geological storage, or natural land-management strategies.

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[60] Implementing Carbon Capture and Storage Technology (Great Plains Institute, 2021) https://carboncaptureready.betterenergy.org/wp-content/uploads/2021/06/PA_5_25_2021.pdf

[61] Ibid.

[62] "Forests of Pennsylvania, 2019" (USDA, 2020), https://www.fs.usda.gov/nrs/pubs/ru/ru_fs251.pdf.

[63] USDA. 2023. 2020 State Agriculture Overview: Pennsylvania. https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=PENNSYLVANIA.

- Revising or supporting local governments to amend rules such as local zoning or permitting to encourage better adoption of CCUS facilities.
- Conducting comprehensive planning efforts in deploying point source and land management CCUS strategies.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory Sector: Industrial, LULUCF
- Cumulative Reductions from 2025-2030: 0.03 $MMTCO_2e$
- Cumulative Reductions from 2025-2050: 28.2 $MMTCO_2e$

Summary of GHG reduction calculations approach

CCUS technology is assumed to be available to some facilities by 2030, ramping up in deployment and availability by 2050. Excluding facilities with annual stationary combustion emissions less than 100,000 MT per year, roughly 85% of stationary combustion emissions are modeled to remain available for the emission reduction potential of CCUS. A trajectory was developed using industry expectations and expert opinion to model CCUS deployment as a percent of total CCUS potential. Emissions reductions are calculated against a BAU that models no implementation of CCUS and holds industry emissions flat through 2050. More detail on this methodology can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

- **Industry:** Members of various industrial sectors such as iron and steel, chemical and petrochemical, cement, and others will play a role by participating in retrofits to their facilities.
- **Federal government agencies (energy, research, and environment related):** Can support the development of new technologies, update regulations, and incentivize investments. The federal government can enable pilot projects by updating regulations, or through permitting once research demonstrates the feasibility of applications of CCUS technologies.
- **Local governments:** Offers oversight and funding opportunities, and disseminates resources for carbon sequestration and capture within their respective jurisdictions.
- **Private landowners:** Private landowners will be partners in reforestation and restoration programs.
- **State Agencies:** Coordination between Pennsylvania agencies can centralize knowledge and processes relevant to deploying agencies that can offer oversight, funding opportunities, and disseminate resources for carbon sequestration and capture.
- **Federal Land Use and Forestry Agencies:** The National Park Service, US Forest Service, and Fish and Wildlife Service, which oversee 80%, 10%, and 10% of federally owned land, respectively may provide resources, oversight, and technical assistance to forestry and restoration projects.
- **Non-governmental and Non-profit Organizations:** NGOs and local non-profits with expertise in conservation and restoration (e.g., Northeast-Midwest State Foresters Alliance) can provide marketing, outreach, and education to Pennsylvania residents. They can also increase awareness of the importance of afforestation and grassland restoration, creating social momentum.
- **Farmers Association and Agricultural Groups**: Engages with farm coalitions and agricultural groups to understand obstacles and opportunities in manure management, fertigation, and no-till practices. Sustainability-oriented groups like Pasa Sustainable Agriculture offer trainings, technical assistance, and other resources throughout Pennsylvania's farming community.
- **Insurance Companies:** The introduction of agricultural insurance requirements that consider climate risk could encourage adoption of emissions reducing agricultural practices.

- **Universities and Research Institutions:** These bodies may investigate and develop further opportunities and best practices for CCUS.

Progress to Date and Future Activities and Milestones

The Commonwealth has several opportunities to support carbon sequestration use and sequestration as a point source capture including:

- Ensuring enabling policy and regulation is in place to accelerate infrastructure deployment to facilitate point source CCUS, such as establishing:
    - Policy for creation of carbon utilization and sequestration hubs. Hubs are instrumental to streamline infrastructure deployment and reduce CO_2 transport costs.
    - Regulation & permitting, including pore space rights, long-term liability, class VI primacy, and permitting for CO_2 pipelines.
    - Supply incentives, such as federal funding/cost-share support, grants, and tax incentives.
    - Demand side-policy, such as state procurement and incentives to spur private sector offtake.
    - Workforce education/training.
- Partnership with local organizations for two-way communication, engagement, and education on carbon management and CO_2 infrastructure.
- Governor's CCUS Inter-Agency Work Group (2019 – Present): DCNR, DEP, and DCED collaboration on technical, regulatory, and economic policy pillars.

The Commonwealth has several existing programs that support carbon sequestration and capture in rural and urban communities.

- DNCR's Urban and Community Forestry Program, formerly TreeVitalize, is a public-private partnership that supports communities with tree planting design and maintenance throughout the Commonwealth. The group also offers educational opportunities about the benefits of trees.
- Clean and Green is a tax assessment program that encourages protection of farmland, forestland, and open spaces. Landowners can save money and preserve land for carbon sequestration. Currently, more than 9.3 million acres are enrolled statewide.

Future actions to support this measure could include:

- Provide education and resource opportunities to landowners and farmers
    - Equip private and public landowners with the proper tools, information, and flexibility to incorporate climate change in management planning and implementation.
    - Incentivize conservation of privately owned forest land, riparian forest buffers – tax relief for ecosystem services provided, funding for management projects.
    - Conduct outreach and education to agricultural networks on the societal and environmental benefits of methane-reducing feed additives, which may otherwise present little to no advantage to farmers.
    - Inform farmers on how and where to implement no-till technologies, which are already available on the market.
    - Support research and development of agricultural practices that will sequester Carbon on-farm.
- Establish incentives and economic development opportunities
    - Incentivize adoption of nitrification inhibitors and feed additives via subsidies.
    - Provide incentives for shopping malls, office buildings, apartment buildings and other major urban centers in cities to establish and maintain greenspaces such as gardens, courtyards, and rooftop greenspaces.
    - Purchase wetland easements on marginal and flood-prone agricultural lands to diversify grower income, buffer productive lands from flood events, and improve the environmental services provided by these lands.
- Update agricultural infrastructure and processes
    - Reduce GHG emissions through feed additives, enhanced efficiency fertilizers, fertigation, and improved manure management.

Authority to Implement

The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the APCA or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs. Pennsylvania's state agencies such as the Department of Agriculture and DCNR have the authority to support policy and programming aimed at reducing carbon through sequestration and other capture efforts.

Geographic Coverage

This measure is applicable to the entire state of Pennsylvania.

Funding Sources

Examples of potential funding sources include, but are not limited to:

- US Forest Service - Urban and Community Forestry Grants
- USDA Natural Resources Conservation Service - Agricultural Conservation Easement Program (AECP)
- 45Q Federal Tax Credit
- PA Department of Agriculture - Agricultural Conservation Assistance Program (ACAP)

LIDAC Benefits and Co-Benefits

There is potential for job creation and retention due to the expansion of CCUS technology in new and existing facilities. Building, operating, and maintaining the infrastructure needed to deploy the technology will require qualified staff. To prioritize equitable implementation, Pennsylvania can prioritize hiring a local workforce. Because CCUS does not capture harmful air co-pollutants along with CO_2, the deployment of CCUS technologies in fence line communities is unlikely to see benefits realized from many of the other decarbonization strategies such as improved localized air quality.

Working with people living or working in environmental justice areas to determine opportunities for beneficial implementation of natural land-based CO_2 sequestration can result in GHG reductions as well as increased resilience in vulnerable communities. Depending on where reforestation, afforestation and harvest cycle extension practices occur, there may be an opportunity for these practices to provide benefits, such as reducing urban heat island effects, or improving ecosystem connectivity or reducing runoff or flood risks. By prioritizing equity, Pennsylvania can target these benefits to communities that disproportionately experience these effects of climate change.

Implementing afforestation practices on abandoned coal mines may have a positive impact on previously highly industrialized communities. This could include public health benefits in communities that previously experienced a high volume of criteria pollutant emissions. Afforestation efforts and the associated public health benefits also align directly with CAEJC-identified actions related to ecosystem conservation and pollution mitigation.

Implementation of best management practices (BMPs) in agriculture such as reduced tillage may also reduce flood risk (e.g., by allowing soils to hold more water), thereby increasing farms' resilience to projected increased flood risks under climate change. BMPs may also improve the sustainability of agricultural practices to cope under changing climate conditions, reduce erosion, and improve soil health. Prioritizing equitable implementation of this strategy will allow these benefits of increased resilience to be realized in LIDACs.

Workforce Planning Analysis

When dealing with novel technologies and pilot projects like CCUS, it can be difficult to know if a workforce is ready. Fortunately, in Pennsylvania there is a significant workforce that is already prepared to meet the technical specifications for these new technologies. The increase in CCUS offers a strong path forward for both high-quality employment and climate goals. The implementation of this priority measure is expected to increase the creation of jobs within the following occupations:

- Carpenters
- Heating, Air Conditioning, and Refrigeration Mechanics and Installers

- Electricians
- Plumbers, Pipefitters, and Steamfitters
- Construction Laborers
- Boilermakers
- Construction Equipment Operators
- Insulation Workers
- Industrial Machinery Installation, Repair, and Maintenance Workers
- Welding, Soldering, and Brazing Workers

Metrics

Potential metrics to track progress for this measure include:

- Tons of CO_2e captured (e.g., as reported through the EPA Greenhouse Gas Reporting Program) and sequestered through different mechanisms
- Number of facilities with carbon capture installed
- Acreage of planned implemented BMPs
- Number of trees planted
- Percent of green space and/or tree canopy in urban environments

4.5.5 Fugitive Emissions Reductions

GHG Measure Description

Methane can be emitted from a variety of sources in the energy, agriculture, and waste sectors. Fugitive leaks can occur in gas and oil systems as equipment ages and deteriorates. Methane is also released from coal mining activities and abandoned mines. Fugitive emissions from energy production contributed 27.82 $MMTCO_2e$ in 2021. Most of these emissions (16.20 $MMTCO_2e$) were from natural gas and oil systems and 11.62 $MMTCO_2e$ were from coal mining.[64] Nearly half of Pennsylvania's methane emissions from oil and gas operations stem from marginal wells that account for less than 1% of statewide oil and gas production.[65,66] Landfills generate methane as the organic waste decomposes without oxygen. While some landfills have gas capture systems in place, significant amounts of methane still escape into the atmosphere, due to insufficient collection system coverage, cover integrity issues, and equipment malfunction.

With a higher GWP than CO_2, methane is a potent GHG, and reducing its emissions yields significant environmental benefits, helping to limit near-term climate change. Reducing fugitive methane emissions can also reduce emissions of harmful co-pollutants, benefiting local air quality, health, and quality of life.

Actions under this measure will prioritize funding, policies, and programs that support infrastructure improvements and policies aimed at plugging inactive and marginal wells and reducing methane emissions from oil and gas infrastructure, coal mine methane, and landfills, through increased implementation of monitoring and capture technologies. Actions could also include:

- Using financing tools to expand deployment of infrastructure improvements to reduce methane leaks at energy, agriculture, and waste facilities.
- Encouraging and providing incentives for infrastructure improvements to reduce methane leaks at energy, agriculture, and waste facilities.

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[64] Pennsylvania DEP. 2023. Pennsylvania Greenhouse Gas Inventory.

[65] "Methane Emissions from Conventional and Unconventional Natural Gas Production Sites in the Marcellus Shale Basin | Environmental Science & Technology," accessed October 31, 2023, https://pubs.acs.org/doi/full/10.1021/acs.est.5b05503.

[66] Mark Omara et al., "Methane Emissions from US Low Production Oil and Natural Gas Well Sites," Nature Communications 13, no. 1 (April 19, 2022): 2085, https://doi.org/10.1038/s41467-022-29709-3.

- Conducting comprehensive planning efforts to more effectively make infrastructure improvements to reduce methane leaks at energy, agriculture, and waste facilities.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory Sector: Industrial, Waste
- Cumulative Reductions from 2025-2030: 18.2 $MMTCO_2e$
- Cumulative Reductions from 2025-2050: 87.8 $MMTCO_2e$

Summary of GHG reduction calculations approach

Reduction of emissions from oil and gas production processes (which accounts for roughly 50% of total production emissions) can be focused on the 10% of wells considered highest emitters. Monitoring and repair efforts can reduce overall oil and gas production emissions by 80% over a 10 year ramp up.

The emissions reductions associated with the plugging of marginal and abandoned wells assumes that 25% of abandoned wells will be plugged by 2050.

Additional industrial fugitive emissions reduction from coal, water and waste activities were estimated using the EPS for Pennsylvania, a model maintained by Energy Innovation and RMI. Strategies estimated using the EPS include methane destruction and capture from coal. The rate of implementation of these strategies is commensurate with meeting 2030 and 2050 targets, and technological readiness.

More detail on the methodology for the fugitive emissions measure, and how the EPS works and the inputs can be found in Appendix B. Quantified GHG Reductions Methodology (note that discussion of EPS and inputs are discussed in the methodology for the Industrial electrification, efficiency, and process emissions measure).

Key Implementing Agency(ies) and Partners

- **Oil and Gas Producers:** The producers would be required to implement and operate leak detection and repair technologies.
- **Coal Mine Operators and Owners.** Operators and owners can implement technologies to capture coal mine methane during the entire mining process.
- **Landfill Operators:** Operators and owners can implement technologies and practices to monitor and capture fugitive methane emissions.
- **Methane Monitoring & Control Technology Companies:** Substantial research and innovation is currently underway to produce more effective and efficient leak detection technologies, across sectors. These technologies, as they are developed and enter the marketplace, will ideally reduce the cost and improve the effectiveness of methane leak detection and repair efforts.
- **State regulators**: The state oversees the implementation of new leak detection and repair requirements, and coal mine methane capture technologies. The state would also be asked to review and approve technologies as they are brought to the marketplace. Pennsylvania can also update the air regulations for municipal solid waste landfills, following leading states like Oregon, Maryland, and California, to incorporate recent advances in methane monitoring and capture and expand adoption of best practices to reduce emissions at landfills across the state.
- **Scientists and engineers**: Research is required to determine the causes of large leaks in oil and gas production operations. This research, largely funded by the federal government and including the participation of the oil and gas industry, is underway.

