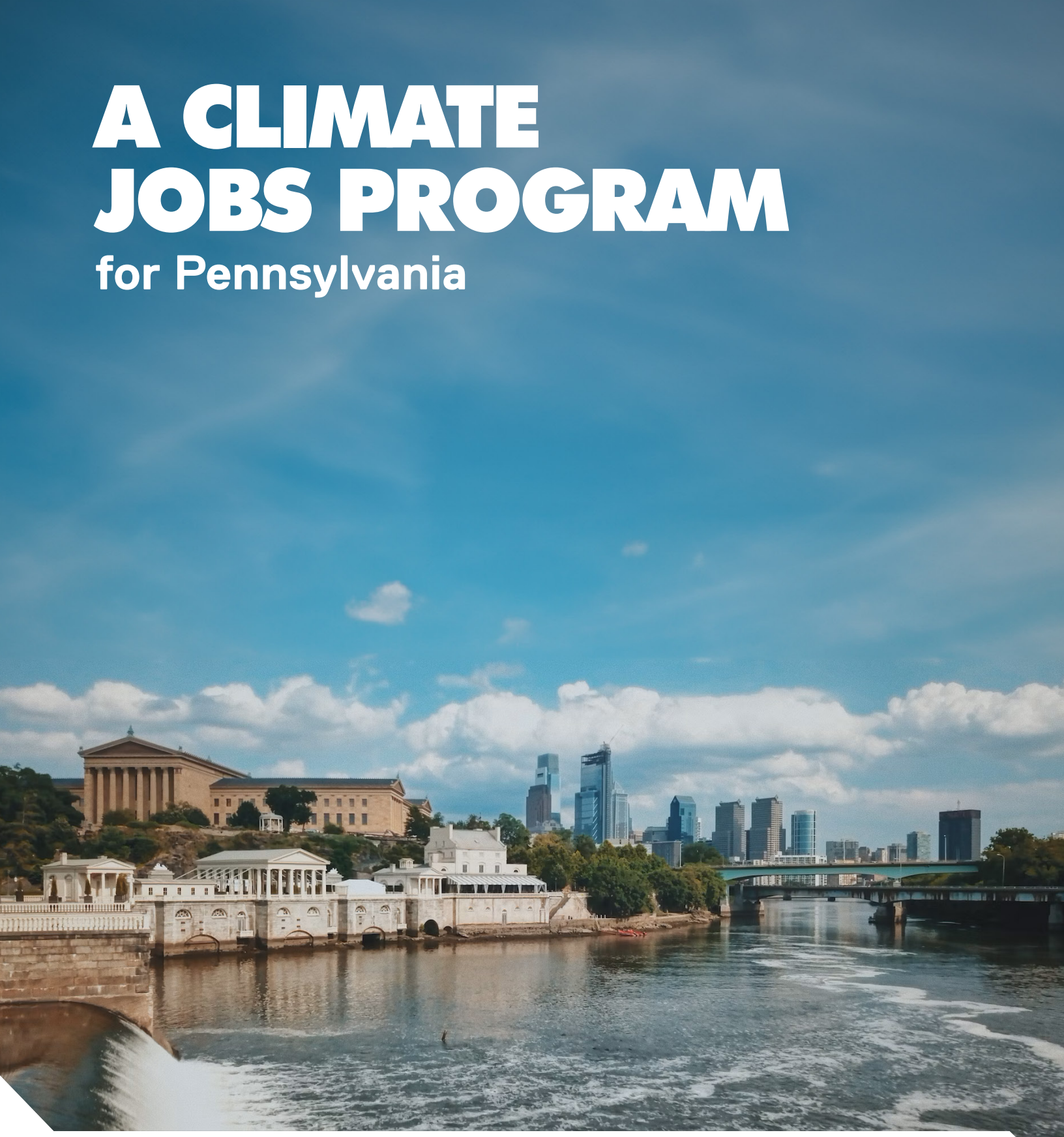
A CLIMATE JOBS PROGRAM

for Pennsylvania



ILR Climate Jobs Institute

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ACKNOWLEDGMENTS

Cornell University's Climate Jobs Institute (CJI) would like to thank the Pennsylvania unions and labor federations that participated in our state research and convening process. We appreciate their bold leadership and commitment to tackling climate change and inequality in the Commonwealth.

CJI would also like to thank all the leaders from local labor, environment groups, academia, government, and industry we interviewed to develop recommendations for this report.

Union / Council / Org	Local
Pennsylvania AFL-CIO	
Pennsylvania Building and Construction Trades Council	
Amalgamated Transit Union	Local 85
American Federation of Government Employees	Local 1916
American Federation of State, County and Municipal Employees	Council 13
American Federation of Teachers Pennsylvania	
Communication Workers of America	Local 13000
International Association of Bridge, Structural, Ornamental & Reinforcing Ironworkers	Local 3
International Association of Heat and Frost Insulators and Allied Workers	Local 2
International Association of Sheet Metal, Air, Rail and Transportation Workers	Local 44
International Brotherhood of Boilermakers	Locals 13 and 154
International Brotherhood of Electrical Workers	Local 5
International Union of Operating Engineers	Local 66
Laborers' International Union of North America	Local 373
Service Employees International Union Healthcare Pennsylvania	
United Association of Pipefitters and Plumbers	Local 524
United Association of Steamfitters	Local 420
United Food and Commercial Workers International Union	Local 1776
United Mine Workers of America	District 2, Local 2300
United Steelworkers	District 10, Local 10

CJI is the academic and educational partner to the Climate Jobs National Resource Center (CJNRC). CJNRC educates workers and the public about policies that will build a clean energy economy at the scale climate science demands, create good union jobs, and create more equitable communities. CJNRC is a labor-led organization that works to combat climate change and reverse racial and economic inequality by building a worker-centered renewable economy.

For nearly three years, the Climate Jobs Institute, along with our partner the Climate Jobs National Resource center, has been working to understand the impact of the climate crisis and the policy response at the local, state, and federal level on Pennsylvania's workers and unions.

This report is the culmination of a participatory process including robust legal, quantitative, and qualitative research; consistent educational convenings; interviews with over 40 key stakeholders; and feedback sessions throughout the research process to develop a Climate Jobs Program for Pennsylvania. We are inspired by the Pennsylvania labor movement's commitment to tackling this crisis and thank them for their steadfast commitment to this process. We hope this program will achieve the best outcomes for rapidly addressing the climate crisis while promoting justice, equity, and high-quality union jobs.

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ILR Climate Jobs Institute

The Climate Jobs Institute (CJI) at Cornell University's ILR School is guiding the nation's transition to a strong, equitable, and resilient clean energy economy by pursuing three aims: to tackle the climate crisis; to create high-quality jobs; and to build a diverse, inclusive workforce.

Through cutting-edge policy studies, deep relationships with on-the-ground partners, and innovative training and education programs, CJI provides information that policymakers, the labor and environmental movements, industry leaders, and others need to navigate this historic transition to a zero-carbon economy.

Core Activities and Objectives

CJI delivers high-quality research, innovative policy solutions, and top-notch educational programming that connects key stakeholders to design and implement climate plans.

The CJI's main areas of work include:

Applied Research and Policy Development for Legislators and Labor, Environmental, and Industry Leaders. CJI crafts equity- and worker-oriented climate policies and analyses indicating how states can address climate change while maximizing high-quality job creation and economic development. The Institute's research and policy efforts result in reports, case studies, policy briefs, and visual tools and maps meant to guide the nation's transition to a clean, equitable economy.

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Technical Assistance. CJI provides rapid response data and policy analysis on the labor, employment, and economic impacts of climate and clean energy issues. The Institute's technical assistance work offers legislators, policymakers, and others real-time support. This work also generates legislative briefings, policy briefs, blog posts, op-eds, and other written materials targeting legislators, local government officials, and leaders in labor, environmental movements, and industry.

Training and Education. CJI organizes a variety of educational convenings that strengthen stakeholders' knowledge, confidence, and motivation to tackle climate change and to build a large, equitable clean energy economy with high-quality jobs. Programs include the Institute's annual Climate Jobs Summit; the design and delivery of member trainings; legislative briefings; educational delegations for legislators, labor leaders, and others; and an online Climate Jobs certificate.

Workforce Development. CJI provides a critical link between the future clean energy workforce we need and workforce development programs that meet these needs. The Institute also provides a pipeline from frontline Black, indigenous, and people of color communities to paid on-the-job training and high-quality careers.

Student Engagement. CJI enriches the ILR and Cornell student experience by engaging undergraduate and graduate students in important aspects of the Institute's core work through fellowships, research assistantships, hands-on clinical experiences, internships, labor-climate undergraduate and graduate courses, and more.

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INTRODUCTION

For more than 150 years, fossil fuels have been the backbone of Pennsylvania's economy, driving the Commonwealth's dominance in oil, gas, and electricity production while powering its integral manufacturing and industrial sector (Pennsylvania Historical & Museum Commission, 2015). Today, Pennsylvania remains an energy powerhouse, ranking as the second-largest producer of total energy, natural gas, and nuclear power nationwide, (U.S. Energy Information Administration [EIA], 2023h). Pennsylvania is also the nation's third-largest producer of coal, with thousands of mines in its Southwestern region (U.S. EIA, 2023h). The Commonwealth's rich energy resources have continued to support its expansive industrial and manufacturing economy, which ranks as the sixth-largest in the country (U.S. Bureau of Labor Statistics [BLS], 2023b). Pennsylvania is home to major industrial corporations, including U.S. Steel, Mack Truck, Boeing, and Westinghouse, and is a key player in fabricated metals, chemicals, plastics, electronics, food processing, defense, and pharmaceuticals (Industry Select, 2023). The Commonwealth's energy and industrial sectors account for a considerable portion of its jobs, tax revenue, and wealth; in fact, some regions are almost entirely dependent on these industries to survive and thrive (Cilento, 2023).

Given Pennsylvania's deep economic and cultural ties to both its energy sector and its energy-intensive industrial sector, the climate crisis simultaneously presents both a significant challenge and an enormous opportunity. With many jobs currently linked to continued fossil fuel extraction and usage, transitioning to a net-zero economy has the potential to be difficult and disruptive (BW Research Partnership [BW Research], 2022). **But the transition to a climate-sustainable future is also a once-in-a-generation opportunity: to rejuvenate Pennsylvania's most critical industries, to restore the middle class and uplift Pennsylvania's workforce and families, and to advance equity and justice for Black Indigenous People of Color (BIPOC) and low- and moderate-income (LMI) frontline communities.** Pennsylvania must seize this opportunity by crafting a transition to climate sustainability that is built on high-quality, unionized, universally accessible clean energy jobs with family-sustaining wages. Simultaneously, the Commonwealth must establish equitable transition pathways for its existing energy workforce into emerging industries as well as pathways for communities who have historically been excluded from this work. Unprecedented investments in utility-scale solar and wind energy, clean energy manufacturing, and decarbonized or low-carbon industrial processes can help to ensure that Pennsylvania continues to be an energy and industry leader.

Without these critical investments, Pennsylvania could face a sharp decline in jobs and economic activity, exacerbating current levels of income, wealth, race, and gender inequality. Fortunately, the passage of three historic federal bills – the Inflation Reduction Act (IRA), the Infrastructure Investment and Jobs Act (IIJA), and the CHIPS and Science Act (CHIPS Act) – offer a historic opportunity for Pennsylvania to rise to this moment and make Pennsylvania a clean energy powerhouse (White House, 2024). These laws have made available billions of dollars for which the Commonwealth is eligible and with which it can invest in maintaining its position as a national energy and manufacturing leader by expanding its clean energy buildout and investing in critical emissions reductions, while also advancing equity by directing the benefits of these investments first to workers and disadvantaged communities (White House, 2024).

PENNSYLVANIA'S ROLE IN CLIMATE CHANGE

As climate change accelerates, Pennsylvania has a vital role to play in responding to this crisis and ensuring its residents are safeguarded from its worst impacts. The Commonwealth is a major contributor to the climate crisis, emitting 263.68 million metric tons (MMT) of greenhouse gasses (GHGs) in 2019 (PA Department of Environmental Protection [PA DEP], 2023b). A plurality of these emissions come from its industrial sector, followed by its electricity and transportation sectors (PA DEP, 2023b). Nearly 65% of the Commonwealth's electricity is generated from natural gas and coal, while renewable energy sources such as solar and wind generate less than 3% (U.S. EIA, 2023d).

Pennsylvania Emissions by Sector (2019)

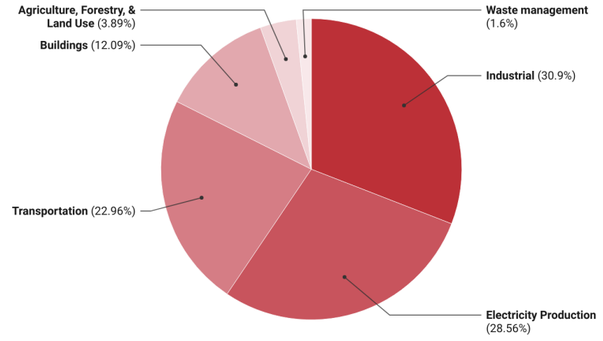


Chart: Nathan Lamm, Research Support Specialist, Cornell ILR Climate Jobs Institute, ndl43@cornell.edu • Source: PA DEP • Created with Datawrapper

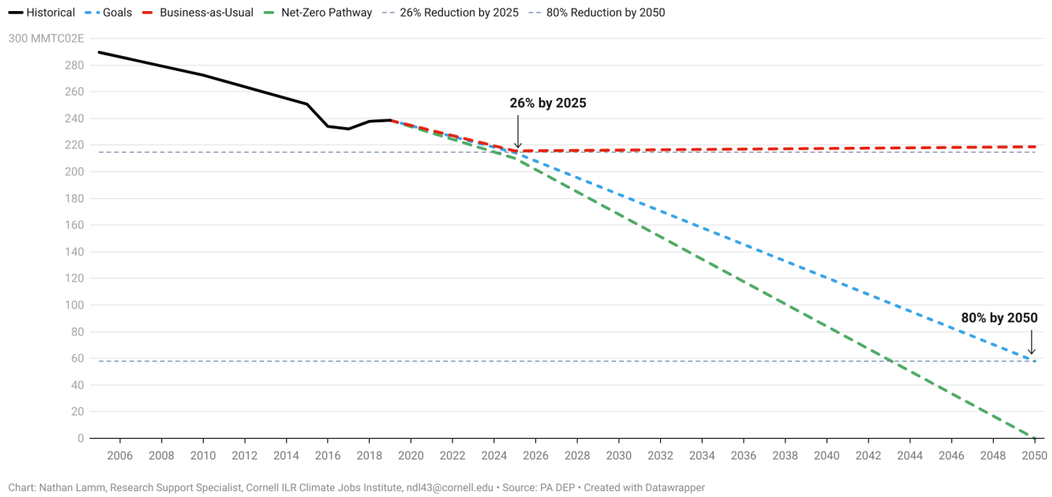
In Pennsylvania's residential buildings, 90% of fuel consumption is emissions-intensive natural gas and fuel oil (PA DEP, 2023b). Pennsylvania also delivers nearly 34% of its fossil fuel generated electricity to other states in the region (U.S. EIA, 2023d).

Pennsylvania has so far been slow to enact more ambitious measures that can both adequately address the Commonwealth's contribution to climate-change-inducing emissions (Pollin et al., 2021a). Moreover, there is a clear lack of provisions that drive high-quality union job creation alongside equitable economic development in the Commonwealth's primary climate policies, which include:

- A goal to reduce state emissions 26% below 2005 levels by 2025 and 80% below 2005 levels by 2050 (Executive Order No. 2019-01 [EO 2019-01], 2019)
- A requirement for 30% of state electricity to come from Tier 1 clean energy technologies (e.g., solar, wind, biomass, low-impact hydropower, geothermal, fuel cells, and coal mine methane) by 2030 (Alternative Energy Portfolio Standards Act, 2007) (Note: several Pennsylvania unions are concerned with the current structure of the Alternative Energy Portfolio Standards Act and are advocating for significant changes to the Act)
- A few voluntary, incentive-based programs that help residents install energy-saving and efficiency measures (PA DEP, n.d.e)
- Guidelines from the Public Utility Commission for electric companies to provide energy efficiency programs and rebates to their customers (Omnibus Amendments Act, 2008; PA DEP, n.d.e)
- A mandate for transit agencies statewide to replace 25% of Pennsylvania's passenger vehicle fleet with electric vehicles by 2025, and/or to explore opportunities to incorporate other clean energy technologies (EO 2019-01, 2019)

Taken together, these existing policies do not provide the strategy needed to fully address the climate crisis while protecting and creating high-quality union jobs (Cao et al., 2023). Pennsylvania needs science-based climate goals, ambitious industrial policy, and strong labor and equity standards to drive high-quality job creation and to build a thriving, equitable, climate-safe economy for Commonwealth residents of the present and future.

Pennsylvania Net Emissions Pathways



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PENNSYLVANIA'S DUAL CRISES: CLIMATE CHANGE AND INEQUALITY

Just as the climate crisis threatens the wellbeing of Pennsylvanians (PA DEP, 2021a), so too do the crises of inequality in income, gender, race, and opportunity (Economic Policy Institute [EPI], 2018; Institute for Women's Policy Research, 2018; PA Department of Human Services, 2021; Research for Action, 2022). In order to adapt to and mitigate climate change, it is imperative that the Commonwealth holistically address these intersecting issues.

Pennsylvania is already experiencing the impacts of climate change. Extreme heat is well on the rise, forcing over 100 schools to shut down in the fall and spring of the 2022–2023 school year (PA DEP, 2021a; The Center for Climate Integrity, 2023). These impacts will worsen in the coming decades: average temperatures in Pennsylvania are expected to increase by between 4 and 8 degrees by 2050 (PA DEP, 2021a), and by 2070 parts of the Commonwealth are projected to see more than 60 days per year where temperatures reach above 90 degrees (ICF, 2023). As extreme heat rises, heat-related deaths are predicted to surge, with disproportionate impacts on the elderly, people without air conditioning, and individuals with pre-existing medical conditions (Whitehead et al., 2023).

Extreme precipitation variability is also increasingly common in Pennsylvania: between 1950 and 2017, 24 Pennsylvania counties experienced at least one flood per year, with heavy precipitation events and flooding projected to increase by 2050 (PA DEP, 2021a). The devastating impacts of these events are already here: flash flooding killed at least six people in Bucks County in July 2023 (The Center for Climate Integrity, 2023). On the other end of the spectrum, warmer temperatures will magnify the natural droughts that the Commonwealth typically experiences in late summer and early fall; by mid-century, Pennsylvania will see a 7% jump in the number of consecutive days of drought (PA DEP, 2021a). These extreme precipitation swings not only pose a direct threat to Pennsylvania's residents, they also threaten the Commonwealth's economy, particularly its agricultural sector, which contributes over $132 billion to its gross domestic product annually (PA Department of Agriculture, n.d.b). Precipitation variability has already caused significant crop loss in Pennsylvania, and the impacts will only increase as the climate crisis worsens (Kukal et al., 2023). All in all, the Commonwealth experienced a minimum of 45 extreme weather-related disasters between 2000 and 2020, each costing a minimum of $1 billion (PA DEP, 2021a).

Members of Laborers Local 373 participating in a Labor Day parade in 2022

Pennsylvania is not immune to the impacts of climate change-induced sea level rise, either (PA DEP, 2021a). Water levels in Philadelphia are anticipated to rise by 1.5–2.7 ft by 2050, and could rise by nearly 4 ft in extreme scenarios (PA DEP, 2021a). This increase would put thousands of homes and tens of miles of Pennsylvania roads at risk of flooding (PA DEP, 2021a).

Climate change also threatens public health in the form of air pollution, extreme weather events, pest-related diseases like Lyme disease, and the disruption of food systems (PA DEP, 2021a). In 2018 alone, nearly 5,000 people in Pennsylvania died prematurely due to air pollution (Dedoussi et al., 2020). These impacts are not distributed equitably: environmental justice and frontline communities in the Commonwealth are most likely to encounter these increased climate risks and have far fewer resources than others to adapt to and recover from these disasters (PA DEP, 2021a).

Climate change is not the only urgent crisis Pennsylvania faces. In fact, the climate crisis has the potential to exacerbate the preexisting crisis of inequality across the Commonwealth.

Pennsylvania has some of the greatest income inequality in the United States, with the Commonwealth's top 1% of earners making nearly 22 times more than the bottom 99% (EPI, 2018). Inequality in Pennsylvania has reached levels unseen since before 1940 (EPI, 2018). Though the median household income in Pennsylvania is $73,170, its poverty rate is almost 12% (U.S. Census Bureau [CB], 2022g). Worse, still, workers are not being fairly compensated for their labor, inevitably contributing to this inequality crisis: although labor productivity in the Commonwealth grew 10% between 2012 and 2021, wages only increased by 2.5% (Muro et al., 2022). Inequality by race and gender is also a significant problem in the Commonwealth: in 2021, 9% of White people lived in poverty compared with 24% of Black people, 24% of Hispanic people, 12% of Asians, and 19% of American Indian/Alaskan Natives (Kaiser Family Foundation, n.d.). Perhaps most strikingly, more than 75% of White households own homes, compared to only 45% of Black and 48% of Latino households (Prosperity Now, n.d.). Additionally, on average women earn approximately $11,500 less than men across all racial and ethnic groups (Wisniewski, 2022).

The high costs of basic needs such as housing, childcare, healthcare, gas, food, and energy have impacted Pennsylvanians' quality of life. Altogether, the estimated costs of these essentials in 2022 ranged from $21,891 for a single adult with no children (thus excluding childcare) to $47,097 for a single adult with one child, thus including childcare (United for ALICE, n.d.). Up to 39% of Pennsylvania households are estimated to be below the ALICE Threshold, which represents the minimum a household must make to afford the costs of these essentials, plus technology, taxes, and a small contingency fund (United for ALICE, n.d.).

Moreover, despite being a major energy producer, Pennsylvania's electricity and energy costs have also climbed over the past two decades (U.S. EIA, n.d.b). Average retail electricity prices in the residential sector jumped by 59% from August 2001 to 2022, and average natural gas prices in the residential sector soared by almost 123% between January 2000 and 2022, causing significant hardship for low-income households (U.S. EIA, n.d.b; Office of State and Community Energy Programs [SCEP], n.d.d).

In short, too many families in Pennsylvania are already struggling to survive, and the climate crisis will only make things worse. Families of color and low-income households are often the least responsible for the climate crisis, yet they are the first and most severely affected by its impacts, with comparatively fewer resources to adjust and recover from extreme climate events (PA DEP, 2021a).

AFSCME members protest at the Pennsylvania Art Museum on behalf of museum workers and members of AFSCME Council 13

HIGH-QUALITY CAREERS WILL SAVE THE PLANET

Climate change is an existential crisis for Pennsylvania and the rest of the world. Fortunately, tackling this challenge provides a historic opportunity to right past wrongs and build a stronger, more just economy, restoring hope and opportunity for millions of Pennsylvania's families.

Pennsylvania must commit to protecting and creating high-quality, family- and community-sustaining careers as it transitions to an equitable clean energy economy. Union density has declined statewide since the 1980s (U.S. BLS, 2023a), coinciding with the rapid rise in income inequality nationwide, including in Pennsylvania (Sommeiller & Price, 2018). Today, Pennsylvania's 749,000 union members represent only 12.9% of its workforce, just above the national average (U.S. BLS, 2023a). Ensuring that people have access to good jobs with family-sustaining wages alongside benefits, training, and health and safety measures is one of the best ways to reverse inequality of income, wealth, race, and gender. **Given the collective power that unionized workers can exercise over their working conditions, denser unionization will be key to ensuring that solutions to the climate crisis include high-quality jobs (BW Research, 2022).**

Currently, over 20% of Pennsylvania's existing traditional power generation workforce belongs to a union (Hirsch et al., 2023). These highly skilled and trained workers are poised to build the 21st-century energy infrastructure the Commonwealth needs to remain an energy powerhouse while combating climate change and building healthier communities. Workers in Pennsylvnia's relatively heavily unionized fossil fuel workforce not only receive higher wages, but also have excellent benefits, including in many cases lifelong access to training and professional development opportunities (BW Research, 2022; Pollin et al., 2021a; Cunningham & Shetler, 2023). Unions must play an instrumental role in preparing today's energy workforce to pioneer the production and operation of clean energy technologies in the United States, such as solar, wind, building efficiency, heat pumps, mechanical insulation, water efficiency, cool and green roofs, electric vehicle charging, and more (AFL-CIO, 2022; BW Research, 2022). As Pennsylvania transitions to low-carbon energy technologies, new jobs should meet high-road criteria for working conditions, offer family- and community-sustaining wages, and allow and incentivize Pennsylvanians to remain in the Commonwealth. Strong labor and equity standards in burgeoning clean energy economies will also be critical to facilitating long-overdue access to these high-quality union careers for frontline communities of color. Pennsylvania must uplift and develop its unionized workforce in order to facilitate a transition to clean energy that is truly a "just transition."

A CLIMATE JOBS PLAN FOR PENNSYLVANIA

Adapting to and mitigating the climate crisis in Pennsylvania must require strategies that reduce inequality while growing a diverse, equitable, unionized clean energy workforce through high-quality transition pathways for existing workers. The following report creates a blueprint for Pennsylvania to implement such strategies to guarantee that the clean energy future is one that includes high-quality jobs, robust economic development, and true equity for all communities. This climate jobs plan is distinctive in that it prioritizes measures that have the highest potential to simultaneously reduce emissions, create accessible high-quality jobs, and provide affordable, clean power and transit to all Commonwealth residents.

In addition to a historic build-out of renewable energy technologies including solar, onshore wind, and offshore wind, this report will recommend that Pennsylvania's transition to a thriving, equitable clean energy economy should include: retrofitting dams for hydroelectric power generation; upgrading homes and buildings at the neighborhood scale, starting in the lowest-income areas; installing zero-emission thermal energy networks that provide an affordable, utility-scale approach to building decarbonization; investing in firm, or baseload, clean power generation that complements solar and wind generation (e.g., small modular nuclear reactor, geothermal, battery storage, and green hydrogen); modernizing public transit and increasing accessibility and convenience; developing clean energy manufacturing and industrial practices; and building a workforce that can guarantee Pennsylvania's resilience to worsening climate change impacts.

This report offers the policy vision that Pennsylvania needs to tackle the dual crises of climate change and inequality: one that is realistic, equitable, economically compelling, and prioritizes the long-term safety and security of the transitioning workforce and of communities at large. Both the nation and the Commonwealth are at a critical juncture in the timeline of climate change and should not miss this historic opportunity to set the course for a future of climate resilience, clean-energy-based equitable economies, and vibrant, healthy communities.

ENERGY

Pennsylvania is a national leader in energy production (U.S. EIA, n.d.d). With approximately 258,200 workers at the end of 2021, the energy sector has long provided good jobs and led Pennsylvania to become the nation's second largest energy producer and the second-largest energy exporter (BW Research, 2022; U.S. EIA, n.d.d; U.S. EIA, n.d.c). Fossil fuels drive Pennsylvania's energy economy: the Commonwealth derives 64% of its in-state electricity generation from fossil fuels – 54% from natural gas alone – and only 2.8% from renewable sources (U.S. EIA, 2023d). Pennsylvania's electricity generation is also integral to powering neighboring states, including those on the PJM grid (U.S. EIA, 2023g). Electricity generation contributes to 28.6% of statewide emissions, making this an important sector to rapidly decarbonize (PA DEP, 2023c). While Pennsylvania's remaining coal plants will be retiring or converting to natural gas by 2028, there is currently no scheduled closure date for its natural gas plants, in part due to the amount of power they currently provide (Carleton, 2023; Willson, 2023). As Pennsylvania scales its renewable energy capacity to add 54.5 gigawatts (GW) on top of existing capacity per this report's recommendations to meet science based climate goals, carbon capture technologies could potentially be useful to reduce natural gas emissions from existing plants.

Despite its energy dominance, Pennsylvania lags behind many states in renewable power generation, ranking 26th for installed solar capacity and 21st for net generation from wind (Solar Energy Industries Association, n.d.; U.S. EIA, n.d.a). The Commonwealth's planned and operating energy in solar and wind – 3 GW and 1.6 GW, respectively – currently represent only 1% of its combined solar and wind technical energy potential, which totals roughly 422 GW (S&P Capital IQ Pro, n.d.; Lopez et al., 2012).

Failing to invest in its renewable and clean energy potential has had a stark impact. While in 2022, jobs in fossil fuels across industries had fallen by 13.7% (7,916 jobs) compared to pre-COVID levels in 2019, jobs in the renewables sector did not scale at a pace matching this decline (BW Research, 2022). Even as jobs in Pennsylvania's renewable sectors (e.g., solar, wind, low-impact hydropower, and geothermal) rose by 8.43% between 2019 and 2021, this resulted in a mere increase of 719 new jobs (BW Research, 2022). Moreover, the Commonwealth has not put forth high-quality labor standards in its emerging clean energy economy to ensure that careers in these fields align with those in the legacy fossil fuel industry in terms of quality, health and safety protections, wages, and benefits (BW Research, 2022). Pennsylvania has therefore yet to deliver on a just and equitable clean energy transition.

Pennsylvania must take bold actions to protect its position as an energy leader in the face of shrinking fossil fuel employment **The Commonwealth has an extraordinary opportunity to jumpstart its clean energy economy with utility-scale renewable projects. Taking advantage of federal incentives to build out renewable energy can create thousands of high-quality union jobs with strong labor standards.** With 49,862 jobs across the natural gas, petroleum, and coal sub-sectors, Pennsylvania's strong fossil fuel workforce can transition to a union-based clean energy economy (BW Research, 2022).

Pennsylvania must also invest in transmission infrastructure to support the increasing supply of renewable electricity and future demand from electrification. The Commonwealth's transmission system is vulnerable to extreme weather such as storms, flooding, and falling tree limbs, earning a "C" letter grade from the American Society for Civil Engineers (Gilstrap et al. 2015; Pennsylvania State Council of the American Society of Civil Engineers [PA State Council of ASCE], 2022). Maintenance work is required from field operators, plant operators, mechanics professionals, and maintenance professionals in specific jobs such as outside linemen, tree-trimmers, equipment operators, and taladata and maintenance members to ensure safe operation of the grid (PA PUC, n.d.; IBEW Local 126, n.d.; IBEW Local 1919, n.d.). The grid must also be upgraded and hardened by a well-trained, highly skilled utility workforce to ensure grid safety, efficiency, and reliability (PA Energy Programs Office, 2022). A build-out of new transmission lines is similarly vital, as the regional electric grid is expected to require a 23% increase in capacity by 2035 (U.S. Department of Energy [DOE], 2023b).

Credit: National Energy Technology Laboratory, U.S. Dept. of Energy

As the second-largest energy producer in the United States, Pennsylvania's energy sector transition must prioritize both fossil fuel workers and their communities. (U.S. EIA, n.d.d). Fossil fuel workers have long been integral to powering Pennsylvania's economy, not to mention powering Pennsylvania itself. At the same time, 85% of Pennsylvania's power plants are in neighborhoods with "more low income and minority families than the state median" and there is a 65% higher concentration of "low income families near coal and gas power plants." (NextGen Climate America & PSE Healthy Energy, 2016, p. 4). This leaves these communities – where many fossil fuel workers may live – disproportionately exposed to the co-emission of health-harming pollutants (NextGen Climate America & PSE Healthy Energy, 2016; U.S. EPA, n.d.d.; Dutzik et al., 2023). A just and equitable clean energy transition must focus on building benefits – including building union-made affordable clean energy – for workers and communities alike.

The clean energy transition also offers the Commonwealth an opportunity to begin redressing injustices that date as far back as the foundation of its fossil fuel economy. Black workers were once a driving force in Appalachia's coal and steel industries, constituting 13% of Western Pennsylvania's steelworkers in 1918 and just shy of 10% of the region's coal workforce in 1930 (Dixon, 2023). It was Black coal miners who played a crucial role in labor disputes and organizing across Appalachia, and whose labor was critical to both Pennsylvania's economic success and the boom of coal and steel in the national economy (Dixon, 2023). Despite having built this critical arm of the economy, generations of systemic racism have prevented these workers and their communities from benefiting from its prosperity. (Dixon, 2023; Black Appalachian Coalition, n.d.; Black Appalachian Coalition, 2022).

Today, unions and environmental justice organizations are fighting for these communities' right to clean air, demonstrating that environmental justice should not come at the cost of good jobs. The United Mine Workers of America (UMWA) supports the transition to clean energy and recognizes the central roles of renewables in job creation and the just transition in Pennsylvania (Deto, 2021). The Ohio River Valley Institute determined

Boilermakers Local 13 members participate in a Labor Day march

that coal ash cleanup in places with these historic injustices can help create jobs and mitigate pollution in the same locations where plant closures are creating job losses (Richardson et al., 2021). Philly Thrive aims to take direct action to turn an extractive economy into a regenerative one by organizing for environmental, racial, and economic justice (Philly Thrive, n.d.); and has publicly stated its support for the United Steelworkers Local 10-1, committing to making good faith efforts in their relationships with labor unions (Philly Thrive, 2019). Pennsylvania must elevate these voices to foster a healthier, more equitable clean energy economy and create strong union jobs to bolster residents' livelihoods.

To transition to an equitable clean energy economy dedicated to high-quality union jobs with family-sustaining wages and benefits, the Commonwealth should take advantage of federal funding and incentives. Communities in all Pennsylvania counties are eligible for the IRA's Energy Communities Bonus Credit, which encourages the development of renewable and clean energy projects in areas that are designated as brownfield sites, have high fossil fuel employment, or have faced a recent coal mine or coal plant retirement either in the community itself or in a neighboring community (Inflation Reduction Act [IRA], 2022c; IRA, 2022d; IRA, 2022h; IRA, 2022i; U.S. Interagency Working Group, n.d.). The IRA also provides additional 10% credits for clean energy projects benefiting low-income communities (IRA, 2022b; U.S. Department of Treasury, 2023; Office of Energy Justice and Equity, n.d.). These credits are especially important for Washington and Greene Counties in Southwestern Pennsylvania, as well as for several counties in the central and northeastern regions – all regions that have been hit particularly hard by fossil fuel job loss, income loss, and population loss (O'Leary, 2023). Additionally, the IIJA allocates money for clean energy projects on current and former mine land and for redevelopments in the Appalachian region (Infrastructure Investment and Jobs Act [IIJA], 2021e). These projects will repurpose land; strengthen the grid; protect human and environmental health; and create family-sustaining, union careers that can boost Pennsylvania's economy. Given the scale of the climate crisis, historic federal investments, and the pace science demands, the time is now for Pennsylvania to build the energy economy of its future, an energy economy which promotes equity; grows safe, high-quality jobs for the working class; and combats the race to the bottom.