Progress to Date and Future Activities and Milestones

DEP worked with Carbon Mapper and the US Climate Alliance to conduct overflights with airborne methane detection technology, gathering data on methane emission sources and rates. Flights occurred nine times over a 3-week period in May 2021. 153 total plumes were detected from 91 individual sources across oil & gas operations, coal mines, and landfills. Operators were notified of observed plumes and in some cases achieved voluntary reductions in observed methane emissions from landfills and oil and gas infrastructure.

Control of volatile organic compounds (VOC) Emissions from Oil and Natural Gas Sources, 25 Pa. Code Chapters 121 and 129 established Reasonably Available Control Technology requirements for VOC emissions including fugitive emission components. It requires that fugitive emission sources located between the wellhead and the natural gas transmission and storage segment are inspected monthly. This ensures the reduction of methane emissions from inactive or marginal gas and oil wells.

Implementation of the EPA's recent (December 2023) final New Source Performance Standards which address methane[67] and the proposed EPA rule to reduce methane as initiated through IRA[68] would further reduce methane emissions through increased controls and detection of leaks. EPA's proposed rule would require all producers in the Commonwealth to enhance leak detection and repair with the following regulations:

- Higher frequency leak detection for high-producing and complex production sites;
- Flexibility in leak detection technology including higher detection thresholds for potentially large emitters; and
- Annual leak detection and repair requirements for all producing sites.[69]

The intent of more frequent leak detection and repair for high-producing and complex production sites is to capture large leaks more rapidly. Enabling flexibility in the technology will enable more cost effective, higher-frequency leak detection technology to be deployed, capable of detecting the large leaks responsible for a majority of methane emissions but potentially costing less to implement and moving toward continuous leak detection methods. Annual leak detection and repair for all producing sites is intended to remove the long-tail of relatively large emissions that can occur even with marginal wells.

Beyond the oil and gas sector, there are also resources like the US Coal Mine Methane Current Projects and Opportunities Mapping Tool that can be used to identify mines in the Commonwealth that have or need methane capture technology.

Future actions to reduce fugitive methane emissions could include:

- Expanding state-wide "super-emitter response" programs across methane sources:
    - Pennsylvania can build on the success of its Carbon Mapper collaboration to quickly alert operators of large methane emission events and inform mitigation. New data will soon be publicly available from methane-detecting satellites, and the Commonwealth can play a role in ensuring operators are acting on this information in a timely manner. EPA's super-emitter program under the new oil and gas Sec. 111 rules will formalize this alert-response process for covered oil and gas sources. Pennsylvania can play a role in ensuring observations of other detected sources, such as landfills, coal mines, and oil & gas infrastructure not covered by EPA's rule (e.g., transmission, distribution), result in timely mitigation.
- Updating state air regulations for municipal solid waste landfills to better control landfill methane emissions.
    - Modernizing air emissions regulations for landfills can promote expanded gas collection, more comprehensive monitoring (e.g., leveraging remote sensing and near-ground approaches), better cover practices, and other common-sense improvements to limit the release of methane to the atmosphere at landfills across the state and protect communities from other harmful co-pollutants. Pennsylvania could consider emulating three states that have taken action to better control their landfill methane emissions by setting stronger standards than EPA's. State rules make several improvements to landfill design, operational, and monitoring requirements to increase methane capture and reduce the risk of large leaks. For example, the Maryland Department of Environment estimates a 25-50% reduction in landfill emissions once the rule is in full effect.

[67] https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-operations/epas-final-rule-oil-and-natural-gas

[68] https://www.epa.gov/newsreleases/biden-harris-administration-announces-proposed-rule-reduce-wasteful-methane-emissions

[69] EPA. 2023. 40 CFR Part 60. https://www.epa.gov/system/files/documents/2023-12/eo12866_oil-and-gas-nsps-eg-climate-review-2060-av16-final-rule-20231130.pdf

- Expanding voluntary adoption of methane monitoring and control technologies at facilities, beyond minimum federal standards.
    - Provide funding (e.g., leveraging GGRF, Methane Emissions Reduction Program, and other federal programs) and incentives to expand the adoption of advanced methane monitoring and control technologies across sectors.
    - State and local governments can work with operators to set quantitative targets to increase gas capture rates and reduce fugitive emissions.
    - In the oil and gas sector, encourage implementing strong Leak Detection and Repair programs in line with voluntary gas certification program best practices.
    - Provide funding and incentives to replace high or low bleed equipment with zero bleed alternatives in oil and natural gas supply chains to reduce methane intensity.
    - Make all data on fugitive methane emissions and reductions publicly available to promote transparency and accountability.
- Plugging inactive and marginal wells.
    - Leverage federal funding (e.g., Orphaned Well Funds from the Bipartisan Infrastructure Law (BIL), Methane Emissions Reduction Program) to accelerate plugging of inactive and marginal wells.
    - Use methane monitoring data to verify successful plugging.

Authority to Implement

The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the APCA or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs. The Pennsylvania DEP also has authority to update air emission regulations for landfills to incorporate the latest best practices in methane monitoring and control. State agencies also have authority to design programs and grant funds to support voluntary methane monitoring and reductions, beyond minimum federal standards. Oil and gas producers, coal mine owners, landfill operators, and local governments have the authority to implement technologies and best practices that monitor and either reduce or capture fugitive emissions.

Geographic Coverage

This measure is applicable to the entire state of Pennsylvania.

Funding Sources

- BIL's Orphaned Oil and Gas Wells Funding
- IRA's Methane Emissions Reduction Program
- IRA's GGRF
- IRA's Community Change Grants
- BIL's Energy Efficiency and Conservation Block Grants (EECBG)
- IRA's Methane Monitoring Funds

LIDAC Benefits and Co-Benefits

Increasing compliance requirements to reduce uncaptured methane emissions was a priority action identified by the CAEJC outreach that directly aligns with this PCAP measure. To help ensure equitable implementation of this measure, the costs of emission reductions should be borne by those who benefit the most from the production and consumption of oil and gas, and not distributed across society in a way that is unrelated to the consumption and production of oil and gas.

Health impacts of leakage of VOCs and other possible air toxics from oil and gas production operations have the greatest impact on people living near production facilities. These populations suffer environmental damages that are inequitable as they often do not benefit in any direct way from oil and gas production close to their homes or businesses. Minimizing leakage of methane from these facilities will also minimize the leakage of VOCs that are a portion of natural gas. Thus, reduced methane leakage from oil and gas production improves environmental equity by minimizing health damages to

people living close to production facilities. As a result, this strategy supports air pollution reduction which was also identified as a priority area by CAEJC outreach.

In addition to cutting planet-heating methane, addressing methane emissions from landfills creates local benefits. Improving methane capture also better controls for emissions of hazardous air pollutants, smog-forming compounds, and odors, while reducing explosion hazards. This improves air quality, safety, public health, and quality of life for communities near landfills. Expanding landfill methane monitoring and implementing BMPs can also create local jobs in methane mitigation, as well as economic benefits through the productive use of captured methane, which can in some cases displace more expensive fossil fuels.

Workforce Planning Analysis

Implementing strategies that reduce fugitive emissions offers a strong path forward for both high-quality employment and climate goals, building on Pennsylvania's existing fossil gas workforce. The implementation of this priority measure is expected to increase the creation of jobs within the following occupations:

- Plumbers, Pipefitters, and Steamfitters
- Construction Laborers
- Construction Equipment Operators
- Industrial Machinery Installation, Repair, and Maintenance Workers
- Welding, Soldering, and Brazing Workers

Metrics

Potential metrics to track progress for this measure include:

- Methane emission reductions
- Number of inactive and marginal wells plugged

4.5.6 Net-Zero Electricity Grid

GHG Measure Description

This measure leverages clean and renewable resources in the region to achieve a net zero electricity generating sector while ensuring grid reliability by implementing a comprehensive framework of incentives and assistance programs. To support the realization of a net zero grid, the state will need to consider policy changes to regulate carbon emissions in the state or require an increasing share of electricity sales to come from clean energy resources within the state and surrounding region. This measure assumes the realization of a net zero electricity grid by 2050, which could be met through a combination of resources including existing nuclear, new small modular reactor nuclear, solar, wind, hydroelectric power, biomass, coal- or gas-fired power plants with carbon capture technology, or gas-fired power plants utilizing low carbon fuels such as biomethane or hydrogen. For these technologies to be deployed at the pace and scale needed, the state will need to consider permitting reform to ensure new clean energy projects can be sited and developed within the state in a timely manner.

In addition, the measure also aims to transition to a clean energy grid while ensuring grid reliability and resilience. To support that, this PCAP measure prioritizes electrification paired with investments in energy efficiency and distributed resources to help mitigate strain on the grid from electrified buildings and vehicles. Electricity producers can help ensure a reliable power supply by balancing intermittent resources with battery storage or other clean baseload sources, such as gas-fired turbines with carbon capture or through the use of low carbon fuels. At the same time, the transmission and distribution grid infrastructure will also require significant investment to be able to handle the influx of new grid-scale and distributed projects developed. Investment will be needed in both core grid infrastructure, such as lines and substations, as well as in software systems to control distributed resources and enhance grid flexibility. There will also be a need for grid modernization investments such as switches, sensors, and controls to improve grid operator's visibility and grid flexibility.

Actions under this measure will prioritize funding, policies, and programs that support the deployment of clean electricity sources and ensuring grid reliability and resiliency. Deploying clean electricity in Pennsylvania can take many forms including:

- Building new clean energy facilities, retrofitting existing facilities with point source capture equipment, and installing new transmission or distribution infrastructure.
- Using clean energy financing tools to build new clean energy facilities, retrofit existing facilities with point source capture equipment, and install new transmission or distribution infrastructure.
- Encouraging and providing incentives to build new clean energy facilities, retrofit existing facilities with point source capture equipment, or install new transmission or distribution infrastructure.
- Revising or supporting local governments to revise permitting, zoning and other reforms to build new clean energy facilities, retrofit existing facilities with point source capture equipment, and install new transmission or distribution infrastructure.
- Conducting comprehensive planning efforts to build new clean energy facilities, retrofit existing facilities with point source capture equipment, and install new transmission or distribution infrastructure.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory sector: Power
- Cumulative Reductions from 2025-2030: 2.6 $MMTCO_2e$
- Cumulative Reductions from 2025-2050: 534.0 $MMTCO_2e$

Summary of GHG reduction calculations approach

This measure modeled the resulting GHG emissions reductions from the achievement of a net zero grid for Pennsylvania by 2050. The IPM, which is used by EPA to analyze the projected impact of environmental policies on the electric power sector. IPM was also used to determine grid emission factors. Additional detail on the constraints and emission factors used can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

- **Electric Utilities and PA PUC:** Close coordination with utilities and the PA PUC will be crucial to transitioning the current grid to lower-emission alternatives while providing reliable power coverage, responsibly managing brownfields and retired infrastructure, and establishing new clean energy infrastructure.
- **Regional organizations including the Federal Energy Regulatory Commission (FERC) and PJM**: FERC is responsible for approving or denying new transmission infrastructure projects and works with the Regional Transmission Organizations (e.g., PJM) to regulate wholesale electricity markets. PJM is the regional transmission organization that oversees the electricity wholesale marketplace in Pennsylvania and the neighboring region. The state will need to coordinate with FERC and PJM to facilitate interconnection queue reforms to reduce delays and to coordinate transmission investments in the region.
- **Independent Power Producers (IPP):** As a third-party owner of generating resources, IPPs will need to be included in coordination on efforts to decarbonize the power grid on similar actions as mentioned for electric utilities and PA PUC.
- **Local participating entities and advocacy groups:** Establishing a working relationship with local participants and advocacy groups will help with permitting, zoning and other local issues associated with the deployment of net zero emissions electricity facilities.
- **Community and Technical colleges:** Workforce development will require partnerships with educational institutions to ensure that Pennsylvania has an adequate workforce to deploy clean energy technologies efficiently and effectively.

Progress to Date and Future Activities and Milestones

Pennsylvania has already seen significant reductions in emissions from electricity generation, with carbon dioxide emissions declining 38% from 1990 to 2021, largely due to a shift from coal-fired to natural gas-fired electricity generation.

Pennsylvania has an AEPS that has helped drive recent increases in renewable power generation. Since 2010, grid-scale wind and solar capacity in the state has doubled to over 1,600 MW, providing about 2% of total electricity generation in 2022.

While grid-scale renewable capacity has also increased in recent years, the Commonwealth has a long way to go to reach a reliable and clean electricity generating portfolio.

To accomplish its goal of a net-zero electricity grid, Pennsylvania will seek to:

- Maintain existing nuclear facilities and develop new small modular reactor nuclear power.
- Support the development of solar, wind, and hydroelectric power by connecting energy developers with financial incentives, facilitating interconnection agreements, and streamlining permitting processes.
- Pursue point source carbon capture technologies to reduce emissions from existing coal and natural gas plants.
- Expand battery storage to improve reliability and availability of renewable energy.
- Establish educational and work training programs to bolster the state's clean energy workforce to support the installation and maintenance of clean energy technologies.
- Promote federal and state funding opportunities for localities, households, and businesses transitioning to clean energy sources.
- Facilitate the responsible closure of high-emission coal fired power plants as supplemented by the installation of new clean energy sources.

Authority to Implement

The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the APCA or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs. In addition, the Commonwealth can support the development of renewable energy under its authority to streamline permitting and siting processes, and collaborate with utility regulatory agencies to make improvements to the interconnection process. Under its own authority, Pennsylvania can conduct outreach to connect developers with the financial incentives to invest in new technologies like carbon capture and build out renewable energy infrastructure. The Commonwealth will need to work in partnership with utilities and local governments to approve, design, and interconnect renewable energy projects. It will also need to work closely with local communities to facilitate the siting and permitting of new projects, as well as implement workforce training programs to support these new energy systems.

Geographic Coverage

This measure impacts the entire state of Pennsylvania.

Funding Sources

- IRA's GGRF
- BIL's Energy Efficiency and Conservation Block Grants (EECBG)
- BIL's Building a Better Grid Grants
- BIL's Grid Innovation Program
- BIL's Grid Resilience Grants
- BIL's Smart Grid Grants
- Production Tax Credit for Electricity Renewables
- Zero Emission Nuclear Power Production Credit
- Energy Credit for Solar & Wind Facilities Placed in Service in Connection with Low-Income Communities
- Clean Electricity Production/Investment Tax Credits

LIDAC Benefits and Co-Benefits

Low-wealth and minoritized communities have been historically disadvantaged by the siting of energy projects that produce environmental hazards and significant public and environmental health impacts. Pennsylvania will ensure that equity concerns are addressed during the siting process and that the economic benefits of the increased renewable energy development benefit affected communities.

Decarbonizing electricity generation will reduce emissions from CO_2 and other GHGs associated with unabated fossil fuel-fired electricity generating sources. In addition to GHGs, reducing the volume of natural gas combustion also reduces criteria pollutant emissions such as NO_x, SO_x, $PM_{2.5}$, and VOCs that are ground-level ozone precursors. As a result, public health outcomes related to air pollution and air quality will improve. This measure also will have significant economic impacts, including the creation of new jobs in construction, operation, and maintenance of these clean energy facilities. Decarbonizing the power grid will improve air quality and reduce the strain on public health from fossil fuel electricity sources.

Precedent exists for developing solar projects on the brownfield sites that remain in the place of closed coal plants. Doing so can increase nearby home property values and maintain the tax base of the area. Repurposing plants can also streamline the permitting process for siting solar, which increases the administrative feasibility of adding clean energy projects to the power mix.

Decarbonizing power generation provides opportunities for job creation. The Commonwealth can prioritize local and historically disadvantaged communities as the beneficiaries of employment opportunities in clean energy industries. Several counties in Pennsylvania were awarded funding to support displaced workers from the coal industry. In addition, there is a need for workers in the power sector to enable updates to transmission and distribution. To prioritize equitable

implementation, Pennsylvania could prioritize local communities for employment in jobs on transmission and distribution projects in the Commonwealth.

Grid reliability will need to be monitored as the grid shifts to lower-carbon resources. With greater reliance on electricity, it will be critical to ensure that renewable energy sources with inconsistent power (e.g., solar and wind are connected to substantial networks of power storage and potential backups in the case of outages or periods of low power provision (e.g., sun or wind exposure).

Metrics

Potential metrics to track progress for this measure include:

- GHG emissions reductions from the electric power sector in Pennsylvania
- Carbon intensity of the electricity mix
- Number, capacity and generation potential of renewable energy projects permitted and/or in operation
- Number, capacity and generation potential of coal and natural gas plants retrofitted with CCUS
- Number, capacity and generation potential of nuclear and small modular reactor facilities

4.5.7 Building Electrification, and Efficiency

GHG Measure Description

Decarbonizing buildings through energy efficiency, fuel switching, adaptive reuse, and other actions are a high priority for the Commonwealth. Emissions from buildings (i.e., residential, commercial, and industrial fuel use, as well as industrial processes) accounted for approximately 31% of GHG emissions in Pennsylvania in 2020. This measure focuses on increasing opportunities for owners and users of all building types to access and install technologies to decrease overall energy consumption, increase energy efficiency, and reduce GHG emissions from the built environment. It covers both market rate and low/moderate income customers, as well as, private and public buildings.

This measure will reduce emissions from this sector through a range of energy efficiency and electrification investments. Types of actions in this measure include the implementation of energy efficiency improvements to reduce gas and electricity usage, maintaining and promoting building codes and green building practices for new buildings, and through electrification of fossil fuel energy use within Pennsylvania's commercial and residential buildings. This measure can be implemented by a range of actors throughout the Commonwealth and is supported by foundational work already in place.

In Pennsylvania, Act 129 established Energy Efficiency & Conservation (EE&C) programs for electricity, which can be expanded on in a range of different ways.

- By increasing targets and removing spending caps while focusing on providing benefits in LIDACs.
- By mandating participation of gas utilities to expand gas efficiency, thus moving beyond voluntary demand-side management programs, and establishing programs to reduce gas usage from residential and commercial buildings.
- By expanding to include beneficial electrification of equipment that can displace use of natural gas and oil by replacing fossil fuel equipment with electric equipment, and as the grid becomes cleaner, emission reductions can be enhanced if equipment has been converted to electric.

Additionally, continued renewal of Pennsylvania's building codes, the adoption of stretch codes and integration of green infrastructure and nature-based solutions will reduce emissions from new construction and major renovations.

Pennsylvania has a range of clean energy financing tools available and under development that are offered through organizations like PEDA, the Philadelphia Energy Authority, and a range of Community Development Financial Institutions (CDFIs) and community lenders.

Actions under this measure will prioritize funding, policies, and programs that support the deployment of building energy efficiency and electrification. Deploying efficiency and electrification can take many forms including:

- Supporting construction, retrofit or redevelopment of new highly efficiency and electrified buildings.
- Using clean energy financing tools to support construction, retrofit or redevelopment of new highly efficiency and electrified buildings.
- Encouraging and providing incentives to support construction, retrofit or redevelopment of new highly efficiency and electrified buildings.
- Revising or supporting local governments to revise permitting, zoning and other reforms to support construction, retrofit or redevelopment of new highly efficiency and electrified buildings.
- Conducting comprehensive planning efforts to support construction, retrofit or redevelopment of new highly efficiency and electrified buildings.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory Sector: Buildings
- Cumulative Reductions from 2025-2030: 12.7 $MMTCO_2e$
- Cumulative Reductions from 2025-2050: 147.2 $MMTCO_2e$

Summary of GHG reduction calculations approach

Emissions reduction for this measure were modeled utilizing the CO2Sight tool, incorporating the Distributed Energy Resources Planner (DER Planner), a bottom-up model used to calculate technical, economic, and achievable potential

estimates for energy change and resulting emission reductions. Building stock is scaled to cover Pennsylvania through the ResStock and ComStock building models. A detailed description of the CO2Sight and DER Planner methodologies can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

State Agencies: State agencies that can support this measure include the PA PUC and PA Department of L&I.

Utilities: Utilities are among the providers of existing energy efficiency and building decarbonization for Pennsylvania rate-payers.

Property Owners, Developers, and Renters: End users of energy can improve efficiency both through changes to the property (i.e., equipment or fuel choice) and through behavioral changes that reduce energy consumption.

Builders, Contractors and Equipment Service Providers: Providers of the services and equipment to decarbonize buildings. This group may expand over the course of measure implementation, especially due to workforce development and expansion.

Inspectors and Regulators: Inspectors and regulators are key implementers of building codes, responsible for assessing compliance of new and existing building supply with standards of the code. Support for inspectors and regulators can include training for increased understanding of how to review buildings for compliance.

Local Energy/Climate Non-profits: Energy non-profits, such as local chapters of the US Green Building Council, can participate in marketing, outreach, and education with Pennsylvania residents to increase awareness of the benefits of new building codes and EE&C programs, as well as demand for programs run by electricity utilities.

Progress to Date and Future Activities and Milestones

Actions that can be taken to support this measure include:

Changes to Act 129, which has already established programs to increase energy efficiency through the utilities and provide programs to allow building decision-makers to increase efficiency.

- Expanding Act 129 and the current programs that support EE&C to provide participants with expanded incentives to undertake energy efficiency measures.
- Implementing a program similar to Act 129 that mandates natural gas utilities to reduce direct natural gas consumption through EE&C programs and establishing annual savings targets.
- Implement electrification after energy efficiency measures. This increases the effectiveness of electrification by reducing the amount of electricity wasted by inefficient appliances and leaks in building envelopes.

Establishing and growing existing programs, such as clean energy financing, commercial building energy performance programs or other incentives and mandates to spur action from large commercial energy consumers to invest in upgrades equipment, appliances, and building envelopes.

- Including carbon as a target of Building Energy Performance Standard (BEPS) programs (instead of the typical overall energy usage target) to incentivize electrification.
- Create or expand voluntary and/or mandatory benchmarking programs for large commercial buildings.

Strengthening of energy codes and green building policies. Implementing strengthened codes, including “stretch codes,” can encourage lower carbon buildings during both construction and operations.

- Facilitate net zero building development. Prioritizing low-emissions practices across the lifecycle (in construction, maintenance, and end of life) of new buildings and retrofits to existing buildings can yield more integrated emissions savings.

Expand or create new programs and incentives for clean energy retrofits and upgrades.

- Single, multifamily homes and small commercial retrofits (e.g., building efficiency retrofits including window replacements, insulation, more efficient and/or electric appliances, hybrid or all-electric heat pumps or more efficient gas heat pumps).

- Implement energy efficiency and fuel switching in large commercial buildings and other large energy users (e.g., hospitals), including implementing solutions to reduce the use of back up diesel generators and transitioning to cleaner alternatives.
- Expand and/or create new programs and incentives for retrofits and upgrades to municipal and government buildings, including public schools, government buildings, and operations (e.g., building efficiency and electrification retrofits, street lighting and stadium lighting retrofits, microgrids).
- Support for energy audits and site assessments. By conducting these assessments, implementers can collect information on which areas of the building inventory, if any, need additional support in achieving improved energy efficiency and decarbonization, and have the highest potential to result in energy savings.
- Planning for electric panel upgrades in properties to better support future electrification.

Authority to Implement

The authority to establish programs that mandate utilities provide energy efficiency programs is well established in Act 129. Expansions on this act or a similar act designed for gas utilities will need to go through the same legislative process as Act 129. The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the APCA or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs.

Energy code implementation across the region is governed by state law, which with some variations limits local governments' ability to implement codes different from those adopted at the state level. All other activities mentioned above can be implemented or are being implemented through existing voluntary or regulatory programs.

Geographic Coverage

This measure is intended to reduce emissions across Pennsylvania.

Funding Sources

Examples of potential funding sources include, but are not limited to:

- US DOE Energy Efficiency and Conservation Block Grants
- DOE Home Efficiency Rebates and Home Electrification and Appliance Rebates
- DOE State Energy Program
- US Department of Housing and Urban Development Green and Resilient Retrofit Program
- DOE and State Weatherization Assistance Programs

LIDAC Benefits and Co-Benefits

Energy efficiency upgrades lead to a decrease in energy costs. Homes in low-wealth areas and communities impacted by environmental justice issues historically bear disproportionately high energy burdens and can be impacted by changes. A reduction in energy burden for homeowners and renters will occur for a majority of energy efficiency and electrification investments, however, actions need to be taken to ensure that the cost of upgrading to more efficient equipment or to electrify buildings does not create either debt or higher energy costs from electricity.

Reductions in fuel use through efficiency upgrades or fuel switching will lead to a reduction in both outdoor and indoor air pollution. Air pollution impacts have been concentrated in LIDACs where community members may have reduced access to medical resources and care. The resulting reductions in air pollution will lead to better health outcomes and economic impact from reduced healthcare costs.

Metrics

Potential metrics to track progress for this measure include:

- Number of units/square footage retrofitted, disaggregated by type of building
- Number of units/square footage of efficient and electrified new buildings

- Dollar amount of energy savings
- Reductions in the use of fossil fuels in buildings (natural gas, fuel oil)
- Number of new construction units constructed as net zero, high efficiency, or certified sustainable (through USGBC, ISO, or other organizations)

4.5.8 Electric and Alternative Fuel Vehicles

GHG Measure Description

This measure aims to transition light-duty conventional internal combustion engine vehicles (ICEs) to electric vehicles (EVs) and accelerate the adoption of zero-carbon medium- and heavy-duty vehicles (MHDVs) including battery electric, hydrogen fuel cell, and plug-in hybrid electric vehicles. Sales of light-duty EVs have already increased over recent years due to reduced costs, increased financial incentives, and improved charging infrastructure. Even though an increase in EVs will result in increased electricity consumption, mile for mile, the additional electricity generated will result in lower GHG emissions than burning gasoline or diesel to drive. This reduction is even greater if the electricity is generated from renewable sources.

For light- and medium-duty vehicles, as well as for some shorter distance heavy-duty vehicles, electrification would be the most impactful decarbonization method, but for long-distance heavy-duty vehicles, hydrogen may play a larger role in decarbonization. This is in line with the joint memorandum of understanding (MOU) with 14 other states and the District of Columbia committing to the adoption of zero-carbon MHDVs that Pennsylvania has committed to.

To further reduce emissions from light-duty vehicles, Pennsylvania will continue to publicize federal tax credits that encourage the manufacture and purchase of electric passenger vehicles. Pennsylvania will also encourage the adoption of zero-emission MHDVs by reducing manufacturing, capital, and infrastructure installation costs This could include tax credits or rebates for vehicle purchases, leveraging federal incentives for clean hydrogen production, and incentivizing networked MHDV charging. To support hydrogen fuel adoption, Pennsylvania will plan, construct, and establish management for hydrogen infrastructure and supply. Hydrogen supply, ideally of the cleanest and lowest emissions variety, must be readily available across refueling stations for effective deployment of hydrogen fuel cell electric vehicles (FCEVs) and resulting emissions reduction.

Actions under this measure will prioritize funding, policies, and programs that support the deployment of electric light-duty vehicles, battery electric, hydrogen fuel cell, and plug-in hybrid electric MHDVs and their associated charging and fueling infrastructure. Deploying electric and alternative fuel vehicles can take many forms including:

- Supporting purchase of new electric and alternative fuel vehicles and associated charging and fueling infrastructure.
- Using clean energy financing tools to purchase new electric and alternative fuel vehicles and their associated charging and fueling infrastructure.
- Encouraging and providing incentives to purchase new electric and alternative fuel vehicles and their associated charging and fueling infrastructure.
- Revising or supporting local governments to revise permitting, zoning and other reforms to purchase new electric and alternative fuel vehicles and their associated charging and fueling infrastructure.
- Conducting comprehensive planning efforts to purchase new electric and alternative fuel vehicles and their associated charging and fueling infrastructure.