RECOMMENDATION

TRANSFORM PENNSYLVANIA'S ENERGY ECONOMY BY BUILDING 54.5 GIGAWATTS OF RENEWABLE ENERGY BY 2035 WITH GOLD-STAR LABOR STANDARDS

Build out 4.5 GW of offshore wind, 9 GW of onshore wind, and 20.5 GW of solar by 2035 with strong labor and equity standards that create high-quality union careers and benefit local communities

Demand for electricity is expected to rise significantly by 2035, reaching 189% of 2021 levels by 2035 due to building, transportation, and industrial electrification; energy-intensive green hydrogen production; and carbon dioxide (CO_2) removal (U.S. EIA, 2023d; National Renewable Energy Laboratory [NREL], n.d.). To meet its own future electricity demand, reduce overall energy costs, and alleviate the climate crisis, Pennsylvania should build 4.5 GW of offshore wind, 10 GW of onshore wind, 13 GW of distributed solar, and 27 GW of utility-scale solar by 2035 (Gagnon et al., 2024). In addition, the expansion of Pennsylvania's clean energy manufacturing industry is expected to grow energy demand, increasing the need for baseload and dispatchable power, which highlights the need for energy storage alongside clean, consistent sources of energy like geothermal, hydroelectric, and nuclear (Tomich, 2023). The scope and scale of this build-out should be accompanied by a pipeline of skilled, unionized workers. Thus, as Pennsylvania builds its renewable energy capacity, it must do so with gold-star labor standards alongside a robust workforce development program. Lastly, mirroring federal Justice40 principles, Pennsylvania should ensure that at least 40% of the benefits of this build-out – including access to renewable energy, jobs, and emissions reductions – are directed toward environmental justice communities (Young et al., 2021). Together, these actions will help establish a net-zero economy while growing high-quality jobs and prioritizing equity.

Rapidly scaling Pennsylvania's renewable energy build-out alongside its energy storage and transmission infrastructure will improve energy security and energy system resilience (Nazaripouya, 2019). It will also provide an opportunity to ensure that both workers and frontline communities benefit from the energy transition. Growing high-quality jobs in the renewable energy, energy storage, and grid sectors with projects that require gold-star labor standards and take advantage of the labor movement's state-of-the-art training infrastructure creates ample opportunity to organize a pro-union clean energy economy. In addition, even without factoring new subsidies coming online at the federal level, the levelized cost of energy per megawatt hour (MWh) in 2023 for onshore wind and utility-scale solar ($24-75 per MWh and $24-96 per MWh respectively) was less than that of natural gas ($39-101 per MWh) (Bilicic & Scroggins, 2023). Thus, the build-out of clean, affordable energy

Pennsylvania's untapped renewable energy potential

Renewable Energy Source	Capacity Installed (GW)	Capacity Potential (GW)	% Untapped Potential
Solar	1.28	413.00	99.69
Onshore Wind	1.39	109.00	98.73
Offshore Wind	0.00	5.74	100.00
Total	2.66	527.74	99.50

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell Climate Jobs Institute, rsc265@cornell.edu • Source: SEIA, NREL (2012), U.S. DOE, NREL (2016) • Created with Datawrapper

Levelized Cost Energy ($/MWh)

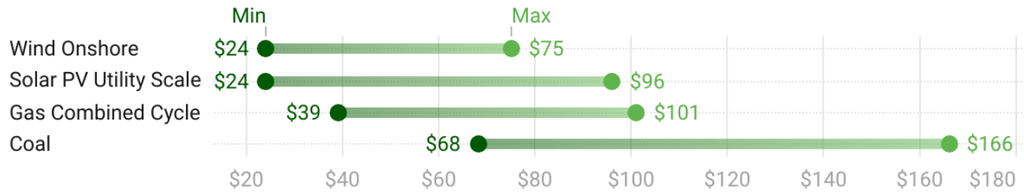


Chart: Lexi Scanlon, M.A., Senior Research Support Specialist, Cornell ILR Climate Jobs Institute, aks287@cornell.edu • Source: Lazard with support from Roland Berger • Created with Datawrapper

promises to lower energy costs, reducing the energy burden – or proportion of income paid on utilities – for low-income households.

The Commonwealth can pursue many renewable energy options, chiefly: solar, onshore wind, and offshore wind. Solar can be deployed in many ways, such as distributed generation via rooftop mounted panels, "agrovoltaics," "floatovoltaics," and larger ground-mounted applications like community solar and grid-scale solar. Agrovoltaics are mounted above farmland and can improve certain crop yields, even protecting them from extreme weather, while "floatovoltaics" are mounted on floating racks and are best suited for industrial waste pools, dam reservoirs, and pumped hydro energy storage reservoirs (Boyd, 2023). The Commonwealth should provide financial incentives, such as grants and tax breaks, for solar in LMI communities, as these communities have energy burden rates three times greater than the national average and are more likely to experience building conditions unsuitable for rooftop solar (SCEP, n.d.c). Community solar in particular thus represents an opportunity to more equitably spread the benefits of renewable energy buildout across the income spectrum.

Wind energy also holds significant potential for Pennsylvania, especially as a resource in higher-elevation land areas and offshore on Lake Erie (Office of Energy Efficiency and Renewable Energy [EERE], n.d.d). The Great Lakes in particular offer a massive and untapped opportunity for offshore wind energy: due to consistently strong coastal winds, their total capacity potential exceeds 614 GW (Musial et al., 2023). The Commonwealth should target 4.5 GW of offshore wind development by 2035 — equivalent to developing the section of Lake Erie in Pennsylvania's waters that is more than three nautical miles offshore (Musial et al., 2016).

Since the Great Lakes offshore industry has yet to be built, Pennsylvania can take several steps to lead. These include: preparing a port for offshore wind construction vessel mooring and turbine staging (Erie, PA is a prime candidate); building up manufacturing capacity for freshwater turbines suitable for lake ice; and constructing vessels for turbine installation and maintenance which can ideally also navigate the Welland Canal, St. Mary's River, and the St. Lawrence River (Pollack, 2023; Laurie, 2023). While the upfront costs are expensive, these initiatives would drive clean energy investments into one of Pennsylvania's poorest cities, Erie, where 24.3% of the population is below the poverty line and the median household income is roughly $30,000 lower than the statewide average (U.S. CB, 2022g; U.S. CB, 2023a).

Pennsylvania's Department of Environmental Protection (DEP) can play a significant role in helping to expand the Great Lakes offshore wind industry by conducting aquatic habitat research as well as bird and bat migration research for the area. Findings could lead to pre-approved siting locations with care for distance to shore. As a founding member of the Great Lakes Offshore Wind Energy Consortium, Pennsylvania should anchor itself in this alliance by coordinating siting, transmission, and development with other members; broadening the Consortium to include Ohio and Wisconsin; and increasing cooperation with Ontario, Canada.

Finally, Pennsylvania must address siting and permitting processes to accelerate renewable deployment while making these processes more inclusive for local communities. Only 13% of Pennsylvania's zoning codes currently mention solar at all, and a mere 5% address grid-scale solar (Cook, 2021). Pennsylvania should create a standardized process for hearings and community involvement with timely scheduling related to large-scale renewable energy project siting to ensure that locals are involved in the process and have their voices heard. Pennsylvania should also establish state-level and uniform standards for height, sound, and setbacks for projects and set a timeline for the permitting process.

High-Quality Labor Standards: Pennsylvania must build out immense renewable energy capacity with high labor standards and a strong workforce development program. For state energy procurement contracts, Pennsylvania should require that developers of renewable energy projects pay the prevailing wage rate; utilize industry-recognized trainings including quality pre-apprenticeship programs *(see Understanding Quality Pre-Apprenticeship on p. XX)*; registered apprenticeships or other similar on-the-job training; establish targeted hire percentages; and prioritize hiring displaced former fossil fuel workers from energy communities. Finally, the Commonwealth can require grant recipients of the low- and moderate-income community solar grant program to comply with prevailing wage, worker classification, training, and targeted hire requirements.

Cost:

Solar: $6,090,000,000 per year.
Onshore Wind: $1,280,000,000 per year.
Offshore Wind: $1,640,000,000 per year.

Job Creation:

Solar: 11,000 direct jobs per year. 77,000 direct jobs through 2030.
Onshore Wind: 1,900 direct jobs per year. 13,300 direct jobs through 2030.
Offshore Wind: 2,400 direct jobs per year. 16,800 direct jobs through 2030.

Emissions Reduction: 86,300,000 metric tons (MT) carbon dioxide equivalent (CO_2e) per year.

Funding: Pennsylvania's Energy Development Authority (PEDA) and the Green Energy Loan Fund (GELF) that it funds should be expanded, and the PEDA should increase technical and grant support for municipalities, school districts, and municipal electric corporations to provide more entities with the cost savings possible through renewable energy.

There are significant federal incentives available for renewables deployment, including the IRA's Investment Tax Credit and Production Tax Credit, which provide a credit of 6% of the investment or 0.3 cents/kilowatt (kW), with an additional 10% for projects that meet domestic content requirements for steel, iron, or manufactured goods and an additional 5 times multiplier for projects that meet prevailing wage and registered apprenticeship requirements (U.S. DOE, n.d.; White House, 2023d). The IRA also expanded preexisting U.S. Department of Energy (DOE) loan programs for clean energy supply chain investments, including the Title 17 Clean Energy Financing Program (IRA, 2022k). In addition, the U.S. DOE operates the Energy Efficiency and Conservation Block Grant program to assist states, municipalities, and tribal governments in planning and implementing policy to reduce energy use and emissions (SCEP, n.d.a).

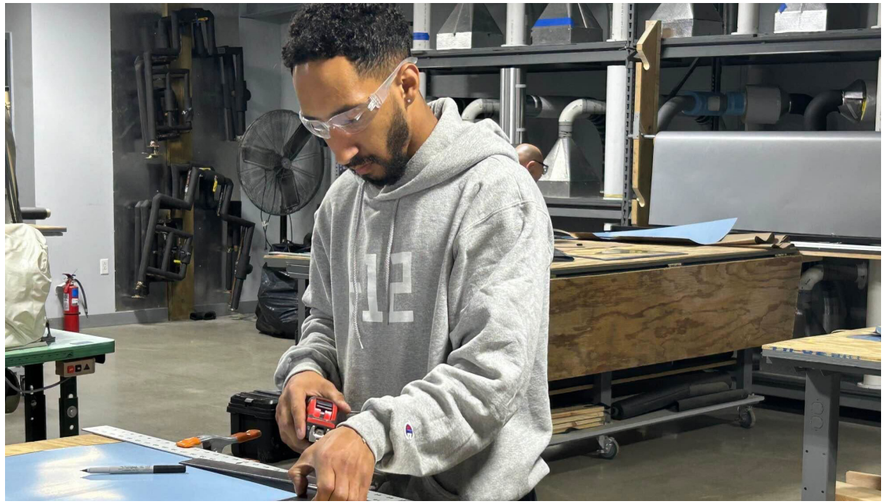
The Energy Community Tax Credit Bonus provides an additional 10% for these two IRA credits in (a) census tracts where a coal mine has closed since 1999 or coal fired power plant has closed since 2009, or (b) metropolitan statistical areas/non-metropolitan statistical areas that meet criteria for fossil fuel employment or tax revenues from fossil fuel activity and unemployment (Interagency Working Group, n.d.). The majority of Pennsylvania qualifies for this bonus, providing additional funding for the Commonwealth to build out renewable energy generation while boosting economic development for impacted workers and communities alike (National Energy Technology Laboratory, 2023). With all of these incentives combined, a clean energy project in an energy community could reach a 50% Investment Tax Credit or a 1.506 cent/kW Production Tax Credit with high-road construction and labor standards (White House, 2023d).

The IIJA also created the Energy Improvements in Rural or Remote Areas Grant Program, which offers grants to "improve the resilience, reliability, and affordability of energy systems in communities across the country with 10,000 or fewer people" (Office of Clean Energy Demonstrations, n.d.e).

Finally, the U.S. EPA is administering the Solar for All program through Greenhouse Gas Reduction Fund monies to provide "grants to states, territories, Tribal governments, municipalities, and nonprofits to expand the number of low-income and disadvantaged communities primed for residential solar investment." (U.S. Environmental Protection Agency [EPA], n.d.f).

UNDERSTANDING QUALITY PRE-APPRENTICESHIP

Apprentices at IUOE Local 542 pose for a picture during a crane class



An apprentice with Insulators Local 2 completes work in July 2023

Pre-apprenticeship, otherwise known as apprenticeship readiness, is designed to "recruit and orient new workers, help them identify the apprenticeship program most suited to them, prepare them to take the test, and support their initial career efforts" (Partnership for Working Families, 2013, p. 62). This definition is mostly reflected in Pennsylvania's guidelines *Registering a Pre-Apprenticeship Program in Pennsylvania: A Guide for Sponsors* released in 2023 (Pennsylvania CareerLink, 2023). Pre-apprenticeship programs may also include "life skills training, financial literacy, and job readiness. Some pre-apprenticeship or pre-training programs provide stipends to help pay for tools and equipment, and may even offer support for transportation and childcare" (Cunningham & Shetler, 2023, p. 17). Importantly, registered pre-apprenticeship programs in Pennsylvania must link directly to registered apprenticeship programs, helping to ensure a continuous training arc – and, ultimately, pathways to career placement – for participants (Pennsylvania CareerLink, 2023).

Pre-apprenticeship programs overall may prove effective for targeting pathways to high-quality careers with family sustaining wages to underrepresented groups, thereby increasing diversity and equity in the workforce (Pennsylvania CareerLink, 2023). The U.S. Department of Labor (DOL) has put forth a definition and framework of "quality pre-apprenticeship" to specifically identify consistent program elements to help achieve these goals (Oates, 2012). These include:

- **Approved Training and Curriculum.** Training and curriculum based on industry standards and approved by the documented Registered Apprenticeship partner(s) that will prepare individuals with the skills and competencies needed to enter one or more Registered Apprenticeship program(s);

- **Strategies for Long-Term Success.** Strategies that increase Registered Apprenticeship opportunities for under-represented, disadvantaged or low-skilled individuals such that, upon completion, they will meet the entry requirements, gain consideration, and are prepared for success in one or more Registered Apprenticeship program(s) including the following:

  - Strong recruitment strategies focused on outreach to populations underrepresented in local, state, and national Registered Apprenticeship programs;

  - Educational and pre-vocational services that prepare individuals to meet the entry requisites of one or more Registered Apprenticeship programs (e.g. specific career and industry awareness workshops, job readiness courses, English for speakers of other languages, Adult Basic Education, financial literacy seminars, math tutoring, etc.); and

  - Assists in exposing participants to local, state and national Registered Apprenticeship programs and provides direct assistance to participants applying to those programs;

- **Access to Appropriate Support Services.** Facilitates access to appropriate support services [including childcare, transportation, and career counseling] during the pre-apprenticeship program and a significant portion of the Registered Apprenticeship program;

- **Promotes Greater Use of Registered Apprenticeship to Increase Future Opportunities.** To support the ongoing sustainability of the partnership between pre- apprenticeship providers and Registered Apprenticeship sponsors, these efforts should collaboratively promote the use of Registered Apprenticeship as a preferred means for employers to develop a skilled workforce and to create career opportunities for individuals;

- **Meaningful Hands-on Training that does not Displace Paid Employees**. Provides hands-on training to individuals in a simulated lab experience or through volunteer opportunities, when possible, neither of which supplants a paid employee but accurately simulates the industry and occupational conditions of the partnering Registered Apprenticeship sponsor(s) while observing proper supervision and safety protocols; and

- **Facilitated Entry and/or Articulation.** When possible, formalized agreements exist with Registered Apprenticeship sponsors that enable individuals who have successfully completed the pre-apprenticeship program to enter directly into a Registered Apprenticeship program and/or include articulation agreements for earning advanced credit/placement for skills and competencies already acquired (Oates, 2012, pp. 2-3).

Organizations including Jobs for the Future and the Center for Law and Social Policy have proposed frameworks that go beyond that offered by the U.S. DOL to further promote high-quality pre-apprenticeships with equitable outcomes (Center for Apprenticeship & Work Based Learning, 2019; Tieszen et al., 2020). These frameworks include elements such as "transparent entry and success requirements" or "ensuring fair compensation" for participants (Center for Apprenticeship & Work Based Learning, 2019, p.2 ; Tieszen et al., 2020, p. 10).

RECOMMENDATION

TAP INTO RENEWABLE ENERGY POTENTIAL BY RETROFITTING PENNSYLVANIA'S NON-POWERED DAMS FOR HYDROELECTRIC ENERGY

Build 400 Megawatts of new hydroelectric power capacity on Pennsylvania's non-powered dams by 2035 while maintaining and repairing Commonwealth dams

Hydroelectric power is a major component of Pennsylvania's energy system and will remain so throughout the clean energy transition. Pennsylvania's existing 927 megawatts (MW) of hydroelectric power capacity generates about 1.1% of the state's total electricity output (U.S. EIA, 2023f). Hydroelectricity is playing a key role in the clean energy transition thanks to its consistent baseload and dispatchable power with exceptionally low operating costs (International Energy Agency [IEA], 2021a). However, many industry experts do not anticipate the construction of new, large-scale hydroelectric dams because of concerns about environmental consequences, reservoir flooding areas, and funding (Dinneen, 2021). Although new dams are unlikely to be constructed, the Commonwealth still has hundreds of non-powered dams (NPDs) on its rivers and streams. These NPDs have great potential to be retrofitted with hydroelectric turbines to increase the Commonwealth's hydroelectric capacity and to strengthen the resilience of its dam stock. In fact, Pennsylvania's NPD stock has the sixth-best hydroelectric power potential in the United States at 679 MW (Hadjerioua et al., 2012).

Many of these NPDs need structural repairs and retrofits to prevent failure. Maintaining this infrastructure is of the utmost importance for public safety and the environment. In Pennsylvania, the average age of dams is 76 years – 20 years older than the national average (PA State Council of ASCE, 2022). Just over half (54%) of Pennsylvania's 1,498 dams are classified as high-hazard, meaning they are likely to cause death and destruction if they fail (PA State Council of ASCE, 2022). The necessary infrastructure upgrades to these dams ***(see the Build Climate-Resilient, Clean, Universally Affordable Water Infrastructure Using Low-Carbon and PA-Made Materials recommendation on p. XX)*** can be coupled with the addition of hydroelectric turbines during the planning, engineering, and construction project stages. Fortunately, "many of the monetary costs and environmental impacts of dam construction have already been incurred at NPDs, so adding power to the existing dam structure can often be achieved at lower cost, with less risk, and in a shorter timeframe than development requiring new dam construction" (Hadjerioua et al., 2012, p. vii). With careful planning, Pennsylvania can retrofit its dams and tap into a reliable source of clean energy avoiding the cost and environmental concerns that full-scale hydroelectric build out would bring.

Pennsylvania should set a goal to develop 400 MW of new hydroelectric power capacity through NPD retrofits by 2035, and set up an NPD Retrofits Program in the PA DEP's Office of Energy to provide dam owners and operators technical assistance in assessing dams' potential for retrofits and soliciting federal funds to complete these projects. Also, Commonwealth agencies should procure hydroelectric power from these retrofitted dams to help meet their annual clean electricity goals and aggregate the demand for hydroelectricity. Finally, the Commonwealth should require these agencies to sell off excess power from these retrofitted hydroelectric dams to provide low-cost clean electricity for LMI households.

High-Quality Labor Standards: For the 61% of Pennsylvania's dams that are privately owned, Pennsylvania can support high-quality jobs by issuing training and development grants to incentivize job creation (PA State Council of ASCE, 2022). These public funds can prioritize applicants that will pay prevailing wages, have a system for ensuring labor peace and stability, hire within the local community, and have a clean record of labor and employment law compliance. The Commonwealth can also assist private dam owners in securing federal IRA and IIJA funding to convert their dams. These funds come with additional labor standards incentives, including prevailing wage (IRA and IIJA) and apprenticeship utilization (IRA) (Pisano et al., 2023). When retrofitting publicly-owned dams, contractors already must comply with Pennsylvania's prevailing wage and Buy American requirements (Regulations for Pennsylvania Prevailing Wage Act, 1975; 73 P.S. § 1881, et seq., 1975). The Commonwealth should go further by promoting targeted hire, requiring contractor affidavits of compliance with local, state, and federal laws, and adding other considerations to guarantee that projects are completed on time, without interruption, and by a well-trained, diverse union workforce.

Cost: $251,000,000 per year.

Job Creation: 1,600 direct jobs per year. 11,200 direct jobs through 2030.

Funding: The IRA's Production Tax Credit applies to hydroelectric power projects, while the Clean Electricity Investment Tax Credit incentivizes use of prevailing wage and apprenticeship standards; domestic steel, iron, and manufactured products; and siting in energy communities for renewable energy projects (IRA, 2022s). The IIJA contains $125 million in funding specifically for NPD retrofits, $75 million in funding for efficiency upgrades at existing hydroelectric facilities, and $553 million in funding for grid resilience, safety, and environmental impact enhancements at dams (Pisano et al., 2023).

RECOMMENDATION

MAKING PENNSYLVANIA A LEADER IN THE INSTALLATION AND MANUFACTURING OF SMALL MODULAR NUCLEAR TECHNOLOGY

1. Install small modular nuclear reactors (SMR) to power Pennsylvania's energy-intensive industrial sector while preserving union jobs
2. Leverage Pennsylvania's manufacturing strength and demand for SMR to become a manufacturing hub for SMR technologies

Install SMR to Power Pennsylvania's Strong Industrial Economy

In addition to this report's recommendation to build 54.5 GW of solar and wind, Pennsylvania will also need to invest in SMRs which are more equipped than traditional renewables to meet industrial requirements and baseload power needs (Liou, 2023; Michaelson & Jiang, 2021; Office of Nuclear Energy, n.d.a). While traditional renewables will provide the bulk of Pennsylvania's clean electricity, they are weather-dependent, variable power sources that will need to be supplemented with controllable or dispatchable, energy sources (Liou, 2023; Michaelson & Jiang, 2021). As the state with the fourth-highest industrial energy consumption (U.S. EIA, n.d.e), SMRs can provide Pennsylvania's industrial users with emissions-free electricity and process heat that is customizable, flexible, and reliable (Idaho National Laboratory, n.d.). With a 300 MW generating capacity, SMRs require much less land than traditional nuclear and can be co-located at industrial facilities to provide electricity generation and process heat onsite (Liou, 2023; Idaho National Laboratory, n.d.). Their size and capacity also make them ideal for repurposing brownfield sites of decommissioned coal-fired plants whose units are similarly sized (World Nuclear Association, 2023). They are also prefabricated and modular, cutting down installation and construction costs as well as time needed to install, and allowing them to be added onto sites as a site's energy demand grows (Liou, 2023). When deployed in a safe, just, and equitable manner, this technology is well-suited for meeting the Commonwealth's industrial energy needs.

SMRs are designed with passive safety features, including low power and operating pressure, and rely on physical signifiers rather than human intervention to trigger a reactor shutdown. (Liou, 2023; Idaho National Laboratory, n.d.). While all commercial SMR projects are subject to the federal Nuclear Regulatory Commission's rulemaking and approval authority (U.S. Nuclear Regulatory Commission, 2023), projects with advanced safety features should be prioritized to protect workers, communities, and the environment against climate and security threats. Moreover, the Commonwealth should collaborate with nuclear experts to create an SMR build-out plan that focuses on safety. To achieve principles of environmental justice, local communities must be consulted when considering the installation of SMR to ensure equitable siting of the technology and its waste, which can be harmful to humans and the environment. Lastly, tools such as community benefits agreements should be standard when installing SMR to ensure that local communities benefit from their impact.

Make Pennsylvania an SMR Manufacturing Hub

Early investments in SMR can make Pennsylvania a manufacturing hub for the region, creating local jobs and supporting the Commonwealth's existing supply chains for materials including steel. Encouraging local manufacturing and in-state prefabrication will make the deployment of SMRs more economically viable. Because of its long history with coal, oil, and gas production and generation, Pennsylvania has a highly-skilled workforce of Boilermakers who are well-positioned to manufacture SMRs. Companies in the Commonwealth are already working in the nuclear subsector (Nuclear Powers Pennsylvania, n.d.), giving Pennsylvania a considerable advantage to lead on the manufacturing and installation of SMRs. In fact, local projects in Pittsburgh, Moon Township, and Cranberry Township have already received close to $20 million in U.S. DOE funding to demonstrate advanced and emerging SMR projects (Office of Nuclear Energy n.d.b).

High-Quality Labor Standards: IRA and IIJA investments for SMR include provisions to ensure that these are high-paying, family-sustaining jobs. Many programs funded through these Acts include Davis Bacon prevailing wage provisions for direct funding, and incentivize apprenticeship utilization through tax credits. (White House, 2023a; Internal Revenue Services [IRS], 2023b; U.S. Department of Labor [DOL], n.d.).

To meet the demand for industrial clean energy, Pennsylvania should directly procure energy from SMR and micronuclear facilities. The Commonwealth can ensure safe, timely completion of the work by highly trained personnel through contractor certifications that there are processes in place to resolve labor disputes, to properly train and classify workers, and to provide comprehensive training during both the construction and operations phases of development. The Commonwealth should also require contractors and subcontractors to sign affidavits about safety training, as nuclear technology can be extremely dangerous if not handled properly. Finally, the Commonwealth should incentivize, or where possible, require contractors to set targeted hiring goals, utilize apprentices, invest in high-quality union or union-affiliated training programs including quality pre-apprenticeships, and invest in frontline communities.

Funding: The IRA's Zero-Emission Nuclear Power Production, Clean Electricity Production, and the Clean Electricity Investment tax credits incentivize SMR nuclear production and deployment. These credits have bonuses to incentivize prevailing wage and apprenticeship standards; domestic steel, iron, and manufactured products; and projects located in energy communities (IRA, 2022s). For applicable communities, the IRA also expanded the US DOE's Tribal Energy Loan Guarantee Program, which can support SMR nuclear projects, and expanded preexisting U.S. DOE loan programs for clean energy supply chain investments, including the Title 17 Clean Energy Financing Program (IRA, 2022l; IRA, 2022j).

The IIJA made $750 million available for Advanced Energy Manufacturing and Recycling grants which can support in-state manufacturing of SMR (IIJA, 2021h). These grants provide funding to small- and medium-sized manufacturers in communities where coal mines or coal power plants have closed, making them particularly relevant to Pennsylvania as the state continues to see a decline in both coal mining and electricity generation from coal and has a large share of abandoned coal mines. (IIJA, 2021h; Bossler, 2023; Frank, 2022; U.S. EIA, 2023g; U.S. EIA, n.d.a). The IRA's Advanced Energy Project Credits can provide manufactures a 30% credit when meeting prevailing wage and apprenticeship requirements on projects that create or re-equip facilities that support SMR projects (IRA, 2022t). The SMR supply chain can be supported by $600 million under the IIJA's Critical Material Innovation, Efficiency, and Alternatives

Community Benefit Agreements (CBAs) are legally binding agreements between developers and coalitions of community-based organizations, often including labor unions. Effective CBAs commit developers to adopting practices that benefit the people most impacted by their projects. CBAs can guarantee targeted hiring, living wages for workers, the construction of affordable housing, investment in local social services, and much more. Effective CBAs are negotiated early in the development process by coalitions that reflect a community's diversity. Best practices include:

- Ensuring transparency throughout negotiations,
- Establishing detailed systems for monitoring progress, and
- Crafting enforceable final agreements (Porterfield, 2021)

In 2018, a coalition called "Stand Up Nashville" negotiated a CBA with the developers of a new MLS stadium (Porterfield, 2021). The deal secured affordable and workforce housing, living wages for stadium workers, childcare facilities, and more (Porterfield, 2021; Morse, 2022). That coalition brought together community organizations and unions such as the Central Labor Council of Nashville and Middle Tennessee, the Ironworkers, IUPAT, LiUNA, and SEIU Local 205 (Stand Up Nashville, n.d.).

grants and $700 million under the IRA's Availability of High-Assay Low-Enriched Uranium program (IIJA, 2021d; IRA, 2022m).

SMR projects that take advantage of IRA and IIJA funding are subject to certain provisions that would encourage equitable placement and siting of these projects. This includes funding sources that ensure that communities who have had negative environmental and health disparities receive clean energy, and communities who have lost jobs from closed fossil fuel sites are prioritized (IRA, 2022j; IRA, 2022g). For both energy and environmental justice communities, the IRA directed $5 billion towards the existing Title 17 loan program established by the Energy Policy Act of 2005 for Energy Infrastructure Reinvestment Financing loan guarantees up to $250 million which can support SMR projects that revitalize, replace, or repurpose former fossil fuel sites (IRA, 2022j). The Advanced Energy Project Credit also sets aside $4 billion specifically for manufacturing and recycling facilities located in energy communities. (IRA, 2022g).

REFORMING PENNSYLVANIA'S PROCUREMENT LAW TO BRING BEST VALUE TO FRONTLINE COMMUNITIES

Apprentices at IUOE Local 542 observe a demonstration at a crane class

Public procurement contracts for goods and services such as renewable energy purchases, building retrofits, energy efficiency measures, Commonwealth vehicles, and public transportation expansion give Commonwealth policymakers a chance to lead by example and invest Pennsylvania's money by creating high-quality jobs in the clean energy transition. However, Pennsylvania procurement law presently requires Commonwealth agencies to select the "lowest responsible bidder" in a competitive sealed bidding process for supplies, services, or construction (Act of May 15, 1998; Procurement and Public Welfare Omnibus Amendments Act of Dec. 3, 2002). Here, "responsibility" means only that the bidder "possesses the capability to fully perform the contract;" it does not involve wider public obligations to taxpayers, the environment, or residents (Procurement and Public Welfare Omnibus Amendments Act of Dec. 3, 2002). This definition greatly constrains the factors agencies can consider when engaging in the competitive bidding process (Kutz & Nichols, 2014). If the Commonwealth wants to consider criteria beyond simply the lowest cost, then a "common standard" must be put in place within bidding documents that is "objectively measurable" (***Steppacher v. Bradley***, 1959; Act of May 15, 1998). Courts have interpreted this law to preclude "subjective" requirements, such as the percent engagement of minority- and women-owned businesses (MWBEs) or the qualifications of key design-build personnel (***Brayman v. DOT***, 2009).

Pennsylvania should adopt a true best value method in its competitive procurement process for all state and local goods and services contracts to permit consideration of intangible but significant factors affecting the public good. This approach is not novel: local governments within the Commonwealth, as well as public–private entities, evaluate proposals based on a best value standard, weighing factors including how the project will "improve economic growth," (Public-Private Transportation Partnerships Act of Jul. 5, 2012), "anticipated job creation," "environmental characteristics" (The Philadelphia Procurement Department, 2017), and "goals for the employment of low-income project area residents," among others (Philadelphia, Pa., 1999). Many municipal agencies outside of Pennsylvania (e.g., in the cities of Chicago, Los Angeles, Atlanta, and New York City) have adopted similar detailed evaluation criteria concerning job creation, wages, targeted hiring, and training plans (Jobs to Move America, 2020). The federal government is also encouraging state applicants for IRA and IIJA funds to look beyond cost and maximize apprenticeship utilization, hiring from frontline communities, and paying family-sustaining prevailing wages (U.S. Department of the Interior [DOI], 2023a; U.S. DOI 2023c). Some grants even require comprehensive labor plans or Community Benefit Plans that support meaningful labor engagement (Office of Clean Energy Demonstrations, 2022).

The Commonwealth should follow suit. By amending its procurement code to account for factors apart from price and capacity to perform the contract, Pennsylvania can ensure that the benefits arising from the billions of dollars in forthcoming public works contracts are passed on to communities most impacted by the energy transition and climate change. The procurement law should require bidders to submit binding plans for:

- Job creation, job quality, and classification of workers
- Targeted recruitment and hiring efforts in various communities (i.e., frontline; high-poverty; justice-involved; veteran; women; BIPOC) particularly through registered apprenticeships, quality pre-apprenticeship programs with direct interview, and other on-the-job training programs
- Workforce training programs and long-term career prospects for employees
- Project labor agreements (PLAs) and labor peace agreements (LPAs), where applicable, to avoid costly disruptions and ensure a steady supply of skilled labor

All commitments in bid documents should be binding and enforceable through liquidated damages (Jobs to Move America, 2020). The Commonwealth should mandate public quarterly reporting, such as via compliance affidavits available on a public database, to ensure monitoring and compliance – especially regarding proper classification and wage payment. Pennsylvania law should also permit government inspections of records and worksites in addition to outlining a process for third parties to flag potential violations (Janis, 2015).

RECOMMENDATION

ADDRESS METHANE LEAKAGE BY ESTABLISHING A LARGE-SCALE PROGRAM TO CAP PENNSYLVANIA'S ABANDONED AND ORPHANED OIL AND GAS WELLS

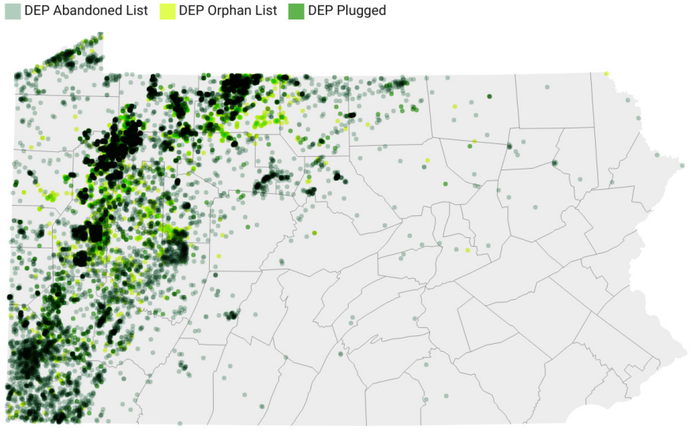
1. Set ambitious goals to locate all remaining undocumented abandoned or orphaned oil and gas wells, and plug all 27,000 documented wells, by 2035
2. Build a highly qualified well-capping workforce by partnering with registered union-affiliated training programs that prioritize transitioning fossil fuel workers
3. Ensure through labor standards that well-capping jobs are high-quality, family-sustaining careers

When oil and gas well operators shut down production on a well, they are required by Pennsylvania law to "cap," or "plug," the well before abandoning it – but this was not always the case (Oil and Gas Well Plugging Oversight, Bonding, Well Plugging Funds and Related Repeal Act, 2022a). Pennsylvania's wells date back to the 1800s, when a lack of regulation and recordkeeping allowed many well operators to skirt accountability for abandoning uncapped wells (PA DEP, 2021b). As a result, an estimated 200,000 to 750,000 uncapped wells likely exist, of which the Commonwealth has identified only around 27,000 (Boettner, 2021; Williams et al., 2020; PA DEP, n.d.h). Of these 27,000, the PA DEP reported in January 2023 that, since the inception of its Wells Plugging Program in 1989, it has plugged around 3,000 wells (Decker, 2023; PA DEP, n.d.h).

The IIJA, acknowledging the urgent need to cap abandoned wells to stop these harmful emissions, made several billion dollars available for applicant states to coordinate programs to locate and plug uncapped wells (U.S. DOI, 2023d). Pennsylvania is expected to receive approximately $400 million of this funding, including $305 million in formula grant funding, over the next few years (PA DEP, n.d.d). This is a good start, but Pennsylvania must pick up the pace to have any hope of thoroughly mitigating this problem in the coming decades. Conservative projections for the cost of plugging one well hover around $30,000; and high-end estimates that account for logistical complications skyrocket to $800,000 for a single well (Boettner, 2023; Decker, 2023). Overall, experts anticipate the Commonwealth would need about $4.5 billion to cap all of its wells (Boettner, 2023).

Oil and gas wells are dangerous polluters when left uncapped, as they can leak poisonous chemicals such as benzene, hydrogen sulfide, and arsenic into the surrounding soil and groundwater, potentially poisoning people, plants, and animals (Turrentine, 2021). In addition, these wells can leak methane, a toxic and explosive gas that has already caused several deadly explosions (Turrentine, 2021). Methane is also a potent GHG – its warming effect per pound is 84 times stronger than CO_2 over a 20-year timeframe (IEA, 2021b). Abandoned oil and gas wells emit roughly 30,000–50,000 MT of methane annually across the Commonwealth (Kang et al., 2014).

Orphan, Abandoned, and Plugged Wells in Pennsylvania



Map: Lexi Scanlon, M.A., Senior Research Support Specialist, Cornell ILR Climate Jobs Institute, aks287@cornell.edu • Source: PA DEP Office of Oil and Gas Management • Created with Datawrapper

Pennsylvania should take immediate advantage of incoming federal dollars to establish a robust well-capping program centered on creating high-quality careers and community benefits, with a pipeline for transitioning fossil fuel workers whose skills will be in high demand as plugging projects rapidly grow. The Commonwealth should proactively plan for generating and investing the necessary funds for sustaining an effective well-capping program that can plausibly cap all documented abandoned wells and locate all remaining undocumented wells by 2035 in order to plug the likely numerous remaining wells once they are discovered.

Pennsylvania can take a number of concrete steps now to build a well-capping program that can truly protect residents of the present and future from toxic uncapped well emissions. (Note that many of the actions suggested below would require that Pennsylvania amend or repeal statutory provisions that currently heavily restrict the PA DEP's autonomy to comply with U.S. Department of the Interior (DOI) mandates by setting worker- and community-centric criteria for disbursal of federal funds, and possibly also restrict the PA DEP's oversight over efficient bundling and scaling of well-capping work (McDevitt, 2022). First, Pennsylvania should start seriously scaling up well-capping work by aggregating capping projects in a strategic manner informed by the expertise of labor unions whose members would be working on these projects. This would reflect the prioritization of efficient bundling in the U.S. DOI criteria for IIJA well-plugging fund applications, which require states to describe their plans, if any, to "bundle" individual uncapped wells into larger capping projects (U.S. DOI, 2023c). The PA DEP should work with Pennsylvania unions to devise the most efficient and scalable system possible for well-bundling. In order to impose greater accountability and compliance with capping laws, the PA DEP should bar oil and gas companies with a record of abandoning their own wells from receiving contracts or grants to plug other companies' uncapped wells (McDevitt, 2022).

Second, the PA DEP will need to expand its employment to adequately staff its well-plugging program. Besides capping wells, staff will need to sift through well records; perform field work to find, verify, and analyze those records; research potentially responsible owners of uncapped wells; and inspect wells after capping (Palmerton, 2023).

This larger footprint will give the Commonwealth an opportunity to do right by transitioning workers who have historically powered Pennsylvania, including the thousands of former mineworkers (BW Research, 2021). Pennsylvania must prioritize training and recruiting the Commonwealth's fossil fuel workforce to transition into thousands of newly-created well-plugging jobs.

The PA DEP should employ in-house well-capping teams to evaluate the most dangerous and most heavily polluting abandoned and orphaned wells, similar to the Bureau of Abandoned Mine Reclamation's in-house reclamation teams (Bureau of Abandoned Mine Reclamation, n.d.). To enable its expanded well-plugging workforce to work as efficiently as possible, the PA DEP should invest in acquiring drones equipped with magnetometers and methane detectors for PA DEP employees tasked with detecting and locating wells to use in the field.

Third, beyond the windfall of IIJA well-capping monies, Pennsylvania should solidify a long-term solution for funding. This is a pressing concern, as even the low end of cost estimates indicates that addressing Pennsylvania's uncapped wells holistically will require funds far exceeding what the Commonwealth currently generates for well-capping purpose. Bearing in mind the average per-well capping cost of $33,000, the Commonwealth's current well decommissioning funding regime is woefully inadequate: the surcharge for drilling permits is a paltry $250, and the decommissioning bonding requirement for conventional wells is just $2,500, with a blanket bond of $25,000 available for operators of multiple wells (PA DEP, 2020). Pennsylvania must rectify these shortcomings, in no small part because this will be critical to eligibility for performance-based federal monies. The U.S. DOI has already earmarked an additional $1.5 billion in well-capping funds for states that increase their own spending on well-capping and tighten regulations to keep more wells from being abandoned in the future; even more is available in matching grants for state funding contributions (Office of Fossil Energy and Carbon Management, n.d.b).

Some potential mechanisms to generate the necessary funding include raising the current gas impact fee, implementing a tax on the transfer of well ownership, and enforcing retroactive fees for the plugging of abandoned wells capped by the Commonwealth if the responsible owner is later identified. In short, Pennsylvania should pursue as many avenues as possible to build combined

funding streams for its well-plugging program. All sources could be directed into a single fund created to ensure the long-term sustenance of large-scale well-capping work, which will remain a necessary and transformative part of the Commonwealth's future for decades to come.

High-Quality Labor Standards: The U.S. DOI encourages states applying for IIJA well-capping funds to detail plans to incentivize contractors to hire transitioning fossil fuel workers and to enter into collective bargaining agreements or PLAs, making clear that federal funds for oil and gas remediation work should be disbursed in tandem with strong labor standards (U.S. DOI, 2023c). Pennsylvania should hold its well-capping contractors to labor standards exceeding the DOI's baseline criteria. Doing so will help not only maximize the Commonwealth's prospects for federal funding, but also ensure that the scaling of well-capping work and attendant benefits make whole the Pennsylvania communities that oil and gas barons exploited and subsequently abandoned.

The PA DEP should leverage the Pennsylvania labor movement's gold-standard apprenticeship training infrastructure by incentivizing or requiring contractors to hire from these programs whenever possible. For instance, the UMWA operates a training facility for dislocated fossil fuel workers that can guide these workers into long-term well-capping careers (United Mine Workers of America [UMWA], n.d.a). The PA DEP should incentivize or require (whenever possible) contractors to pay prevailing wages, provide comprehensive safety training, maintain competitive benefits for workers, and invest in affected communities through targeted hire and community benefits agreements. When the PA DEP administers federal well-capping money through grants (Oil and Gas Well Plugging Oversight, Bonding, Well Plugging Funds and Related Repeal Act, 2022b; Omnibus Amendments Act, 2022), it should condition funds on meeting these labor standards. Lastly, to protect the environmental health of Pennsylvania's well-capping workforce as well as the communities host to these uncapped wells, the PA DEP should increase the number of mandated soil and water samples taken near polluting abandoned and orphaned wells. The Commonwealth should also expand the methane monitoring program.

A memorial honoring Pennsylvania coal miners located in Pittston

Cost: $95,900,000 per year.

Job Creation: 75 direct jobs per year. 525 direct jobs through 2030.

Emissions Reduction: 107,000 MT CO_2e per year.

Funding: Pennsylvania is anticipated to receive in total around $400 million in funding appropriated by the IIJA for well-capping, including $305 million in formula funding, $25 million from the initial grant, and additional estimated $70 million in performance-dependent matching grants if the Commonwealth increases state funding for well-capping and demonstrates continued, satisfactory progress in the execution of this program (U.S. DOI, 2023d; PA DEP, n.d.d.).

POTENTIAL FOR GEOTHERMAL ENERGY IN ABANDONED WELLS

Many oil and gas wells have the potential for further use after they stop producing, such as by hosting geothermal energy technology (Carroll, 2022). If used for geothermal energy, these wells could connect to district thermal energy networks, providing a strong anchor to these heating and cooling networks ***(see the Adopt a Carbon-Free Keystone State Act to Jumpstart a Just Transition Through Building Decarbonization in Pennsylvania recommendation on p. XX)***. Deeper wells could even produce electricity using advanced geothermal systems for energy extraction (Carroll, 2022). The PA DEP is already working to develop a strategy to use wells for this and other purposes, including carbon sequestration (PA DEP, n.d.d). To maximize the program's benefits for the working class, the PA DEP and the labor movement must collaborate throughout this process.

CASE STUDY

UNITED MINEWORKERS OF AMERICA CAREER CENTERS

Since 1996, the United Mine Workers of America Career Centers (UMWACC) have been operating skills and vocational training programs to help displaced miners. The UMWACC has trained over 19,000 dislocated mineworkers and their spouses (UMWA, 2023). As the energy transition accelerates, there will be a much greater need for training and job placement over the coming decades.

At the UMWACC flagship Ruff Creek Campus in Prosperity, PA, they work to identify, recruit, train, and place long-term displaced miners in other career fields earning living wages (UMWA Career Centers, Inc., n.d.). They currently offer training programs for fields like mechatronics (mechanical systems engineering) and commercial truck driving, and are preparing programs for cybersecurity, applied data analysis, and diesel mechanics (UMWA Career Centers, Inc., n.d.). At the end of 2023, as the UMWACC was on the verge of closing its doors, the Climate Jobs National Resource Center (CJNRC), The Just Transition Fund, the Claude Worthington Benedum Foundation, and the Heinz Endowments together contributed $750,000 to the Center, unlocking another $2.9 million in matching funds from the federal Build Back Better grant program (UMWA, 2023). This will allow the UMWACC to continue to provide a pathway for mineworkers to transition from mining into other high-quality careers. The UMWACC model of care, training, and placement for dislocated mineworkers is a shining example of the work that Pennsylvania and the nation need to replicate and expand upon to rebuild coalfield communities. This model could also be useful to help train mineworkers for jobs like well-capping and mineland reclamation, for which they already possess some skills.

RECOMMENDATION

EXPAND AND MODERNIZE PENNSYLVANIA'S POWER GRID USING UNION LABOR

Create a Grid Development Authority to:

1. Oversee and coordinate the expansion of intraregional transmission capacity by 2.97 terawatt-miles (TW-Mi), distribution peak capacity by 10.67 GW, and energy storage capacity by 12.3 GW by 2040
2. Enable the acceleration of the planning and siting processes for grid infrastructure
3. Support workforce development and community outreach for grid projects
4. Promulgate regulations to ensure grid resilience and reliability

The electric grid must be expanded, improved, and modernized to enable the clean energy transition. To oversee and coordinate the response to this challenge, Pennsylvania should create a Grid Development Authority including representatives from relevant regulatory, labor, community, and industry bodies to coordinate interstate cooperation; pre-plan and pre-approve siting; contribute to grid workforce development; conduct community outreach and organizing; and promulgate regulations for comprehensive and resilient grid development.

Pennsylvania is part of the PJM Interconnection, a regional transmission organization (RTO) including all or part of 13 states and D.C. As a result, most grid action is done in cooperation with the Commonwealth's neighbors. Increasing interregional transmission capacity between the PJM grid and other nearby RTOs will help balance regional grids and offer Pennsylvania low-cost power when other areas experience a production boon (e.g., during a particularly windy or sunny week) (U.S. DOE, 2023). The PJM Interconnection as a whole must expand its interregional power transfer capacity by 143.9 GW total by 2040 (U.S. DOE, 2023). Pennsylvania's border with New York, which is part of its own RTO (the New York State Independent System Operator or NYISO), will play a critical role in this process, responsible for up to 12.7 GW of this expansion (U.S. DOE, 2023).

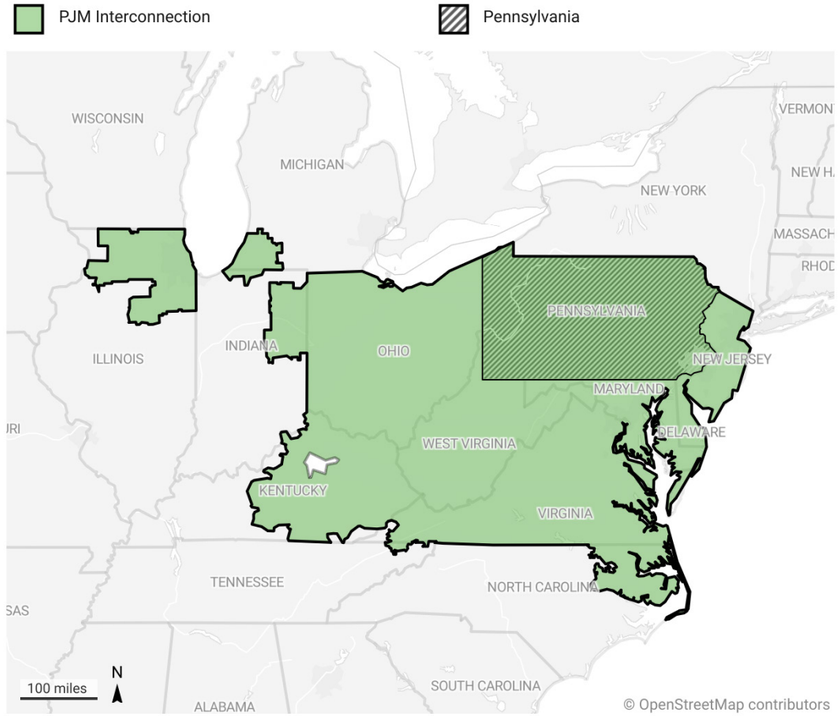
In addition to interregional expansion, the PJM grid needs to construct additional intraregional transmission lines within the RTO territory itself. This will allow for more generation and storage interconnections, prevent existing corridors from being overwhelmed, and mitigate transmission losses. The PJM Interconnection as a whole must increase its intraregional transmission capacity by 11.69 TW-Mi by 2040 – with the expansion in Pennsylvania specifically expected to be as much as 2.97 TW-Mi (U.S. DOE, 2023; PJM Interconnection [PJM], 2023).

Pennsylvania will also need to expand and upgrade its own electricity distribution infrastructure to meet the demands of widespread electrification: by 2040, the Commonwealth should be prepared to meet a peak electric distribution load 10.67 GW higher than today's peak – an expansion of 36% (Larson et al., 2021).

To ease the intermittency of wind and solar power generation, Pennsylvania must build power storage resources and interconnect them to the grid. This will store power during peak production periods that can be used in times of high demand or low production. Pennsylvania already ranks in the top three states for pumped hydroelectric energy storage capacity in the United States, having generated more than 2.4 million MWh of electricity from pumped hydroelectric in 2022 (U.S. EIA, 2023a). But additional storage capacity is still needed. Pennsylvania should base a target on 25% of installed solar capacity of storage by 2035 (10.3 GW), and behind-the-meter storage equal to 5% of peak demand of storage by 2040 (an additional 2 GW) (Burgess et al., 2021; Gagnon et al., 2023; Larson et al., 2021).

The interconnection of large amounts of renewable energy and storage will require the development of new grid ties and transmission lines. The PJM queue is facing an interconnection request backlog of over 260,000 MW of energy resources, including both storage and generation projects, far surpassing the PJM system's total current resources which are at 184,000 MW (PJM Inside Lines, 2023). The discrepancy is so large that the organization stopped accepting interconnection applications in

PJM Interconnection States



Map: Alejandra Rodriguez Diaz, M.S., Research Support Specialist, Cornell ILR Climate Jobs Institute, adr223@cornell.edu • Source: PJM Interconnection LLC, • Created with Datawrapper

February 2023 (PJM Inside Lines, 2023). A completely new interconnection process was introduced in July 2023 in the hopes of clearing 62,000 MW by the end of 2024, followed by 100,000 MW per year until 2027 (PJM Inside Lines, 2023). To ease the process of planning and siting all the necessary infrastructure for PJM, the PA PUC, and the PA DEP – including renewable energy, energy storage, interconnection lines, transmission lines, and distribution lines – the proposed Pennsylvania Grid Development Authority should devote resources to pre-planning and pre-approving siting areas and corridors for this infrastructure with minimal disruption to the local environment and communities.

These undertakings call for a highly trained and skilled workforce. The Pennsylvania Grid Development Authority should prepare for workforce demands by providing funding to and partnering with quality pre-apprenticeship and registered apprenticeship programs. Furthermore, the Pennsylvania Grid Development Authority should conduct outreach and organizing in local communities to hear their concerns on grid development as well as convene stakeholders for community benefit agreement negotiations for significantly disruptive projects. These actions will help to direct benefits from this infrastructure development to the local communities and workforce who need them the most.

The Pennsylvania Grid Development Authority should work toward regulations that ensure comprehensive and resilient grid development measures. Breakers, capacitors, and inverters must be upgraded so that power distribution can be safely expanded. The Commonwealth must also prioritize reliability and fire resilience measures such as power line corridor tree trimming, infrastructure hardening, and power line burying to enable the grid to

handle stress from climate change and continue powering critical infrastructure. Furthermore, smart meters should be mandated for power consumers. These devices will make it simpler to analyze demand and to dispatch energy generation and storage to manage grid fluctuations (IBM, n.d.). Finally, the Commonwealth should develop clean microgrids for critical infrastructure and large power consumers to ensure local baseload power is maintained around the clock.

High-Quality Labor Standards: Pennsylvania needs to responsibly build power transmission and distribution infrastructure commensurate with the renewable energy build-out, and include high labor standards on this work. The proposed Pennsylvania Grid Development Authority's board should have representatives from labor unions that do grid work to ensure that this group features expertise on labor-based matters and provides a voice for this workforce. The Commonwealth should also issue RFPs for critical transmission infrastructure projects, such as those related to Lake Erie offshore wind development and other particularly large or energy-dense projects (e.g., nuclear facilities or massive grid-scale projects). These RFPs should consider criteria on developer/contractor health and safety standards, apprenticeship utilization, worker training, targeted hiring provisions, and timely project completion without labor disputes. Finally, as part of the application process for transmission projects under the Pennsylvania Public Utility Commission, developers should be required to commit to a workforce plan indicating how they will adhere to health and safety protocols.

Cost:

Intraregional Transmission: $332,000,000 per year.
Distribution Peak Capacity: $872,000,000 per year.
Energy Storage: $56,100,000 per year.

Job Creation:

Intraregional Transmission: 860 direct jobs per year. 6,020 direct jobs through 2030.
Distribution Peak Capacity: 2,300 direct jobs per year. 16,100 direct jobs through 2030.
Energy Storage: 150 direct jobs per year. 1,050 direct jobs through 2030.

Emissions Reduction:

Energy Storage: 5,730,000 MT CO_2e per year.

Funding: The IRA allocated $2 billion in direct loan authority through the U.S. DOE for transmission facility financing, as well as $760 million in grants for transmission siting and permitting, and $100 million in grants for offshore wind and interregional transmission planning (Grid Deployment Office, n.d.b). The IRA also expanded preexisting U.S. DOE loan programs for clean energy supply chain investments, including the Title 17 Clean Energy Financing Program (IRA, 2022k). The IIJA allocated $2.5 billion in Grid Resilience Utility and Industry grants, with another $562 million in FY2024 for Grid Resilience State and Tribal formula grants, $3 billion in Smart Grid Grants, and $5 billion in Grid Innovation Program grants (Grid Deployment Office, n.d.a), and the IIJA's $2.5 billion Transmission Facilitation Program will provide important interregional transmission projects with contracts, loans, and partnerships in national interest electric transmission corridors (Grid Deployment Office, n.d.c). The IIJA also created the Energy Improvements in Rural or Remote Areas Grant Program, which offers grants to "improve the resilience, reliability, and affordability of energy systems in communities across the country with 10,000 or fewer people" (Office of Clean Energy Demonstrations, n.d.e).

INDUSTRY

Pennsylvania has a strong industrial sector that employs around 566,375 manufacturing workers and contributes approximately $101.5 billion to the Commonwealth's economy (U.S. BLS, n.d.d; U.S. Bureau of Economic Analysis, 2023). This sector is a major producer of materials and manufactured products that are pivotal to the country, including metals, food and beverages, and chemical products (National Association of Manufacturers, n.d.). As the sixth-largest manufacturing economy in the United States, industry accounts for about 37.8% of Pennsylvania's energy consumption (U.S. BLS, 2023c; U.S. EIA, n.d.c).

The Commonwealth's Industry sector has the highest emissions of any sector and is responsible for 30.9% of GHG emissions statewide (National Association of Manufacturers, n.d.; PA DEP, 2023b). Fossil fuel combustion heavily contributes to industrial emissions in Pennsylvania (46.59%), but emissions also occur through industrial processes and fuel systems (PA DEP, 2023b). One report found that in 2021, the Commonwealth's top 12 industrial emitters produced nearly 17 MMT of GHG emissions (Dutzik et. al., 2023). Consol Energy and U.S. Steel own almost half of these high-emitting facilities, which jointly yield over 10 MMT (approximately 4%) of the Commonwealth's total emissions (Dutzik et. al., 2023).

Transitioning to a low-carbon, energy-efficient industrial sector presents an opportunity to modernize industry while further affirming Pennsylvania as a national leader in industrial production and manufacturing. Additionally, and equally as importantly, this transition should reckon with the disproportionate harms that industrial polluters have caused to already marginalized communities.

It is well documented that industrial plants are most often built in communities with a majority population of BIPOC people and people living in poverty (Starbuck & White, 2016). These trends are also reflected in Pennsylvania: for example, Pittsburgh has both high industrial emissions as well as one of the Commonwealth's higher poverty rates (19.7%) and a significant BIPOC population (35.5%) (U.S. CB, 2023b). Thus, racial and economic inequities often

translate into increased vulnerability to industrial emissions of harmful particulate soot, toxic air pollutants, and smog-forming pollutants (Dutzik et al., 2023). Very frequently, communities most suffering from these pollutants are also the communities in which workers at industrial plants live, meaning that these workers are exposed both on the job and when they go home (Ash & Boyce, 2018). Worse still, workers who belong to racial or ethnic minority groups are less likely than white workers to gain employment at the industrial plants sited in their communities and when they do, are disproportionately relegated to lower-paying jobs (Ash & Boyce, 2018). **The transition to a truly sustainable industrial sector presents a long-delayed opportunity to both protect workers and communities from harmful pollutants and to redress historic racial and class inequities in environmental health and access to high-quality industrial jobs.**

Pennsylvania's labor movement has already been leading the call for greener industrial practices in the Commonwealth. In summer 2023, the United Electrical, Radio and Machine Workers of America (UE) Locals 506 and 608 representing roughly 1,400 workers at the country's largest locomotive manufacturer, Wabtec, drew national interest as they successfully negotiated an agreement for better wages and benefits (United Electrical, Radio, and Machine Workers of America [UE], 2023). Workers gave special attention to the Green Locomotive Projects, which aimed to clean pollution in rail yards; create jobs; and pressure railroads to upgrade to modern, more fuel-efficient locomotives (UE, 2023; UE, n.d.). The success of the Wabtec strike demonstrates the power of unions in Pennsylvania to push for better working conditions, cleaner communities, and greener business practices and operations — all of which can produce and preserve union manufacturing jobs in the Commonwealth.

The Commonwealth's industrial sector can further expand by manufacturing the very technologies needed for decarbonization in-state, including source materials and related components for clean and renewable energy technologies. Pennsylvania should take advantage of increased regional investments in renewable energy projects by positioning itself as a hub for green energy supply chain manufacturing. For example, many of the steel products that support wind turbines are (or can be) manufactured by Pennsylvania's growing primary metal manufacturing and fabricated metal product manufacturing sectors (Allegheny Conference on Community Development, 2023). The Commonwealth should also position itself as a renewable energy product recycling hub. When large-scale solar, wind, and battery projects complete their life cycle, local manufacturers (if properly equipped) could help process these waste materials, creating jobs while reducing the environmental impacts of renewable energy infrastructure, and establishing a new industry sub-sector with Pennsylvania as the regional leader.

Retrofitting industrial processes to ensure they are energy-efficient and electric wherever possible is key to decarbonizing the sector while prioritizing equity and preserving union jobs. SMRs ***(see the Making Pennsylvania a Leader in the Installation and Manufacturing of Small Modular Technology recommendation on p. XX)*** and hydrogen electrolyzers can be combined with industrial processes to provide emissions-free, off-grid energy (Liou, 2023; IEA, 2019). Green hydrogen can also replace existing hydrogen produced from fossil fuels as an input in industrial processes, further reducing the Commonwealth's industrial carbon intensity (Bower et al., 2021; IEA, 2019).

Members of Insulators Local 2 in a Labor Day parade in Altoona, PA. Credit: John Stewart

Of course, some industrial processes, like cement production, will generate emissions irrespective of the fuel used (Williams & Bell, 2022). For essential industries like these that present complications in reducing actual emissions, Pennsylvania must take action to not only regulate and incentivize decarbonization, but also to push for the adoption of emerging technologies that allow for cleaner industrial processes. Carbon capture and storage can directly and permanently (if done correctly) sequester pollution, and direct air capture can filter and store carbon from the atmosphere (IEA, 2023a; IEA, 2023b). These technologies will be vital to offsetting long-term climate change effects and should be a priority for industrial processes where decarbonization is anticipated to be slower or more difficult to accomplish.

Reducing industrial emissions while building out the clean energy supply chain is crucial for Pennsylvania to meet its climate goals. It is necessary to simultaneously protect workers and create accessible union jobs. Given the industrial sector's size and proportion of statewide emissions, immediate decarbonization action is urgently needed. The Commonwealth should make sure to allocate the benefits of incoming federal funding for and investment in cleaning up industrial processes to workers and communities that have been most affected by the harms of carbon-intensive industrial operations. Federal funding sources like the IRA, IIJA, and the CHIPS Act incentivize and support green technologies, green manufacturing, and industrial GHG emissions reduction. Pennsylvania should take full advantage of these resources to kickstart its industrial decarbonization now.

RECOMMENDATION

TRANSFORM THE KEYSTONE STATE INTO A HUB FOR UNIONIZED CLEAN ENERGY AND CLIMATE-ALIGNED MANUFACTURING

1. Expand Pennsylvania's Steel Products Procurement Act to a Buy American Procurement Act targeting sectors integral to clean energy manufacturing
2. Amend and expand Pennsylvania's existing clean energy manufacturing incentive programs and establish additional programs for energy storage, electric vehicles, and conversion to clean energy manufacturing
3. Establish union workforce protections; establish more joint labor-management registered apprenticeship programs, mentorship programs, on-the-job training stipends; and ensure targeted recruitment in priority communities

Pennsylvania is home to one of the most critical manufacturing economies in the United States. Yet despite its continued leadership in the national manufacturing economy, the Commonwealth's manufacturing workforce has shrunk by nearly half in the last 30 years, losing over 200,000 workers since 2002 alone (U.S. BLS, 2002; U.S. BLS 2022). This decline is due in part to the gradual trajectory of deindustrialization that has affected the entire nation (Rowthorn & Ramaswamy, 1997). Pennsylvania's strong history of manufacturing, coupled with its enduring strength in industries essential to clean energy components – e.g., steel, concrete, and aluminum, which feature in both solar and wind installations (Cilento, 2023) – make it particularly well-placed to lead the nation in climate-aligned manufacturing. Pennsylvania's potential to grow its clean energy manufacturing sector is bolstered by the strong renewable energy mandates in neighboring northeastern states that have created a robust market for clean energy technologies and components (New York State Climate Leadership and Community Protection Act, 2019; An Act Concerning Clean Energy, 2018; Clean Energy Jobs Act, 2019), and could be further advanced by an expansion of the Commonwealth's clean energy buildout, as proposed above ***(see the Transform Pennsylvania's Energy Economy by Building 54.5 Gigawatts of Renewable Energy by 2025 with Gold Star Labor Standards recommendation on p. XX).*** Armed with an influx of federal investments from the IRA, IIJA, and CHIPS Act, now is the time for Pennsylvania to grow its clean energy manufacturing industry.

To make a clean energy, climate-sustainable, union manufacturing sector with universally accessible jobs a reality for Pennsylvanians, the Commonwealth should start by reconfiguring its current incentives for the manufacturing industry. First, Pennsylvania should amend its procurement policies, both expanding its Steel Products Procurement Act and adopting a "Buy Clean" program ***(see Expand Pennsylvania's "Buy American" Requirements and Promote Clean Domestic Manufacturing to Support Good Jobs on p. XX)*** to leverage the Commonwealth's own spending power to grow its clean energy manufacturing economy. Pennsylvania should also create incentive programs that target manufacturing for energy storage, electric vehicles (EVs), and for converting existing manufacturing capacity toward clean energy and climate-aligned supply chains.

As mentioned, Pennsylvania's labor movement is leading the push to reignite its manufacturing economy through the clean energy transition. Starting in June 2023, members of UE Locals 506 and 618 went on strike for 10 weeks across seven different picket lines in Erie, advocating for both improved worker conditions *and* a commitment to transitioning the Wabtec facility to manufacturing zero-emission locomotive technologies (UE News, 2023). Shortly thereafter, the United Auto Workers' (UAW's) Pennsylvania members took part in the historic 2023 UAW strike against Ford, Stellantis, and GM (ABC27, 2023), helping to win a historic agreement with GM to secure its EV battery manufacturing under UAW contract (Shapero, 2023). Aligning Pennsylvania's manufacturing sector with the burgeoning clean energy economy will not only help combat the climate crisis, it will also reinforce these labor voices, thus fostering a truly just transition.

High-Quality Labor Standards: To encourage greater equity in the manufacturing sector, all clean energy manufacturing incentives should include both (a) grant or tax deduction plus-up opportunities for companies that target job training and hiring for priority populations including women, justice-involved individuals, and members of both environmental justice and energy communities; and (b) incentives for establishing joint labor-management registered apprenticeships and employee mentorship training programs, including $1,500 per apprentice trained and $3,000 for hiring an apprentice. Additional funding will be essential for wraparound and retention services such as stipends, childcare, and transportation support. Pennsylvania should also focus on incentivizing labor neutrality and community benefits agreements through its clean energy manufacturing policies and programs, and should make sure to include policy language that preserves existing industrial collective bargaining agreements in the transition.

Funding: The IRA created the Federal Advanced Manufacturing Production Tax Credit and expanded the Advanced Energy Project Tax Credit to jumpstart the renewable energy manufacturing economy (IRA, 2022a). It also operationalized $500 million under the Defense Production Act for manufacturing clean energy technologies including heat pumps (IRA, 2022a). The IRA also expanded preexisting U.S. DOE loan programs for clean energy supply chain investments, including the Title 17 Clean Energy Financing Program (IRA, 2022k). The IIJA made $750 million available for Advanced Energy Manufacturing and Recycling grants, which provide funding to small- and medium-sized manufacturers in communities where coal mines or coal power plants have closed (IIJA, 2021h). Lastly, the CHIPS Act unlocked more than $52 billion in semiconductor manufacturing production and research funding for components like power semiconductors which conserve energy and promote efficiency in electronics (White House, 2023c). To stimulate demand for products derived from converted captured carbon emissions, the U.S. DOE is running the Carbon Utilization Procurement Grant Program with $100 million in funding (Office of Fossil Energy and Carbon Management, n.d.a).

EXPAND PENNSYLVANIA'S "BUY AMERICAN" REQUIREMENTS AND PROMOTE CLEAN DOMESTIC MANUFACTURING TO SUPPORT GOOD JOBS

Pennsylvania has been renowned for its iron and steel industries for 300 years. The Commonwealth promotes and protects these industries in its Pennsylvania Steel Products Procurement Act, requiring contractors to ensure that at least 75% of the cost of materials in steel products is produced in the United States (73 P.S. § 1881, et seq., 2013). The Commonwealth should expand this law to cover additional domestic products, including cement, solar panel and wind turbine components, glass, fiber optic cables, asphalt, HVAC systems, batteries, and other elements necessary for the energy transition.

The Commonwealth should further incentivize 'cleanly made' products (i.e., those built with low embodied carbon [LEC] construction materials) by setting a net-zero-emission procurement goal for public contracts by 2050. Pennsylvania can look to the Federal Buy Clean Initiative (Exec. Order No. 14057, 2021), and join the dozen states leading the Federal-State Buy Clean Partnership (White House, 2023b). Contract commitments should be publicly available to ensure that public interest groups, among others, can monitor and flag compliance concerns for enforcement (Janis, 2015).

Pennsylvania union members on a construction job

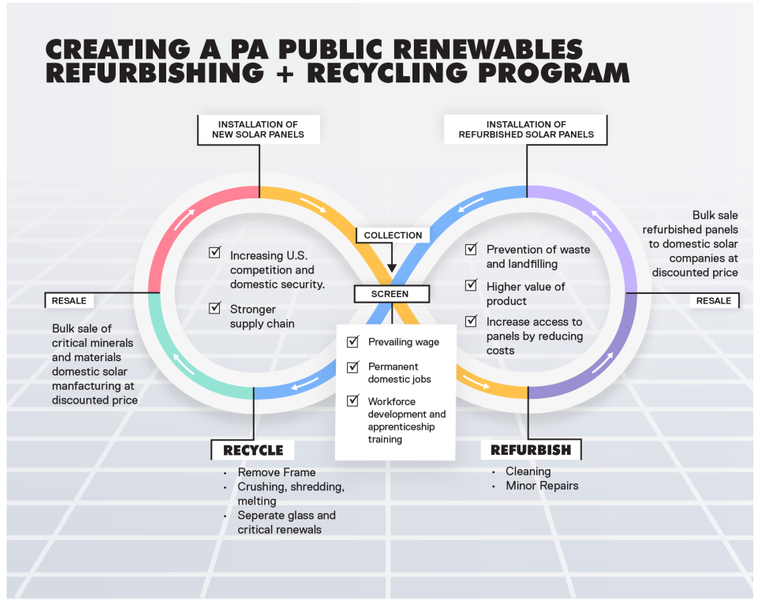
RECOMMENDATION

CATALYZE PENNSYLVANIA TO BECOME A RENEWABLES RECYCLING POWERHOUSE

Prepare a renewables recycling industry by:

1. Establishing a state solar panel takeback program to refurbish or recycle 100% of in-state end-of-life panels by 2050
2. Establishing a state wind turbine blade program to recycle 100% of in-state end-of-life blades by 2050
3. Banning the landfilling of solar panels and wind turbine blades
4. Requiring bonds to cover the cost of decommissioning, refurbishment, or recycling of panels and blades

The United States is currently installing solar panels and wind turbines at a breakneck pace, but eventually, these components will be decommissioned. Solar panels typically reach their end of life 25 years after installation (Chowdhury et. al., 2020). Solar installations from the 90s and the 2000s are beginning to reach this stage. However, if end-of-life solar panels are not damaged, they can maintain high production levels: they can still generate 90% of the electricity they produced when first installed after 25 years (Mow, 2018). Refurbishing or recycling panels is economically and environmentally prudent. Solar panels contain materials such as indium, glass, silicon, tellurium, silver, and copper, some of which are valuable when recycled but environmentally toxic if landfilled (Curtis et al., 2021).



The question of how to properly decommission end-of-life solar panels will only grow as the number of panels installed grows. 70% of all solar panels in the United States have been installed in the last six years (EERE, n.d.a). Globally, solar panel waste could reach a cumulative 78 million MT by 2050, and the potential recovered material from that waste stream is valued at $15 billion – and could be used to assemble two billion new panels (Weckend et al., 2016). In the United States, the cumulative solar panel waste is expected to reach 170,000 MT by 2030, 1,700,000 MT by 2040, and 7,500,000 MT by 2050 (Weckend et al. 2016).

Wind turbine blades represent another potentially immense waste stream as towers are repaired, retooled, or retired. Estimates suggest that the United States could see a cumulative 2,200,000 MT of wind turbine blade waste by 2050, assuming a 20-year lifespan for wind turbines (Cooperman et al., 2021). The technology to recycle the blades is significantly different from solar panel recycling; however, processes exist to recover materials from the blades to produce syngas, pyrolysis oil, and different kinds of plastics. The materials can also be turned back into fiberglass (Bushwick, 2022).