Quantified GHG Reductions ($MMTCO_2e$)

- Sector: Transportation
- Emissions Reductions by 2030: 19.6 $MMTCO_2e$
- Emissions Reductions by 2050: 616.1 $MMTCO_2e$

Summary of GHG reduction calculations approach

This measure models the resulting GHG emissions reduced if Pennsylvania meets the zero-emission vehicle (ZEV) sales targets outlined by California's Advanced Clean Cars II (ACCII) rule for light-duty vehicles (LDVs) and Advanced Clean Fleets (ACF) rule for medium and heavy-duty vehicles. The model uses outputs from the EPA Motor Vehicle Emissions Simulator (MOVES3) to project baseline vehicle miles traveled (VMT), vehicle population, energy consumption, and Scope 1 emissions for on-road transportation in the state by fuel type (gasoline, diesel, ethanol (E-85), and compressed natural gas), vehicle source type, and model year. Additional detail for the methodology of this measure can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

- **PA DEP and PennDOT**: Encourage and facilitate the transition to clean fuels.
- **Automakers**: Car manufacturers must be able to meet the demand for both light-duty EVs and MHDVs to fully utilize the increased commercial interest supported by increased grant funding.
- **Electric Utilities**: Supply and handle the charging load requisite for the large influx of EVs. Consider networked EV charging to reduce overall loads where possible.
- **Hydrogen Fueling Network Partners**: Build out the hydrogen fueling infrastructure within PA to allow for any significant transition to hydrogen vehicles.

Progress to Date and Future Activities and Milestones

Pennsylvania has completed a range of work to support electric and alternative vehicle adoption throughout the Commonwealth including:

- PennDOT's Electric Vehicle Mobility Plan and management of the National Electric Vehicle Infrastructure (NEVI) Formula Program for Pennsylvania
- Pennsylvania DEP's Electric Vehicle Roadmap
- Signing on to the joint MOU with 14 other states and the District of Columbia committing to the adoption of zero carbon MHDVs. The MOU committing to accelerating the adoption of zero carbon MHDVs has goals of 30% of MHDV sales being zero carbon by 2030, increasing to 100% by 2050.
- DEP's Alternative Fuel Vehicle (AFV) Rebate and Alternative Fuels Incentive Grant (AFIG) Program.

Actions that could be taken to support this measure include:

- Establishing fast public charging (L2/DC) for EVs, and ensuring that it is frequent, easy to locate, and easily accessible along highways. A reasonable availability goal is to have chargers ("charging corridors") every 50 miles, each less than five miles from the highway. Increased presence of public charging can help reduce range anxiety and increase perception of EV ownership as convenient and worry-free.
- Seeking out landowners, federal properties, and business owners who are close to highways that may be interested in hosting charging stations.
- Reducing capital costs through increased funding for the statewide rebate program or implementing a tax credit program complementing federal incentives for both EVs themselves and home chargers. Home chargers also include upfront costs for purchase, installation, and "make-ready," or the need to upgrade wiring and other technical specs of the vehicle; reducing such costs may ease deployment.
- Increasing public familiarity and knowledge of EVs, such as existing model varieties, charging station locations, and incentives and available rebates for both LDVs and MHDVs.
- Establishing statewide EV LDV sales goals, and publicly report on progress.
- Increase incentives for businesses, government entities, and other landowners to install public charging stations.
- Encouraging companies and agencies with vehicle fleets to apply for Heavy-Duty Emission Reduction Grants (via the IRA) to electrify their fleets and train workers.
- Collaborating with utilities to ensure the grid can handle loads from charging. Managed network charging could help reduce peak loading. Utilities can also consider electric distribution system planning, beneficial rate design and investment in "make-ready" charging infrastructure.
- Implementing Pennsylvania DEP's EV roadmap.
- Planning, constructing, and establishing management for Hydrogen infrastructure and supply, for effective deployment of Hydrogen FCEVs and resulting emissions reduction. Hydrogen supply and its various varieties (green, blue, pink, and more, each with their own emissions profiles) must be readily available across refueling stations.
- Conduct outreach and education, particularly to small and/or minority-owned businesses to communicate the available tax credits, rebates, and other financial incentives and opportunities related to fleet electrification.

Authority to Implement

The Pennsylvania Department of Transportation has the authority to issue recommendations for individuals and businesses to switch to zero carbon fuels. However, it will need to work in partnership with other agencies to leverage financial incentives to build charging infrastructure on state and federal land. For state or local jurisdictions, the purchase of vehicles for the fleet is within the authority of those entities. Purchasing or procurement policies may need to be adjusted to prioritize electric and AFVs. Private and personal purchasing of low and no emissions vehicles does not have any statutory limitations. Local zoning or code changes may need to be made for charging and fueling infrastructure. The state will be able to utilize the funds received from federal sources to support this measure.

Geographic Coverage

This measure is intended to reduce emissions across all of Pennsylvania.

Funding Sources

Examples of potential funding sources include, but are not limited to:

- IRA – Clean Vehicle Tax Credit
- IRA – Previously Owned Vehicle Tax Credit
- IRA – Clean Commercial Vehicle Tax Credit
- IRA – Alternative Fuel Vehicle Refueling Property Tax Credit
- Clean Heavy-Duty Vehicle Program
- FHWA – NEVI Formula Program
- FHWA – Charging and Fueling Infrastructure Grants
- EPA – Clean School Bus Program
- EPA Diesel Emissions Reduction Program
- EPA Clean Heavy-Duty Vehicle Program
- PA DEP – Alternative Fuels Incentive Grants and Rebates

LIDAC Benefits and Co-Benefits

As identified from Climate Action for Environmental Justice Communities[70] outreach, reducing air pollution from the transition from ICE to electric and alternative fuel vehicles, and particularly medium and heavy-duty vehicles, has the co-benefit of improving public health outcomes for individuals living or working in environmental justice areas and the community overall.

Incentives that reduce the gap in purchasing price between ICE compared to electric and alternative fuel vehicles, as well as electric micro-mobility options with lower costs/barriers to entry (e.g., electric bikes) will lead to reductions in ongoing fuel and operations and maintenance costs for EVs. This has an outsized impact in communities impacted by environmental justice issues as those costs are a more significant part of total expenses, increasing the impact of the EV transition in low-wealth areas. At the same time, care must be taken to ensure that EV infrastructure does not displace important resources or supersede the needs of the community where it is installed.

The EV transition, along with the installation of infrastructure to support it will also support the expansion of the clean energy workforce. In accordance with the Justice40 priorities, steps will be taken to ensure that these benefits are seen in LIDACs.

In addition, smaller businesses, including family and minority-owned businesses, may face greater strains in electrifying their fleets. Smaller vehicle fleets may purchase MHD EVs from secondary markets, excluding them from incentives for the purchases of new vehicles. Smaller businesses transitioning to clean fleets may also be more strained for workforce development and personnel training on EV operation and maintenance, so it is important that state-wide incentives,

[70] Climate Action for Environmental Justice Communities (pa.gov)

rebates, or grant funding addresses the transition process after purchasing. Municipalities or PennDOT may also consider offering technical assistance to smaller fleets.

Metrics

Potential metrics to track progress for this measure include:

- Number of EVs and alternative fuel vehicles registered and/or purchased.
- VMT by vehicle type and fuel.
- Number of publicly accessible charging stations (tracking total, Level 2, and DC fast chargers).
- Charging station uptime hours.
- Number of maintenance and repair workers trained.

4.5.9 Public and Active Transportation

GHG Measure Description

This strategy aims to reduce emissions from the transportation sector by reducing VMT for passenger vehicles in Pennsylvania. It aims to provide other robust modes of transportation that are not only used alongside passenger vehicles, but ultimately become the default option instead of passenger vehicles.

There is no "one-size-fits-all" solution to reduce VMT. Modes of transportation other than personal vehicles are highly dependent on population density, local topography, existing infrastructure, demographics, and even weather. As such, solutions must be tailored at the local level to meet the specific needs of each community. Paired with land-use and development policies, efforts to incentivize sustainable transportation modes (e.g., walking, biking, transit) in urban areas, to expand multimodal options outside urban areas (e.g., bus rapid transit, carpool), and to optimize when travel does occur (e.g., through telecommuting, trip consolidation) will reduce VMT.

Pennsylvania can take advantage of BIL grant programs, like the Congestions Mitigation and Air Quality Improvement Program or the Transportation Alternatives Set-Aside from the Surface Transportation Block Grant Program, which provide funding for a variety of projects from public transit charging equipment to shared micro-mobility (e.g., bike sharing) to constructing bike and pedestrian infrastructure.

Actions under this measure will prioritize funding, policies, and programs that support public and active transportation throughout the Commonwealth. Supporting public and active transportation can take many forms including:

- Supporting the development of new facilities, infrastructure, vehicles and associated supporting work for public and active transportation.
- Using clean energy financing tools to support the development of new facilities, infrastructure, vehicles and associated supporting work for public and active transportation.
- Encouraging and providing incentives to support the development of new facilities, infrastructure, vehicles and associated supporting work for public and active transportation.
- Revising or supporting local governments to revise permitting, zoning and other reforms to support the development of new facilities, infrastructure, vehicles and associated supporting work for public and active transportation.
- Conducting comprehensive planning efforts to support the development of new facilities, infrastructure, vehicles and associated supporting work for public and active transportation.

Quantified GHG Reductions ($MMTCO_2e$)

- Inventory Sector: Transportation
- Cumulative Reductions from 2025-2030: 7.5 $MMTCO_2e$
- Cumulative Reductions from 2025-2050: 45.3 $MMTCO_2e$

Summary of GHG reduction calculations approach

This measure models the resulting GHG emissions reductions if Pennsylvania implements a variety of strategies to reduce VMT. These strategies included land use changes, transit fare reductions, travel demand strategies, transit enhancements, and bicycle/pedestrian/micro-mobility enhancements. VMT reduction impacts are assumed to be only applicable to urban areas since the impacts of VMT policies and strategies is expected to be minimal in rural areas. More detail on the methodology for this measure can be found in Appendix B. Quantified GHG Reductions Methodology.

Key Implementing Agency(ies) and Partners

- **Regional and Local Transportation Agencies:** Agencies such as PennDOT can initiate and implement transit expansion, transit-oriented design, and multimodal transportation options.
- **Metropolitan and Rural Planning Organizations (MPOs and RPOs)**: MPOs and RPOs can evaluate regional transportation system performance, assess resources required for improvements, and liaise with PennDOT for intrastate projects.

- **Local governments.** Responsible for land use planning and comprehensive planning; transportation planning, development and operations, including local transit; program development and administration (e.g., travel demand management programs), and local policies.
- **Private sector partners.** Private sector partners, such as land-owners, developers, and businesses play a key role in development decisions and design that affect the viability of using alternatives to driving. Businesses can also implement telecommuting policies and other policies that help manage travel demand.

Progress to Date and Future Activities and Milestones

Pennsylvania has many existing resources, programs, and planning to shift public use of ICEVs to public transit and active transportation methods. For example:

- PennDOT's Bicycle Routes Map identifies trails, paths, and roads to bike within the Commonwealth. The map is available on PennDOT's website for access.
- PennDOT's 2045 Long Range Transportation Plan (LRTP) aligns with this measure, with expressed priorities in safety, equity and accessibility, and climate resilience.

Future actions the state can take as part of this measure include:

- Increase the number and/or frequency of public transit stops.
- Increase the efficiency and reliability of public transit by ensuring that buses and trains arrive on time. For accountability, easy reporting of issues, and consumer trust, establish a PennDOT-wide transit app for users to find nearest routes and timetables.
- Designate bus lanes in high-traffic areas or during high-traffic times of day, so that bus travelers may avoid traffic congestion.
- Improve and/or establish protected bike lanes where possible, to ensure that biking remains safe, easy, and unintimidating. Improve signage and traffic lights to keep bicyclists safe.
- Subsidize bikeshares, especially electric bikeshare programs, which are already well-established in urban areas of the state.
- Improve the safety and desirability of micromobility via adequate, smooth, and regularly maintained sidewalk space for pedestrians, and protected bike lanes where possible.
- Improve safety, cleanliness, and security for public transportation, including transit stops, platforms, and trains or buses themselves.
- Communicate and promote each of these implementation strategies. Conduct outreach, education, and community involvement so that transit expansion is tailored to the needs and interests of communities.

Authority to Implement

The Conservation and Natural Resources Act of Jun 28, 1995, P.L. 89, No. 18 (1995 Act 18, Section 504) and the APCA or 35 P.S. §4001-4015 grants the authority to the DEP to establish programs related to the control, prevention, abatement and reduction of air pollution and air contamination, which would include new clean energy financing, incentive, or other associated programs. Regional and local transportation agencies like PennDOT have the authority to implement this measure through policies and programming within their respective jurisdictions.

Geographic Coverage

This measure is applicable to the entire state of Pennsylvania.

Funding Sources

- Federal Transit Administration (FTA) Urbanized Area Formula Program
- FTA Bus and Bus Facility Grants
- FTA Capital Investment Grants
- FTA Low or No Emission Grant Program
- Federal Highway Administration (FHWA) Carbon Reduction Program
- FHWA Congestion Mitigation and Air Quality Improvements (CMAQ) Program

- FHWA Surface Transportation Block Grant (STBG) Program
- FHWA Active Transportation Infrastructure Investment Program (ATIIP)
- EPA Clean Heavy-Duty Vehicle Program
- Department of Transportation (DOT) Reconnecting Communities and Neighborhoods Grant Program
- National Park Service (NPS) Rivers, Trails, and Conservation Assistance program (RTCA)
- PA DEP – Alternative Fuels Incentive Grants and Rebates

LIDAC Benefits and Co-Benefits

Investment in public transit and transit options often directly benefits people living or working in environmental justice areas, who are statistically more likely to use transit or to work jobs that have rigid schedules and are more affected by peak hour congestion. Such investments were identified as areas of interest for people living in environmental justice areas, during outreach conducted by the CAEJC program. LIDAC communities and individuals may be neglected by public transit systems with high costs to ride, or distance from work or residential centers. Increasing public transit opportunities should address these existing barriers and improve the physical accessibility and affordability of transit. Safety of multimodal areas should also be considered. Equitable transit-oriented design should consider locating public housing or otherwise affordable housing near transit hubs.

Efforts to reduce VMT through transit and active transportation investment will result in more mobility options for those who are unable to own or operate a vehicle. Additionally, it will reduce the criteria air pollutants that result from gasoline and diesel combustion, which will improve air quality and reduce the burden of health issues associated with these air pollutants. This will be especially true for communities near highways or major roadways that are disproportionately impacted by vehicle air pollution.

In addition, reducing VMT reduces congestion and ultimately leads to a safer and more pleasant experience for all who use the road. Shifting to active transportation modes like biking and walking will also have a positive impact on public health by increasing exercise. When paired with nature-based land management solutions, utilizing active transportation modes can improve wellness through access to nature and cleaner air. Expanded public transportation options can also result in better social cohesion and community access to resources and services.