Recycling all these solar panels and wind turbine blades will take a large workforce. Pennsylvania needs to prepare ahead of time by developing a plan to make sure that renewables recycling jobs are high-quality, family-sustaining careers. The Commonwealth should therefore establish a State Solar Panel Takeback program with multiple elements. To start, Pennsylvania should ban the landfilling of solar panels and place a per-kilowatt bond requirement on solar installations for decommissioning and recycling costs. Then, it should establish an in-house screening, separating, refurbishing, and recycling program for the panels; purchase all decommissioned solar panels; and sell the refurbished panels and recycled materials. Pennsylvania must also prepare a similar pathway toward wind turbine blade recycling; banning landfilling, establishing a recycling bond requirement, and establishing a recycling program.

Pennsylvania should also enact extended producer responsibility (EPR) laws for other products and materials beyond renewable energy, placing responsibility on manufacturers for the end-of-life of their products, decreasing the total amount of waste to be landfilled, and incentivizing producers to design products that are easier to repair, reuse, and recycle. States like Maine, Oregon, and California have already implemented EPR laws for products like paper and plastic packaging and food service ware (American Council for an Energy-Efficient Economy [ACEEE], 2022).

High-Quality Labor Standards: As Pennsylvania prepares for decommissioning renewable energy in the future, lawmakers must ensure that this work is done with high labor standards. When soliciting bids for decommissioned solar panels for reuse, the Commonwealth can attach criteria relating to this industry's workforce, such as prevailing wages, training benefits, apprenticeship utilization, health and safety, and targeted hiring. Once the panels are refurbished, the Commonwealth may also establish a discount for purchasers who commit to using a highly skilled, local workforce; meet high health and safety standards; and have a process to avoid labor disputes on panel installation, as well as for purchasers on projects that benefit LMI communities. The Commonwealth should also establish a separate, voluntary program for direct refurbishment and recycling support for solar project owners who decommission projects if these owners accept and commit to reinstalling refurbished panels with strong labor standards. Finally, the Commonwealth should work with labor unions to develop a training program on solar panel refurbishing and recycling skills that will ensure the availability of a robust, highly-qualified, union workforce to drive the new renewables recycling industry.

Cost:

Solar Recycling: $61,600,000 per year.
Wind Blade Recycling: $2,000,000 per year.

Emissions Reduction:

Solar Recycling: 8,990 MT CO_2e per year.
Wind Blade Recycling: 1,380 MT CO_2e per year.

Funding: The IRA includes $10 billion for the Advanced Energy Project Credit (48C), a tax credit for advanced energy projects including clean energy recycling facilities (Office of Clean Energy Infrastructure, n.d.). The IIJA also made $750 million available for Advanced Energy Manufacturing and Recycling grants, which provide funding to small- and medium-sized manufacturers in communities where coal mines or coal power plants have closed, and could apply to renewables recycling plants sited in those communities (IIJA, 2021h). The U.S. DOE also made available significant funds for research and development of renewables recycling tech, including $20 million for solar and $40 million for wind (EERE, n.d.b; EERE, n.d.c).

RECOMMENDATION

REDUCE PENNSYLVANIA'S INDUSTRIAL EMISSIONS WHILE MAINTAINING UNION JOBS

1. Require industrial facilities that emit more than 20,000 tons of CO_2eq per year to become net-zero by 2035
2. Establish a grant program to fund emissions reduction projects required to meet this goal, prioritizing projects that are economically efficient, socially beneficial, or abate the most challenging emissions
3. Adopt a "Buy Clean" standard to spur demand for low-emission materials
4. Expand public financing options available for industrial decarbonization projects
5. Establish a Working Group of labor, industry, and regulatory leaders to develop new policy to enable and advance industrial decarbonization

The industrial sector is critical to the society and economy of Pennsylvania, but it is also the largest contributor to statewide GHG emissions, accounting for 30.9% (PA DEP, 2023b). Decarbonization in the industrial sector is thus a critical undertaking, and must also redress glaring historic inequities in the impact of toxic industrial emissions as well as hiring practices for the industrial workforce (Ash & Boyce, 2018). Pennsylvania can and should target decarbonization efforts to not only ensure the security of jobs and economic output, but also to allocate the health and other benefits of industrial decarbonization toward the primarily BIPOC and low-income communities that have been most affected by both industrial pollution and industrial exploitation of workers: nationally, half of the people who live within 1 mile of industrial facilities enrolled in the EPA's Risk Management Program are people of color, and one fifth are people living in poverty (Starbuck & White, 2016).

A number of technologies are readily deployable to reduce industrial emissions. First and foremost is energy and material efficiency, which includes insulation, waste heat recovery, and resource optimization. The economic gains from these strategies can be significant, and in some cases, even pay for themselves. For waste heat recovery specifically, 20-50% of the process heat input can be recovered depending on the industry (ACEEE, 2022). Another high-impact emission-reduction strategy is electrification. This is especially useful for low-temperature process heat (<200°C) which represents 44% of all process heat in the US (ACEEE, 2022). Power producers – including solar, wind, micro or SMR nuclear, and geothermal – that are built at, on, or near industrial facilities can directly provide those facilities with power, bolstering the economic feasibility of industrial electrification and helping to meet baseload needs. Next, industrial decarbonization should focus on fuel and feedstock switching. Low-carbon fuels such as green hydrogen will be necessary to decarbonize higher temperature process heat, which is critical for processes like low-carbon cement and steel production (ACEEE, 2022). These fuels can also be used to synthesize other chemicals such as methanol, ammonia, and syngas (ACEEE, 2022). Finally, while energy and material efficiency, alongside electrification, will be the most vital aspects of industrial emissions reductions, there are some industrial emissions that cannot be abated through the employment of other technologies. In these cases, carbon capture and storage (CCS) through clean, captive power generation will be an important but costly piece of the solution (ACEEE, 2022).

To deploy all of these technologies at the scale required to sufficiently decarbonize industry, Pennsylvania must create a comprehensive program to analyze, regulate, and incentivize industrial decarbonization. The Commonwealth should require that industrial facilities emitting more than 20,000 tons of GHGs per year conduct emissions and energy use audits to determine the best available emissions control technologies and best available energy management practices. These facilities should then be required to implement onsite, technologically feasible, and cost-effective strategies to hit net-zero emissions by 2035.[1] To help industrial facilities fund these projects – as well as their clean captive power generation needs – the Commonwealth should start a grant program designed to implement the emissions reduction plans that bring the highest emissions reductions per dollar, the largest social benefit, or abate the most difficult-to-abate emissions. Applications for these grants should be scored on criteria including: (CO Energy Office, n.d.)

- Total estimated GHG emissions and co-pollutants avoided per year
- Job creation and retention
- Job quality including pay and benefits
- Targeted hiring for installation work
- Registered apprenticeship establishment and utilization
- Benefit to the local community
- Project readiness
- Project innovation and demonstrated funding need and non-grant funding leveraged

The Commonwealth should also arrange additional financing mechanisms including tax incentives to reduce the cost of installing emissions reducing technologies and expanding public loan and bond funding – like the funds available through GELF and PEDA. To stimulate demand for materials produced with low emissions processes, Pennsylvania should start a "Buy Clean" program for municipal and state procurement processes, where a material's embodied emissions are considered as a criteria for selection ***(for more, see Expanding Public Financing for the Clean Energy Economy on p. XX and Expand Pennsylvania's "Buy American" Requirements to Promote Clean Domestic Manufacturing and Good Jobs on p. XX).*** Demand stimulation and public financing combined with this grant program will help provide the stability necessary for Pennsylvania's manufacturing and processing industries to preserve jobs through this transition.

Lastly, Pennsylvania will need an effective governance structure to carry out industrial decarbonization policymaking. It should thus establish a cross-government working group including representatives from, among others, the Department of Labor and Industry, the Department of Community and Economic Development (DCED), the PA DEP, and key stakeholders like representatives of labor unions in the industrial sector and members of industrial communities. This working group should focus on producing a plan for statewide industrial decarbonization and identifying policy measures to reach that goal while maximizing job retention and creation alongside the benefit to the Commonwealth's industrial communities. They should also convene stakeholders between the Regional Clean Hydrogen Hub projects, the Regional Direct Air Capture Hub projects, and industrial facilities that will install CCS technology to link CO_2 pipelines together and coordinate the drilling of CO_2 sequestration wells.

High-Quality Labor Standards: Pennsylvania can include preservation of high-quality jobs and minimum labor standards in its state-based incentives for industrial decarbonization. For example, the Commonwealth may provide grants or subsidies to industry to support equipment upgrades and mandate that any work accomplished through these funds benefit local workers, pay a wage equivalent to the prevailing rate, and utilize registered apprentices.

Cost: $3,860,000,000 per year for facilities with high emissions.

Proportion of Industrial Emissions by Process (2019)

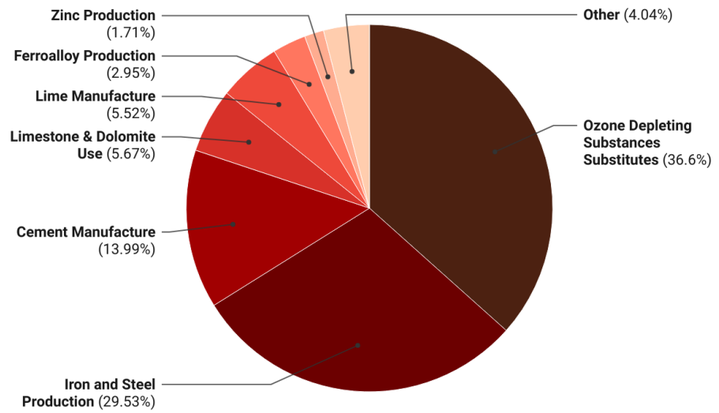


Chart: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.edu • Source: PA DEP • Created with Datawrapper

1 Idea based on CO GEMM 2 Rule. Colorado Department of Public Health and Environment. (2023, October 20). Greenhouse gas emissions and energy management for manufacturing phase 2 (GEMM 2) rule, as approved by the air quality control commission. https://cdphe.colorado.gov/greenhouse-gas-emissions-and-energy-management-for-manufacturing-phase-2-gemm-2-rule-as-approved-by

Job Creation: 8,000 direct jobs per year. 56,000 direct jobs through 2030.

Emissions Reduction: 25,400,000 MT CO_2e per year for facilities with high emissions.

Funding: Through the IRA and IIJA, three major industrial decarbonization funding programs have been established, two of which are still available: the $5.8 billion Advanced Industrial Facilities Deployment Program and the $2.5 billion Carbon Capture Demonstration Projects program (Office of Clean Energy Demonstrations, n.d.a, Office of Clean Energy Demonstrations, n.d.b). The Advanced Energy Project tax credit applies to industrial facility decarbonization projects, with a multiplier for prevailing wage and apprenticeship standards that raises the credit to 30% (White House, 2023d). There is also the Carbon Oxide Sequestration credit; a $17 per ton tax credit, which rises to $85 per ton if the project meets prevailing wage and apprenticeship requirements, for carbon capture deployment (Clean Air Task Force, 2023). As a complement, the U.S. DOE is operating the Carbon Capture Large-Scale Pilot Projects grant program (Office of Clean Energy Demonstrations, n.d.c). Lastly, there is now a multi-billion dollar federal Buy Clean program to stimulate demand for low-emissions commodities, as well as the Federal-State Buy Clean Partnership program, of which Pennsylvania is not a member but which it should seek to join (Office of the Federal Chief Sustainability Officer, n.d.).

A member of United Steelworkers Local 10 operates machinery

EXPANDING PUBLIC FINANCING FOR THE CLEAN ENERGY ECONOMY

Pennsylvania has a strong framework already in place for public loan and bond funding for an array of clean energy, energy efficiency, and emissions reduction projects. PEDA awards grants, loans, loan guarantees, and both taxable and tax-exempt bond financing for clean energy projects in the state (PA DEP, n.d.k). GELF provides loans for building retrofit projects for commercial properties, nonprofit facilities, local government buildings, multifamily residential buildings, and industrial plants (Reinvestment Fund, n.d.). This program includes funding for crucial emissions reduction activities like energy retrofits, equipment replacements, gut rehabs, and on-site renewable energy installations, but it should still be adjusted to only zero-emissions technologies to prevent stranded assets in the future.

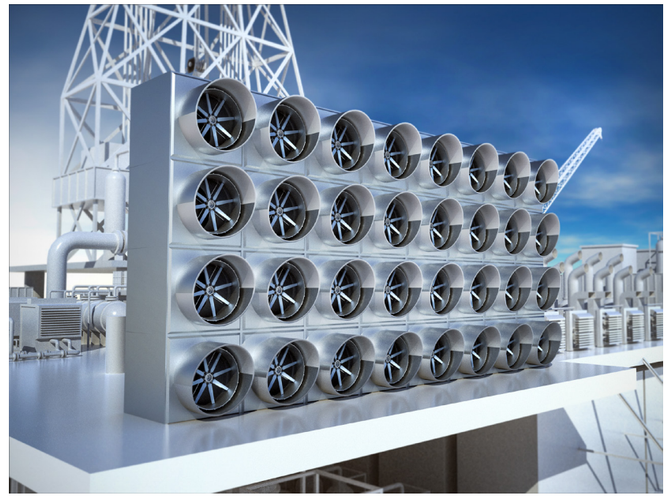
The Commonwealth should also increase funding for PEDA and GELF to maximize their impact, and should consider combining these two programs into one Green Bank whose primary mission is financing emissions reduction and clean energy projects. Many states and municipalities across the United States have already formed green banks (Coalition for Green Capital, n.d.).

RECOMMENDATION

ESTABLISH PENNSYLVANIA AS A LEADER IN DIRECT AIR CAPTURE

1. Collaboratively prepare a state plan for DAC buildout, including coordinating CO2 pipeline and sequestration project development among DAC, Hydrogen, and CCS industry players
2. Incentivize clean captive power generation for DAC facilities
3. Implement regulations on siting, monitoring, and liability for carbon capture, transport, and sequestration projects

Minimizing the most devastating impacts of climate change requires removing CO_2 from the atmosphere (Babiker, et. al, 2023). CO_2 removal (CDR) is not a substitute for climate action, but a necessary last-resource component to reaching net-zero, since some emissions sources are difficult and costly to mitigate (New Insights in Climate Science, n.d.). Pennsylvania has several natural techniques at its disposal for CDR, including both land-based and ocean-based strategies for increasing natural absorption of CO_2 (New Insights in Climate Science, n.d.). However, technological approaches like direct air capture (DAC) may also be important (Intergovernmental Panel on Climate Change, n.d.).



A depiction of Direct Air Capture technology

DAC is performed with equipment that uses electrochemical processes to extract CO_2 from the atmosphere, forming concentrated CO_2 gas or solid carbon rocks, depending on the process (Lebling et al., 2022). This CO_2 can then be permanently sequestered underground in rock fissures, caves, or wells. In some cases, it can be reused when manufacturing concrete, plastic, or synthetic fuels (Lebling et al., 2022).

Pennsylvania is well positioned for DAC action for several reasons. First, it has an estimated geologic sequestration capacity of 2.4 billion MT, among the highest in the country (Regional Carbon Capture Deployment Initiative, 2021b). Second, Pittsburgh is home to a National Energy Technology Laboratory focused on DAC and carbon sequestration (National Energy Technology Laboratory, 2020). Third, Pennsylvania's workforce is experienced in compressed gas infrastructure as well as manufacturing complex technologies (BW Research, 2021).

Pennsylvania can take multiple steps to become a leader in DAC, taking advantage of its position to access forthcoming federal funds. First, the Pennsylvania labor movement should work with government and industry to establish a state plan for DAC buildout. Based on the Commonwealth's successes in the Regional Clean Hydrogen Hub program, this proposal should include PLAs for construction work, funding for workforce development, and a community benefits agreement (PA Department of Community and Economic Development [DCED], 2023b). Pennsylvania's DAC plan should also maximize cooperation with existing and future facilities that require the development of sequestration wells and a CO_2 pipeline, such as Regional Clean Hydrogen Hub projects and industrial facilities throughout the Commonwealth that are installing carbon capture technology, to scale a connected system of carbon sequestration as efficiently as possible and allow for an expanded, coordinated network.

The development of clean, captive power is imperative for DAC installation to be effective, as this will ensure that electricity powering carbon removal machinery will not itself emit carbon, and will prevent grid overload. Pennsylvania should issue grants and tax incentives to incentivize clean captive power generation – including solar, wind, micro or SMR nuclear, and geothermal built at or near DAC facilities – to provide baseload power for DAC installations. Finally, Pennsylvania should set standards that clarify the siting, monitoring, and liability rules for captured carbon transportation and storage projects, including taking over Class VI well primacy from the U.S. EPA, defining ownership of the CO_2 and the pore space, and establishing a trust fund to ensure the long-term monitoring and management of sequestered carbon. States like Montana, Wyoming, and North Dakota have already implemented regulations like these (U.S. EPA, 2022a; Regional Carbon Capture Deployment Initiative, n.d.; National Association of State Energy Officials, 2021).

High-Quality Labor Standards: DAC will be an integral part of Pennsylvania's climate change response as to emissions sources that are particularly difficult and/or costly to reduce, and scaling of DAC technologies presents an opportunity to create good jobs for residents. Unions and industry should center community benefits and PLAs in any advocacy for bringing more DAC facilities and projects into Pennsylvania. The Commonwealth should also initiate a training and skills development program for DAC work with priority entry for transitioning fossil fuel workers. Finally, the Commonwealth can require recipients of captive clean power grant funding to comply with prevailing wage, worker classification, training, and targeted hire requirements.

Funding: The IIJA included $2.5 billion for carbon storage validation and testing, $2.1 billion for the transportation of captured CO_2, $310 million for CO_2 utilization, and $48 million for states to do permitting and monitoring for Class VI wells (IIJA, 2021a; IIJA, 2021b; IIJA, 2021c). The IRA included a tax credit of $180 per ton of CO_2 directly captured from the air and sequestered, and $130 per ton of CO_2 directly captured from the air and used (IRA, 2022e). To stimulate demand for products derived from converted captured carbon emissions, the U.S. DOE is running the Carbon Utilization Procurement Grant Program with $100 million in funding (Office of Fossil Energy and Carbon Management, n.d.a).

BUILDINGS

Pennsylvania's building stock accounts for 12.1% of GHG emissions statewide (PA DEP, 2023b). Although this is a relatively small proportion of the Commonwealth's emissions, wide-scale building decarbonization efforts can yield innovative opportunities to transition Pennsylvania's union workforce into clean energy union careers while dramatically improving the conditions of the buildings in which Pennsylvanians live, learn, and work.

Achieving decarbonization at the scope, pace, and scale demanded by the climate crisis while centering equity is the core challenge to reducing building emissions (Walker et al., 2023).

Building decarbonization has traditionally been synonymous with electrification and deep energy retrofits, key strategies which create some of the highest number of jobs per dollar invested in unionized construction sectors in the clean energy economy (Pollin et al., 2021a). However, the current piecemeal, building-by-building approach to decarbonization is not cost effective, equitable, or scalable (Brown et al., 2019). Moreover, the question of how to transition the many union workers responsible for installing the gas infrastructure predominantly used to heat homes today into new careers remains unanswered. Recently, however, policies and pilot programs incentivizing the implementation of zero-emission thermal energy networks have been rapidly adopted at the state and local level across the United States, including in New York, Massachusetts, Illinois, and even Philadelphia (Klein, 2023). Zero-emission thermal energy networks utilize a network of ground-source heat pumps to heat and cool buildings interconnected through a system of pipes without the use of fossil fuels ***(for a more in-depth explanation, see Understanding Thermal Energy Networks on p. 52).*** These systems decarbonize at the block, neighborhood, campus, or community scale, unlocking a key opportunity for widespread building decarbonization (Walker et al., 2023). This utility-scale approach also alleviates some of the economic barriers to building decarbonization, leveraging economies of scale to lower decarbonization costs overall while reducing individual residents' utility bills, making for a more affordable transition (Mills, 2023; Buro Happold Engineering [Buro Happold], 2019; Vicinity Energy, 2023). Lastly, these systems are also highly energy-efficient compared to other heating and cooling systems, which boosts their cost effectiveness and reduces peak demand, thereby boosting grid resilience (Buro Happold, 2019).

As the second-oldest state, Pennsylvania's housing is among the oldest in the nation: roughly 25% of houses were built before 1939, and the median housing structure was built in 1964 (U.S. CB, 2022f). Pennsylvania's aging housing stock also presents a challenge to transitioning to zero-emission buildings equitably and efficiently. **Housing age correlates both with decreased energy efficiency and with increased risk of environmental health hazards due to poor housing quality (Bardhan et al., 2014; Reina et al., 2020), reflected in the high energy burden alongside extensive housing remediation needs Pennsylvanians face (SCEP, n.d.d; U.S. CB, n.d.a). These affordability, health, and quality-of-life issues exacerbate existing inequalities.** In Pennsylvania, roughly one in ten White households experiences severe housing problems, while one in four Black, Hispanic, and American Indian/Alaska Native households face the same challenges, including lack of plumbing, lack of complete kitchen facilities, and severe cost burdens (America's Health Rankings, n.d.). Moreover, people of color and low-income households have higher energy burdens nationwide (ACEEE, 2019). Pennsylvania households making less than 80% of the area median income face a 8% energy burden on average, much higher than the 2% average across all Pennsylvania households (SCEP, n.d.d).

Philadelphia and Pittsburgh, Pennsylvania's two largest cities where buildings account for a much larger share of GHG emissions than they do statewide – 37% and 76% for Philadelphia and Pittsburgh respectively (City of Philadelphia Office of Sustainability, 2022b; City of Pittsburgh, 2018), are taking the lead on building decarbonization. Philadelphia aims to reduce municipal building emissions 50% by 2030 (City of Philadelphia Office of Sustainability, 2022a), while Pittsburgh has the same goal community-wide (City of Pittsburgh, 2018). As Pennsylvania envisions a pro-union, pro-equity climate plan, it has a unique opportunity to lead the way on building decarbonization, leveraging federal funding and innovative technologies to spearhead ambitious public programs while creating union jobs and delivering equity. The recent introduction of Solar for Schools legislation reflects Pennsylvanians' growing interest in making public buildings healthier and more sustainable (Solar for Schools Act, 2023). Yet, because the Commonwealth has nearly 40 million square feet of its own buildings to decarbonize – in addition to repairing and retrofitting unsafe, unhealthy, and overcrowded school infrastructure – Pennsylvania can, and should, think bigger (Penn State Facilities Engineering Institute [PSFEI], 2019; Pennsylvania's State System of Higher Education, 2023).

Pennsylvania has already put federal funding to work addressing critical needs of its building sector, such as with its 2022 Whole-Home Repairs Program (Senator Nikil Saval, n.d.). With the passage of both the IRA and the IIJA, which combined provide over $15 billion in funding for building decarbonization (White House, 2023a; Modaffari & Alleyne, 2022), Pennsylvania is well-positioned to leverage billions of federal dollars to transition to healthier, more sustainable zero-emission buildings.

RECOMMENDATION

ADOPT A CARBON-FREE KEYSTONE STATE ACT TO JUMPSTART A JUST TRANSITION THROUGH BUILDING DECARBONIZATION IN PENNSYLVANIA

1. Update Pennsylvania's Commonwealth Facilities Decarbonization mandates to achieve 100% emissions reduction by 2030 through buildings and district energy system retrofits
2. Incentivize the adoption of utility-scale zero-emission thermal energy networks
3. Establish a $2.69 billion annual Carbon-free Keystone Communities Grant to fully fund decarbonization in LMI communities at scale by 2040
4. Adopt priority hire for displaced union fossil fuel workers and targeted hire for underrepresented communities

Adopt a Carbon-Free Keystone State Act to Mandate 100% Emissions Reduction in Commonwealth Facilities by 2030

In developing a robust plan for building decarbonization, Pennsylvania's policymakers should start at home with Commonwealth agencies, including its fourteen State colleges and universities (Pennsylvania's State System of Higher Education, n.d.). Pennsylvania's existing public building decarbonization policy, which consists of non-binding goals laid out in Executive Order 2019-01, does not meet the scope or scale demanded by the climate crisis (EO 2019-01, 2019). These goals are: (1) to reduce energy consumption from State Agencies three percent annually or 21% below 2017 levels by 2025, and (2) to require new building construction projects, build-to-suit leased buildings, or agency renovation projects with costs exceeding 50% of the building's replacement cost to be high-performance buildings with energy consumption 10 percent lower than 2016 American National Standards Institute guidelines (EO 2019-01, 2019). These unambitious goals not only fail to contemplate wholesale emissions reduction, they also require less work, limiting the jobs creation potential from building decarbonization.

The dearth of public building decarbonization policy leaves open a wide window for policymakers to push ambitious public facility emissions reduction mandates that create clean energy union jobs. To this end, Pennsylvania policymakers should adopt a Carbon-Free Keystone State Act. Such an Act, modeled on New York's 2023

Decarbonization of State-owned Facilities Act, would push the state to lead by example on building decarbonization at the intersection of labor and equity (S.4006-C, 2023b).[2] First and foremost, this legislation should require Commonwealth facilities – including state colleges and universities – to meet 100% emissions reduction by 2030, driving job creation for deep energy retrofit work. To achieve this mandate, the Act should also incentivize the adoption of thermal energy networks by requiring the installation of new zero-emission networked geothermal systems anchored at Commonwealth buildings wherever feasible. In addition, this legislation should require that Commonwealth-owned facilities with heating and cooling

2 The 2023 Decarbonization of State-owned Facilities Act devised by UpgradeNY, a building decarbonization collaboration between New York's labor, environmental, and environmental justice movements from the NY State AFL-CIO to WE ACT for Environmental Justice, set the blueprint for transforming building decarbonization in the United States through large-scale adoption of thermal energy networks. S. 4006-C Budget Bill, N.Y.C.L. §§ 90, 91 (2023b). https://legislation.nysenate.gov/pdf/bills/2023/s4006c

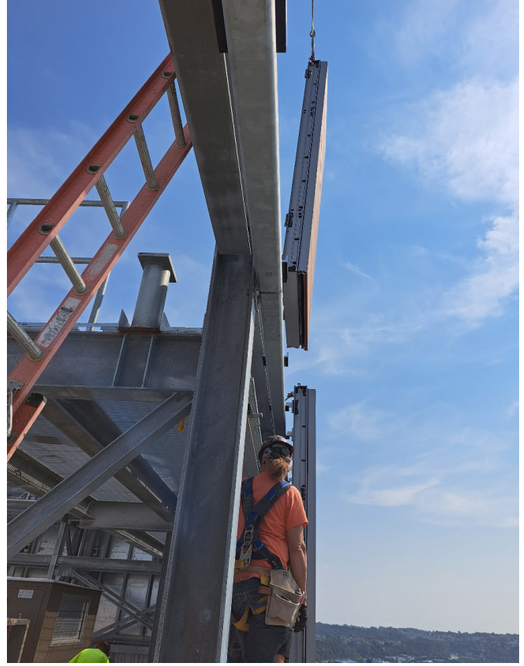
needs currently met by existing fossil-based district energy systems be retrofitted with industrial-scale geothermal heat pumps to become 100% emissions-free. This includes the Cordia Harrisburg District Energy System and the district energy systems at many State colleges and universities ***(see Appendix).*** Lastly, the Carbon-Free Keystone State Act should require an annual reporting mechanism to ensure thorough implementation by monitoring energy efficiency gains, emissions reductions, costs, jobs creation, registered apprenticeship utilization, and jobs quality metrics.

Public building campuses, capitol complexes, colleges, and universities are all prime candidates for new zero-emission thermal energy networks. This is in part because campuses with one property owner but multiple tenants and users present one of the simplest approaches to tackling the rights and permitting issues involved in thermal energy network projects (Hart et al., 2021). Public facilities can also serve as anchors for thermal energy networks, scaling decarbonization into neighboring residential and commercial blocks. In addition, existing fossil fuel-dependent district energy systems such as the Cordia Harrisburg District Energy System can fuel-switch to green technologies (e.g., electric boilers, industrial-scale heat pumps, and thermal storage), avoiding costly investments in all-new infrastructure (Vicinity Energy, 2023).

Decarbonizing Commonwealth facilities also promises to deliver positive community impacts in a just manner. For instance, neighborhoods in and around Pennsylvania's Harrisburg Capitol Complex, East Stroudsburg University, and Mansfield University of Pennsylvania are all considered environmental justice areas (PA DEP, n.d.j). Eliminating building emissions from Commonwealth facilities will help alleviate pollution burden in these neighborhoods, a key step toward addressing environmental justice.

Establish a Carbon-Free Keystone Communities Grant to Make Residential Decarbonization At Scale Affordable and Accessible to LMI Households

Residential buildings account for the largest share of building sector emissions (PA DEP, 2023b). However, the high up-front cost of deep energy retrofits is often prohibitive for residential homeowners (Casquero-Modrego et al., 2022). This is especially true for LMI



A member of Ironworkers Local 3 working on construction. Credit: Marshall Long

individuals and families. LMI homeowners "already face multiple economic barriers and likely do not have the means to invest in electrification" (York et al., 2022). LMI renters are largely subject to the discretion of their building owners to opt into potentially costly retrofits while passing on the benefits to their tenants, resulting in a split incentive (York et al., 2022). This prevents LMI homeowners and renters from accessing the financial savings, health, and quality-of-life benefits of home decarbonization. It also reifies equity concerns in the long-term by leaving LMI households responsible for paying higher and higher fossil fuel rates to heat and power their homes as more and more high-income households electrify and decarbonize, exacerbating energy burdens (York et al., 2022).

To address cost barriers and scale residential building decarbonization, the Commonwealth should establish a Carbon–Free Keystone Communities grant program under the Carbon-Free Keystone State Act. The Commonwealth should allocate $2.69 billion annually to enable county governments or county-authorized agencies to fully fund residential decarbonization at scale for LMI homeowners and renters by 2040. At its base funding level, this program should allow housing agencies to apply for monies to fully decarbonize their public and subsidized housing stock, removing the split incentive for affordable housing building owners while easing affordability barriers for LMI homeowners and renters. To drive both residential decarbonization and a just transition for workers, this grant program should include a second tier of funding to incentivize the adoption of community-scale retrofit efforts and zero-emission thermal energy networks. For this tier, housing agencies would be responsible for recruiting homeowners and building owners in majority-LMI communities to both join a proposed zero-emission thermal energy network and to consent to fully-funded deep energy retrofits. This integrated approach is similar to the project proposed in Buro Happold's (2019) *Geothermal Networks 2019 Feasibility Study.* Housing agencies can anchor zero-emission thermal energy networks at public housing buildings and utilize data concerning applicants for existing home weatherization, repair, and retrofit programs (e.g., Weatherization Assistance Program, Whole-Home Repairs Program) to target recruitment efforts (PA DCED, n.d.d; PA DCED, 2023a). In disbursing grant funds, the Commonwealth should favor applications that:

- Propose a circular economy model, connecting zero-emission thermal energy networks to source industrial and commercial waste heat
- Recruit and train public housing, affordable housing, and LMI residents into newly created jobs
- Utilize registered apprenticeships and quality pre-apprenticeships with direct interview agreements
- Include priority hire for displaced fossil fuel workers where zero-emission thermal energy networks are adopted

High-Quality Labor Standards: Public sector decarbonization projects over $25,000 will be considered "public works projects," meaning that Pennsylvania's prevailing wage law should apply to these contracts (Regulations for Pennsylvania Prevailing Wage Act, 1975). To take full advantage of potential IRA funding and increase equity outcomes in the Commonwealth's renewable energy economy, the Commonwealth should incentivize – and require when possible – that contractors completing retrofitting or other decarbonization projects on publicly-owned facilities abide by the following guidelines: 1) adopt priority hire for displaced fossil fuel workers; 2) meet a certain percentage for targeted hiring; and 3) require registered apprenticeship utilization. The Commonwealth should also explore more innovative approaches to achieving high-quality labor standards, including crafting a memorandum of understanding with utility workers' unions on the operation and maintenance of the thermal energy network(s) that serve Commonwealth facilities and wage protections for building services workers in Commonwealth facilities. Where not mandated by state or federal law, the Carbon-Free Keystone State Act should extend Pennsylvania's Buy America procurement commitment to all materials for Commonwealth facility retrofits. Lastly, the Commonwealth should require that contractors performing retrofits submit affidavits of compliance with local, state, and federal laws, and should also encourage contractors to take all possible measures to guarantee that work is performed on time, without labor disruptions, and by a well-trained workforce.

Cost:

Facilities Decarbonization: $86,600,000 per year
Residential Decarbonization: $2,690,000,000 per year

Job Creation:

Facilities Decarbonization: 330 direct jobs per year. 2,310 direct jobs through 2030.
Residential Decarbonization: 10,000 direct jobs per year. 70,000 direct jobs through 2030.

Emissions Reduction:

Facilities Decarbonization: 167,000 MT CO_2e per year through 2030.
Residential Decarbonization: 4,340,000 MT CO_2e per year through 2040.

Funding: For Commonwealth facilities decarbonization, Pennsylvania can tap into the IRA's Investment Tax Credit's direct pay provision, which could cover up to 50% of project costs if it meets domestic content (U.S. Department of the Treasury & IRS, 2023), apprenticeship utilization, and prevailing wage requirements (U.S. Department of the Treasury & IRS, 2022).

The Commonwealth can take advantage of the IRA's Energy Efficient Commercial Buildings Deduction for wider energy efficiency measures (e.g., updating lighting, HVAC, and hot water systems and building envelopes); this provision offers up to $2.50 per square foot of the

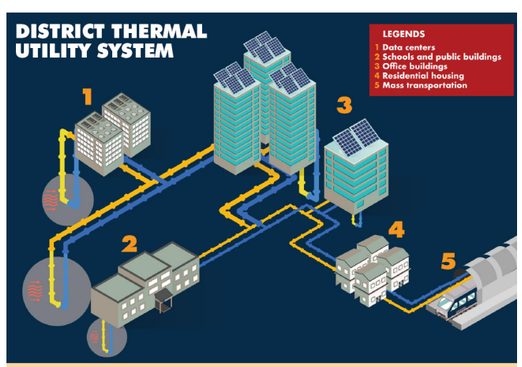
facilities area if a project meets prevailing wage and apprenticeship utilization requirements and reduces energy costs by at least 25% (Massey, 2022). The incentive rises to $5.00 per square foot for projects that reduce costs by 50% or more and meet the same standards (Massey., 2022). In addition, the U.S. DOE operates the Energy Efficiency and Conservation Block Grant program to assist states, municipalities, and tribal governments in planning and implementing policy to reduce energy use and emissions (SCEP, n.d.a).

Geothermal systems are eligible for federal programs such as the Residential Clean Energy Credit (IRS, 2023a), the Investment Tax Credit (IRA, 2022s), the Energy-Efficient Commercial Buildings Tax Deduction (IRS, 2023d), and the Home Energy Rebates Program (SCEP, n.d.b). The Energy Efficiency Home Improvement Credit provides additional incentives for home energy audits and energy efficiency improvements (White House, 2023d).