Metrics

Potential metrics to track progress for this measure include:

- Transit ridership
- Frequency and number of public transit stops
- Miles of expanded pedestrian and bicycle trails
- Creation or expansion of an e-bike program

5 Moving Forward

5.1 CPRG Implementation Grants

DEP, other executive branch-level agencies, offices, and departments in Pennsylvania are eligible to participate in the general competition for CPRG implementation grants, competing against other similar entities for up to $4.3 billion in funding through individual grants ranging from $2 million to $500 million each.[71] Implementation grant applications are due April 1, 2024, with awards anticipated by the end of 2024. Pennsylvania submitted a Notice of Intent to Apply to EPA on January 19, 2024, and intends to apply to fund a statewide Industrial Decarbonization Incentive Program. For more information about the implementation grant applications and competition see: https://www.epa.gov/inflation-reduction-act/about-cprg-implementation-grants.

5.2 Other CPRG Planning Grant Deliverables

As the lead organization for CPRG planning deliverables, along with this PCAP DEP is responsible for developing a CCAP, which will serve as a comprehensive update to this PCAP, and a Status Report on CCAP progress. Through the CCAP process, DEP will continue to meaningfully engage with interested parties, including other state agencies, industry, community organizations, local governments, the public and more.

Per the CPRG guidance, the CCAP will include the following:

- An updated GHG inventory for the Commonwealth
- BAU GHG emissions projections and an economy-wide GHG emissions reduction scenario
- GHG reduction targets for Pennsylvania (short- and long-term)
- A comprehensive list of GHG reduction measures that address economy-wide emissions. Building on the PCAP, this will include the following for each measure:
    - Quantified estimates of GHG reduction and costs
    - Key implementing agency or agencies
    - Implementation schedule and milestones
    - Expected geographic location if applicable
    - Quantified estimates of co-pollutant reductions (e.g., $PM_{2.5}$, NO_x, SO2, VOCs, air toxics)
    - A more robust or quantified analysis of benefits for LIDACs
    - A review of the statutory or regulatory authority to implement the measure (and a schedule and milestones for key entities to obtain it if not existing).
    - Identification of funding sources that have been secured for implementation.
    - Metrics for tracking progress.
- A workforce planning analysis

In 2027 DEP will develop and share a CPRG Status Report that will include:

- The implementation status of the quantified GHG reduction measures from the CCAP.
- Relevant updated analyses or projections supporting CCAP implementation.
- Next steps and future budget or staffing needs to continue CCAP implementation.

[71] US EPA. "CPRG Implementation Grants." October 23, 2023. https://www.epa.gov/inflation-reduction-act/cprg-implementation-grants.

Appendices

A. LIDAC Census Tract IDs

County	Census Tract
Allegheny County	42003101700
Allegheny County	42003281400
Allegheny County	42003320700
Allegheny County	42003515300
Allegheny County	42003517000
Allegheny County	42003403500
Allegheny County	42003561200
Allegheny County	42003120400
Allegheny County	42003464400
Allegheny County	42003492700
Allegheny County	42003492800
Allegheny County	42003262000
Allegheny County	42003261500
Allegheny County	42003484600
Allegheny County	42003486700
Allegheny County	42003486900
Allegheny County	42003424000
Allegheny County	42003050100
Allegheny County	42003250700
Allegheny County	42003980500
Allegheny County	42003290200
Allegheny County	42003499400
Allegheny County	42003488400
Allegheny County	42003510000
Allegheny County	42003982200
Allegheny County	42003980900
Allegheny County	42003111500
Allegheny County	42003462100
Allegheny County	42003180700
Allegheny County	42003561900
Allegheny County	42003561600
Allegheny County	42003561700
Allegheny County	42003562300
Allegheny County	42003562400
Allegheny County	42003562900
Allegheny County	42003462600
Allegheny County	42003483800
Allegheny County	42003550900

County	Census Tract
Allegheny County	42003523200
Allegheny County	42003552100
Allegheny County	42003260900
Allegheny County	42003241200
Allegheny County	42003250300
Allegheny County	42003250900
Allegheny County	42003261400
Allegheny County	42003512000
Allegheny County	42003561000
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Allegheny County	42003561400
Allegheny County	42003552000
Allegheny County	42003484300
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Allegheny County	42003488200
Allegheny County	42003562500
Allegheny County	42003562600
Allegheny County	42003563200
Allegheny County	42003492900
Allegheny County	42003515100
Allegheny County	42003551200
Allegheny County	42003552300
Allegheny County	42003560600
Allegheny County	42003010300
Allegheny County	42003040600
Allegheny County	42003101600
Allegheny County	42003130200
Allegheny County	42003494000
Allegheny County	42003050900
Allegheny County	42003512800
Allegheny County	42003508000
Allegheny County	42003051100
Allegheny County	42003120300
Allegheny County	42003522000
Allegheny County	42003090300
Allegheny County	42003551900

County	Census Tract	County	Census Tract
Allegheny County	42003130300	Beaver County	42007604500
Allegheny County	42003180300	Beaver County	42007604000
Allegheny County	42003202200	Beaver County	42007601200
Allegheny County	42003271500	Beaver County	42007602100
Allegheny County	42003552400	Beaver County	42007604600
Allegheny County	42003120800	Beaver County	42007605400
Allegheny County	42003427000	Beaver County	42007605700
Allegheny County	42003509400	Bedford County	42009960400
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Allegheny County	42003561100	Bedford County	42009960100
Allegheny County	42003120700	Bedford County	42009960300
Allegheny County	42003130600	Berks County	42011000500
Allegheny County	42003130400	Berks County	42011001700
Allegheny County	42003290100	Berks County	42011001200
Allegheny County	42003290400	Berks County	42011000100
Allegheny County	42003300100	Berks County	42011002500
Allegheny County	42003401200	Berks County	42011002200
Allegheny County	42003450800	Berks County	42011012600
Allegheny County	42003463900	Berks County	42011000300
Allegheny County	42003030500	Berks County	42011001500
Allegheny County	42003485000	Berks County	42011001600
Allegheny County	42003402000	Berks County	42011000900
Allegheny County	42003480101	Berks County	42011002600
Allegheny County	42003481000	Berks County	42011001100
Allegheny County	42003552200	Berks County	42011001800
Allegheny County	42003512900	Berks County	42011002300
Allegheny County	42003513800	Berks County	42011013200
Allegheny County	42003420000	Berks County	42011000200
Allegheny County	42003468800	Berks County	42011000800
Allegheny County	42003111400	Berks County	42011001000
Allegheny County	42003130100	Berks County	42011001300
Armstrong County	42005950100	Berks County	42011001900
Armstrong County	42005951000	Berks County	42011000700
Armstrong County	42005951100	Berks County	42011001400
Armstrong County	42005950700	Berks County	42011002000
Armstrong County	42005951400	Berks County	42011000400
Armstrong County	42005951800	Berks County	42011002700
Armstrong County	42005951900	Berks County	42011002100
Beaver County	42007602800	Blair County	42013010102
Beaver County	42007603500	Blair County	42013011002
Beaver County	42007604100	Blair County	42013100400
Beaver County	42007601300	Blair County	42013100500
Beaver County	42007601400	Blair County	42013011600

County	Census Tract	County	Census Tract
Blair County	42013101400	Centre County	42027010800
Blair County	42013101600	Chester County	42029308000
Blair County	42013010800	Chester County	42029300700
Blair County	42013100700	Chester County	42029305400
Blair County	42013101900	Chester County	42029305500
Blair County	42013101700	Chester County	42029306503
Blair County	42013010101	Chester County	42029311600
Blair County	42013100300	Chester County	42029305600
Bradford County	42015950200	Chester County	42029305700
Bradford County	42015951400	Clarion County	42031160400
Bucks County	42017100304	Clarion County	42031160500
Bucks County	42017100207	Clarion County	42031160700
Bucks County	42017101605	Clarion County	42031160900
Bucks County	42017100700	Clarion County	42031160200
Bucks County	42017100104	Clearfield County	42033331401
Bucks County	42017103103	Clearfield County	42033331402
Butler County	42019902200	Clearfield County	42033331000
Butler County	42019902400	Clearfield County	42033331800
Butler County	42019902500	Clearfield County	42033330500
Butler County	42019902300	Clearfield County	42033330900
Cambria County	42021001200	Clearfield County	42033331300
Cambria County	42021011000	Clearfield County	42033331200
Cambria County	42021000200	Clearfield County	42033331900
Cambria County	42021000700	Clearfield County	42033331500
Cambria County	42021011400	Clearfield County	42033331600
Cambria County	42021000500	Clearfield County	42033331100
Cambria County	42021011900	Clinton County	42035030100
Cambria County	42021013400	Clinton County	42035030900
Cambria County	42021010200	Clinton County	42035030600
Cambria County	42021012100	Columbia County	42037051200
Cambria County	42021013500	Columbia County	42037050700
Cambria County	42021013600	Crawford County	42039110300
Cambria County	42021011700	Crawford County	42039110900
Cambria County	42021013200	Crawford County	42039110202
Cambria County	42021011600	Crawford County	42039111600
Cambria County	42021000300	Crawford County	42039111200
Cambria County	42021000100	Crawford County	42039111900
Cambria County	42021000600	Crawford County	42039110400
Cameron County	42023960100	Crawford County	42039110100
Carbon County	42025020106	Crawford County	42039111100
Carbon County	42025020600	Cumberland County	42041013102
Carbon County	42025020400	Cumberland County	42041012900
Centre County	42027012100	Cumberland County	42041012100

County	Census Tract	County	Census Tract
Dauphin County	42043020300	Delaware County	42045403402
Dauphin County	42043021100	Delaware County	42045404500
Dauphin County	42043020800	Delaware County	42045404900
Dauphin County	42043020600	Delaware County	42045406402
Dauphin County	42043021300	Delaware County	42045400302
Dauphin County	42043023300	Elk County	42047950400
Dauphin County	42043022200	Erie County	42049001100
Dauphin County	42043022300	Erie County	42049002500
Dauphin County	42043020700	Erie County	42049002700
Dauphin County	42043021400	Erie County	42049001500
Dauphin County	42043021600	Erie County	42049001600
Dauphin County	42043023400	Erie County	42049002300
Dauphin County	42043024900	Erie County	42049001700
Dauphin County	42043021200	Erie County	42049002600
Dauphin County	42043021500	Erie County	42049000800
Dauphin County	42043023500	Erie County	42049000400
Dauphin County	42043023700	Erie County	42049001900
Dauphin County	42043025000	Erie County	42049002000
Dauphin County	42043021700	Erie County	42049000100
Delaware County	42045403702	Erie County	42049000500
Delaware County	42045410500	Erie County	42049000900
Delaware County	42045410700	Erie County	42049001000
Delaware County	42045400500	Erie County	42049001800
Delaware County	42045400402	Erie County	42049000300
Delaware County	42045402600	Erie County	42049001200
Delaware County	42045406401	Erie County	42049001300
Delaware County	42045405400	Erie County	42049001400
Delaware County	42045402700	Erie County	42049003000
Delaware County	42045404300	Erie County	42049000600
Delaware County	42045402900	Erie County	42049002400
Delaware County	42045405200	Erie County	42049000700
Delaware County	42045406500	Fayette County	42051261800
Delaware County	42045406300	Fayette County	42051262200
Delaware County	42045400301	Fayette County	42051260300
Delaware County	42045400700	Fayette County	42051260700
Delaware County	42045405100	Fayette County	42051261300
Delaware County	42045405300	Fayette County	42051260800
Delaware County	42045400401	Fayette County	42051261401
Delaware County	42045405000	Fayette County	42051261402
Delaware County	42045404700	Fayette County	42051262701
Delaware County	42045406600	Fayette County	42051262702
Delaware County	42045402400	Fayette County	42051262300
Delaware County	42045404800	Fayette County	42051262500

County	Census Tract	County	Census Tract
Fayette County	42051263200	Lackawanna County	42069110700
Fayette County	42051261700	Lackawanna County	42069101100
Fayette County	42051261200	Lackawanna County	42069102600
Fayette County	42051263000	Lackawanna County	42069100300
Fayette County	42051262600	Lackawanna County	42069100600
Fayette County	42051261900	Lackawanna County	42069102900
Fayette County	42051260600	Lackawanna County	42069102000
Fayette County	42051262900	Lackawanna County	42069102100
Fayette County	42051263100	Lackawanna County	42069100800
Fayette County	42051263300	Lackawanna County	42069100400
Fayette County	42051261600	Lackawanna County	42069101600
Forest County	42053530100	Lackawanna County	42069101900
Forest County	42053530201	Lackawanna County	42069102300
Forest County	42053530300	Lackawanna County	42069102500
Franklin County	42055010100	Lackawanna County	42069103000
Franklin County	42055012200	Lackawanna County	42069111600
Franklin County	42055011200	Lackawanna County	42069112500
Greene County	42059970800	Lancaster County	42071011200
Huntingdon County	42061950900	Lancaster County	42071000400
Huntingdon County	42061951000	Lancaster County	42071001200
Huntingdon County	42061950500	Lancaster County	42071014700
Huntingdon County	42061951200	Lancaster County	42071014101
Huntingdon County	42061951100	Lancaster County	42071000100
Huntingdon County	42061951300	Lancaster County	42071014102
Indiana County	42063960100	Lancaster County	42071001400
Indiana County	42063960300	Lancaster County	42071010400
Indiana County	42063960200	Lancaster County	42071011300
Indiana County	42063960400	Lancaster County	42071001000
Jefferson County	42065951100	Lancaster County	42071000300
Jefferson County	42065950100	Lancaster County	42071000700
Jefferson County	42065951000	Lancaster County	42071000900
Jefferson County	42065950300	Lancaster County	42071000800
Jefferson County	42065950900	Lancaster County	42071011400
Jefferson County	42065951200	Lancaster County	42071000200
Jefferson County	42065951300	Lawrence County	42073011800
Juniata County	42067070300	Lawrence County	42073000600
Juniata County	42067070201	Lawrence County	42073000800
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Lackawanna County	42069111400	Lawrence County	42073000300
Lackawanna County	42069101400	Lawrence County	42073000400
Lackawanna County	42069102200	Lawrence County	42073001000
Lackawanna County	42069110800	Lawrence County	42073000100
Lackawanna County	42069100200	Lawrence County	42073000900