UNDERSTANDING THERMAL ENERGY NETWORKS

Thermal energy networks, otherwise known as networked geothermal or "GeoMicroDistricts," present a completely clean, more efficient alternative to investing in aging natural gas infrastructure. Networked geothermal consists of a main horizontal pipe loop that distributes thermal energy drawn from a series of connected vertical pipe loops laid within drilled boreholes that are typically hundreds of feet deep. A fluid, usually water or a water-glycol mixture, circulates through this pipe system to provide heating in the winter and cooling in the summer via heat pumps installed within interconnected buildings. This system facilitates the exchange of thermal energy from building to building, as well as between buildings and the underlying bedrock (where thermal energy can be naturally stored). At scale, these systems can heat and cool entire neighborhoods without any fossil fuel emissions.

Constructing, operating, and maintaining a networked geothermal system parallels the work of utility gas companies. Horizontal distribution mains, vertical loops, and service lines would all be installed within the utility right-of-way, where current natural gas infrastructure exists. Transitioning from natural gas to networked geothermal affords gas utilities a chance to amend and decarbonize their operations while both retaining workers and lowering customer costs. Eversource Gas and National Grid in Massachusetts are launching the first pilot program of this kind in the nation, and Philadelphia Gas Works is considering doing the same. Groups such as POWER Interfaith see the potential for networked geothermal in Pennsylvania as a win for both equity and labor (Power Interfaith, 2021).



Buildings are interconnected by pipes and ground source heat pumps, creating a district thermal utility system. The temperature difference between a building and the system heats or cools that building.

RECOMMENDATION

INCENTIVIZE UNION-BUILT ZERO-EMISSION AFFORDABLE HOUSING

1. **Increase equitable access to resilient affordable housing by 2030 through the:**
2. **Build-out of 300,000 net-zero affordable housing units**
3. **Deep retrofitting and whole-home repair of all existing affordable and public housing units**
4. **Zonal decarbonization of all zip codes that contain affordable or public housing units**

Housing is a human right (United Nations, n.d.). However, in the United States, inequitable access to safe, affordable, healthy housing has perpetuated structural and racial inequality across the country, including in Pennsylvania. 28% of all Pennsylvania renters are considered extremely low income, with 33% of those being senior households (National Low Income Housing Coalition [NLIHC], n.d.). The Commonwealth currently faces a deficit of more than 260,000 affordable housing units (NLIHC, n.d.). Pennsylvania must ensure that its existing affordable housing stock is more resilient in the face of climate change. Further, the Commonwealth must build additional units to rectify current deficits and meet future demand from population changes.

Pennsylvania recently announced plans to distribute $98 million in American Rescue Plan Act funding through the Housing Options Grant Program to preserve and expand affordable housing building stock (Rodgers, 2023). This money will aid in the preservation and repair of over 2,700 affordable housing units and the construction of 150 new units across 20 counties (Rodgers, 2023). Investments like these must be greatly expanded to meet the scale of the housing and climate crises in Pennsylvania.

Community zonal decarbonization within zip codes with affordable and public housing is an opportunity to scale retrofit and whole-home repair work in frontline and at-risk communities. Additionally, there is an opportunity for public and private partnerships to bulk purchase retrofit materials, increasing the potential for enforcing strong labor standards in production of these materials by designating certain facilities to produce high volumes specifically for the Commonwealth and encouraging LPAs at these facilities. Bulk purchasing will also decrease costs by rendering feasible the simultaneous servicing of multiple buildings in vulnerable communities. Of course, the retrofit and repair work performed using these materials must be performed by a skilled union workforce to ensure timely and high-quality completion that will truly make the Commonwealth's investment in these affordable housing units worthwhile.

High-Quality Labor Standards: Affordable housing projects that receive more than $25,000 in Commonwealth funds must meet Pennsylvania's prevailing wage requirements (Regulations for Pennsylvania Prevailing Wage Act, 1975). To ensure compliance, the Commonwealth should require contractors attest through periodic compliance affidavits that they are following applicable federal prevailing wage rates, as well as make this data publicly available for monitoring. The Commonwealth should use the procurement process for bidding out affordable housing work to incentivize – and require when possible – contractors to commit to utilizing and recruiting from registered union apprenticeship programs and quality pre-apprenticeship programs, establishing targeted hiring policies, hiring locally from communities where affordable housing projects are constructed, and taking other proactive measures to ensure that a diverse, highly qualified workforce is able to complete important construction and retrofitting work without disruptions.

Cost:

New Construction of Net-Zero Affordable Housing: $17,200,000,000 per year.
Retrofits of Existing Affordable & Public Housing: $341,000,000 per year.

Job Creation:

New Construction of Net-Zero Affordable Housing: 76,000 direct jobs per year. 532,000 direct jobs through 2030.
Retrofits of Existing Affordable & Public Housing: 1,300 direct jobs per year. 9,100 direct jobs through 2030.

Emissions Reduction:

Retrofits of Existing Affordable & Public Housing: 774,000 $MTCO_2e$ per year through 2030.

Funding: The Commonwealth can utilize funds from federal and state sources, particularly from the IRA and IIJA, to decarbonize affordable housing. The Department of Energy's Home Energy Rebates Program provides $8.8 billion in financial assistance for state and local governments to increase energy efficiency in existing buildings (SCEP, n.d.b). Additionally, the Department of Housing and Urban Development's Office of Housing has launched the Green and Resilient Retrofit Program (Office of Housing, n.d.a, Office of Housing, n.d.b, Office of Housing, n.d.c). This program provides over $2 billion in funding for HUD-assisted housing for building retrofits, energy efficiency, and climate resilience (Office of Housing, n.d.a, Office of Housing, n.d.b, Office of Housing, n.d.c). The Commonwealth provides additional funds through the Pennsylvania Housing Affordability and Rehabilitation Enhancement Program (PHARE) to subsidize housing costs for low and moderate income households (Wiessman, 2023).

IUOE Local 542 Apprentices learning how to operate a construction crane

RECOMMENDATION

MAKE PENNSYLVANIA HOMES SAFER, HEALTHIER, AND MORE EFFICIENT THROUGH AN AMENDED WHOLE-HOME REPAIRS PROGRAM

Transform Pennsylvania's innovative Whole-Home Repairs Program to become a model of residential one-stop shop repairs and retrofit funding at the intersection of climate, jobs, and justice by:

1. **Reinstating and increasing year-over-year funding for the Whole-Home Repairs Program to $300 million**
2. **Raising the per-project funding cap to $70,000**
3. **Bundling projects for contractors to complete at the community or county level**

Pennsylvania homes are the fourth-oldest in the country, with the average home built in 1964 (PA DCED, 2023a; U.S. CB; 2022f). In Pennsylvania's largest cities – including Philadelphia, Pittsburgh, Allentown, and Erie – homes are even older, with the median housing stock being over 70 years old (Reina et al., 2020). The age of Pennsylvania's housing stock has consequences for the habitability of its homes: over 300,000 Pennsylvania homes are considered either "moderately" or "severely" inadequate based on their plumbing, heating, electrical wiring, and other building conditions (U.S. CB, n.d.c). The condition of Pennsylvania homes is not only hazardous to the health and wellbeing of residents, it also impedes weatherization and decarbonization efforts – in fact, over one-third (36%) of Pennsylvania homes were deferred from receiving Weatherization Assistance Program (WAP) funding between 2015 and 2017 due to their conditions, including: "1) moisture, mold, and mildew, 2) roof damage, 3) overall structural problems, and 4) knob and tube wiring" (PA DCED, 2020).

To address these issues, energy, housing, labor, and justice advocates including but not limited to the Pennsylvania Utility Law Project, POWER Interfaith, and Philly Thrive helped the Pennsylvania legislature pass the innovative Whole-Home Repairs Program in 2022 (Senator Nikil Saval, n.d.). The program allocates formula funding to counties to provide bridge grants up to $50,000 for homeowners who earn up to 80% of the area median income to complete habitability and safety repairs, accessibility renovations, and energy- and water-efficiency retrofits (PA DCED, 2023a). Small landlords are also eligible for the same amount in loans (PA DCED, 2023a). The Commonwealth allocates funding to counties based on the number of homes built before 1940, the median income of the county, and household condition by county (Lori Straub, personal communication, August 1, 2023); and counties can choose to target their funding based on their communities' needs (Lori Straub, personal communication, August 1, 2023). Counties must also invest part of their funding into workforce development programs, and could choose to invest in multiple programs at once (PA DCED, 2023a).

Workforce Development Programs Funded by PA Counties through the Whole-Home Repairs Act

(Lori Straub, personal communication, August 1, 2023)

- **44** invested in a job training program
- **19** invested in apprenticeship/pre-apprenticeship programs
- **18** invested in on-the-job training
- **17** invested in stipends for trainees

Row houses in South Philadelphia

The program received $125 million from American Rescue Plan Act funds in 2022 (General Appropriation Act of 2022, 2022). Since then, Pennsylvania counties have already demonstrated higher interest in this program than existing funding can support: nearly all counties (64 out of 67) applied for funding in the first year (Pennsylvania Senate Democrats, 2023). Data from program administrators show that, as of September 30, 2023, 54 of those 64 counties had opened applications, and 19 saw such high demand that their programs had already closed (Lori Straub, personal communication, November 16, 2023). Allegheny County, home to Pennsylvania's second–largest city, Pittsburgh (World Population Review, 2023), received 3,400 applications in its first month alone (Morrison, 2023). While counties have already identified 408 projects for completion and anticipate finishing more than 3,000 projects during this round of funding, another 8,000 applicants remain on waiting lists (Lori Straub, personal communication, November 16, 2023). Counties have also reported braiding together multiple funding sources per applicant, including from Community Services Block Grants, the Weatherization Assistance Program (WAP), and the Pennsylvania Housing Affordability and Rehabilitation Enhancement Fund, to: (a) increase the total project funding for a home, and (b) address the widest scope of repairs, remediations, and retrofits possible per home (Lori Straub, personal communication, November 16, 2023).

Despite the overwhelming popularity and overall success of the Whole-Home Repairs Program, Pennsylvania counties have still faced barriers to implementation. While counties have reported that local agency staffing is a key limitation to program administration (Lori Straub, personal communication, November 16, 2023), the primary barrier stems from a lack of contractors who can perform these relatively small projects and pay the prevailing wage, which is required by Pennsylvania statute for any project receiving $25,000 or more in public funds (Daniel Marzec, personal communication, August 4, 2023; Lori Straub, personal communication, August 1, 2023). As a result, some counties have capped project funding just below the prevailing wage threshold, revealing a missed opportunity to leverage this program as a pipeline to good, green union careers that pay family-sustaining wages (Lori Straub, personal communication, November 16, 2023). Funding is another key barrier: the sheer number of applicants versus the number of projects counties expect to complete underlines the need for more program funding, which advocates have been pushing to expand (Leigh, 2023).

To improve upon this innovative policy, addressing barriers to the program's implementation while enhancing its ability to deliver both safe, efficient housing and green union jobs accessible to all, the Commonwealth should:

- **Increase program funding from $0 in the Fiscal Year 2023-24 budget to $300 million per year** as advocates have called for, and ensure that this funding is permanent to prevent another lapse (H.B. 1300, 2023; Leigh, 2023)

- **Raise the per-grant cap from $50,000 to $70,000**

- **Bundle projects** at the county level (or, depending on county size, at the neighborhood/town level) to make projects more appealing to contractors who can pay the prevailing wage

- **Put forth a legislative amendment or modified guidelines to ensure that workforce development investments support quality pre-apprenticeship programs**

- **Allocate additional funding to counties whose workforce development proposals support programs targeting** residents from environmental justice communities and from populations underrepresented in the construction sector (e.g., women and people of color) as well as training for minority- and women-owned businesses and enterprises (MWBEs) contractors (Burrows, 2023)

High-Quality Labor Standards: Whole-Home Repairs Act projects receiving state funding over $25,000 must pay construction workers the state's prevailing rate for wages and benefits (Regulations for Pennsylvania Prevailing Wage Act, 1975). For work funded through other sources, the Commonwealth should ensure enforcement of any applicable prevailing wage requirements. The Commonwealth should incentivize – and require when possible – contractors performing Whole-Home Repairs Act projects to utilize registered apprentices from programs with direct entry agreements with pre-apprenticeship programs, adopt targeted hire goals, certify compliance with all applicable laws (e.g. through compliance affidavits), and take proactive measures to minimize labor or other disruptions. The Commonwealth should also incentivize these contractors to adopt paid on-the-job training.

Cost: $300,000,000 per year

Job Creation: 1,100 direct jobs per year. 7,700 direct jobs through 2030.

Emissions Reduction: 49,300 MTCO2e per year through 2030.

RECOMMENDATION

ADOPT A WHOLE-SCHOOL REPAIRS ACT TO MAKE PENNSYLVANIA SCHOOLS SAFE, HEALTHY, AND SUSTAINABLE

Make all Pennsylvania public schools zero-emission by:

1. Dedicating $1.1 billion per year in permanent grant funding to Title I schools for repairs, remediation, and deep energy retrofits with prevailing wage and registered apprenticeship utilization to complement the Pennsylvania Solar for Schools program and existing school construction funding streams
2. Establishing a School Buildings Authority to oversee all school construction, repairs, remediation, and retrofits
3. Requiring a semi-annual Statewide Facilities Assessment with mandated public reporting

With over 1.7 million students (National Center for Education Statistics [NCES], 2022) and 343 million square feet (ft^2) of school facilities (New Buildings Institute [NBI], 2021), Pennsylvania is home to one of the largest public school systems in the country (Christ, 2023). It is therefore unsurprising that Pennsylvania's school system has some of the highest emissions among U.S. public schools, producing an estimated 1,733,419 MT per year (NBI, 2021). The Pennsylvania School Board Association's 2023 State of Education Report revealed that over 70% of the 281 school districts that responded to its survey have buildings that need major repair or replacement (Christ, 2023). Beyond emissions, Pennsylvania's schools also face extreme health hazards: about two-thirds (66%) of school facilities were built before 1970 (Public School Building Construction And Reconstruction Advisory Committee, 2018), indicating that they likely contain asbestos and lead (U.S. EPA, 2023j). As the Commonwealth does not require the regular collection of data on school facilities' conditions, the total cost of repairs is impossible to estimate (Miller, 2023), but by all accounts the need is immense. Pennsylvania schools already have the second-highest long-term construction debt in the country at $15,638.00/student (Duffy & Lapp, 2020), and repair costs for the School District of Philadelphia alone have been estimated to exceed $4.5 billion (Parsons, 2017).

The condition of Pennsylvania school facilities greatly affects schools' ability to provide an equitable education. Students of color and those from low-income households are more likely to attend schools with health and safety risks, (Duffy & Lapp, 2020) conditions which are associated with worse educational outcomes (PennState Center for Evaluation and Education Policy Analysis, n.d.). Low-wealth districts spend a higher proportion of their operating budgets on facility repairs than their high-wealth counterparts, diverting resources from instruction or other critical services (Duffy & Lapp, 2020). The state of school facilities thus worsens inequitable educational funding in Pennsylvania, which already ranks as the fourth-most regressive in the country (Baker, et al., 2021) and has been ruled unconstitutional by the Commonwealth Court (William Penn School District v. Pennsylvania Department of Education, 2023).

Moreover, the poor state of Pennsylvania school facilities creates roadblocks to adopting safe, sustainable learning environments (Duffy & Lapp, 2020; Rubio, 2021). Although Pennsylvania doubled the amount of solar installed on schools between 2020 and 2022, the proportion of solarized schools is still less than 2% (Generation180, 2022). The proposed Pennsylvania Solar for Schools Grant Program, which contains strong labor standards (e.g., prevailing wage requirements, worker safeguards vis-à-vis contractors and subcontractors performing solar work, and Buy American provisions), promises to increase the adoption of solar and use energy savings to invest in school facilities (Solar for Schools Act, 2023). But without first addressing schools' critical infrastructure needs and energy retrofits, the state of these facilities may impede the Solar for Schools program's uptake as well as its associated cost savings, equity, and emissions reduction impacts.

Pennsylvania should jumpstart the green transformation of its schools by streamlining and allocating funding to existing school facilities programs that are currently unfunded or underfunded, including PlanCon, the Maintenance Project Grant Program, the School Environmental Repairs, and the Public School Facility Improvement Grant Program (Duffy & Lapp, 2020; Miller,

Members of the American Federation of Teachers, Pennsylvania at a rally holding "Philly is a Union Town" signs

2023; H.B. 301, 2023; H.B. 1300, 2023). Taking lessons from its highly successful Whole-Home Repairs Program, which enables homeowners to bridge the funding gap for home repairs to then access weatherization, renewable energy installation, and energy efficiency funding programs, a Whole-School Repairs Act could similarly help schools bridge the gap by funding repairs, retrofits, and accessibility measures necessary to make larger emissions-reduction and renewable energy build-out projects feasible. A Whole-School Repairs Act should:

- **Establish a School Building Authority** to manage school construction, coordinate key school facilities funding programs, oversee a statewide facilities assessment (see below), and help schools access additional facilities funding (e.g., for energy efficiency and renewable energy programs) at the federal level.
- **Require a statewide facilities assessment once every four years** to address the information gap around school facility conditions and to accurately estimate repair costs. Several states, including Maryland (Maryland Public School Construction, n.d.)., Rhode Island (State of Rhode Island Department of Education, 2023), and Kentucky (Kentucky School Facilities Planning Manual Implementation Guidelines, n.d.), require such assessments on a semi-annual basis. This assessment should include an energy analysis that benchmarks energy usage, identifies measures to improve energy efficiency and reduce energy demand, and analyzes the feasibility of adopting renewable energy systems, as is done in Rhode Island (Rhode Island School Building Authority, 2017). All information collected through the statewide facilities assessment should be publicly accessible.
- Based on the Whole-Home Repairs Act, the Commonwealth should
  - **Allocate $1.1 billion in year-over-year grant funding for schools to complete health and safety remediation, roof and window repairs, energy retrofits (e.g., for building envelope upgrades, ventilation, mechanical insulation, lighting systems, and electrical appliances) and accessibility amendments,** helping schools bridge the gap to then benefit from other funding programs, such as the Pennsylvania Solar for Schools Program and the Renew America's Schools

Program under the IRA (SCEP n.d.e). Unlike existing school construction funding streams, these grants should not require matching funds, which disadvantage low-wealth districts and perpetuates inequality. Title I schools and those in environmental justice communities should be prioritized for funding opportunities.

- **Dedicate a portion of grant funding to workforce development programs**, specifically quality pre-apprenticeship programs and career/technical education for students, all prioritizing placing environmental justice and underrepresented communities into union careers.

These recommendations answer calls from researchers, advocates, and schools themselves including Research for Action (Duffy & Lapp, 2020), Women for a Healthy Environment (Rubio, 2021), and the Philadelphia Federation of Teachers (Miller, 2023). Along with the proposed ***Carbon-Free Keystone Communities Act (see recommendation on p. XX)***, adopting a Whole-School Repairs Act will help rapidly scale both public building decarbonization and union construction jobs. It will also pave the way for schools to become zero-emission community resilience hubs by generating renewable solar energy, tapping into energy storage through an all-electric bus fleet, and offering core community services such as heating, cooling, and shelter.

High-Quality Labor Standards: Whole-School Repairs Act construction projects receiving IIJA funds would be required to meet federal prevailing wage rates (Pisano et al., 2023). Any projects receiving more than $25,000 in Commonwealth funds would be subject to Pennsylvania's prevailing wage law (Regulations for Pennsylvania Prevailing Wage Act, 1975). The Commonwealth should also incentivize – and require when possible – contractors completing Whole-School Repairs Act work to meet registered apprenticeship utilization goals, adhere to targeted hire principles, certify compliance with all applicable laws, and take proactive measures to minimize labor or other disruptions to ensure timely project completion.

Cost: $1,070,000,000 per year.

Job Creation: 4,100 direct jobs per year. 28,700 direct jobs through 2030.

Emissions Reduction: Repairs will partially reduce the emissions of 1,100,000 MT CO_2e per year for Title I K-12 schools.

Funding: Federal funding opportunities are available through the IRA and the IIJA to help schools become safer, more efficient, and sustainable. These opportunities include $50 million for schools in low-income and disadvantaged communities to monitor and reduce air pollution and GHG emissions (IRA, 2022o), $3 million for Environmental and Climate Justice Block Grants to disadvantaged communities to address harms from pollution and climate change (IRA, 2022p), the Investment and Production Tax Credits (IRA 2022q), the Energy-Efficient Commercial Buildings tax deduction (IRA, 2022f), and $500 million for the Renew America's Schools program to make schools more energy efficient, lower utility bills, and improve air quality (IIJA, 2021i). In addition, the U.S. DOE operates the Energy Efficiency and Conservation Block Grant program to assist states, municipalities, and tribal governments in planning and implementing policy to reduce energy use and emissions (SCEP, n.d.a).

TRANSPORTATION

Transportation is the second-largest source of Pennsylvania's GHG emissions, producing nearly a quarter (24%) of net emissions among the Commonwealth's eight top-emitting sectors (PA DEP, 2023b). Gasoline use, primarily from passenger vehicles, contributes to nearly two-thirds of the transportation sector's emissions (PA DEP, 2023b). The Commonwealth has taken steps to reduce emissions in this sector, with measures like increasing fuel-economy standards and exploring the acquisition of zero-emission fuel cell electric buses, but many of these measures assume the continued increase of single-occupancy vehicles on Pennsylvania roads (Pennsylvania Clean Vehicles Program, 2006; Southeastern Pennsylvania Transit Authority [SEPTA], 2023). To meaningfully lower transportation emissions on a timeline that meets the Commonwealth's overall goals for emissions reductions, Pennsylvania's transportation sector requires a larger restructuring that reduces the need for passenger vehicles, creates many more good, green union jobs, and addresses current inequities in Pennsylvania's transportation landscape. Pennsylvania now has a critical opportunity to expand transportation access, creating high-quality jobs and improving residents' quality of life by enhancing their access to workplaces, schools, services, and local communities.

Pennsylvania has great potential to be a regional leader in low-carbon transit. The Commonwealth can take advantage of its prime location along the Northeast Corridor electrified railroad line (primarily owned by Amtrak), which infuses an estimated $50 billion annually into the U.S. economy (Northeast Corridor Commission [NEC Commission], 2018). If Pennsylvania collaborated with neighboring states to construct a northeastern high-speed rail network using the existing Northeast Corridor infrastructure, Philadelphia would be a key connection point for the system (NEC Commission, n.d.b). Commonwealth efforts to bring high-speed rail to the Northeast Corridor would stimulate Pennsylvania's local economies, generate quality jobs, and expand low-emissions travel throughout the entire region, bringing billions of dollars in benefits to commuters as well as communities surrounding high-speed rail hubs (NEC Commission, 2018).

Pennsylvania is fortunate to have some of the most robust public transportation systems in the United States. The Southeastern Pennsylvania Transit Authority (SEPTA), which serves Philadelphia and four surrounding counties,

has the sixth-highest regional transit ridership in the country (American Public Transportation Association, 2020). Public transit provides a link to employment for low-income workers and is a critical connector of social and medical services for transit-dependent populations (including seniors and people with disabilities), who made up 13% of Pennsylvania public transit riders in 2019 (Pennsylvania Department of Transportation [PennDOT], 2021). These riders earn a lower median wage and are more racially diverse than the rest of Pennsylvania's population (PennDOT, 2021). In addition, 16.7% of the Commonwealth's public transportation workers are unionized (Pollin et al., 2021a), with TWU Local 234 representing more than 5,000 SEPTA workers (TWU Local 234, n.d.) and ATU Local 85 representing thousands of Pittsburgh's light rail workers (ATU Local 85, n.d.). Public transportation is one of the most accessible fields of public sector employment based on education level, with more than half of Pennsylvania's public transit workers having at most a high school degree (Pollin et al., 2021a). The transportation workforce is also one of the Commonwealth's most diverse, with about a third of transportation workers identifying as women and a third identifying as non-white (Pollin et al., 2021a). These ridership and workforce demographics underscore the enormous potential to use continued public transit investments as a lever for promoting good union jobs alongside equity in the Commonwealth.

Although the Commonwealth's two largest public transit agencies have begun investing in electric fleets (Pittsburgh Regional Transit, n.d.), many other Pennsylvania transit authorities still rely on carbon-intensive travel, generating ongoing emissions and public health consequences for transit operators and the communities they serve (National Institutes of Health, 2021). At the same time, large swaths of Pennsylvanians face barriers to accessing transit, particularly in the more rural central and northern parts of the state (Council on Environmental Quality, 2022). Pennsylvania must invest in decarbonizing public transit and expanding transit options to currently underserved communities. These investments will yield significant returns for local communities and expanded career pathways for Pennsylvania's developing workforce.

Private sector actors have already recognized Pennsylvania's attractive environment for transportation-related investments – the Commonwealth has emerged as a regional leader over the past decade for logistics and distribution across the eastern seaboard, in part thanks to its central location (Besecker et al., 2023). However, the economic boom from the burgeoning logistics industry is not without drawbacks: workers and nearby communities have confronted substantial labor, environmental, and public health impacts (Jaffee & Bensman, 2016), impacts which disproportionately affect low-income communities of color (Office of Planning Advocacy, 2022). Pennsylvania has an opportunity to directly address the rapid expansion of this new, transit-dependent industry and ensure that its future development comes with strong worker and environmental protections.

Pennsylvania can and should pursue all possible pathways to create good, green union jobs in transportation and transit-dependent sectors, taking maximum advantage of IRA and IIJA funding, as well as state and local funds, to reduce GHG emissions and offer Pennsylvanians high-quality, family-sustaining careers in transportation work.

RECOMMENDATION

CONSTRUCT HIGH-SPEED RAIL INFRASTRUCTURE IN THE NORTHEAST CORRIDOR

By 2035, develop high-speed rail through the Northeast Corridor, including a branch line to Harrisburg, with high quality labor standards

High-Speed Rail (HSR) is a significant opportunity for Pennsylvania. The Northeast Corridor (NEC), which spans the eastern seaboard, is an ideal candidate for high-speed rail due to its concentration of large population centers and favorable geography. The NEC Commission comprises delegates from Pennsylvania, Connecticut, Delaware, the District of Columbia, Maryland, Massachusetts, New Jersey, New York, and Rhode Island (NEC Commission, n.d.a). The commission has proposed constructing a high-speed rail line from Washington, D.C. to Boston, Massachusetts to ferry passengers between the major cities along routes at unprecedented speeds of up to 220 mph (NEC Commission, n.d.b). In Pennsylvania, the proposed high-speed rail line will stop in Philadelphia and have a spur westward, stopping in Paoli and Harrisburg (NEC Commission, n.d.b). Previous Climate Jobs Institute reports recommended an even greater vision for NEC high-speed rail that would expand north beyond Boston to include Portland, Maine and Bangor, Maine (Cha et. al., 2022; Cha et al., 2017; Skinner et al., 2022). This vision should also be extended south to Richmond, Virginia.

Northeast Corridor and Proposed Expansion Route

Map: Alejandra Rodriguez Diaz, M.S., Research Support Specialist, Cornell ILR Climate Jobs Institute, adr223@cornell.edu • Source: Northeast Corridor Commission, CONNECT NEC 2035 • Created with Datawrapper

High-speed rail will bring transportation-related benefits to Pennsylvania and beyond. Trips between Philadelphia and Washington, D.C. and Philadelphia and New York City would be at least 11 and 15 minutes shorter, respectively (NEC Commission, 2021b). Additionally, service frequency would improve and train delays would decrease: the maximum average time between trains for passengers traveling from Philadelphia on SEPTA would fall from 20 minutes to 17 minutes (NEC Commission, 2021b). Better speed, reliability, and service are expected to increase ridership, resulting in lighter road traffic, fewer vehicle accidents, and less time lost to driving (NEC Commission, 2021a). This service will also be electrified, leading to a significant reduction in transportation emissions. NEC electric rail currently emits roughly 0.2 pounds (lbs) of CO_2 per passenger mile traveled and could become emissions-free with a decarbonized electric grid (NEC Commission, 2021a). In comparison, driving an automobile emits 1.2

lbs of CO_2 on average per passenger mile traveled (NEC Commission, 2021a). The reduction in transportation emissions will also help reduce health-harming co-pollutants such as PM2.5, to which people of color across Pennsylvania are disproportionately exposed, especially in Philadelphia (Union of Concerned Scientists, 2019).

Constructing the infrastructure necessary for this line will directly and indirectly stimulate participating states' economies by creating jobs, promoting travel, and saving on more expensive transportation infrastructure in the future (NEC Commission, 2021a). As the fastest travel option along the eastern seaboard, rates of flying and driving should decrease, thereby further reducing emissions. With Philadelphia a main hub for this line, Pennsylvania can maximize the project's benefits by developing high-speed rail service to Harrisburg as well.

High-Quality Labor Standards: The Commonwealth should require contractors working on the high-speed rail build-out to submit affidavits of compliance with all applicable federal or state prevailing wage laws. Pennsylvania should also maximize the amount of federal funding it receives for high-speed rail work by requiring recruitment from registered apprenticeship programs on HSR projects whenever feasible. The Commonwealth should further extend its Buy American procurement requirement for iron and steel to all materials utilized in high-speed rail construction, taking advantage of the opportunities that a mass high-speed rail build-out presents to Pennsylvania and U.S. industrial sectors. The Commonwealth should encourage contractors to prioritize targeted hiring and certify compliance with all applicable laws. Finally, the Commonwealth should shore up its investment in high-speed rail and guarantee timely completion of this critical infrastructure by requiring, wherever possible, that contractors maintain PLAs and LPAs to avoid labor disruptions.

Cost: High speed rail infrastructure development could cost up to $18 billion in the Mid-Atlantic North region by 2035 (NEC Commission, 2021b).

Job Creation: High speed rail infrastructure development will create more than 173,000 direct, indirect, and induced jobs in the Mid-Atlantic North region by 2035 (NEC Commission, n.d.b).

Emissions Reduction: 15,500 MT CO2e per year.

Funding: The IIJA included $16.4 billion for passenger rail infrastructure in the Northeast Corridor (Zukowski, 2023).

RECOMMENDATION

ELECTRIFY AND TRANSFORMATIVELY EXPAND PENNSYLVANIA'S PUBLIC TRANSIT BY 2035; INVEST IN A RETRAINING PROGRAM FOR THE ELECTRIC VEHICLE TRANSITION

1. Mandate a transition to zero-emission public transit fleets by 2035 and invest in an EV public worker retraining program to facilitate an accelerated transition
2. Transformatively expand transit networks and access while prioritizing underserved communities

Expanding and electrifying Pennsylvania's public transit systems will be crucial to reducing statewide emissions. An electrified, expansive system will eliminate public-fleet emissions and enable more residents to transition from single-occupancy vehicles to public transit (Hodges, 2010). A comprehensive update that integrates electrification with expansion prioritizing current transit deserts would also align well with Commonwealth residents' ongoing advocacy for more accessible, affordable transit (Pittsburghers for Public Transit, 2021).

The Commonwealth has already built momentum toward full transit electrification. Executive Order 2019-01 mandates replacing 25% of the state passenger car fleet with battery electric and plug-in electric hybrid cars by 2025 (EO 2019-01, 2019). In 2021, SEPTA set a goal of transitioning to a completely zero-emission fleet by 2040, and has been exploring acquisition of several types of zero-emissions vehicles to realize this vision (SEPTA, 2023; PA DEP, n.d.m). SEPTA received $80 million in 2023 from the IIJA to upgrade bus maintenance facilities to accommodate zero-emission buses (Sharber, 2023). SEPTA and other transit agencies should maximize the impact of this influx of federal funding for electrification projects and ensure the transition will benefit all Pennsylvania workers and residents.

Transit agencies should set a more ambitious timeline for zero-emission fleets of 2035, rather than 2040, taking into account the most up-to-date climate science, inevitable process delays, and the critical importance of avoiding prolonged transit system disruptions. The sooner Pennsylvania gets electrification and expansion work under way, the quicker the Commonwealth can create hundreds of new jobs, first in constructing the necessary expanded and electrified infrastructure, and subsequently in operating and maintaining this infrastructure. Notably, Pennsylvania's public transit workforce already has significant representation of women and Black residents (Murtaza, 2020). The Commonwealth should prioritize retraining of its existing transit workforce to set current transit employees up for success as the transit system electrifies and expands. Strategic policies that incentivize or require contractors to work with union apprenticeship programs and to maintain progressive hiring practices will help the Commonwealth ensure that new careers in public transit continue to be accessible and exciting to a diverse range of local communities.

Pennsylvania's transformation of its transit systems should simultaneously prioritize not only electrification, but also accessibility and appeal, particularly for residents and workers of communities currently underserved by public transportation. Most Pennsylvania counties have at least one neighborhood that falls within the U.S. Department of Transportation (DOT)'s 90th percentile of communities with transit barriers (Council on Environmental Quality, 2022). Expanding transit routes should center these "transit deserts" by implementing more accessible transit options and hiring labor directly from the communities where expansion projects take place — ideally in collaboration with existing registered apprenticeship programs. Pennsylvanians have successfully campaigned for municipal-level public transit expansions that strategically eliminate transit deserts by prioritizing service to high-density affordable

housing units (Pittsburghers for Public Transit, n.d.). This model could be adopted at the Commonwealth level so that expansion is as effective as possible.

To make transit truly equitable and accessible (and thus impactful in reducing statewide emissions), municipalities should dedicate money toward a future of free transit for all low-income riders and frontline workers. This vision is already being realized around the Commonwealth; for instance, the Philadelphia City Council earmarked $62 million in its 2023 budget to implement a pilot transit access program that includes free fares based on income (City of Philadelphia, 2023). A free fare program could have far-reaching benefits for residents and the economy. Philadelphia's free fares pilot partly came in response to the city's 2020 Community Needs Assessment, which found that transportation access was the highest-ranking barrier to finding and sustaining employment for people living below the poverty line (City of Philadelphia, 2020).

High-Quality Labor Standards: Pennsylvania should create additional labor-management apprenticeship training programs for transit work, which would reduce barriers to entry into civil service transit careers and build a workforce with the skills needed for electrification and expansion work (National Governors Association, 2023). The Commonwealth should further incentivize, and when possible require, contractors to recruit from underserved communities. Finally, given the importance of timely project completion by highly skilled staff, Pennsylvania should pursue PLAs and LPAs for transit-related contracts for goods or services whenever feasible and appropriate. The Commonwealth should also explore bulk purchasing of zero-emission vehicles from designated in-state manufacturers, which would render enforcement of strong labor standards more feasible, as the Commonwealth could concentrate enforcement efforts in these designated manufacturing facilities.

Cost:

Bus Transit: $412,000,000 per year.
Rail Transit: $51,400,000 per year.

Job Creation:

Bus Transit: 71 direct jobs per year. 497 direct jobs through 2030.
Rail Transit: 130 direct jobs per year. 910 direct jobs through 2030.

Emissions Reduction:

Bus Transit: 9,740,000 MT CO_2e per year.
Rail Transit: 1,420 MT CO_2e per year.

Funding: Pennsylvania will receive $2.8 billion in IIJA funds over the next five years to improve its public transportation system and ensure sustainability (Cann, 2022). SEPTA has committed to investing between $105 and $140 million annually from 2026 to 2034 to support the transition to zero-emission fleets (MacDonald, 2022). In 2023, the PA DEP awarded $1.5 million in alternative fuels grant funding to support municipalities, among other entities, in switching to clean-fuel vehicles (Pennsylvania Pressroom, 2023). Additionally, any tax-exempt municipal transit agencies or governmental bodies that purchase qualifying electric or mixed-fuel commercial vehicles may be eligible for Commercial Clean Vehicle Credits of between $7,000-$40,000 per vehicle (IRA, 2022r).

The Commonwealth should make every effort to apply for and obtain allocations of forthcoming federal funding to support state and municipal investment in clean transit options, including: $1 billion in Clean Heavy-Duty Vehicle grants and rebates that the U.S. EPA will administer between 2022-2031 (IRA, 2022v); $60 million in grants, rebates, and loans for Diesel Emissions Reductions administered by the U.S. EPA to continue the DERA program currently authorized through FY2024 (IRA, 2022n); $550 million in currently available formula and competitive grants administered by the U.S. DOE (none of which have yet gone to Pennsylvania) for state energy efficiency and conservation efforts (IIJA, 2021j); and allocations from the Congestion Mitigation and Air Quality Improvement Program and Carbon Reduction Program administered by the U.S. DOT and calculated according to statutorily-specified ratios (IIJA, 2021f; IIJA, 2021g). In addition, the U.S. DOE operates the Energy Efficiency and Conservation Block Grant program to assist states, municipalities, and tribal governments in planning and implementing policy to reduce energy use and emissions, including in the transportation sector (SCEP, n.d.a).

RECOMMENDATION

DECARBONIZE PENNSYLVANIA'S LAST-MILE TRUCKING BY 2030 WHILE EXPANDING WORKER PROTECTIONS IN THE LOGISTICS, DISTRIBUTION, AND WAREHOUSING SECTOR

1. Mandate the decarbonization of last-mile and logistics transportation by 2030 and the remaining heavy-duty transport and freight rail by 2035
2. Establish robust emissions reduction and environmental regulations to limit the warehousing sector's climate impacts and increase resilience, including by adopting an indirect air source rule and air quality monitoring for warehouses
3. Adopt worker protections to promote workers' health and well-being while incentivizing worker organizing

The Commonwealth is home to one of the most significant logistics, distribution, and warehousing sectors in the country (CBRE, 2022), particularly concentrated in the Lehigh Valley (Besecker et al., 2023) and Northeast Pennsylvania (McElwee, 2022; Besecker et al, 2023). The location of these regions along the Washington–Boston corridor at the intersection of five major interstates and within 500 miles (or one truck shift) of one-third of the U.S. population has sparked a logistics explosion in recent years (Besecker et al., 2023; McElwee, 2022). These regions' affordable industrial real estate markets when compared to other nearby markets in New Jersey and New York, alongside their historically low unionization rates, have also drawn major corporations to Pennsylvania (Besecker et al., 2023).

As Pennsylvania's logistics, distribution, and warehousing sector booms, jobs have undoubtedly also grown (McElwee, 2022). However, these are not high-quality, zero-emission career union jobs: truckers in this industry – whose trucks emit harmful diesel emissions – are often misclassified as "independent contractors" or "owner-operators," although their employment is often dependent on one firm (Jaffee & Bensman, 2016). Therefore, despite effectively having employer–employee relationships, they generally lack benefits such as pensions and healthcare (Jaffee & Bensman, 2016). These workers are also excluded from unemployment, workers' compensation and are unable to unionize (Jaffee & Bensman, 2016). They also face significant health impacts due to prolonged exposure to transportation emissions, both from truck driving itself and from overall traffic congestion (Jaffee & Bensman, 2016). Jobs in the warehousing and distribution center side are similarly characterized by hazardous workloads or work intensification, anti-union employers, low wages, and a lack of job security (Jaffee & Bensman, 2016).

Beyond its negative labor effects, this sector's unregulated growth has significant climate and environmental health ramifications (Office of Planning Advocacy, 2022; Kohut, 2022). Firstly, the boom in Pennsylvania's shipping industry, amplified by the boom in shipping overall (Buccholz & Richter, 2022), has likely contributed to transportation's high share of the Commonwealth's overall emissions. While gasoline emissions, primarily associated with passenger vehicles, have fallen incrementally over the last five years, emissions from diesel began to rise again after 2017 (PA DEP, 2022). This uptick roughly correlates with the start of the Commonwealth's logistics boom in 2015 (McElwee, 2022). Logistics, warehousing, and distribution contribute not only to increased diesel emissions, but also to traffic congestion, degraded habitat, air, and water resources; and consequences for quality of life, public health, safety, infrastructure, and transportation networks (Office of Planning Advocacy, 2022). The Commonwealth's expanding logistics and distribution warehouses have garnered attention from environmental advocates, with PennFuture having developed a model ordinance to help localities ease the environmental impacts of logistics facilities through zoning (Meyer, 2023). Constructing these warehouses has been an important source of high-quality, family- and community- sustaining careers in Pennsylvania (Rob Bair, personal communication, January 15, 2024). At the same time, low-income communities, communities of color, and those already bearing disproportionate health risks are most likely to feel the environmental and health impacts (Office of Planning Advocacy, 2022; Kohut, 2022). Addressing the last-mile sector and logistics overall

through integrated, ambitious climate and labor policy can therefore help improve workers' well-being and job quality while reducing transportation emissions, tackling the dual climate and economic crises facing Pennsylvania today.

Building on the work of the labor, environmental, and environmental justice movements in Pennsylvania and nationwide, the Commonwealth should adopt regulations to green the logistics sector while advancing workers' rights and collective representation.[3] In addition to mandating that Pennsylvania's freight transportation transition to zero-emission by 2035, Pennsylvania should also adopt rules to mitigate warehouses' negative climate and health impacts on both workers and surrounding communities, by monitoring key issues such as traffic and transportation impacts on the proliferation of health-harming atmospheric pollutants. Such rules could also boost the long-term resilience of this critical green logistics infrastructure in the face of climate change, potentially creating further jobs while bolstering the protection of communities. Similar regulations have been adopted in California and proposed in New York (Whitaker & Mogharabi, 2021; A.B. 1718, 2023). In consultation with stakeholders from the labor, environment, and environmental justice movements, the Commonwealth should also issue guidance to localities, such as those based on PennFuture's model zoning ordinance (see above) and Intro 1054-2023 (Int. 1054-2023, 2023). These guidelines should also contain recommendations on worker protections grounded in best practices from guidance documents produced by New Jersey (Office of Planning Advocacy, 2022) and California (California Attorney General's Bureau of Environmental Justice, 2022).

High-Quality Labor Standards: Alongside climate and environmental regulations, the Commonwealth should implement robust worker protections, including: adopting the anti-misclassification policies that the General Assembly's Joint Task Force on Employee Misclassification recommended in 2022 (Joint Task Force on Misclassification of Employees, 2022), for logistics employees at minimum; a heat safety standard for all workplaces, including in logistics ***(see the Establish a Robust State OSHA Plan by 2025 to Protect Public and Private Sector Workers from Heat and Air Quality Hazards recommendation on p. XX)***; increasing legislative checks to ensure that joint employers are collectively liable to employees and cannot dodge accountability on the basis of joint employment; and a wage board for the logistics sector.

Cost:

Heavy-Duty Freight Trucks: $3,280,000,000 per year.
Freight Rail: $3,670,000,000 per year.

Job Creation:

Heavy-Duty Freight Trucks: 570 direct jobs per year. 3,990 direct jobs through 2030.
Freight Rail: 8,900 direct jobs per year. 62,300 direct jobs through 2030.

Emissions Reduction:

Heavy-Duty Freight Trucks: 7,650,000 MT CO_2e per year.
Freight Rail: 842,000 MT CO_2e per year.

Funding: The IRA and the IIJA have unlocked monies through a variety of programs to help decarbonize and electrify truck fleets. These include: the Qualified Commercial Clean Vehicle and Alternative Fuel Vehicle Refueling Property Tax Credits (IRS, 2023c), the Clean Heavy-Duty Vehicle Program (U.S. EPA, 2023g), and the Carbon Reduction Program (Federal Highway Administration [FHWA], 2022a). The IRA and IIJA also dedicated additional funding for the Diesel Emissions Reduction Act Program (U.S. EPA, n.d.b), the Congestion Mitigation and Air Quality Improvement Program (FHWA, 2022b), the Clean Ports Program (U.S. EPA, n.d.a), the Port Infrastructure Development Program (Electrification Coalition, 2023), and the National Freight Highway Program (Electrification Coalition, 2023), into all of which Pennsylvania can tap to support heavy-duty fleet decarbonization (Electrification Coalition, 2023).

3 See the Last Mile Coalition coordinated by the New York City Environmental Justice Alliance (Last Mile Coalition, 2023); the launch of the International Brotherhood of Teamsters' (2022) Amazon Division; the campaign for the indirect source rule led by the Center for Community Action and Environmental Justice (Ibrahim, n.d.)

CASE STUDY

THE ELECTRIC VEHICLE INFRASTRUCTURE TRAINING PROGRAM AND THE IBEW

The Electric Vehicle Infrastructure Training Program (EVITP) provides electricians with training and certification to install electric vehicle charging infrastructure (U.S. Department of Transportation [DOT], 2023). It was developed in part by the IBEW, and is taught in union-run Electrical Training Alliance centers (IBEW, 2022). The National Electric Vehicle Infrastructure (NEVI) Formula Program, established through funding from the IIJA and administered by the FHWA, requires that all electricians installing EV charging infrastructure have an EVITP certification or have graduated from a Registered Apprenticeship Program for electricians that includes electric vehicle supply equipment (EVSE)-specific training (PennDOT, 2022b). Additionally, for projects requiring more than one electrician, at least one electrician must meet the requirements above, and at least one electrician must be enrolled in an electrical registered apprenticeship program (PennDOT, 2022b). All other onsite, nonelectrical workers directly involved in the installation, operation, and maintenance of EVSE must have graduated from a registered apprenticeship program or have appropriate licenses, certifications, and training as required by each state (PennDOT, 2022b). Pennsylvania is slated to receive $171.5 million from the NEVI program from 2022 to 2026 (FHWA, n.d.), and plans to use some of the NEVI funds earmarked for workforce development to expand the EVITP and recruit more EVITP certified electricians. Union electricians in Pennsylvania have been installing EVSE since 2011 (Fletcher Jr., 2022). There are 15 Electrical Training Alliance training centers across Pennsylvania, and training centers like the West Pennsylvania Electrical Joint Apprenticeship Training Committee in Pittsburgh are already providing EVITP certification courses (IBEW-NECA Training Alliance, n.d.; Reinert et al., 2023). These training centers will be instrumental in NEVI implementation in Pennsylvania and for the buildout of EVSE for the decades beyond. The model of building infrastructure by building out union training centers leverages a key strength of American unions – the provision of gold-standard training and registered apprenticeship opportunities to workers by worker-led organizations with incomparable industry expertise – to expand access to family-sustaining union careers, build equity, and drive the clean energy transition.

An electric vehicle charging station. Credit National Energy Technology Laboratory, U.S. Dept. of Energy

AGRICULTURE

Farms are integral to Pennsylvania: the Commonwealth ranks first in mushroom production, fourth in wine production, and seventh in dairy production in the U.S., and the sector generates $132.5 billion in direct economic output (Grissinger, 2023). Agriculture is such a huge part of Pennsylvania's economy that one in ten jobs in the Commonwealth is in the agriculture and food industries (PA Department of Agriculture, n.d.e). While agriculture accounts for only 3.8% of total emissions, emissions in this sector have increased 22.2% since 2005, while most other sectors' emissions declined (PA DEP, 2023b). Agriculture is thus a key sector to address in forward-looking emissions mitigation through creation of high-quality jobs.

Addressing rising agricultural GHG emissions, predominantly driven by use of fossil fuels, will help Pennsylvania farmers not only reduce their footprint but also keep costs down, all while creating healthier working conditions for workers. Moreover, Pennsylvania's farms will be highly vulnerable to worsening climate change impacts if the Commonwealth does not invest in innovative solutions that reduce emissions, support local farmland, and protect workers (Grissinger, n.d.). Numerous elements of the agricultural operations process could present opportunities to reduce emissions, including on-farm energy use and livestock management.

Farmworkers already experience physical threats from climate change: heat waves, droughts, and floods continue to exacerbate heat exposure and health issues within the farming community (Castillo et al., 2021). There is a pressing need for equitable, high-quality farm jobs with workplace protections such as heat and air quality standards ***(see the Establish a Robust State OSHA Plan by 2025 to Protect Public and Private Sector Workers from Heat and Air Quality Hazards recommendation on p. xx).*** Empowered with the right to collectively bargain with their employers, agricultural workers could secure union contracts enshrining a vast range of workplace safety and other standards. With the protection collective bargaining affords, these workers would have a much stronger position from which to advocate for the enforcement of those standards (International Labour Organization, 2023). Notably, BIPOC communities in the United States have a lengthy history of grassroots organizing against the privatization of food and the exploitation of farmworkers under capitalism (Singh-Reynoso, 2023). The 1965 Delano Grape Strike led to the creation of the United Farm Workers union and gained better pay, benefits, and protections for workers; the Freedom Farm Cooperative purchased land to empower Black farmers and sharecroppers in 1969; and the Green Guerillas began planting seeds across New York City in 1973 as a radical act for environmental justice, spurring the guerilla gardening movement across the United States (Kim, 2017; SNCC Digital Gateway, n.d.; Green Guerillas, n.d.).

Finally, **to have a truly just transition, Pennsylvania will need to consider the moving parts of farming from the beginning to the end of the life cycle.** A circular biofuel economy will enable Pennsylvania to honor the three tenets of eliminating waste and pollution, circulating materials, and regenerating nature – namely by turning waste into biofuel, circulating materials used for biodigester creation, and regenerating land through Indigenous stewardship (Angarova, 2022).

UFCW 1776 President Wendell Young IV and Secretary-Treasurer Michele Kessler at the Philadelphia Pride Parade in June 2022

RECOMMENDATION

ESTABLISH PENNSYLVANIA'S FIRST AGRICULTURAL WORKERS' RIGHTS ACT TO STRENGTHEN WORKER POWER AND INCENTIVIZE EMISSIONS REDUCTIONS

1. Enact an Agricultural Workers' Rights and Fair Labor Practices Act to ensure organizing and employment protections for farmworkers
2. Increase funding for the Agriculture Energy Efficiency Rebate Program to $12,000 per applicant and amend selection criteria to incentivize strong labor standards

Industrial farmworkers (e.g., people working at large production scales in agriculture) have very few protections on the job, yet face a plethora of physical, biological, and legal hazards in the workplace. These include bacteria, fungi, viruses, and parasites from close contact with livestock; machine-related injuries (tractor accidents were the leading cause of death for farmworkers in 2017); and climate-related threats such as heat exposure, heat illness, and depleted water sources (Castillo et al., 2021).

Half of U.S. farmworkers are undocumented, and many fear the risk of deportation for speaking out about poor working conditions (Castillo et al., 2021). As a result, workplace violations are underreported (EPI, 2020a). Farmworkers in Pennsylvania also lack state legal protections for overtime, paid sick leave, employment discrimination, and sexual harassment (Farmers Assuring Responsible Management, 2021). Agricultural workers are also excluded from the National Labor Relations Act and thus do not have the right to organize or collectively bargain – this exception was established in the 1930s specifically to prevent primarily Black professions, such as agricultural labor, from gaining organizing power (Perea, 2011). Given these long-standing exclusions and disadvantages, Pennsylvania farmworkers have much to gain from protective policies that will at last enable them to organize and advocate for themselves without fear of reprisal.

Do Pennsylvania Farmworkers Have State Law Protections For The Following?
(Farmers Assuring Responsible Management, 2021)

Right to Organize and Collectively Bargain	NO
Overtime	NO
Minimum Wage	
(seasonal)	YES ($7.25)
(permanent)	NO
Hours Worked	
(seasonal)	YES
(permanent)	NO
Paid Vacation or Sick Leave	NO
Paid Family and Medical Leave	NO
Employment discrimination	NO (some federal laws may apply)
Harassment/Sexual Harassment	NO (federal laws may apply)
Farm Labor Housing Conditions	
(seasonal)	YES
(permanent)	NO

In Colorado, the Agricultural Workers' Rights bill authorized agricultural employees to organize and join labor unions, prohibiting employers from retaliation (Agricultural Workers' Rights Act, 2021). In New York, the Farm Laborer Fair Labor Practices Act [FLFLPA] permits farm laborers, including those who are undocumented, to join unions, organize, and collectively bargain (Farm Laborers Fair Labor Practice Act, 2019). The United Farm Workers have successfully unionized 500 workers across five farms in New York since the passage of the FLFLPA (Greenhouse, 2023). Pennsylvania should develop an Agricultural Workers' Rights and Fair Labor Practices Act, modeled after successful legislation in other states, to finally allow the workers who feed the Commonwealth to safely organize and collectively bargain around the aforementioned issues.

Reduce emissions through energy efficiency measures on farms across the state

To further shore up labor standards while reducing agricultural emissions, the Commonwealth should couple measures to upgrade energy efficiency on farms with incentives for employers to offer workers higher-quality careers with stronger protections. Firstly, because energy efficiency upgrades have strong emissions reduction potential – for example, dairy farms that have implemented efficiency measures have seen an average of 46% reduction in their energy costs (Gould, 2022). Pennsylvania should make available to agricultural employers the same energy efficiency upgrade funding incentives offered in other sectors – while the PA DEP's Small Business Advantage Grant Program covers up to 80% of efficiency project costs, with 50% as the floor (PA DEP, n.d.m), the Agriculture Energy Efficiency Rebate Program currently only covers up to 50% of project costs (PA DEP, n.d.b). The Commonwealth should increase this rebate program to offer $12,000 per applicant, which would cover roughly 80% of project costs. The Commonwealth should also attach these rebate incentives to selection criteria based on applicant employers' commitment to adopting pro-worker and pro-equity energy efficiency measures. These measures could include directing cost savings from emissions-reducing adaptations toward demands that agricultural workers have long been making, such as increasing worker pay, benefits, and health and safety standards on the job; creating more high-quality agricultural careers; funding skills training for workers; providing yearly bonuses; and providing paid leave (Fair Food Standards Council, 2022).

High-Quality Labor Standards: Pennsylvania should enact Agricultural Workers' Rights and Fair Labor Practices legislation that affords Pennsylvania agricultural workers the right to organize and collectively bargain with protection from retaliation. Once agricultural workers have organizing rights, the Commonwealth must invest in necessary administrative costs to ensure timely processing of petitions for union recognition and adjudication of disputes arising from collective bargaining or other labor-management relations.

Cost: $7,010,000 per year.

Job Creation: 27 direct jobs per year. 189 direct jobs through 2030.

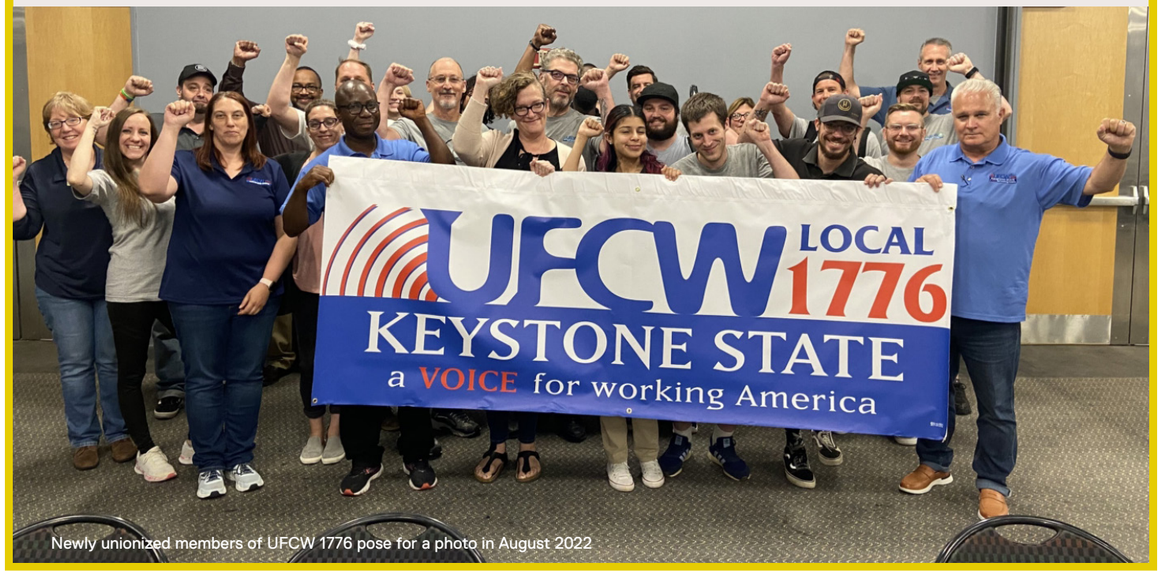
Funding: In June of 2023, the U.S. DOL awarded the Pennsylvania Department of Labor and Industry $2.9 million for workforce development (Urie, 2023). These funds are meant to help states design services that improve employment opportunities, especially for members of underserved and underrepresented populations, and could be used to improve these opportunities in the agricultural sector (U.S. DOL, 2023a).

The Commonwealth should also ensure continued, adequate funding for programs created through or supported by the 2019 Pennsylvania Farm Bill Package (PA Farm Bill Package, 2019). The 2019 Farm Bill and subsequent related legislation have funded numerous grant programs and other resources for removing barriers to entry in the agricultural sector and creating more opportunities for professional growth (PA Dept. of Agriculture, n.d.c). Future allocations to Farm Bill initiatives should include funds to support the passage of an Agricultural Workers' Rights and Fair Labor Practices Act, such as funds needed to cover administrative costs associated with new organizing by agricultural workers once empowered to unionize.

CASE STUDY

UNITED FOOD AND COMMERCIAL WORKERS' UNION CITIZENSHIP ACTION NETWORK

Nearly half of all American farmworkers are undocumented immigrants, and many fear retaliation from their bosses – up to and including removal from the United States – if they speak up about their working conditions (Castillo et al, 2021). The United Food and Commercial Workers (UFCW's) Union Citizenship Action Network (UCAN) program is helping undocumented workers in the food and commercial industries on the path to citizenship. The UCAN program trains UFCW stewards and staff in navigating the naturalization process and provides the proper documents, legal counsel, and other assistance to undocumented workers (UFCW Local 1776, n.d.). The Pennsylvania-based UFCW Local 1776 has helped more than 600 members and their families become naturalized citizens and has also started "The Dream Fund," a scholarship program to help cover the cost of applying for citizenship, which is currently $725 (UFCW Local 1776, n.d.). More unions should look to this model of helping workers seeking to organize to learn about and assert their rights without fear of retaliation, thus facilitating unionization and growing more equitable, inclusive union membership.



Newly unionized members of UFCW 1776 pose for a photo in August 2022

RECOMMENDATION

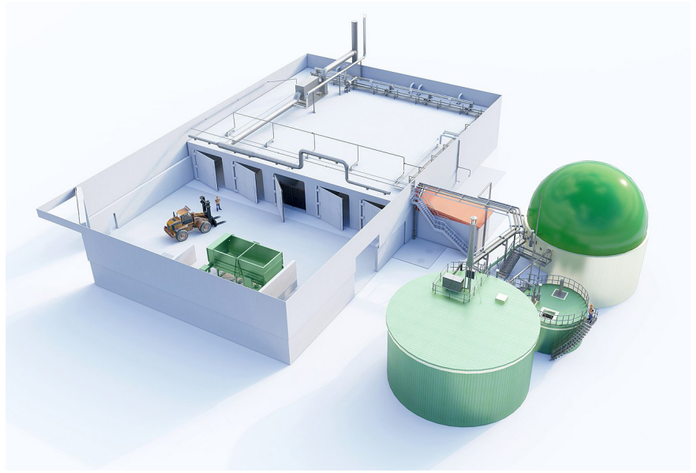
CREATE A CIRCULAR BIOFUEL ECONOMY TO BOLSTER LAND USE RETENTION, RENEWABLE ENERGY, AND DOMESTIC PRODUCTION

To create a circular agricultural biofuel economy, the Commonwealth should:

1. **Establish bulk procurement process to build community-owned domestic anaerobic digesters (ADs) on over 300 of Pennsylvania's dairy farms by 2035 with union labor**
2. **Increase funding sources from the Pennsylvania Department of Agriculture and the PA DEP by $68.6 million per fiscal year to build ADs**
3. **Utilize existing land easement programs to create land back initiatives for indigenous stewardship**

Pennsylvania agriculture is a robust sector (Grissinger, n.d.). However its future remains uncertain: acres of farmland across the Commonwealth fell by 6% between 2012 and 2017, and the sector's workforce is aging, as 26% of producers are 55–64 years old, whereas a mere 3% are younger than 25 (Gill, 2021; PennState College of Agricultural Sciences, 2017). Livestock waste threatens local ecology such as the Chesapeake Bay, with roughly 16% of nitrogen pollution and 35% of phosphorus pollution originating from manure runoff (Chesapeake Bay Foundation, 2015). Lastly, the costs of farming keep rising: in 2020, the annual baseline energy cost on farms surpassed $54 billion collectively (PA DEP & EnSave, 2020).

Moving toward new farming systems has never been more essential. A circular economy model for Pennsylvania's agricultural sector would establish a throughline between agricultural production areas, bolstering the sector's domestic production, increasing land use retention, and benefiting Pennsylvania's historic agricultural communities all while reducing both costs and emissions (United Nations



A diagram demonstrates anaerobic digesting infrastructure

Industrial Development Organization, n.d.).

Fund and build community-owned domestic anaerobic digesters on large livestock farms by 2035

Generating, or the process by which anaerobic digesters break down organic waste and convert it to energy, is one of the most technical and crucial elements of the circular model. To scale this process most effectively, the Commonwealth should focus on larger farms – e.g., those with more than 200 dairy cows. There are 317 farms within this scope in Pennsylvania that are not yet equipped with ADs, representing 25% of the dairy cow population throughout the Commonwealth (U.S. EPA, 2023f; U.S. Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2023). These 317 farms currently emit around 1.1 billion MTCO2e annually, equivalent to almost 250,000 gasoline-powered vehicles being driven for an entire year (U.S. EPA, n.d.c).

To achieve a significant build-out of anaerobic digestion infrastructure by 2035, the Commonwealth will need to fund the manufacturing and deployment of ADs to these farms over the next 12 years at $62.9 million annually. The Commonwealth can use bulk procurement to build and implement anaerobic digestion infrastructure in a more financially feasible way, and should aim to purchase from in-state producers to bolster Pennsylvania's steel and manufacturing industries (McCabe et al., 2020). Pennsylvania should leverage its bulk purchasing power by incentivizing providers of materials and services to meet prevailing wage requirements, adhere to targeted hiring goals, and maintain LPAs or take equivalent proactive measures to avoid disruption from labor disputes.

Integrating anaerobic digester systems with farms can reduce the threat of pathogens and GHG emissions in manure while increasing access to low-carbon electricity and biogas to offset fossil fuels on agricultural land (McCabe et al., 2020). Some farms in Pennsylvania are already using anaerobic digestion for electricity and cogeneration purposes. For instance, the Brubaker Farms digester in Mount Joy, PA uses a cogeneration model for more than 1,200 dairy cows; the farm has USDA funding and produces 90,000 cubic feet of biogas per day along with 1,025,303 kilowatt hours (kWh) of electricity annually (U.S. EPA, 2023f).

Expanding financial support for the creation of community-owned and -operated anaerobic digesters, at a larger scale than some existing generation models, will enable more farms in the region to attain clean energy security, setting the Commonwealth's agricultural sector on a path to a robust, promising future.

Use Pennsylvania's land easement programs to return land to Indigenous peoples and expand productive farmland statewide

Pennsylvania has protected land through government land trusts and conservation programs that can be used to expand long-term native land stewardship (USDA Natural Resources Conservation Service, n.d.). Legally recognized Indigenous territories around the world have lower deforestation rates than the surrounding areas (Stevens et al., 2014). This is important because when "communities like [Indigenous groups] get full rights to [their] forests, [they] protect them, preserve huge stores of carbon, and help mitigate climate change" (Tegar, 2020, para. 7).

About 25% of land area in Pennsylvania is farmland, and counties with high agricultural productivity are facing urbanization pressures (Gill, 2021). The agricultural land easements component of the Agricultural Conservation Easement Program seeks to prevent productive land from being converted for non-agricultural uses and allows state and county governments to purchase easements from farmowners (USDA Natural Resources Conservation Service, n.d.; PA Department of Agriculture, n.d.a). Eligible partners and landowners include Indigenous peoples, creating an opportunity for productive land under the threat of urbanization and development to be returned to Indigenous groups and allowing working farmland that has been in decline to begin the growing cycle again (USDA Natural Resources Conservation Service, n.d.).

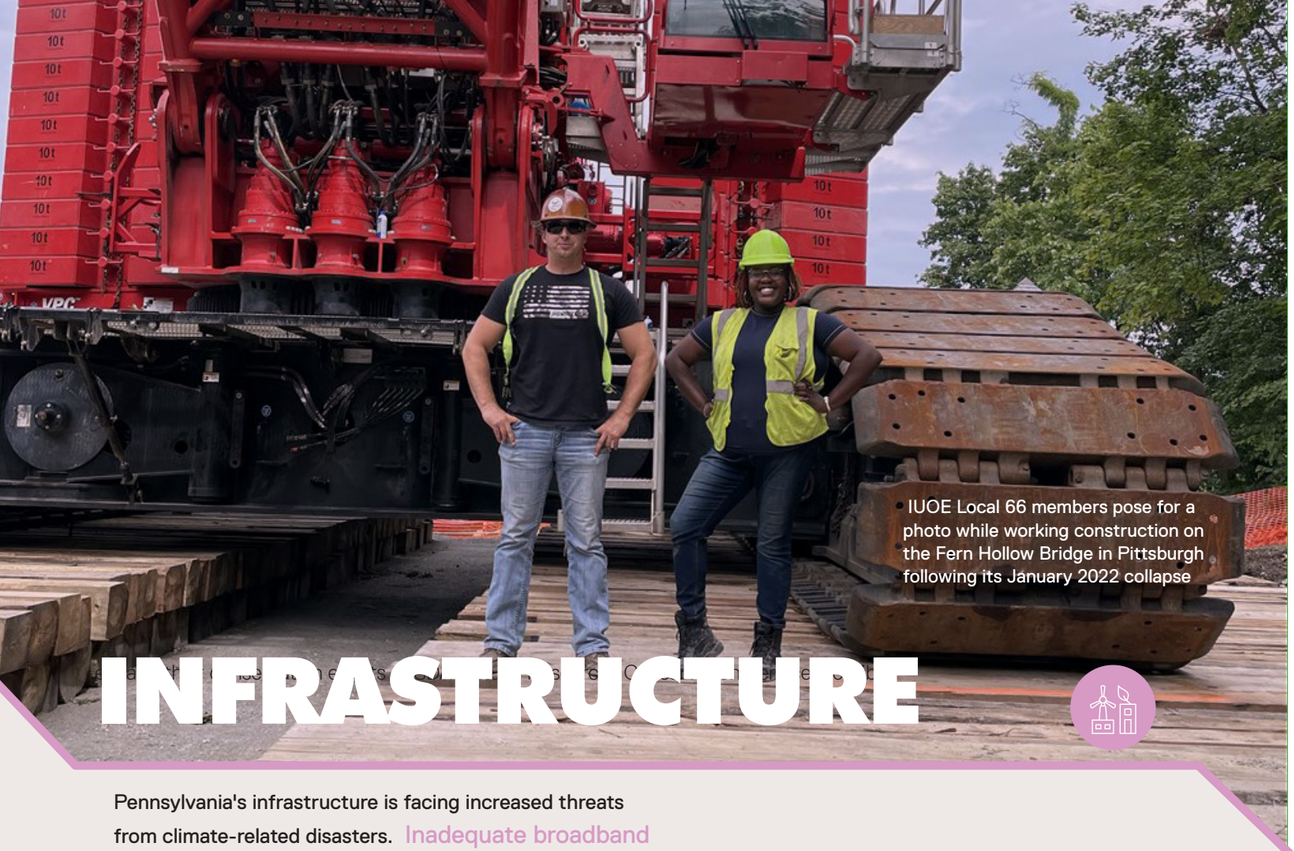
High-Quality Labor Standards: When engaging in bulk procurement (e.g. for the construction of anaerobic digesters), Pennsylvania should incentivize – or require when possible – providers of materials and services to meet prevailing wage requirements, participate in quality registered apprenticeship ad pre-apprenticeship programs, pursue targeted hiring, and maintain LPAs or PLAs or equivalent proactive measures to minimize disruption from labor disputes. Additionally, through its leases for publicly-owned land, Pennsylvania can look to setting minimum standards for labor conditions for the construction and agricultural work on said land.

Cost: $62,900,000 per year.

Job Creation: 180 direct jobs per year. 1,260 direct jobs through 2030.

Emissions Reduction: 647,000 MT CO_2e per year.

Funding: Several programs can help support emerging biofuel technologies: the USDA's Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program; the Environmental Quality Incentives Program (EQUIP); and the Pennsylvania Department of Agriculture's Machinery and Equipment Loan Fund (MELF) (USDA Rural Development, 2015; Topper et al., 2023). Additionally, the IRA provides funding for the Agricultural Conservation Easement Program to help farmers

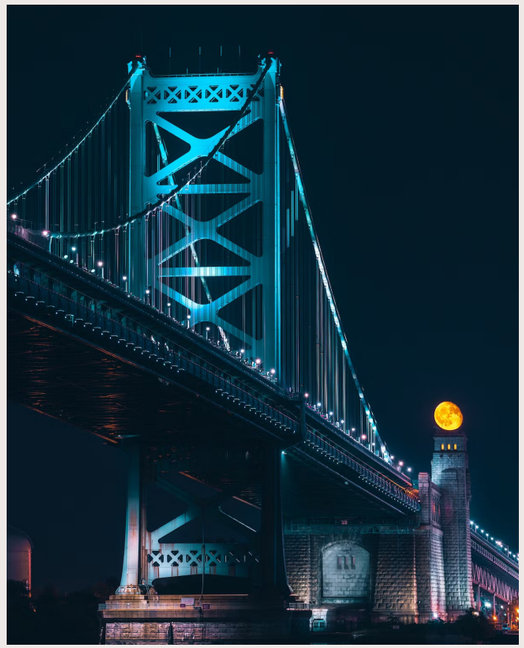


IUOE Local 66 members pose for a photo while working construction on the Fern Hollow Bridge in Pittsburgh following its January 2022 collapse

INFRASTRUCTURE

Pennsylvania's infrastructure is facing increased threats from climate-related disasters. Inadequate broadband infrastructure, deficient water management systems, and insufficient readiness for escalating heat risks require urgent attention. The Commonwealth's infrastructure challenges may worsen as climate shifts intensify. Yet these challenges also hold promise – specifically the chance to generate high-quality employment opportunities through essential infrastructure enhancements that make Pennsylvania healthier and safer for its residents.

Digital infrastructure should be a central component of any plan to update Commonwealth infrastructure overall. Pennsylvania must invest in making secure high-speed internet available to every resident who wants it, not only because high-speed internet is now often required for many essential professional, medical, and educational services (PA Broadband Development Authority [PBDA], 2023), but also because digital access will be key to allowing residents to deploy advanced energy technology that can render homes much more energy-efficient (for example, by allowing residents to safely store power and deploy it only when needed). Currently, numerous Commonwealth communities are unserved or underserved by broadband, negatively impacting Pennsylvanian students, employees, telemedicine patients, and job seekers, among others (Miller, 2022). The digital divide is particularly steep for marginalized communities (Hale, 2023).