County	Census Tract	County	Census Tract
Lawrence County	42073000700	Luzerne County	42079200100
Lebanon County	42075000200	Luzerne County	42079200600
Lebanon County	42075002900	Luzerne County	42079201200
Lebanon County	42075000401	Luzerne County	42079217400
Lebanon County	42075000402	Luzerne County	42079217800
Lebanon County	42075000500	Luzerne County	42079217700
Lebanon County	42075000300	Luzerne County	42079217600
Lebanon County	42075000100	Luzerne County	42079214100
Lehigh County	42077002000	Luzerne County	42079215100
Lehigh County	42077002201	Luzerne County	42079216700
Lehigh County	42077001700	Luzerne County	42079216000
Lehigh County	42077001800	Luzerne County	42079217200
Lehigh County	42077002100	Luzerne County	42079213000
Lehigh County	42077006500	Luzerne County	42079213800
Lehigh County	42077005703	Luzerne County	42079211101
Lehigh County	42077005100	Luzerne County	42079212700
Lehigh County	42077001000	Luzerne County	42079213600
Lehigh County	42077001900	Luzerne County	42079214200
Lehigh County	42077001501	Luzerne County	42079201000
Lehigh County	42077000800	Luzerne County	42079217002
Lehigh County	42077000900	Luzerne County	42079200800
Lehigh County	42077006800	Lycoming County	42081001000
Lehigh County	42077001600	Lycoming County	42081000600
Lehigh County	42077000500	Lycoming County	42081011200
Lehigh County	42077000400	Lycoming County	42081000100
Lehigh County	42077000700	Lycoming County	42081000300
Lehigh County	42077001200	Lycoming County	42081011700
Lehigh County	42077009600	Lycoming County	42081011900
Lehigh County	42077009700	Lycoming County	42081000400
Luzerne County	42079200500	Lycoming County	42081000800
Luzerne County	42079200900	McKean County	42083420200
Luzerne County	42079201300	McKean County	42083420300
Luzerne County	42079210900	McKean County	42083420900
Luzerne County	42079210700	McKean County	42083420600
Luzerne County	42079217900	Mercer County	42085033400
Luzerne County	42079200400	Mercer County	42085030100
Luzerne County	42079201500	Mercer County	42085030500
Luzerne County	42079217500	Mercer County	42085032100
Luzerne County	42079200700	Mercer County	42085033200
Luzerne County	42079201400	Mercer County	42085033300
Luzerne County	42079201100	Mercer County	42085030900
Luzerne County	42079210800	Mercer County	42085031100
Luzerne County	42079213700	Mifflin County	42087960200

County	Census Tract
Mifflin County	42087960900
Mifflin County	42087960800
Mifflin County	42087960300
Mifflin County	42087960700
Mifflin County	42087960400
Monroe County	42089300301
Monroe County	42089300308
Monroe County	42089300309
Monroe County	42089300700
Montgomery County	42091203801
Montgomery County	42091208802
Montgomery County	42091203700
Montgomery County	42091203901
Montgomery County	42091203601
Montgomery County	42091203500
Montgomery County	42091203804
Montgomery County	42091207201
Montgomery County	42091208801
Montgomery County	42091203803
Montgomery County	42091208904
Montgomery County	42091209000
Montgomery County	42091201302
Montgomery County	42091203902
Montour County	42093050300
Northampton County	42095014300
Northampton County	42095011200
Northampton County	42095014600
Northampton County	42095011300
Northampton County	42095011000
Northampton County	42095014200
Northampton County	42095014400
Northampton County	42095015201
Northampton County	42095010500
Northampton County	42095010900
Northumberland County	42097080300
Northumberland County	42097080900
Northumberland County	42097081000
Northumberland County	42097081100
Northumberland County	42097081200
Northumberland County	42097081300
Northumberland County	42097081400
Northumberland County	42097081500
Northumberland County	42097081600
Northumberland County	42097081700
Northumberland County	42097081800
Northumberland County	42097082100
Northumberland County	42097082200
Perry County	42099030602
Perry County	42099030601
Philadelphia County	42101002500
Philadelphia County	42101003300
Philadelphia County	42101004201
Philadelphia County	42101038900
Philadelphia County	42101039000
Philadelphia County	42101032900
Philadelphia County	42101014600
Philadelphia County	42101014800
Philadelphia County	42101014900
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Philadelphia County	42101007400
Philadelphia County	42101009200
Philadelphia County	42101010000
Philadelphia County	42101027800
Philadelphia County	42101009600
Philadelphia County	42101028200
Philadelphia County	42101028800

County	Census Tract	County	Census Tract
Philadelphia County	42101027500	Philadelphia County	42101024200
Philadelphia County	42101026400	Philadelphia County	42101024500
Philadelphia County	42101016200	Philadelphia County	42101025200
Philadelphia County	42101989100	Philadelphia County	42101026200
Philadelphia County	42101028100	Philadelphia County	42101027300
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Philadelphia County	42101011900	Philadelphia County	42101028600
Philadelphia County	42101010100	Philadelphia County	42101031200
Philadelphia County	42101010700	Philadelphia County	42101027901
Philadelphia County	42101029800	Philadelphia County	42101027902
Philadelphia County	42101030900	Philadelphia County	42101031501
Philadelphia County	42101032000	Philadelphia County	42101031502
Philadelphia County	42101028300	Philadelphia County	42101033101
Philadelphia County	42101019100	Philadelphia County	42101033102
Philadelphia County	42101035800	Philadelphia County	42101033701
Philadelphia County	42101035900	Philadelphia County	42101034501
Philadelphia County	42101010600	Philadelphia County	42101034502
Philadelphia County	42101024400	Philadelphia County	42101027100
Philadelphia County	42101024600	Philadelphia County	42101003702
Philadelphia County	42101024900	Philadelphia County	42101014100
Philadelphia County	42101026500	Philadelphia County	42101014400
Philadelphia County	42101000902	Philadelphia County	42101015200
Philadelphia County	42101026700	Philadelphia County	42101015300
Philadelphia County	42101026800	Philadelphia County	42101015700
Philadelphia County	42101031900	Philadelphia County	42101016800
Philadelphia County	42101033000	Philadelphia County	42101020200
Philadelphia County	42101034600	Philadelphia County	42101020300
Philadelphia County	42101006100	Philadelphia County	42101016901
Philadelphia County	42101008400	Philadelphia County	42101017400
Philadelphia County	42101010200	Philadelphia County	42101029000
Philadelphia County	42101010900	Philadelphia County	42101003100
Philadelphia County	42101006500	Philadelphia County	42101005600
Philadelphia County	42101006600	Philadelphia County	42101006700
Philadelphia County	42101013900	Philadelphia County	42101007000
Philadelphia County	42101014700	Philadelphia County	42101009400
Philadelphia County	42101017900	Philadelphia County	42101009500
Philadelphia County	42101019000	Philadelphia County	42101035500
Philadelphia County	42101019700	Philadelphia County	42101036400
Philadelphia County	42101020000	Philadelphia County	42101020500
Philadelphia County	42101010800	Philadelphia County	42101028901
Philadelphia County	42101014500	Philadelphia County	42101028902
Philadelphia County	42101016500	Philadelphia County	42101030501
Philadelphia County	42101023900	Philadelphia County	42101011000

County	Census Tract	County	Census Tract
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Philadelphia County	42101004102	Philadelphia County	42101006900
Philadelphia County	42101016400	Philadelphia County	42101002701
Philadelphia County	42101016902	Philadelphia County	42101018800
Philadelphia County	42101017100	Philadelphia County	42101019200
Philadelphia County	42101002100	Philadelphia County	42101019800
Philadelphia County	42101026100	Philadelphia County	42101003001
Philadelphia County	42101027200	Philadelphia County	42101007101
Philadelphia County	42101028000	Philadelphia County	42101007102
Philadelphia County	42101029400	Philadelphia County	42101008101
Philadelphia County	42101031000	Philadelphia County	42101008102
Philadelphia County	42101033300	Philadelphia County	42101008602
Philadelphia County	42101033600	Philadelphia County	42101012201
Philadelphia County	42101029900	Philadelphia County	42101015101
Philadelphia County	42101027700	Philadelphia County	42101015102
Philadelphia County	42101028500	Philadelphia County	42101016701
Philadelphia County	42101029300	Philadelphia County	42101016702
Philadelphia County	42101030200	Philadelphia County	42101017701
Philadelphia County	42101031600	Philadelphia County	42101017702
Philadelphia County	42101008301	Philadelphia County	42101017201
Philadelphia County	42101008302	Philadelphia County	42101017202
Philadelphia County	42101006300	Philadelphia County	42101018002
Philadelphia County	42101007300	Philadelphia County	42101019501
Philadelphia County	42101008500	Philadelphia County	42101019502
Philadelphia County	42101015600	Philadelphia County	42101020101
Philadelphia County	42101016300	Philadelphia County	42101020102
Philadelphia County	42101017800	Philadelphia County	42101027401
Philadelphia County	42101027000	Philadelphia County	42101027402
Philadelphia County	42101024700	Philadelphia County	42101024100
Philadelphia County	42101026600	Philadelphia County	42101024800
Philadelphia County	42101010400	Philadelphia County	42101006400
Philadelphia County	42101013200	Philadelphia County	42101010300
Philadelphia County	42101017601	Philadelphia County	42101010500
Philadelphia County	42101031700	Philadelphia County	42101000500
Philadelphia County	42101031800	Philadelphia County	42101003701
Philadelphia County	42101032300	Philadelphia County	42101028700
Philadelphia County	42101033400	Philadelphia County	42101029100
Philadelphia County	42101033500	Philadelphia County	42101032600
Philadelphia County	42101036000	Philadelphia County	42101033200
Philadelphia County	42101019900	Philadelphia County	42101030502
Philadelphia County	42101000200	Philadelphia County	42101031101
Philadelphia County	42101004101	Philadelphia County	42101031102
Philadelphia County	42101004202	Philadelphia County	42101031401

County	Census Tract
Philadelphia County	42101031402
Philadelphia County	42101003200
Philadelphia County	42101035601
Philadelphia County	42101035701
Philadelphia County	42101035702
Philadelphia County	42101037200
Philadelphia County	42101037700
Philadelphia County	42101038000
Philadelphia County	42101038100
Philadelphia County	42101038200
Philadelphia County	42101038300
Philadelphia County	42101030100
Philadelphia County	42101030000
Philadelphia County	42101002801
Philadelphia County	42101013700
Philadelphia County	42101016600
Philadelphia County	42101017300
Philadelphia County	42101017500
Philadelphia County	42101017602
Philadelphia County	42101025300
Pike County	42103950603
Pike County	42103950900
Potter County	42105950200
Potter County	42105950100
Potter County	42105950500
Schuylkill County	42107000601
Schuylkill County	42107000602
Schuylkill County	42107000900
Schuylkill County	42107000500
Schuylkill County	42107002800
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Schuylkill County	42107001300
Schuylkill County	42107002300
Schuylkill County	42107002600
Schuylkill County	42107001000
Schuylkill County	42107000200
Schuylkill County	42107001500
Snyder County	42109070500
Somerset County	42111021100
Somerset County	42111021000
Somerset County	42111021902
Somerset County	42111021600
Somerset County	42111020900
Somerset County	42111021700
Somerset County	42111020500
Somerset County	42111020300
Somerset County	42111021500
Sullivan County	42113960100
Susquehanna County	42115032200
Susquehanna County	42115032300
Susquehanna County	42115032902
Tioga County	42117950100
Tioga County	42117950200
Tioga County	42117950300
Tioga County	42117951000
Union County	42119090102
Venango County	42121200900
Venango County	42121200500
Venango County	42121200700
Venango County	42121200300
Warren County	42123970800
Warren County	42123970400
Warren County	42123970300
Warren County	42123971400
Warren County	42123971200
Washington County	42125754600
Washington County	42125782700
Washington County	42125795700
Washington County	42125792200
Washington County	42125704100
Washington County	42125783200
Washington County	42125783300
Washington County	42125751200
Washington County	42125754300
Washington County	42125754400
Washington County	42125791000
Washington County	42125775200
Washington County	42125775300
Wayne County	42127961300
Wayne County	42127960700
Wayne County	42127960200
Wayne County	42127961200
Westmoreland County	42129804100
Westmoreland County	42129802600
Westmoreland County	42129804000
Westmoreland County	42129805400

County	Census Tract
Westmoreland County	42129808200
Westmoreland County	42129801500
Westmoreland County	42129806000
Westmoreland County	42129808100
Westmoreland County	42129801400
Westmoreland County	42129805200
Westmoreland County	42129800900
Westmoreland County	42129807600
Westmoreland County	42129801600
Westmoreland County	42129800300
Westmoreland County	42129800200
Westmoreland County	42129800100
Westmoreland County	42129804801
Westmoreland County	42129800700
Westmoreland County	42129802800
Westmoreland County	42129800600
Wyoming County	42131400100
York County	42133000700
York County	42133000500
York County	42133022000
York County	42133000100
York County	42133000200
York County	42133001500
York County	42133000300
York County	42133000600
York County	42133022100
York County	42133022300
York County	42133001200
York County	42133001600
York County	42133021300
York County	42133000400
York County	42133000900
York County	42133001000
York County	42133001100

B. Quantified GHG Reductions Methodology

The following is a summary of methods used for calculating emissions reductions in the Pennsylvania PCAP. In developing these values, modelers sought to determine reasonable GHG emissions reductions from the deployment of specific measures. In some cases, there may be areas of overlap between emissions reduction values between measures. For example, modelers used electricity emissions factors associated with a progressively cleaner grid to determine emissions reduction potential for a range of measures (such as efficiency and electrification). This might result in double counting when comparing it to the Net Zero Electricity Grid measure, which also accounts for emissions reductions from cleaner electricity. Any conflicts and double counting between measures will be resolved in the modeling for the CCAP phase of this plan.