The Ben Franklin Bridge in Philadelphia illuminated at night. Credit Dylan Sauerwein

While broadband expansion is critical to achieving Pennsylvania's climate and equity goals, it also has notable carbon effects (Crawford, 2022). As Pennsylvania continues to direct funds towards increasing access to broadband internet, the Commonwealth's broadband infrastructure will need to expand (Miller, 2022). However, the more users are connected to a network, the lower the footprint of each user, meaning that high volumes of connection will be critical to any energy efficiency plan for internet service (Crawford, 2022). Given the existing need to expand broadband access, Pennsylvania is uniquely positioned to simultaneously address these accessibility issues and enhance its overall network's efficiency.

As precipitation and flooding become more severe, Pennsylvania's water management infrastructure – including its many aging bridges and dams – requires major updates (PA State Council of ASCE, 2022). The Commonwealth's stormwater management and sewer systems are ill-equipped to handle heavy precipitation induced by climate change (PA DEP, n.d.a). Pennsylvania has the most combined sewer overflows (CSOs) of any state, which can dump untreated sewage into recreational and drinking water sources, posing a significant risk to public health (Zhorov, 2015). Lead poses another threat to drinking water in Pennsylvania, which has the fourth-highest number of lead service lines in the country at 689,000 (Bilinski, 2023; Office of Water, 2023). Mitigation will be costly – among all states, the Commonwealth's water infrastructure requires the fifth-highest total investment over the next 20 years (Office of Water, 2023).

In addition to addressing water management issues, as temperatures rise throughout Pennsylvania, heat-related complications present a growing threat to all residents. Pennsylvania's urban residents – who are disproportionately BIPOC and lower-income – experience more severe heat waves due to the urban heat island effect (Climate Central, 2023). Some neighborhoods in Philadelphia are up to 22ºF hotter than others (PA DEP, 2021a). Extreme heat is also more dangerous for outdoor laborers, people without access to air conditioning or shade, and individuals without adequate workplace safety protections – in 2015, 80 workers experienced nonfatal injuries or illness from heat exposure (U.S. BLS, 2017). This number may rise as temperatures climb annually.

Importantly, hiring public sector workers to perform infrastructure upgrades will allow Pennsylvania to set high-road labor standards on these projects and grow an even more robust public sector workforce through its response to climate challenges. The climate crisis demands innovative solutions, collaborative efforts, and decisive action to secure a resilient and equitable future for all Pennsylvanians. Ensuring that the Commonwealth's infrastructure is sustainable, built by highly skilled workers, and can keep residents safe for decades to come will be essential to any such future.

Deer Lake Dam in Schuylkill County

RECOMMENDATION

EXPAND HIGH-SPEED BROADBAND ACCESS TO 1.3 MILLION DIGITALLY EXCLUDED HOUSEHOLDS BY 2028 USING LOCAL, UNION WORKERS

1. Install 5,361 miles of fixed wireless cable, construct 80 cell towers, and build 200 service locations to connect or upgrade 333,000 locations to provide clean-energy-powered broadband with a local, unionized workforce
2. Regulate internet service providers as utilities to ensure uniform standards and expedited rollout to underserved communities
3. Provide free home broadband internet to 548,000 low-income families
4. Increase broadband in schools and expand schools' information technology departments to support new technologies and train personneltechnologies and train personnel

Statewide, over 652,000 households – nearly the entire population of Pittsburgh and Philadelphia combined – did not have a broadband internet subscription between 2018 and 2022 (U.S. CB, 2022e). Furthermore, only half of each county's residents have true broadband as demonstrated by download speeds (Meinrath et al., 2019). In total, 1.3 million households are digitally excluded, meaning they lack reliable broadband, access to necessary technologies, digital skills, and/or technical support (PBDA, 2023).

Lack of connectivity has widespread effects: residents without Internet have fewer job opportunities and limited healthcare, and students without Internet – of which there are nearly half a million in Pennsylvania – experience lower school attendance and performance (Task Force and Advisory Committee on High-Speed Broadband Service, 2022; Miller, 2022). Low-income, BIPOC residents disproportionately feel the impact of poor connectivity. In Pennsylvania, Black households are nearly twice as likely as White households to lack a broadband subscription (U.S. CB, 2022e).[4]

Install broadband infrastructure with a local, unionized workforce

Building out high-speed internet in all corners of the Commonwealth will create substantial job opportunities in the next five years. **Installing the necessary 5,361 miles of fixed wireless cable, constructing 80 cell towers, and building 200 broadband service locations will require more than 38,000 crews containing over 116,000 total workers** (PBDA, 2022). Many of these jobs are union, whether in-house with utilities (i.e., Communications Workers of America) or through contractors using union hiring halls (i.e., the International Brotherhood of Electrical Workers). By expanding services to all residents, Pennsylvania can support climate resilience and equity while promoting local economic opportunities.

Empower the Public Utility Commission to regulate internet service providers

One in four Pennsylvanians lives in a rural county, and one-quarter of students attend public schools in rural districts (Center for Rural Pennsylvania, n.d.). Reliable internet can help rural residents to stay connected, especially where cell phone service is inconsistent. It is also essential to many home energy efficiency and electricity demand management measures, such as 'smart' thermostats, energy storage, and management. Unfortunately 14.4% of rural households lack internet (Showalter et al., 2023).

Currently, Pennsylvania law prevents local governments from operating as internet service providers themselves (Scicchitano, 2023). Additionally, telephone companies have used their "right of first refusal" over local governments to block broadband expansion into smaller, rural areas (Keith, 2022). Federal guidance

4 Based on the 2018-2022 ACS survey, while only 3.8% Pennsylvania's white households were without a broadband internet subscription, 7% of Black households were without broadband internet. U.S. Census Bureau. (2022-e). *Types of Internet Subscriptions by Selected Characteristics - 2018-2022 American Community Survey 5 Year Estimates.* https://data.census.gov/table/ACSST5Y2022.S2802?g=040XX00US42

BROADBAND ACCESS IS AN EQUITY ISSUE

One in three poorest households have no internet subscription

Percent of PA Households with No Internet Subscription by Income Block

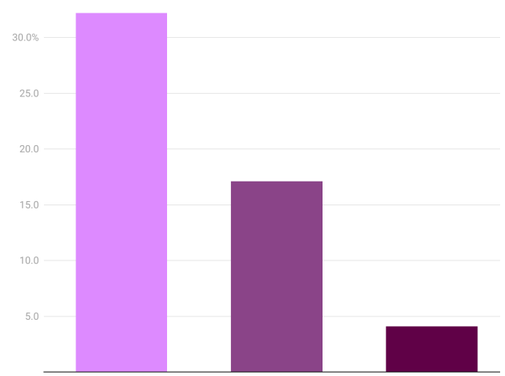


Chart: Jillian Morley, M.P.A., Research Support Specialist, Cornell ILR Climate Jobs Institute, jam835@cornell.edu • Sourc
2018-2022 American Community Survey • Created with Datawrapper

Black households are almost 2x as likely to be without internet as white households

Percent of PA Households Without Internet Subscription by Race

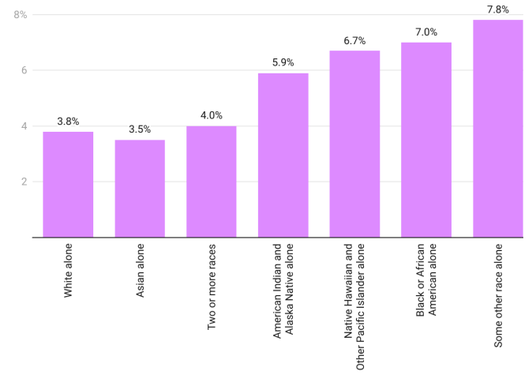


Chart: Jillian Morley, M.P.A., Research Support Specialist, Cornell ILR Climate Jobs Institute , jam835@cornell.edu • Sourc
2018-2022 American Community Survey • Created with Datawrapper

Pennsylvania should target its broadband expansion efforts to reach low income and Black households, which disproportionately lack internet subscriptions.

encourages states to suspend laws like these to assist with the prompt rollout of universal broadband (National Telecommunications and Information Administration, 2022), but Pennsylvania has yet to do so (Keith, 2022). Further, Pennsylvania's Public Utility Commission (PUC) does not have the power to regulate cable providers or other non-telephone companies that provide internet (PA Public Utility Commission, n.d.a), nor can the Commission regulate prices or download speeds above a very low minimum (Act 183, 2004).

However, if state law gave the PUC power to regulate internet service providers (ISPs) as public utilities, it could ensure that planned projects meet public needs through its approval process. Once this law is in place, the PUC should consider both the socioeconomic impact on local residents as well as environmental factors when approving projects. The Commonwealth can incentivize the most efficient network structure to minimize energy consumption (Crawford, 2022). Finally, the Commonwealth should prioritize broadband expansion on existing public rights of way to minimize disruption and maximize public benefit, as it has done on public highways (PA Turnpike Commission, 2022).

Establish a free broadband program for low-income households

As Pennsylvania finalizes its broadband plan for the next five years, it should incorporate free home internet for the estimated 548,000 low-income households without internet subscriptions, as well as subsidize costs for additional low-income households that are currently paying beyond their means for connectivity (U.S. CB,

2022e).[5] Current state and federal programs provide only minimal subsidies ($30/month or about half of the current cost of a broadband subscription), and the eligibility cutoff is 200% of the federal poverty line – merely $60,000 for a family of four (U.S. Affordable Connectivity Program, 2023; Scicchitano, 2023). To cover the estimated 548,000 low-income households without internet, Pennsylvania should (a) increase eligibility for these subsidies up to 400% of the federal poverty line, and (b) expand its eligibility criteria to include households within frontline or energy communities (U.S. CB, 2022e).

Increase broadband access and technology training in schools

Cities including Philadelphia have piloted free internet programs for students and their families with great success (Office of Innovation and Technology, 2022; Partnership for Los Angeles Schools, 2022; Kids First Chicago, 2020). Only 70% of Philadelphia households had Internet before the pilot program; now, 84% of households have wired, high-speed internet (Office of Innovation and Technology, 2022). The Commonwealth should also hire additional teachers and technology experts in school districts and public libraries to assist families with adopting and utilizing these technologies.

High-Quality Labor Standards: Pennsylvania has taken strong steps toward a union build-out of broadband internet, but can go further to ensure maximum benefits for workers. The Commonwealth created the Pennsylvania Broadband Development Authority (PBDA) to regulate the distribution of $1.16 billion in federal funds to local entities (Act 96, 2021). As part of its Broadband Action Plan, the Commonwealth has proposed a scoring rubric for localities and businesses applying for sub-grants from these funds that would award applicants 15% for paying the prevailing wage and another 10% for prioritizing equitable workforce and job quality (e.g., PLAs, union letters of support, on-the-job training, and targeted hire) (PBDA, 2023). Unions have been engaged in this process and have recommended best practices for ensuring a highly trained workforce (IBEW, 2023).[6] However, the grant process should give greater weight to labor standards, discourage subcontracting (especially when it interferes with targeted hiring goals), and include a clawback provision to withdraw state funds for violations of labor commitments (IBEW, 2023).[7] These quality standards are essential for meeting the program's equity and access goals (Erlich & Herzenberg, 2023).

Pennsylvania should also bulk-purchase supplies for rural broadband expansion, including cables and construction materials, which it can then sell to its sub-grantees at cost. Bundling these materials will allow Pennsylvania to maximize savings as well as support Buy American policies, by ensuring that supplies produced in high volume for Commonwealth use are made in facilities that conform to strong labor standards and even by encouraging LPAs at these facilities to guarantee uninterrupted supply. Additionally, all leases to expand broadband on state-owned or leased land should have standard terms promoting high-quality, on-time work for construction and operations workers on site (e.g., PLAs). Further, prevailing wage requirements may apply to all or a portion of the work under Pennsylvania's Unserved High-Speed Broadband Funding Program (UHSB) grants to nongovernmental entities for middle-mile and last-mile broadband deployment to unserved areas (PA DCED, 2021). The Commonwealth should amend the UHSB grant application procedure to evaluate grant applicants' plans for local job creation and workforce development goals, as well as check applicants for any history of labor law violations.

Job Creation: The Broadband, Equity, Access and Deployment Action Plan is anticipated to produce 116,807 jobs over five years to reach 333,000 unserved or underserved PA locations (PBDA, 2023). This reach covers 460 workers and 540 splicers and 115,807 fixed wireless personnel over the five-year construction period (PBDA, 2023).

5 548,854 households without internet subscription fall below 375% of the lowest ACS income category. U.S. Census Bureau. (2022-e). Types of Computers and Internet Subscriptions - 2018-2022 American Community Survey 5-Year Estimates. https://data.census.gov/table/ACSST5Y2022.S2801?q=broadband&g=040XX00US42

6 IBEW Comments on BEAD Vol. II (November, 2023) (on file with the authors).

7 IBEW Comments on BEAD Vol. II (November, 2023) (on file with the authors).

Cost:

Broadband Infrastructure: $414,000,000 per year.
Internet Coverage: $557,000,000 per year.

Funding: The federal Broadband, Equity, Access and Deployment program, established in the IIJA, granted Pennsylvania $1.16 billion for broadband deployment, mapping, equity, and adoption services (Office of Governor Josh Shapiro, 2023). Through the IIJA's Digital Equity Act, states will receive another $2.75 billion to support skills development in individuals and communities. Pennsylvania can use these funds to hire and train new employees who will support households and students receiving free broadband (National Telecommunications and Information Administration, n.d.). Additionally, Pennsylvania's Unserved High-Speed Broadband Funding Program (UHSB) provides grants of up to $1 million per project – up to 75% of project costs (PA DCED, 2021; PA DCED, n.d.e).

RECOMMENDATION

BUILD CLIMATE-RESILIENT, CLEAN, UNIVERSALLY AFFORDABLE WATER INFRASTRUCTURE USING LOW-CARBON AND PA-MADE MATERIALS

1. Invest in repairing Pennsylvania's high-hazard bridges and delivering clean, universally affordable drinking water to all residents by 2030 by replacing all lead service lines and cleaning up per- and polyfluoroalkyl substances (PFAS)
2. Incentivize private dam repairs and modernization by 2030 with funds attached to labor standards
3. On all public work or work receiving public funds, require PLAs, prevailing wage, and union apprenticeship program hiring

Pennsylvania union members responding to the Fern Hollow Bridge collapse in Pittsburgh in January 2022

Pennsylvania's bridges, dams, and pipelines urgently require repairs and updates to ensure residents have access to clean drinking water and remain safe in the face of worsening climate change. Historical and recent data on flooding indicate that Pennsylvania will see a marked increase in climate change–related rainfall and floods by 2050 (McDevitt, 2021; Sharma et al., 2021). In 2018, the PA Department of Transportation estimated that record-high rainfalls (which were again exceeded in subsequent years) caused more than $105 million in damage to state-maintained roads and bridges (PennDOT, 2018; Kellar, 2019).

From bridges to dams to water service lines, Pennsylvania's water infrastructure is ill-equipped to withstand these increasingly extreme weather events. Pennsylvania has the second-highest number of poor-condition bridges in the country; they are also 45 years older than the national average (PA State Council of ASCE, 2022). Pennsylvania's dams, which are essential to managing potential floods and general water flow during storms, are also 20 years older than the national average at 76 years old (PA State Council of ASCE, 2022). With 285 Pennsylvania bridges closed due to safety concerns – primarily flood hazards – and more than half of the Commonwealth's dams considered "high-hazard" (operating precariously enough that failure or misoperation could cause fatalities), the Commonwealth's aging water infrastructure poses imminent and significant risks (PA State Council of ASCE, 2022). As just one example, in January 2022, Pittsburgh's Fern Hollow Bridge spontaneously collapsed as a result of corrosion caused by undrained water deposits (National Transportation Safety Board, 2023). The risks associated with Pennsylvania's outdated water systems go beyond the threat of structural collapse: the Commonwealth also has the fourth-highest number of lead service lines for drinking water in the country, and nearly 9,000 Pennsylvania children suffer from lead poisoning each year (Office of Water, 2023; Bilinski, 2023).

As in many states, Pennsylvania's lower-income residents are most vulnerable to current and potential harms from deficient water infrastructure. Lower-income households disproportionately live in areas with greater flood risks and are less likely to be covered by flood insurance (Rosenfeld & Hartman, 2023). A 2022 study showed that both household income and race are correlated with a higher risk of lead poisoning in Philadelphia, aligning with studies conducted in other geographic areas (Baillie, 2022).

Increasing the weather resilience of municipal infrastructure usually entails fortifying the built environment (Jongman, 2018). Efforts must also address disparate impacts on lower-income communities that are more susceptible to infrastructure failures, including by focusing hiring for new public works jobs on areas where these communities live, and by prioritizing funding for repairs in those areas (Jongman, 2018). Pennsylvania can support the Commonwealth's industrial economy by procuring low-carbon cement, green steel, and other sustainable materials – sourced in-state when possible – for these climate resilience construction projects ***(see Expand Pennsylvania's "Buy American" Requirements and Promote Clean Domestic Manufacturing to Support Good Jobs on p. XX).***

The Commonwealth should also create insurance subsidies for private dam owners to incentivize consistent maintenance work performed by high-quality union labor on Pennsylvania's privately-owned dams, which constitute 61% of all in-state dams (including 391 "high-hazard" dams) (PA State Council of ASCE, 2022). Commonwealth agencies could also allocate federal funds earmarked for dam infrastructure toward grants or loans to fund private dam repairs. For both public and private dam repairs, the Commonwealth should prioritize funding dams that are high-hazard and located in close proximity to disproportionately vulnerable, lower-income communities ***(see the Tap Into Renewable Energy Potential by Retrofitting Pennsylvania's Non-Powered Dams for Hydroelectric Energy recommendation on p. XX).***

The Commonwealth has initiated several updates to its water systems, including by setting a goal of replacing all lead service lines by 2026 and committing more than $200 million to updating its stormwater and sewage overflow management (PA DEP, 2023a; Ridlington & Rumpler, 2022). Pennsylvania is also slated to receive hundreds of millions of dollars of IIJA funds for dam safety and rehabilitation, highway and bridge repairs, and improvements for drinking water and stormwater pipelines (PA State Council of ASCE, 2021; Turner, 2021).

While federal funding is a critical piece of the plan to fix Pennsylvania's water infrastructure, recent federal allocations still fall short of the estimated $18 billion needed for bridge repairs (PA State Council of ASCE, 2022) and the estimated $16 billion needed to repair the Commonwealth's public water system (U.S. EPA, 2023c; PA DEP, 2023b). Additional funding from the Pennsylvania legislature will be required to make the necessary improvements to the Commonwealth's overall water infrastructure. To ensure that this infrastructure is both safe and remains universally affordable, state and municipal policymakers should prevent any further privatization of Commonwealth sewer or water systems and should reverse policies that have allowed profiteering private companies to buy water utilities in order to hike rates astronomically and displace costs onto vulnerable residents (66 Pa. C.S. § 1329, 2004; Brown, 2023).

Repair and modernization work on Pennsylvania's water systems will create numerous jobs across Commonwealth industries, including for pipefitters, plumbers, construction workers, and electricians (E2 & United Association of Plumbers & Pipefitters, 2021). Pennsylvania should ensure that a robust in-state workforce can meet these forthcoming labor demands by investing now in supporting and partnering with union-affiliated quality pre-apprenticeship and registered apprenticeship programs.

High-Quality Labor Standards: Pennsylvania should encourage, and when possible require, contractors to ensure timely, undisrupted, and maximally impactful completion of public water system projects by entering into PLAs, requiring recruitment from registered apprenticeship programs, and targeting hiring in communities most impacted by water system failures. When disbursing federal funds through grants or loans to private entities, the Commonwealth should condition those grants or loans on meeting similar labor standards. Conditions for contractors or private recipients can be enforced through compliance affidavits. In any cases where a water system rehabilitation project is exempted from federal prevailing wage requirements, if such cases exist, the state legislature should apply Pennsylvania's prevailing wage law to these projects – when necessary by regulation or statutory amendment.

Credit: Nathan Kelly

Cost:

Bridge Repair: $2,920,000,000 per year.
Clean Drinking Water: $3,910,000,000 per year.
Dam Repair: $433,000,000 per year.

Job Creation:

Bridge Repair: 28,000 direct jobs per year. 196,000 direct jobs through 2030.
Clean Drinking Water: 18,000 direct jobs per year. 126,000 direct jobs through 2030.
Dam Repair: 2,700 direct jobs per year. 18,900 direct jobs through 2030.

Funding: Over the next five years, Pennsylvania will receive $3.85 million from the IIJA for dam rehabilitation and dam safety programs (Adams, 2022), $13 billion from the IIJA for bridge and highway repairs (Turner, 2021), and nearly $266 million from funds directed to the EPA's State Revolving Loan Fund by the IIJA for drinking water pipeline improvements and wastewater management (U.S. EPA, 2023c). The Commonwealth has also allocated nearly $200 million of combined state and federal money toward drinking water, wastewater, and stormwater management projects across 20 counties (PA DCED, 2024).

RECOMMENDATION

ESTABLISH A ROBUST STATE OSHA PLAN BY 2025 TO PROTECT PUBLIC AND PRIVATE SECTOR WORKERS FROM HEAT AND AIR QUALITY HAZARDS

1. Establish a state OSHA plan that covers both public and private sector workers
2. Mandate specific protections for extreme temperatures and poor air quality
3. Create a health hazard fund for workers to take paid leave during unsafe climate events

Increasing temperatures and airborne pollutants are endangering Pennsylvania's workers and communities

2023 was the hottest summer on record and likely the hottest year in human history (Abnett & Dickie, 2023; McDevitt, 2023). Cities in Pennsylvania experienced heat indexes over 105 degrees, and more than 100 schools had early dismissal for the first week in September because they lacked adequate air conditioning (Wood, 2023; CBS News Philadelphia, 2023; CBS News Pittsburgh, 2023). This year was not an anomaly: **in 2022, twice as many Pennsylvanians died from heat exposure than in any year in the previous decade (U.S. Centers for Disease Control and Prevention, n.d.).**[8] Unfortunately, this trend will continue: by mid-century, Pennsylvania will likely face more than 60 days each year exceeding 90 degrees in many parts of the state (PA DEP, 2021a).

Heat presents a compounding threat to human health. Higher temperatures also increase pollen and ground-level ozone levels, which are related to the burning of fossil fuels and industrial processes (U.S. EPA, 2023d; Burrows, 2016). Hotter, drier summers increase the prevalence of wildfires across the continent, which caused multiple "Code Red" and "hazardous" air quality days in 2023 (Tornoe, 2023). Pennsylvania counties averaged nearly one in four days with "moderate" to "unhealthy" air quality over the past decade (U.S. EPA, 2021h; U.S. EPA,2022c).[9] This, in turn, led to poorer air quality for residents and exacerbated health risks including cancer as well as cardiovascular, respiratory, and neurological diseases (National Institute of Environmental Health Sciences, n.d.).

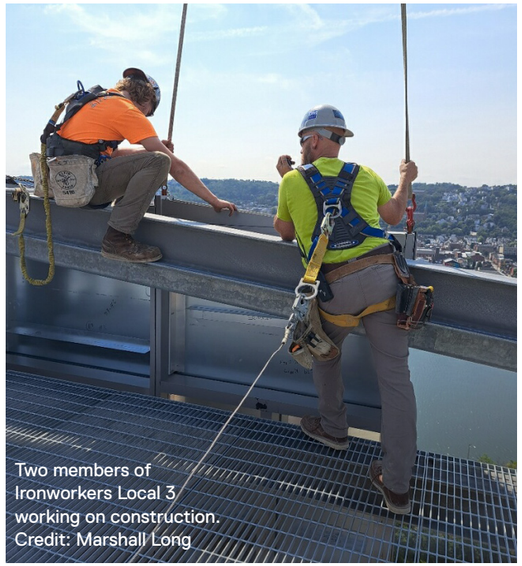
Low-wage workers and frontline communities are most affected by dangerous heat and poor air quality

Pennsylvanians do not experience these climate impacts equally. Nearly one in four Pennsylvanians is at increased risk of heat-related illnesses based on age (e.g. under 5 or over 65 years old), and one in 10 residents younger than 65 has a disability, putting them at greater risk (U.S. CB, n.d.b). **Residents in Pennsylvania's environmental justice communities are nearly twice as likely to experience more high-heat days than the rest of the state (PA DEP, 2021a).** Nationally, non-Hispanic Black adults are more than four times more likely to die of heat-related cardiovascular causes than non-Hispanic White adults (Khatana et al., 2023). Finally, low-wage workers are vulnerable to high heat because they are likely to work and live in areas with limited access to air conditioning (Schmidt, 2022). They also have a higher tendency to work outside in jobs that require exertion, such as landscaping and construction (Schmidt, 2022).

More than 1,000 PA workers reported suffering from heat-related illnesses on the job in the past decade (U.S.

8 Fifty-three people died of heat-related causes in 2022; reported deaths were in the teens or 20s for every year since 2011. U.S. Centers for Disease Control and Prevention. (n.d.). *National Environmental Public Health Tracking Network Data explorer.* https://ephtracking.cdc.gov/DataExplorer/?c=35&i=212&m=-1. Citing 2011-2022 data

9 From 2013-2022, PA counties averaged at least 23% of measured days with moderate to unhealthy air quality levels. U.S. Environmental Protection Agency. (2022-c, November 14). *Air data, "air quality by county,"* (data for PA averaged from 2013-2022). https://aqs.epa.gov/aqsweb/airdata/download_files.html#Annual. Note that during the pandemic, air quality overall improved across the country as people drove less and industry slowed. We do not yet have data for 2023, during which PA experienced several "hazardous" to "very hazardous" AQI days due to Canadian wildfires.



Two members of Ironworkers Local 3 working on construction. Credit: Marshall Long

Centers for Disease Control and Prevention, n.d.).[10] Heat exposure causes the vast majority of exertion-related workplace deaths, and with 81% of construction laborers constantly outdoors, it is most common among construction and nonunion workers who lack the protections of a voice at work (U.S. BLS, n.d.c; ICF, 2023; Morrissey et al., 2023).[11] Workers in key climate mitigation and adaptation industries are especially vulnerable because they are primarily outside while installing infrastructure (e.g. solar arrays, wind turbines, broadband, water and sewage systems, and transportation), making them more susceptible to hazardous conditions.

Pennsylvania must adopt a state OSHA plan that establishes heat and air quality safety standards for public and private sector workers

No state or national laws mandate that employers take steps to ensure workplaces are free from climate-related hazards. The federal Occupational Safety and Health Act (OSHA) mandates only that private employers provide a work environment "free from recognized hazards that are causing or are likely to cause death or serious physical harm;" however, the Act does not contain specific heat safety or air quality standards dictating how employers are to protect workers from these harms (Occupational Safety and Health Act, 2022; Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings, 2021; U.S. DOL, 2022; U.S. DOL, 2023b).[12] It is therefore challenging to hold employers accountable when workers suffer illnesses or injuries related to unsafe temperatures or air quality (U.S. DOL 2001; U.S. DOL, 2011;).[13] Although states can adopt their own plans, which may be more protective than federal law, Pennsylvania does not currently have one. A recent bill passed by the Pennsylvania House of Representatives would establish an OSHA plan for the state's public sector workers that mirrors federal OSHA standards, but would not go further in creating explicit heat or air hazard protections for private or public sector employees (The Jake Schwab Worker Safety Bill, 2023).

10 U.S. Centers for Disease Control and Prevention. (n.d.). *National Environmental Public Health Tracking Network Data explorer.* https://ephtracking.cdc.gov/DataExplorer/?c=35&i=212&m=-1
This number is likely an undercount, as the data comes from employers' voluntary reporting, and many workers and employers do not report occupational illness or injury for fear of reprisal or government oversight.

11 "Constant" outside work is defined as more than two-thirds of the time. U.S. Bureau of Labor Statistics. (n.d.c). *Workplace injuries and job requirements for construction laborers: Spotlight on statistics.* U.S. Department of Labor. https://www.bls.gov/spotlight/2022/workplace-injuries-and-job-requirements-for-construction-laborers/home.htm.
87.6% of exertion-related deaths were due to heat exposure. Morrissey, M. C., Kerr, Z. Y., Brewer, G. J., Tishukaj, F., Casa, D. J., & Stearns, R. L. (2023). Analysis of exertion-related injuries and fatalities in laborers in the United States. *International Journal of Environmental Research and Public Health, 20*(3), 2683. https://doi.org/10.3390/ijerph20032683

12 In 2021, OSHA published an advance notice of proposed rulemaking, but it has been tied up in the administrative process, and is not currently enforceable. Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings, 86 F.R. 59309-59326 (October 27, 2021) (to be codified at 29 CFR Parts 1910, 1915, 1917, 1918, 1926, 1928). https://www.regulations.gov/document/OSHA-2021-0009-0001.
In 2022, OSHA initiated a National Emphasis Program (NEP) that prioritizes inspections at high-risk industries, but this program is not legally enforceable. U.S. Department of Labor. (2022, April 8). *National Emphasis Program—Outdoor and Indoor Heat-Related Hazards.* (CPL 03-00-024). Occupational Safety and Health Administration. https://www.osha.gov/sites/default/files/enforcement/directives/CPL_03-00-024.pdf.

13 In the absence of a specific heat standard, OSHA relies on the General Duty Clause when workers suffer heat-related illnesses and injuries; however, this is difficult to enforce. U.S. Department of Labor. (2001), October 17). *Standard Interpretations: Acceptable methods to reduce heat stress hazards in the workplace.* Occupational Safety and Health Administration. https://www.osha.gov/laws-regs/standardinterpretations/2001-10-17-0#:~:text=Although%20OSHA%20does%20not%20have,are%20free%20%20from%20%20recognized%20%20hazards. OSHA does not have an indoor air quality standard, and relies on the General Duty Clause. U.S. Department of Labor. (2011). *Indoor Air Quality in Commercial and Institutional Buildings* (OSHA 3430-04). Occupational Safety and Health Administration. https://www.osha.gov/sites/default/files/publications/3430indoor-air-quality-sm.pdf

The Commonwealth can protect residents from mounting climate-related risks by creating its own robust state plan for both public and private sector employees that establishes evidence-based requirements to protect workers from climate-related illness and injury. The National Institute for Occupational Safety and Health, as well as several state plans, have adopted rules that can serve as a model for Pennsylvania. These measures include mandated paid breaks at regular intervals, cool water, shade, training, and acclimatization procedures for high temperatures, as well as rules for personal protective equipment, filtration, rest periods, and air flow for hazardous indoor and outdoor air quality (Jacklitsch, 2016; Occupational Safety and Health Administration, n.d.; Wash. Admin. Code § 296-307-097 et. seq., 2024; National Institute for Occupational Safety and Health, 2023; Protection from Wildfire Smoke, 2024; Indoor Ventilation and Temperature in Places of Employment, 2014; Rules to Address Employee Exposure to Wildfire Smoke, 2022).[14] These state-based safety standards must apply to all types of outdoor work (e.g., construction, utility, renewable energy, agriculture, and landscaping) as well as to indoor workplaces, where extreme temperatures and impure air also endanger workers' health.

High-Quality Labor Standards: Thousands of Pennsylvania's workers will continue to suffer heat- and hazardous air-related illnesses as temperatures rise and airborne pollutants become annual realities. The Commonwealth can establish a statewide paid hazard leave law to assure workers they will not incur a loss of pay or benefits if (a) they suffer illness or injury from exposure to these or other climate hazards, or (b) their workplace is closed due to a public health emergency. Philadelphia, Pittsburgh, and Allegheny County already mandate at least 35 hours of paid leave for most employees, including during public health emergencies (Alleghany, 2022; Philadelphia, 2019; Pittsburgh, 2015). These policies can serve as a roadmap for the Commonwealth in crafting a mandatory leave law for vulnerable workers. Such policies should be written inclusively to apply to all forms of work, including "precarious" labor that might not be subject to traditional wage and hour laws, such as independent contractors and domestic and agricultural laborers (Dubuisson et al., 2023) ***(for more on extending labor and employment laws to exempted workers, see the Establish Pennsylvania's First Agricultural Workers' Rights Act to Strengthen Worker Power and Incentivize Emissions Reductions recommendation on p. XX).*** Moreover, when selecting contractors for public works projects, the Commonwealth can screen bidders based on their compliance with state and federal health and safety standards, and can award points to applicants with clean records and rigorous workplace safety training programs regarding heat and hazardous air.

14 California's Cal/OSHA regulates wildfire smoke exposure when the Air Quality Index for PM2.5 (particulate matter) is above 150. Protection from Wildfire Smoke, Cal. Code Regs. tit. 8 § 5141.1 (2024). https://www.dir.ca.gov/title8/5141_1.html.

RECOMMENDATION

EXPAND THE COMMONWEALTH'S PUBLIC SECTOR WORKFORCE TO BUILD CLIMATE-RESILIENT INFRASTRUCTURE

1. Expand the public sector workforce with targeted hiring from frontline communities that have been most affected by climate change
2. Establish a card check recognition process for public sector employees to support quality jobs with low turnover

As Pennsylvania faces increasing climate-related threats, it must rapidly adapt to the new, expensive reality of hotter summers, stronger storms, and harsher winters. Mitigation measures such as expanding and maintaining parks; extending urban tree canopies; reforestation; engaging in environmental protection; upgrading sewage, drinking, and wastewater systems; green and cool roofs, and constructing schools can protect residents, reduce peak summer temperatures, minimize flooding risks, and reduce health hazards (U.S. EPA, 2022b). However, the private sector has no incentive to undertake such adaptations for the public good.

Unionized public sector careers can uplift frontline communities

The Commonwealth can improve its infrastructure by using its own workforce rather than by hiring contractors on a temporary basis. Doing so will open entry-level careers for a new generation of Pennsylvania workers to be part of the climate solution. It will also uplift the local economy; create opportunities for stable, family-supporting careers for residents; and provide direct benefits for the communities most affected by climate change.

Pennsylvania policymakers should ensure that entry-level public sector jobs in the Commonwealth set a high-road standard for the public and private sectors alike by offering family-sustaining wages, comprehensive benefits, and collective bargaining rights. This is already often the case: for example, a unionized entry-level groundskeeper working for the Commonwealth can earn 20% more than a new groundskeeper in the private sector (Master Agreement, 2023; The Center for Workforce Information & Analytics, 2022).[15] The total value of belonging to a union far surpasses the wage differential. A unionized groundskeeper working for the Commonwealth receives comprehensive health benefits for less than $900 per year (2.75% of their base salary), free dependent coverage, and $15,340 in employer contributions (Master Agreement, 2023). Their contract also provides paid sick and vacation leave as well as pension benefits (Master Agreement, 2023). Conversely, just over half of private sector employers in Pennsylvania offer any form of health coverage to employees, let alone pay the bulk of the cost (Kaiser Family Foundation, 2022).

Although Pennsylvania's public employees have the right to collectively bargain under state law (Recognition: Jointly Requested Certification, 2022), the Supreme Court's historic 2018 decision in *Janus v. AFSCME* now prohibits public sector unions from charging fees to nonmembers who benefit from union representation *(Janus v. American Federation of State, County, and Municipal Employees, Council 31,* 2018). This move has had stark consequences for union density: in the four years following *Janus,* public sector union membership in the Commonwealth declined by more than 6% (Hirsch, 2023). By contrast, in the four years before *Janus,* public sector membership grew by 4% (Hirsch, 2023).