Industrial Electrification, Efficiency, and Process Emissions

This measure models the resulting GHG emission reductions from thermal efficiency gains and is applied to stationary combustion emissions from direct emitters in the industrial sector, fuel switching and electrification of industrial facilities, and process emissions reductions.

Thermal Efficiency Improvements

To estimate the emissions reductions that could be achieved through the adoptions of more efficient thermal processes in industrial applications, total emissions from stationary industrial sources are quantified by industry type. Using the latest DOE resource for industry sector decarbonization, efficiency potentials were identified for each industry type using thermal efficiency potentials when available and combined (thermal and electric) potentials otherwise. Summing up the products of the efficiency potentials and the stationary combustion emissions yielded a total thermal efficiency potential of 22.3%. Assuming this thermal efficiency potential is achieved through linear, incremental growth from 2020 to 2050, emissions reductions were calculated against the BAU energy use case, which had no assumed efficiency gains.

Data used was from EPA Flight Facility-level GHG Emissions Data, Greenhouse Gas Reporting Program[72] and the DOE Industrial Decarbonization Roadmap.[73]

Industrial Electrification and Fuel Switching

Two different calculations were made to estimate emission reduction that could be achieved from fuel switching (oil to gas) and through the electrification of gas industrial processes. An assumption that 80% of fuel oil application could transition to gas and 22.5% of gas uses could be electrified (from DOE's Industrial Decarbonization Roadmap[74]) was implemented through 2050, along with assumptions on existing and new equipment. Assumptions of change were made against a BAU projection of industrial energy use. It was assumed that existing fuel oil boilers would have an average efficiency between 80-85% between 2022 and 2050 and new gas boilers would have an average efficiency between 85-90% over the same time period. For electrification of industrial processes, it was assumed that components of industrial would have an efficiency change in efficiency to commercial buildings use and a factor of 18% was used in alignment with ACEEE's Commercial Electrification Study[75]. A straight-line implementation curve was assumed to transition from fuel oil to gas and gas to electricity, which resulted in approximately 3% of fuel oil use changing to gas every year and 0.8% of gas use changing to electricity. Emissions factors for fuel oil, gas and electricity were applied to determine the emissions reductions.

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[72] https://ghgdata.epa.gov/ghgp

[73] DOE. "Industrial Decarbonization Roadmap." 2022. https://www.energy.gov/industrial-technologies/doe-industrial-decarbonization-roadmap

[74] Ibid.

[75] Source: Electrifying Space Heating in Existing Commercial Buildings, ACEEE 2020, p. 56 https://www.aceee.org/sites/default/files/pdfs/b2004.pdf

Process Emissions Reductions

Industrial process and industrial fugitive emissions reductions were estimated using the Energy Policy Simulator (EPS) for Pennsylvania, a model maintained by Energy Innovation and RMI. Strategies estimated using the EPS include methane destruction and capture, fluorinated gas equipment retrofits, cement clinker substitution, N2O abatement, and material efficiency. The rate of implementation of these strategies is commensurate with meeting 2030 and 2050 targets, and technological readiness.

The Energy Policy Simulator (EPS) is a free-to-use, publicly available, open-source model for estimating the environmental, economic, and human health impacts of climate and energy policies.

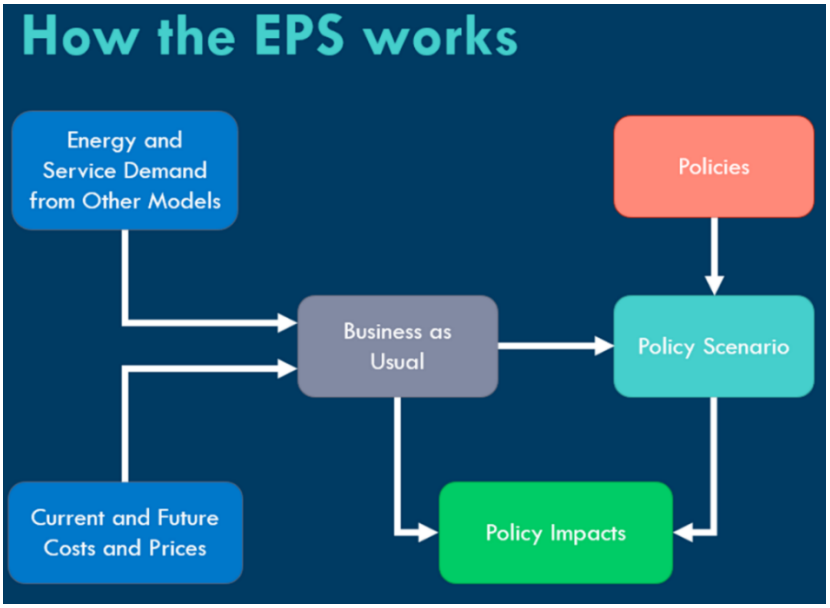
RMI and Energy Innovation have developed state-level EPS models for all lower 48 states. The models use official data from the EPA, DOE, NREL, and other federal and state sources.

Sector	Subsectors	Source
Electricity	In-state capacity and generation; out of state imports	Energy Information Administration (EIA) State Electricity Data
Building Energy Use	All energy use, all building components, residential and commercial buildings	EIA's State Energy Data Systems from 2020 NREL 2017 Electrification Futures Study - Reference Scenario
Industrial Energy Use	All fuel use for industrial sector	EIA's Annual Energy Outlook tables on Industrial Energy Use EIA's State Energy Data Systems
Industrial Process Emissions	Agriculture and industrial process emissions	EPA's US State-level Non-CO2 GHG Mitigation Report
Land Use	Natural carbon sinks and sources (LULUCF)	EPA's State GHG Emissions and Removals 2020 Inventory Report
Transportation	All energy use, vehicle miles	EIA's State Energy Data Systems from 2020 EIA's Annual Energy Outlook tables on Industrial Energy Use NREL Electrification Futures Study - Reference Scenario

The EPS allows the user to control a large variety of policies that affect energy use and emissions in every major sector of the economy including transportation, electricity, buildings, industry, agriculture, and land use. It also includes various smaller components, such as hydrogen supply, district heat, waste management, and geoengineering. The model reports outputs at annual intervals and provides outputs such as GHG emissions, energy usage, cash flow, and others.

The EPS works by drawing upon outputs from other energy and service models, plus current and future costs and prices, to form a BAU scenario. That scenario is then acted upon by policy strategies set by the user to become a policy scenario. The EPS then calculates policy impacts from both the BAU and Policy Scenario.[76]

[76] Detailed documentation of the EPS is available can be found on Energy Innovation's website.



For the Pennsylvania PCAP, the EPS was only used for estimating certain industrial and waste sector emissions and energy usage. 12 strategies within the EPS were utilized:

EPS Subsector	EPS Strategy	Implementation Amount and Timeline
Water and Waste*	Methane Destruction	100%, beginning in 2025 and reaching 100% in 2030
Water and Waste*	Methane Capture	100%, beginning in 2025 and reaching 100% in 2030
Other Metals	F-Gas Eqpt. Maintenance & Retrofits	100%, beginning in 2025 and reaching 100% in 2050
Chemicals	F-Gas Eqpt. Maintenance & Retrofits	100%, beginning in 2025 and reaching 100% in 2050
Coal Mining*	Methane Destruction	100%, beginning in 2025 and reaching 100% in 2030
Coal Mining*	Methane Capture	100%, beginning in 2025 and reaching 100% in 2030
[Applied to entire industry sector]	F-Gas Substitution	100%, beginning in 2025 and reaching 100% in 2050
Energy Pipelines and Gas Processing*	Methane Destruction	100%, beginning in 2025 and reaching 100% in 2030
Cement and Other Nonmetallic Minerals	Cement Clinker Substitution	100%, beginning in 2025 and reaching 100% in 2050
Cement and Other Nonmetallic Minerals	Material Efficiency, Longevity, & Re-Use	10% demand reduction, beginning in 2025 and ramping to 2050
Iron and Steel	Material Efficiency, Longevity, & Re-Use	15% demand reduction, beginning in 2025 and ramping to 2050
Chemicals	N2O Abatement	100%, beginning in 2025 and reaching 100% in 2050
*** Included in fugitive emissions quantification**		

The implementation amount and timeline were based set commensurate with meeting 2030 and 2050 targets, and technological readiness. Although the level of implementation of a strategy may reach 100% that does not mean that source of emissions has reached zero. For example, there is a technical limitation to how much substitute material can be used in cement clinker.

Outputs from the EPS were post-processed to be in alignment with estimates from ICF modeling.

Low Carbon Fuels

Hydrogen Fuels

This measure modeled the approximate emissions reductions of switching from natural gas fuel to hydrogen fuel in the built environment, transportation, and power generation sectors. Projected hydrogen use in transportation was calculated for each model year, using outputs of EPA Motor Vehicle Emissions Simulator (MOVES3), taking the fraction of VMT outputted by the model that was designated as fuel type "electricity" or "hydrogen" based on the sales curve. The resulting energy consumption was found using the following equation:

$$Energy\ Consumption = VMT\ \times Energy\ Efficiency,$$

where energy efficiency was in units of kJ/mi for battery EVs (BEVs) and FCEVs. FCEV energy efficiencies were sourced from the California ACF rule making and the Alternative Fuels Data Center.

For projecting hydrogen consumption for the building sector ICF used proprietary market modeling of projected hydrogen market growth in the United States. Hydrogen consumption was assumed to replace an increasing proportion of natural gas demand. These assumptions are summarized in the table below.

	2030	2040	2050
% of Natural Gas Demand Replaced by Hydrogen Consumption	1%	7%	19%

Hydrogen consumption for the power sector was generated by IPM (see Net-Zero Electricity Grid measure for details on IPM and power sector modeling).

Total hydrogen consumption was then divided into assumed percentages of blue, green, and pink hydrogen based upon assumed changes in the Pennsylvania energy generation mix. Based upon currently available IRS guidance on 45V tax credit application, pink hydrogen was assumed to be generated only from new steam methane reformer construction. Percentages of blue hydrogen were assumed to be higher in initial years with green and pink percentages increasing over time.

To model GHG emissions reductions in the measure, for each model year emissions from hydrogen consumption were first calculated based on the identified consumption per hydrogen color, using the following emissions factors:

	MTCO2e per BBTU
Blue Hydrogen Carbon Intensity	8.16
Green/Pink Hydrogen Carbon Intensity	0.00

Reductions were then determined based on subtracting the hydrogen production emissions from the assumed natural gas emissions based on baseline usage in the BAU.

Ten percent of the natural gas used in blue hydrogen production was assumed to be from biomethane.

Biomethane

This measure modeled the approximate emissions reductions of switching from natural gas fuel to biomethane in the built environment, transportation, and power generation sectors. It was based on an evaluation for the American Gas Foundation (AGF)[77] in 2019 found various feedstock options for considering biogas and renewable gas in the Mid-Atlantic region and allocated a proportional amount of gas us in Pennsylvania. The modeling team assumed a high availability of biomethane from anaerobic digestion feedstock and a low amount of thermal gasification feedstocks through 2050 in

[77] Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, AGF, 2019. https://gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf

alignment with AGF's study and compared Mid-Atlantic regional feedstocks to 2021 Annual Energy Outlook (AEO) Reference Case gas use for all sectors through 2050.

It was assumed that the available renewable natural gas (RNG) supply will be injected into the pipeline to decarbonize the gas supply in Pennsylvania. For emissions accounting purposes, RNG is assumed to be carbon neutral.

On-Site Renewable Energy

Emissions reductions from renewable energy were projected through the forecasted adoption of rooftop solar systems in Pennsylvania. The total technical potential for rooftop solar was aggregated from Project Sunroof's estimates of the technical potential in each of the counties and cities in Pennsylvania.[78] To determine an adoption rate, the most aggressive 2050 adoption scenario from NREL's Storage Futures Study was applied to the total technical potential.[79] Existing rooftop solar capacity assumptions for Pennsylvania were sourced from PJM's 2023 Load Forecast for all utilities within Pennsylvania and then grown to meet the assumed 2050 level.

To calculate the kWh of solar output, the analysis used the capacity factor for residential solar from NREL's annual technology baseline corresponding to the geography of Pennsylvania. The incremental growth in solar output from current levels, multiplied by grid emissions factors, resulted in the potential avoided emissions from rooftop solar.

Assumptions

- Constant technical potential per building over time
- Constant ratio of commercial to residential rooftop solar capacity
- No incremental rooftop photovoltaic (PV) installation beyond existing in BAU case
- Linear growth of PV installations between 2023 and 2050 in Policy Case
- BAU emissions factors (2020 eGRID held flat)
- PCAP Policy emission factors (2020 eGRID grown based on 2023 AEO Reference Case)

Data Sources

- Storage Futures Study: Distributed Solar and Storage Outlook: Methodology and Scenarios (2021), NREL.
- 2023 Load Forecast, PJM (2023).
- Solar Activity Reports, NJBPU (Dec 2023).
- Project Sunroof data explorer, (June 2019), Google.
- Annual Technology Baseline, Residential PV (2023), NREL.
- Electric Grid Emission Factor Projections for PCAP Use, AEO 2023.
- EPA eGRID, 2020.

Carbon Capture Utilization and Storage

CCUS technology is assumed to be available to some facilities in the industrial and power sectors by 2030, ramping up in deployment and availability by 2050.

Industrial sector potential modeling is based on EPA Flight Emissions data and excludes facilities with annual stationary combustion emissions less than 100,000 MT per year. After removing smaller facilities, roughly 85% of stationary combustion emissions are modeled to remain available for the emission reduction potential of CCUS. A trajectory was developed using industry expectations and expert opinion to model CCUS deployment as a percent of total CCUS potential as follows: 1% in 2030, 10% in 2035, 40% in 2040, 60% in 2045, and 80% in 2050. Assuming a capture rate of 87.5%, consistent with assumptions from the Congressional Budget Office in 2023, emissions reductions in the policy case are calculated against a BAU projection of industrial emissions that models no implementation of CCUS and holds industry emissions flat through 2050. Data used was from EPA Flight Facility-level GHG Emissions Data, Greenhouse Gas Reporting

[78] Google. "Project Sunroof". Accessed Feb 13, 2024. https://sunroof.withgoogle.com/
[79] NREL. "Storage Futures Study." https://www.nrel.gov/analysis/storage-futures.html

Program[80] the DOE Industrial Decarbonization Roadmap[81], and the Congressional Budget Office Carbon Capture and Storage in the United States.[82]

For the power sector, the Net Zero Grid measure includes the use of carbon capture technology on some natural gas-fired generators where cost-effective to help the state achieve a net zero carbon supply of electricity while maintaining grid reliability. The cost-effectiveness of the technology in the power sector modeling is largely driven by the available federal tax credit.

Fugitive Emissions Reduction

The aim of this measure is to reduce emissions from oil and gas production. It is known that roughly 50% of emissions of oil and gas production process comes from the production process rather than midstream/downstream processing. Around 10% of the wells are considered to be the highest emitters, monitoring and repairing these wells can reduce overall oil and gas production emissions by 80%[83]. This strategy models the emission reduction from repairing all of these high emitter wells. A ramp up speed of 10-year is assumed.

Fugitive emissions are also expected to be reduced through the plugging of all the marginal and abandoned wells. These wells have an estimated emission rate of one kilogram of methane gas per hour[8485]. Modeling assumed that 25% of the abandoned wells will be plugged by 2050 and action to plug the wells will begin in 2030.

Additional fugitive emissions related to the industrial sector (including methane capture and destruction from waste, water, and coal sectors) were modeled using the EPS, the methodology of which is described in the methodology section for industrial electrification, efficiency, and process emissions (found above).

Net Zero Electricity Grid

This measure models the resulting GHG emissions reductions from achievement of a 100% net zero electric grid for the state by 2050. The IPM was used to model changes in the electric generating mix over time in Pennsylvania in line with clean grid goal. IPM is the same model used by EPA to analyze the projected impact of environmental policies on the electric power sector. Detailed documentation of the model is available here.

The grid emissions factor used was the output of electric power sector modeling conducted using IPM. IPM is a multi-regional, dynamic, and deterministic linear programming model of the North American electric power sector. The model provides forecasts of least cost capacity expansion, electricity dispatch, and emission control strategies, while meeting energy demand, environmental, transmission, dispatch, and reliability constraints.

Key assumptions for Pennsylvania include:

- Load: 2023 PJM load forecast
- Cost: 2023 NREL ATB capital cost and performance assumptions for new clean energy resources, with the additional inclusion of IRA tax credits for existing nuclear resources as well as new clean energy resources.
- Policy: Assumed to meet a net zero power sector for the state of Pennsylvania. Pennsylvania is assumed to be a participant in the Regional Greenhouse Gas Initiative (RGGI)[86].

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[80] https://ghgdata.epa.gov/ghgp/main.do?site_preference=normal

[81] DOE. "Industrial Decarbonization Roadmap." 2022. https://www.energy.gov/industrial-technologies/doe-industrial-decarbonization-roadmap .

[82] CBO. "Carbon Capture and Storage in the United States." 2023. https://www.cbo.gov/publication/59345 .

[83] Dana R. Caulton et al., "Importance of Superemitter Natural Gas Well Pads in the Marcellus Shale," Environmental Science & Technology 53, no. 9 (May 7, 2019): 4747–54, https://doi.org/10.1021/acs.est.8b06965 .

[84] Mark Omara et al., "Methane emissions from US low production oil and natural gas well sites," Nature (April 19, 2022): https://www.nature.com/articles/s41467-022-29709-3 .

[85] OAR US EPA, "EPA Issues Supplemental Proposal to Reduce Methane and Other Harmful Pollution from Oil and Natural Gas Operations," Other Policies and Guidance, October 11, 2022, https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/epa-issues-supplemental-proposal-reduce .

[86] Pennsylvania's participation in and implementation of RGGI is on hold pending active litigation.

Emissions from the clean grid policy scenario were compared to a BAU scenario to determine emission reductions. The BAU scenario modeled the same assumptions except that the net zero grid goal for 2050 was not included.

Applicable Emission Factors

GHGs

The CO_2 emissions factors from IPM were combined with CH_4 and N_2O eGRID emission factor data from the RFCE region to estimate a CO_2 emission factor for the state.

Building Electrification and Efficiency

Methods, Data, and Key Assumptions

This measure calculated emissions reductions from electrification and energy efficiency in the building sector. Building energy use and building emission projections are based on energy consumption from electricity, natural gas, fuel oil, and propane in existing residential (single-family, multifamily, and mobile homes) and commercial buildings (office, food service, school, hotel, healthcare, retail, and warehouse). The base year and projections for energy consumption in existing buildings are built from the 2022 AEO, which represented projected energy user prior to the passage of the IRA, from the US EIA. AEO data is scaled to cover Pennsylvania by scaling AEO census level data with the ResStock and ComStock building models of North American building stock with county-level resolution. The tool first calibrates ComStock and ResStock energy consumption to AEO energy consumption on a census division level. It then proportionally adjusts county-level energy consumption to the scaled census division level. Energy use values have been integrated with emissions factors for primary fuels (electricity, gas, propane and fuel oil) to provide total emissions. Results are provided every five years from 2020 to 2050 and interpolated for years in between.

For Pennsylvania, modeling assumed an accelerated electrification scenarios for HVAC as well as Water Heating and Cooking, and a High scenario for building envelope implementation in alignment with sources outlined below.

Calculating Energy Change

CO_2Sight utilizes ICF's DER Planner model for modeling existing buildings. DER Planner is a bottom-up model that is built upon the best practice principles for potential modeling outlined by the National Action Plan for Energy Efficiency in their Guide for Conducting Energy Efficiency Potential Studies.[87] The model can be used to calculate technical, economic, and achievable potential estimates. Together, the CO_2Sight platform and DER Planner estimate energy and emissions changes from a range of decarbonization strategies, including electrification retrofits and energy efficiency.

Building characteristics and energy use data for modeling buildings are derived from ResStock[88] and ComStock[89] datasets provided by NREL. These datasets integrate large public and private data sources statistical sampling, detailed sub-hourly building simulations, and high-performance computing. By synthesizing multiple sources into a single resource, these data allow for a granular understanding of the housing and commercial stock and the impacts of building technologies in different communities and businesses. These data are comprehensive and widely used across similar analyses and modeling efforts, and thus allow for development of comparable results. The ResStock and ComStock energy use data are calibrated to match the EIA's AEO dataset.

Distributed Energy Resource Planner Model is ICF's leading edge potential study model built on more than a decade's worth of ICF's experience performing potential studies. It offers a simple Excel-based front end and employs an open-source R script plug-in for all computationally intensive calculations.

DER Planner, informed by stock CO_2Sight measures data, has the capabilities to model various energy efficiency, electrification, and building envelope measures in selected building types. This tool allows the analysis of over

[87] National Action Plan for Energy Efficiency (2007). *Guideline for Conducting Energy Efficiency Potential Studies*. https://www.epa.gov/sites/production/files/2015-08/documents/potential_guide_0.pdf
[88] https://www.nrel.gov/buildings/resstock.html
[89] https://comstock.nrel.gov/

80 residential and commercial measures in selected regions applied to the Pennsylvania building characteristics. The model uses key inputs such as equipment stock, participation rate curves, and energy change per measure and estimates potential savings from applying efficient measures available for each building type and end-use. Given the efficient technologies available, this quantifies how much energy could be reduced. To compute total savings potential, the model runs all permutations combining savings per energy efficiency measure unit, expected measure penetration, and total number of measure units (or total eligible stock) by all adoption types (ROB and RET).[90]

By integrating DER-Planner and comprehensive datasets such as ResStock and ComStock, CO2Sight aggregates energy and emissions changes to estimate changes in energy use. ICF's program experience and available national data sources inform these measures' impacts on energy use.

Applicable Emission Factors

Electricity Emission Factors

CO_2Sight uses ICF's IPM tool to generate a trajectory of grid emissions factors associated with the electricity grid. Emissions factors for this measure were derived from the Net-Zero Electricity Grid measure.

Natural Gas and Propane Emission Factors

Values from EPA's Center for Corporate Climate Leadership GHG Emission Factors Hub were used for natural gas and propane reductions.[91]

Fuel	Emission Factors (kg CO2e/MMBTU)
Natural Gas	53.06
Propane	62.39

Measure Intensities and Participation Curves

As an input into DER Planner, each measure has participation (or technology adoption curves) connected to them. A range of factors can impact whether new electric or efficiency technologies are adopted. This approach builds from NREL's Electrification Future Study[92], from which many of the adoption curves are provided. It accounts for costs, supporting infrastructure, ownership and availability, health and sustainability (including policies) and other factors that could influence technology change. Adoption curves are also provided from the implementation energy efficiency programs and informed by ICF expertise. For ease of use, users can select prepopulated groupings of participation curves to match the types of energy change they want to model. The groupings are outlined below:

HVAC, Water Heating, and Cooking Pathways

- **Business-as-Usual:** Small amount of energy efficiency, no specific electrification strategy or fuel switching
- **Gas Efficiency:** Significant amount of energy efficiency, no electrification, specific emphasis on efficiency for gas equipment. Gas heat pumps in future years.
- **Beneficial Electrification:** Significant amount of energy efficiency, small amount of electrification for those projects that are presently cost-effective.
- **End of Life Electrification:** Significant amount of energy efficiency, large amount of electrification when equipment reaches the end of its useful life.

[90] Measures' adoption type definitions: **Replace on Burnout (ROB)** is Replace On Burnout and implies that the technology will be adopted when the previous technology needs to be replaced**. Retrofit (RET)** implies that the technology is adopted before the previous technology needs to be replaced.
[91] https://www.epa.gov/climateleadership/ghg-emission-factors-hub
[92] https://www.nrel.gov/analysis/electrification-futures.html

- **Accelerated Electrification:** Signification amount of energy efficiency, large amount of electrification prior to equipment reaching the end of its useful life.

Water Heating and Cooking Pathways

- **Business as Usual:** Small amount of energy efficiency, no specific electrification strategy or fuel switching.
- **Gas Efficiency:** Significant amount of energy efficiency, no electrification, specific emphasis on efficiency for gas equipment. Gas heat pumps in future years.
- **Beneficial Electrification:** Significant amount of energy efficiency, small amount of electrification for those projects that are presently cost-effective.
- **End of Life Electrification:** Significant amount of energy efficiency, large amount of electrification when equipment reaches the end of its useful life.
- **Accelerated Electrification:** Signification amount of energy efficiency, large amount of electrification prior to equipment reaching the end of its useful life.

Building Envelope Pathways

- **Business as Usual:** Small amount of energy efficiency on building envelope.
- **Low:** Moderate building envelope work, some deep energy retrofits.
- **High:** Significant building envelope work, Significant deep energy retrofits.

In addition to HVAC; Water Heating and Cooking Pathway selection is being chosen, there are opportunities to influence core energy efficiency work occurring in each pathway including:

- Full lighting retrofits and lighting controls
- Smart Thermostats and Building Automation Systems
- New energy efficient appliances
- New energy efficient HVAC equipment

Electric and Alternative Fuel Vehicles

This measure models the resulting GHG emissions reduced if Pennsylvania meets the ZEV sales targets outlined by California's Advanced Clean Cars II (ACCII) rule for LDVs and ACF rule for medium and heavy-duty vehicles. This results in the following range of ZEV sales fractions:

	2030	2040	2050
Light-Duty Vehicles (T3)	52%	100%	100%
Medium and Heavy Duty Vehicles (T4)	29%-74%	100%	100%
Transit Buses (T4)	100%	100%	100%

Sales curves by vehicle type within each category varied. The fractions shown in the above table represent total ZEV sales, and were further broken down by technology (e.g., BEV, FCEV, and plug-in-hybrid-electric vehicles (PHEV)) to sum to the total ZEV sales.

The model uses outputs from the EPA Motor Vehicle Emissions Simulator (MOVES3) to project baseline VMT, vehicle population, energy consumption, and Scope 1 emissions for on-road transportation in the state by fuel type (gasoline, diesel, ethanol (E-85), and compressed natural gas), vehicle source type, and model year. Default input values were used.

To model GHG emissions reductions in the policy scenario, for each model year, a fraction of VMT was designated as fuel type "electricity" or "hydrogen" based on the sales curve. The resulting energy consumption was found using the following equation:

$$Energy\ Consumption = VMT\ \times Energy\ Efficiency,$$

where energy efficiency was in units of kJ/mi for battery EVs (BEVs) and FCEVs. BEV energy efficiencies were sourced from the Alternative Fuel Life-Cycle Environmental and Economic Transportation tools and FCEV energy efficiencies were sourced from the California ACF rule making and the Alternative Fuels Data Center. Scope 1 emissions were found by reducing baseline

internal combustion engine vehicle (ICEV) emissions by the ZEV sales fraction. Scope 2 emissions were found using the following equation:

$$Scope\ 2\ Emissions = Electricity\ Consumption\ \times\ Electricity\ Emission\ Factor$$

Electricity emissions factor projections were sourced from the result of the net-zero electricity grid measure.

The following additional key assumptions were made throughout the analysis:

- ZEVs exist in the vehicle fleet for the same length of time as ICEVs.
- ZEV activity/use is identical to an ICEV.
- The annual ZEV sales fraction applies to every fuel type.

Public and Active Transportation

This measure models the resulting GHG emissions reductions if Pennsylvania implements a variety of strategies to reduce VMT. These strategies included land use changes, transit fare reductions, travel demand strategies, transit enhancements, and bicycle/pedestrian/micro-mobility enhancements.

This measure assessed three different mode shift and travel behavior scenarios, and the VMT reduction targets for Pennsylvania for this measure are based off the low VMT reduction scenario for that study. To extrapolate these results to account for rural areas in Pennsylvania, it was assumed that these VMT reductions are only applicable to urban areas since the impacts of VMT policy and strategies is expected to be minimal in rural areas.

According to FHWA Highway Statistics, in 2020, on average nationally 70% of Pennsylvania VMT was associated with urban travel, while rural travels accounted for the remaining 30%. The targets of 7% passenger VMT reduction from baseline by 2030 and 9% passenger VMT reduction from baseline by 2050, with linear growth in interim years starting in 2025, were derived using this proportion of urban versus rural VMT. The same baseline VMT, vehicle population, energy consumption, and emissions by fuel type and vehicle source type from EPA MOVES3 used for electric and alternative fuel vehicles was used for this measure.