Pennsylvania should adopt a card check recognition process for public sector workers

To reverse the decline post-*Janus* and support public employees' right to organize, the Commonwealth can join a growing list of states that formally recognize public sector unions through a procedure called "card check" (Herbert, 2011; Gely & Chandler, 2011).[16] This process allows workers to demonstrate majority support for unionization with signed authorization cards instead of through an often contentious union election. Card check has been shown to result in much higher unionization rates because workers are free to express their support without enduring the pressures of employers' anti-union campaigns (Gely & Chandler, 2011; Bronfenbrenner & Juravich, 1994; Slater, 2011). For instance, win rates in Illinois and Ohio before enacting a card check law were 85%, but were certified 100% of the time thereafter (Gely & Chandler, 2011). Unions have experienced significant growth as a result of instituting this process: states such as New York, Maryland, California, Illinois, New Hampshire, Oregon, and Massachusetts all passed card check legislation and averaged a 34% increase in annual membership rates shortly after doing so (Chandler & Gely, 2012). Pennsylvania should similarly amend its public employee relations law to create a formal procedure to certify state and local public sector employees' majority support for a union without an election or employer consent (Public Employee Relations Act, 1970).

Members of AFSCME Council 13 on their Staff The Front Lines bus tour

High-Quality Labor Standards: As the Commonwealth builds out a cohort of adaptation and resilience staff at the state and local levels, it should strengthen existing standards for pre-apprenticeship and apprenticeship programs to ensure inclusive, equitable, high-quality programs. The Commonwealth should further assess civil service entry requirements and lift barriers to access, supporting a diverse pool of local workers. Outreach should be targeted in environmental justice communities so the benefits of these climate investments are equitably distributed among individuals most affected by climate change ***(see the Build Out a Diverse Pipeline of Union Clean Energy Workers recommendation on p. YY.)***

Funding: The Commonwealth can use federal funding sources to build out its workforce for adaptation and resilience projects, including $55 billion in the IIJA for water infrastructure projects, and $50 billion for resilience (White House, 2022). The EPA's Environmental and Climate Justice program grants fund community projects that benefit frontline communities (American Cities Climate Challenge, n.d.) Regional grants (e.g., the EPA's Green Streets, Green Jobs, Green Towns (G3) grant program) award funds for green infrastructure work in the public sector, such as installing green roofs or permeable pavement and planting trees (U.S. EPA, 2024a). The Commonwealth may also look to municipal examples like Philadelphia's and Pittsburgh's beverage and property taxes, respectively, to raise funds for necessary hiring and infrastructure improvements (PA Department of Conservation and Natural Resources, n.d.).[17] Notably, research has shown that creating a climate conducive to union organizing in the public sector will not require additional funding or costs (Keefe, 2015).

15 The entry annual wage for all landscaping and groundskeeping workers in the state was $26,160 in 2022, while entry level groundskeepers who worked for the state and were represented by AFSCME Council 13 started at $31,256 and increased by 5% to $32,819 in 2023, indicating that the gap between unionized and nonunionized groundskeepers will likely increase over time. Master Agreement between Commonwealth of Pennsylvania and Council 13, American Federation of State, County and Municipal Employees, AFL-CIO (July 1, 2023 to June 30, 2027). https://www.afscme13.org/wp-content/uploads/CBA-2023-2027-AFSCME-wbookmark10262023-Master-Agreement-combined.pdf; The Center for Workforce Information & Analysis. (2022). *PENNSYLVANIA OCCUPATIONAL WAGES STATEWIDE MAY 2022.* PA Department of Labor and Industry. https://www.workstats.dli.pa.gov/Documents/Occupational%20Wages/PA_ow.pdf

16 Under 34 Pa. Code § 95.11(8), employees and the employer may jointly submit a request for certification to the PLRB, but there is no process for employees to be certified without employer agreement.

17 2017 Philadelphia beverage tax (1.5 cents per ounce) for sugar sweetened beverages is being used to fund the Rebuild parks rehabilitation program which has a $500 million total cost; 2019 Pittsburgh tax 0.5 million property tax to be used for park maintenance and improvements. These funds should generate about $10 million yearly to go toward $400 million worth of projects that have been awaiting funding. PA Department of Conservation and Natural Resources. (n.d.). *Pennsylvania Statewide Comprehensive Outdoor Recreation Plan: Recreation for All.* https://elibrary.dcnr.pa.gov/GetDocument?docId=3223603&DocName=PASCORP2020-2024Final.pdf

Apprentices at IUOE Local 542 pose for a picture in front of a crane

EXPANDING PATHWAYS TO A JUST, EQUITABLE, AND UNIONIZED CLEAN ENERGY TRANSITION

Pennsylvania's energy dominance has been well-documented throughout this report. The Commonwealth's fossil fuel resources have driven its economy for nearly 300 years; from coal mining in the 1700s, to the nation's first oil boom starting in Pennsylvania in the mid-1800s, to the fracking boom in the Marcellus Shale region from 2007–2012, the Commonwealth has earned its status as the second-largest net energy supplier in the United States today (PA DEP, n.d.i; Cruz et al., 2014; U.S. EIA, 2023h). Pennsylvania's strong energy industry has helped fuel other integral economic sectors, most notably its industrial sector (U.S. EIA, 2023g). The energy and industry sectors have had not only substantial economic impacts, but also substantial social, cultural, and political impacts on Pennsylvania, especially in the context of the labor movement (Black et al., 2015; Frazier, 2014; Pollin et al., 2021a). In particular, the United Mine Workers of America's efforts during the 1897 Lattimer Massacre of striking coal miners in Hazleton, followed by significant labor gains during the 1902 Anthracite Strike, left an indelible mark on Commonwealth history (UMWA, n.d.). These events represent a watershed moment in the U.S. labor movement's fight to protect all workers and empower them to organize for a voice in the workplace (Grossman, n.d.; Blatz, 2002).

Yet, as the country has deindustrialized, Pennsylvania's workers and communities have suffered (Cilento, 2023). Pennsylvania's fossil fuel industries have lost more than 20,000 jobs in the last decade, representing a near 34% decline; and some sub sectors such as oil and gas well drilling lost up to 70% of their workforce in that time (U.S. BLS, n.d.a; U.S. BLS, n.d.b; U.S. DOL, 2023).Pennsylvania's manufacturing sector has also been marked by a number of high-profile closures, including those of U.S. Steel's three oldest coke batteries (Frazier, 2023). Meanwhile, the communities who helped sustain these industries have borne the brunt of their harmful environmental, health, and economic impacts (Ogneva-Himmelberger & Huang, 2015). For instance, communities home to abandoned mine lands (AML) from the Commonwealth's coal industry now face environmental degradation like water pollution and deforestation, as well as threats including mine fires, landslides, and gas leaks (Dixon, 2021). They also face higher poverty rates than the national average, particularly among women, people of color, and individuals without college degrees (Dixon, 2021). In addition, the majority of Pennsylvania's fossil fuel plants, the presence of which is linked to increased incidents of asthma, heart attacks, water contamination, and other environmental and human health hazards, are sited in low-income communities and communities of color (NextGen Climate America & PSE Healthy Energy, 2016).

As Pennsylvania's energy-intensive economic powerhouse sectors continue to shrink while the United States begins to transition to a clean energy economy, the Commonwealth has failed to capitalize on the opportunity to lead the nation in a just, equitable clean energy transition (Neumann & Dutzik, 2023). A transition to new economic formations can only be considered "just" if it delivers a "meaningful social safety net" to displaced workers (Cha et al., 2021, p. 21), echoing some of the original principles behind labor leader Tony Mazzachi's conception of the term "just transition" (Cahill & Allen, 2020). Pennsylvania must provide a safety net to both workers and communities by: legislating wage and benefits guarantees for displaced fossil fuel workers, investing in former fossil fuel communities' economic health and development, remediating the environmental and human health harms wrought by legacy fossil fuel industries, and ensuring representation of these stakeholders in decision-making bodies.

The Commonwealth must also utilize its transition to a green economy to rectify historic inequities and injustices facing underrepresented groups who have historically been excluded from family-sustaining careers, as well as frontline communities who will bear the brunt of the climate crisis. Oftentimes, these groups and communities are one and the same (PA DEP, 2021a). These historic inequities are not uncommon; they are rooted in all institutions, including the Pennsylvania labor movement itself. The first central labor union in the United States – the Mechanics' Union of Trade Associations – was born in Philadelphia and excluded Black workers from membership (Reyes, 2022). Over a century later, in 1967, the consequences of these early exclusionary decisions persisted, resulting in the nation's first federal workplace affirmative action plan, dubbed "The Philadelphia Plan," to diversify the Philadelphia Building Trades (Reyes, 2022). National data indicate that other marginalized groups such as women (Moir et al., 2011), justice-involved individuals (Reich & Prins, 2020), and immigrants have faced patterns of exclusion from organized labor unions (Gonyea, 2013). While Pennsylvania's unions have made strides to become more equitable, adding nearly 900 Black members since 2018 despite an overall downward trend in unionization (U.S. Equal Employment Opportunity Commission, n.d.), women and most people of color remain underrepresented in the building trades, indicating continued need to improve equity and accessibility. (U.S. Equal Employment Opportunity Commission, n.d.; Data USA, n.d.) Pennsylvania remains marked by substantial racial inequities in income (Kent, 2020), educational opportunity (Research for Action, 2022), health (PA Department of Human Services, 2021), and environmental justice (Ukenye, 2021). A just, equitable transition to a clean energy economy in Pennsylvania must not only include strong labor standards and create union family-sustaining jobs, it must also redress historic harms and exclusionary practices, remediate these inequities, and build power and wealth in marginalized communities from the ground up (Climate Justice Alliance, 2023; Cahill & Allen, 2020).

Many researchers, advocates, and organizers working in Pennsylvania have called for a just and equitable transition of this kind, including but not limited to the Ohio River Valley Institute (Ohio River Valley Institute, 2023), the Political Economy Research Institute (Pollin et al., 2021a), Reimagine Appalachia (Relmagine Appalachia, 2021), POWER Interfaith (Power Interfaith, n.d.), and the PA Climate Equity Round Table (PA Climate Equity Table, n.d.). Across the country, states including but not limited to Illinois, Maine, New York, and New Mexico have begun creating the blueprint for a transition of this kind through groundbreaking legislation to ensure a pro-labor equitable clean energy economy (see following page). Now, Pennsylvania can heed these calls to action, take this blueprint, and deliver justice.

MANY STATES ARE PIONEERING THE VISION FOR A JUST TRANSITION THROUGH RECENTLY WON LEGISLATION THAT PROMULGATES A JUST TRANSITION AT THE INTERSECTION OF CLIMATE, LABOR, AND EQUITY.

Illinois' Climate and Equitable Jobs Act (2021) includes (1) robust supports for displaced workers by establishing a Displaced Worker Bill of Rights and Dependent Transition Scholarships (Energy Community Reinvestment Act, 2021), and (2) the Climate Works Pre-Apprenticeship Program, Energy Transition Barrier Reduction Program, Returning Residents Clean Jobs Training Program, and Energy Transition Community Grants provisions to deliver justice to marginalized communities (Energy Transition Act, 2021). The omnibus law also contains many other provisions that should be considered in any just transition from a fossil fuel to a fossil-free economy (Pruitt & Munson, n.d.).

Maine's Act Concerning Equity in Renewable Energy Projects and Workforce Development (2022) Created criteria for certified pre-apprenticeship programs, including commitments to include individuals from historically marginalized communities, partnerships with registered apprenticeship programs, and wraparound services like childcare and transportation to facilitate participation from these communities (An Act Concerning Equity in Renewable Energy Projects and Workforce Development, 2022).

New Mexico's Energy Transition Act (2019) Established an Energy Transition Economic Development Fund for former fossil fuel communities and an Energy Transition Displaced Worker Assistance Fund (Energy Transition Act, 2019).

New York's Climate Leadership and Community Protection Act (2019) Pioneered gold-star equity standards through the adoption of the Justice 40 provision, directing 35%–40% of the benefits of its historic climate act – which mandates 70% renewable energy by 2030, 100% zero-emission electricity by 2040, and a goal of an 85% reduction in GHG emissions by 2050 – to disadvantaged communities (Climate Leadership and Community Protection Act, 2019).

New York's Climate Action Fund (2023) Funded under its Cap and Invest program, established gold-star labor standards including prevailing wage, PLAs, LPAs, required use of apprenticeship and pre-apprenticeship programs, Buy American provisions, preservation of collective bargaining agreements for all covered climate risk–related and energy transition projects, as well as investment in/priority hire for displaced fossil fuel workers (S. 4006-C, 2023a).

RECOMMENDATION

KEEP WORKERS AND COMMUNITIES WHOLE AND THRIVING THROUGHOUT THE CLEAN ENERGY TRANSITION

1. Establish an Investing in Fossil Fuel Workers and Communities Office and Fund to support fossil fuel workers and fossil fuel-dependent communities through the clean energy transition
2. Adopt targeted hire policies and priority hire for displaced fossil fuel workers and workers from environmental justice communities
3. Provide incentives for companies to transition operations toward the clean energy economy while retaining workers

As the Commonwealth invests billions into transitioning to a zero-emission economy, it must simultaneously invest in fossil fuel workers who have helped propel its economy for centuries. For existing workers, this investment must be two-fold, ensuring that displaced workers and their families are kept whole through the transition while also future-proofing their careers. To do right by Pennsylvania workers and their families, policymakers should create an Investing in Fossil Fuel Workers and Communities Fund that:

- Safeguards workers' benefits, including their healthcare, pensions, and retirement funding;
- Implements wage guarantees for up to two years post-displacement to help transitioning workers and their families maintain their quality of life;
- Provides early retirement bridge funding for workers close to retirement age who opt to retire rather than transition;
- Establishes scholarships for dependents of displaced workers for further education and workforce training – including for direct entry pre-apprenticeships and registered apprenticeship programs – to honor the legacy of those whose families have been employed in these industries for generations; and
- Incentivizes employers to maintain and transition their existing workforce to clean energy industries while maintaining wage and benefit levels

Investments in workforce retraining, job counseling, and priority hire for displaced workers on clean energy projects will further help ensure the longevity of these workers' new careers.

Beyond its displaced workers, Pennsylvania must also invest in fossil fuel-dependent communities, helping diversify their economies while keeping local governments and schools well-supported. Remediating and redeveloping fossil fuel sites with robust health and safety protections, prevailing wage guarantees, priority hire for displaced fossil fuel workers, and extended regulations on corporations for site cleanup will begin to address this investment need. The Commonwealth should extend its support by tapping into the Investing in Fossil Fuel Workers & Communities Fund to financially support the following:

- Tax payment in lieu of taxes (PILOT) revenue replacement and school funding replacement for fossil fuel-dependent communities;
- Investments in technical assistance, planning grants, and seed grants for former fossil fuel communities to develop community-based clean energy projects with guaranteed representation from labor and community voice in all economic development planning; and
- Developing high school training programs with direct interview access for fossil fuel communities

Finally, the Commonwealth should incentivize, and where possible require, the use of community benefits agreements on projects across the renewable energy economy to ensure that *all* communities benefit from this transition.

RECOMMENDATION

BUILD OUT A DIVERSE PIPELINE OF UNION CLEAN ENERGY WORKERS

1. Create a statewide, union-affiliated quality pre-apprenticeship network with regional hubs targeting underrepresented groups as well as BIPOC, environmental justice, and frontline communities
2. Center women, immigrants and refugees, justice-involved individuals, and marginalized communities by investing in quality pre-apprenticeship programs that target these populations
3. Establish a fund supporting quality pre-apprenticeship programs aligned with clean energy economy projects, with wraparound services and programs to support equity and diversity outcomes
4. Establish apprenticeship requirements and require or incentivize project labor agreements and registered apprenticeship utilization on clean energy projects

Pennsylvania should invest in fossil fuel workers and communities by building a robust pipeline of clean energy workers accessible to all transitioning fossil fuel workers. In tandem, the Commonwealth must ensure that new jobs in the clean energy economy are equitably distributed and accessible to all. This calls for both a bottom-up approach of targeted recruitment and training pathways for underrepresented and marginalized populations (e.g., women, justice-involved individuals, and BIPOC individuals) as well as a top-down approach of creating a policy landscape that expands access to family-sustaining, clean energy union careers. Modeled on Illinois' historic Climate and Equitable Jobs Act (CEJA) (Energy Transition Act, 2021), the Commonwealth should create a network of regional quality pre-apprenticeship hubs to provide target populations with the skills required to enter registered apprenticeship programs using North America's Building Trades Unions' Multi-Craft Core Curriculum (MC3) for apprenticeship readiness (North America's Building Trade Unions, n.d.). As directed in CEJA, these hubs should prioritize recruitment of underrepresented and marginalized populations, including by setting recruitment goals (Energy Transition Act, 2021). These hubs should also support the expansion of established quality pre-apprenticeship programs through articulation agreements with registered apprenticeship programs designed to target these populations, such as Women in Nontraditional Careers ***(see Rosie's Girls and Women in Nontraditional Careers: Pre-Apprenticeship Programs For Gender Equality Case Study on p. XX)*** or Reimagine Reentry (Apprentice.org, n.d.; Reimagine Reentry, n.d.).

The Commonwealth should ensure that workforce development funds prioritize training programs that lead to family sustaining careers, and expand the allocation of funds that support wraparound services such as:

- Flexible childcare vouchers and/or childcare services
- Vouchers for transit, equipment, and food costs
- Training program stipends
- Translation services

Though not specifically a wraparound service, quality pre-apprenticeship programs should also be offered at flexible hours for participants who have inflexible responsibilities such as additional employment, childcare or eldercare emergencies, or parole appointments (Tieszen et al., 2020). Lastly, the Commonwealth should ensure that recruitment for its statewide quality pre-apprenticeship programs reaches target populations. Advertisements could be featured at schools, churches, food banks, or community events. State actors could also partner with community-based organizations or adopt other innovative approaches to meet local communities where they are at.

As for top-down policy changes, Pennsylvania should require targeted hiring, quality pre-apprenticeship, and registered apprenticeship utilization on all clean energy projects. Pennsylvania's unions and employers have built a world-class apprenticeship training infrastructure across the very industries that will be key for transitioning from fossil fuels and building out climate-resilient infrastructure (Cunningham & Shetler, 2023). The Commonwealth should seize the opportunity to invest in existing gold-standard union-affiliated training programs so that these programs can build and diversify the workforce building Pennsylvania's climate-safe economy at the necessary scale and pace. Simultaneously, the Commonwealth should raise standards for registered pre-apprenticeship programs, such as those in Maine's 2022 An Act Concerning Equity in Renewable Energy Projects and Workforce Development, including measures like (26 MRSA §3201 et. seq, 2022):

- Quality assurance assessments, including minimum instructional hours (120);
- Equal employment opportunity compliance reviews;
- Equity goals for recruitment and training;
- Stipends to ensure meaningful participation by members of historically marginalized groups;
- Wraparound services like child care, transportation, probation officer advocacy, and English as a new language instruction; and
- Regular reports on rates of 1) pre-apprenticeship completion and direct entry, 2) enrollment in registered apprenticeship programs, and 3) completion of these programs

Beyond investing in traditional workforce development, the Commonwealth should consider adopting other strategies modeled on CEJA to help marginalized communities accrue wealth and power in the new clean energy economy. For instance, the Commonwealth should create a Clean Energy Contractor Incubator for MWBEs to diversify both the worker and contractor pipelines. Pennsylvania should target funding to MWBEs to help them pay their workers family- and community-sustaining prevailing wages, thus enabling these businesses to participate in public contracts while similarly diversifying the contractor pipeline in the clean energy economy. Pennsylvania can also consider raising the floor for registered apprenticeships to more selectively filter for union-affiliated programs when approving this status.

CASE STUDY

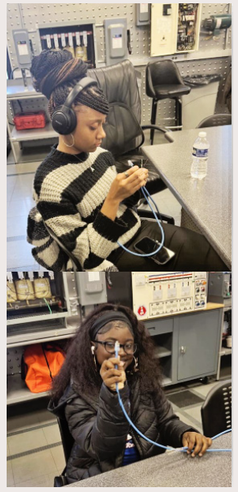
ROSIE'S GIRLS AND WOMEN IN NONTRADITIONAL CAREERS: PRE-APPRENTICESHIP PROGRAMS FOR GENDER EQUALITY

Rosie's Girls participants at the March 2023 Rosie's Girls Trade Fair. Courtesy of the IBEW, 3rd District

Jobs in the construction industry have the smallest gender pay gap of any industry – women earn 93% of male wages, compared to the economy-wide average of 76% – and offer family-sustaining careers for those who do not have college degrees (Government Accountability Office, 2023). However, women make up only 3.9% of the building trades workforce in the United States, far below their workforce participation rates (Institute for Women's Policy Research, n.d.; U.S. BLS, 2023b). In the male-dominated construction field, women often face discrimination in the hiring process, as well as discrimination and harassment on the job (Institute for Women's Policy Research, n.d.; Burrows, 2023). To combat these historic inequities and create more opportunities for women in the trades, unions and their partners have been operating pre-apprenticeship education and aid programs for women and girls to start their paths into the trades.

IBEW Local 98 in the Philadelphia area works with Apprentice Training for the Electrical Industry (ATEI) to operate the "Rosie's Girls" program – a registered pre-apprenticeship program to familiarize high school age girls with electrician careers (Monk, 2023). The program has been in operation since 2021, and more than doubled the number of girls enrolled in the program in its second year (6ABC, 2023). The program received a grant of over $115k in 2023 from the PA Department of Labor & Industry to continue its great work (Monk, 2023).

In addition, the Pennsylvania AFL-CIO, PhilaPOSH, the Keystone Development Partnership, Philadelphia Works, Inc., and Chicago Women In Trades created Women in Nontraditional Careers (WINC) (Philadelphia Works Inc., n.d.). WINC recruits women in the Philadelphia region, helps them earn certifications necessary to work in these fields, and supports them in applying to and getting placed in different pre-apprenticeship, registered apprenticeship, and training programs (Philadelphia Works Inc., n.d.). WINC also teaches MC3, a comprehensive pre-apprenticeship curriculum developed by the North America's Building Trade Unions to provide people with the necessary skills for registered apprenticeship programs (North America's Building Trade Unions, n.d.).


Two Rosie's Girls participants learning about electric cables. Courtesy of hte IBEW, 3rd District

WINC and Rosie's Girls are critical steps towards creating gender equity in the trades and closing the gender pay gap, especially because apprenticeship programs with a union sponsor tend to have higher participation rates from women, women are more likely to become journeywomen, and these effects are more pronounced for women of color (Chicago Women in Trades, n.d.). The WINC and Rosie's Girls models should be upheld and replicated across the country as an important first step for bringing more women into careers in the trades.

RECOMMENDATION

SCALE UP FOSSIL FUEL SITE RECLAMATION AND REDEVELOPMENT TO CREATE JOBS AND IMPROVE ENVIRONMENTAL HEALTH

1. Expand the state's Abandoned Mine Land Reclamation Program
2. Establish an Office of Fossil Fuel Lands Reclamation and Redevelopment to streamline and scale redevelopment efforts
3. Ensure the transition provides jobs for former fossil fuel workers and benefits their communities

Coal mining is an integral part of Pennsylvania's history; Commonwealth coal has been used to fuel the state and nation for generations (PA DEP, n.d.i). As surface and underground mines close down, significant remediation work must be done to ensure that coal extraction hazards do not continue to threaten the environment and surrounding communities. Mine land reclamation work can take various forms, from putting out mine fires to abating coal ash and waste coal deposits, cleaning up hazardous bodies of water, and unclogging streams (Dixon, 2021). A staggering amount of work is required: over one million acres of Pennsylvania's land falls under the Pennsylvania Abandoned Coal Mine Lands program, encompassing roughly 41% of abandoned mine land in the country (Dixon, 2021). This is equal to 3.76% of the Commonwealth's total land area – a total area slightly larger than the state of Rhode Island (Office of Communications, Partnerships and Analysis, 2022; U.S. CB, 2022c). Many acres of other contaminated lands (e.g. Brownfields, Resource Conservation and Recovery Act lands, and Superfund sites) and many retiring/retired fossil fuel energy generation sites should also be remediated. Pennsylvania is poised to receive a funding windfall for the Abandoned Mine Reclamation Fund under the IIJA – it has the greatest eligibility for AML funds of any state in the United States, and these funds will increase both the capacity for, and pace of, future mine land reclamation work (U.S. DOI, 2023b).

Following mine land reclamation, there is significant opportunity for the redevelopment of some sites, as many possess terrain or infrastructure advantages for repurposing (Office of Clean Energy Demonstrations, n.d.d). This makes mines particularly attractive for redevelopment activities including pumped hydroelectric energy storage, mineshaft gravity energy storage, compressed air energy storage, geothermal energy, and carbon sequestration – all technologies that IRA funding incentivizes (White House, 2023d). The reclamation process enables land to be restored to varying working levels: some might only have the soil quality or environmental health for redevelopment activities, whereas others may be able to grow grass for grazing, pollination plants, or even plots of produce, like orchards (Kentucky Farm Bureau, 2023). In areas that can be developed for agrovoltaics, using livestock to graze around the solar development can create a new revenue stream for ranchers – cultivating a symbiotic relationship between renewable generation and environmental conservation (Hirtzer, 2023).

Create an Office of Fossil Fuel Lands Redevelopment (OFFLR)

To maximize the potential benefits of reclamation and redevelopment – not just for the environment, but also for the surrounding communities and Pennsylvania's economy – the Commonwealth should establish an Office of Fossil Fuel Lands Redevelopment (OFFLR) in the PA DCED. Such an office will have the capacity to analyze redevelopment potential, building on the PA DCED's (n.d.a) Coal-Fired Power Plant Redevelopment Playbooks series. This office should also provide support for stakeholders through reclamation and redevelopment processes. To facilitate this work while investing in the Commonwealth's economic transition, the office should streamline access to federal programs targeting fossil fuel site remediation and redevelopment. It should also provide small-scale grant funding and technical assistance to aid organizations doing mine land and other contaminated-land redevelopment work. Moreover, this office should convene partners for large-scale reclamation and redevelopment projects, including developers, local communities (especially those most affected by environmental health hazards from former fossil fuel sites), and labor unions. Bringing these stakeholders together will expedite negotiation, feedback, and planning processes to maximize the benefits for all parties. Collective efforts can also encourage job creation in high-impact unionized job sectors while guaranteeing that environmental impact and equity considerations are addressed (O'Leary & Hunkler, 2021).

While remediation and redevelopment work are underway, the OFFLR should establish a transition pipeline for former fossil fuel workers – especially mineworkers – with the intention of prioritizing funds for contractors and developers who employ former fossil fuel workers and local community residents. The office should also incentivize the adoption of community benefits agreements on redevelopment projects, as well as issue guidance on how to make these agreements as equitable and beneficial as possible.

Finally, Pennsylvania should expand the Bureau of Abandoned Mine Reclamation's (BAMR) in-house reclamation teams to create additional jobs and bolster its capacity to respond to high-risk mine land reclamation scenarios (e.g., fires, subsidence, and poorly-contained waste materials) (Dixon, 2021). The state should also increase funding for these reclamation teams' machinery purchases. The program's capacity is currently severely constrained, causing the Bureau to contract out a large portion of work, which then delays responses to dangerous mineland situations (Dixon, 2021).

High-Quality Labor Standards: Mine land and fossil fuel land reclamation and redevelopment represent a valuable opportunity for economic development and good job creation in Pennsylvania. Redevelopment coalitions will serve as a key forum: the proposed Office of Fossil Fuel Lands Redevelopment can convene developers, local governments, communities, and – perhaps most critically – labor representatives to negotiate specifics for workforce and community impact agreements. Establishing a transition pipeline to train and reskill former fossil fuel workers and environmental justice community residents is an essential piece of the mine land reclamation and redevelopment plan. Through grants and technical assistance, the state can support union training programs and establish bundled project requests for quotations that give preference to developers who employ program-trained workers in high-quality jobs.

Funding: In addition to available resources, the Abandoned Mine Lands Economic Revitalization (AMLER) Program increased appropriations in 2023, including $29.347 million for Pennsylvania, tied for the highest amount in the country (U.S. DOI, n.d.). Many other grant opportunities apply: the Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) Program, through the Appalachian Regional Commission; the U.S. Economic Development Administration's Assistance to Coal Communities Program; the U.S. DOL's Employment and Training Administration Grants; and the U.S. EPA's Brownfield Grant Funding (with grants targeting job training for residents affected by brownfields in their communities) (Cullen, 2021; & U.S. EPA, n.d.g). Bonuses of 10% are also available for the IRA's Production and Investment Tax Credits (via the Energy Community Tax Credit Bonus) in (a) census tracts where a coal mine has closed since 1999 or where a coal-fired power plant has closed since 2009 or (b) metropolitan statistical areas/non-metropolitan statistical areas that meet criteria for fossil fuel employment or tax revenues from fossil fuel activity and unemployment (Interagency Working Group, n.d.).

RECOMMENDATION

MANDATE REPRESENTATION OF LABOR AND WORKERS ON ALL CLIMATE-RELATED ADVISORY BOARDS AT THE STATE LEVEL

Workers and their organizations must be represented in all decision-making processes around Pennsylvania's transition from fossil fuels, if this transition is to be truly just for all Commonwealth families. Guidance from labor unions, who have unparalleled cross-industrial expertise, will be critical to ensuring that jobs powering the transition to a sustainable world offer high labor standards that retain qualified workers and repurpose their skills and experience as efficiently as possible.

Pennsylvania legislators and agencies have created a number of climate advisory bodies that give input on legislation related to clean energy and climate resilient transitions. Currently, none of these bodies have designated representation of organized labor or worker voices. This is a missed opportunity to benefit from organized workers' expertise in drafting and implementing energy transition policies to ensure that such policies enforce strong labor standards that can get workers and their organizations excited about a just transition. Legislators and agencies must install adequate seats for labor representation on each of these bodies, and should designate seats for both elected union leaders and workers affected by the transition from fossil fuels. Pennsylvanians deserve a transition to renewable energy and climate resilient infrastructure built on policies that are scientifically sound and fair for all workers who have been powering Pennsylvania and the nation. A few examples of committees and boards that should have representation of labor voice and worker voices:

- PA DEP Climate Change Advisory Committee (CCAC): This Committee advises the PA DEP on implementing the state's 2008 Climate Change Act, which governs the process for developing climate action plans (PA DEP, n.d.c). As of October 2023, CCAC membership had no representation from a major labor union or affected workers (PA DEP, 2023).

Members of the AFL-CIO Pennsylvania gather at a rally in the Capitol during the 2023-2024 legislative session

- PA DEP Environmental Quality Board: This Board is a 20-member independent board that reviews and adopts all regulations put forth by the PA DEP; the organization is chaired by the PA DEP Secretary (PA DEP, n.d.o). The EQB reserves five membership slots for citizen advisors (elected annually), but no advisor slots are designated for representatives from the labor movement or affected workers in their official capacity (PA DEP, n.d.f).
- PA DCED State Planning Board: This State Planning Board is a 25-member advisory board that studies demographic and economic trends in the Commonwealth and prepares strategic plans that include land use and zoning plans (PA DCED, n.d.c). Although the Board's membership includes people affiliated with local businesses throughout the state, no members are affiliated with organized labor or intended to represent worker voices (PA DCED, n.d.c)

SUMMARIES
APPENDIX: ESTIMATED COST SUMMARY

Recommendations	Project Type	Investment per Year	Years of Investment	Total Cost
Energy				
Transform Pennsylvania's Energy Economy by Building 54.5 Gigawatts of Renewable Energy by 2035 with Gold-Star Labor Standards Onshore Wind 10 gigawatts Offshore Wind 4.5 gigawatts	40 GW Solar	$6.09 billion	12	$73.0 billion
	10 GW Onshore Wind	$1.28 billion	12	$15.4 billion
	4.5 GW Offshore Wind	$1.64 billion	12	$19.7 billion
Tap Into Renewable Energy Potential by Retrofitting Pennsylvania's Non-Powered Dams for Hydroelectric Energy	400 MW Hydroelectric Power	$251 million	12	$3.01 billion
Address Methane Leakage by Establishing a Large-Scale Program to Cap Pennsylvania's Abandoned and Orphaned Oil and Gas Wells	Plugging All 27,000 Documented Abandoned Wells	$95.9 million	12	$1.15 billion
Expand and Modernize Pennsylvania's Power Grid Using Union Labor Expansion of Intraregional Distribution Peak Capacity Energy Storage Capacity 12.3 gigawatts	2.97 TW-Mi Intraregional Transmission	$332 million	17	$5.65 billion
	10.67 GW Distribution Peak Capacity	$872 million	17	$14.8 billion
	12.3 GW Energy Storage	$56.1 million	17	$953 million
Industry				
Catalyze Pennsylvania to Become a Renewables Recycling Powerhouse	Solar Panel Recycling	$61.6 million	27	$1.66 billion
	Wind Blade Recycling	$2 million	27	$54.0 million
Reduce Pennsylvania's Industrial Emissions While Maintaining Union Jobs	Net-Zero Industrial Facilities	$3.86 billion	12	$46.4 billion
Buildings				
Adopt a Carbon-Free Keystone State Act to Jumpstart a Just Transition Through Building Decarbonization in Pennsylvania LMI Community Decarbonization	Decarbonize State Facilities	$86.6 million	7	$606 million
	Decarbonize Low-Income Residential Homes	$2.69 billion	17	$45.7 billion
Incentivize Union-Built Zero-Emission Affordable Housing Deep-retrofits of all Affordable Housing	New Construction of Net-Zero Affordable Housing	$17.2 billion	7	$120 billion
	Retrofits of Existing Affordable & Public Housing	$341 million	7	$2.4 billion
Make Pennsylvania Homes Safer, Healthier, and More Efficient Through an Amended Whole-Home Repairs Program	Whole-Home Repairs Program	$300 million	7+	$2.1 billion
Adopt a Whole-School Repairs Act to Make Pennsylvania Schools Safe, Healthy, and Sustainable	Whole-School Repairs Act	$1.07 billion	7+	$7.5 billion
Transport				
Construct High-Speed Rail Infrastructure in the Northeast Corridor	High-Speed Rail in Mid-Atlantic North region	$1.5 billion	12	$18 billion
Electrify and Transformatively Expand Pennsylvania's Public Transit by 2035; Invest in a Retraining Program for the Electric Vehicle Transition New Electric Transit Rail	Transition Public Transit Buses and Paratransit Shuttles	$412 million	12	$4.94 billion
	Transition Passenger Rail	$51.4 million	12	$617 million
Decarbonize Pennsylvania's Last-Mile Trucking by 2030 While Expanding Worker Protections in the Larger Logistics, Distribution, and Warehousing Sector Freight Rail Decarbonization	Decarbonize Heavy-Duty Freight Trucks	$3.28 billion	12	$39.4 billion
	Decarbonize Freight Rail	$3.67 billion	12	$44 billion
Agriculture				
Establish Pennsylvania's First Agricultural Workers' Rights Act to Strengthen Worker Power and Incentivize Emissions Reduction	Increase Funding for the Agriculture Energy Efficiency Rebate Program	$7.01 million	12	$84.1 million
Create a Circular Biofuel Economy to bolster land use retention, renewable energy, and domestic production	Anaerobic Digesters on Large PA Dairy Farms	$62.9 million	12	$755 million
Infrastructure				
Expand High-Speed Broadband Access by 2028 to 1.3 Million Digitally Excluded Households Using Local, Union Jobs	Broadband Infrastructure	$414 million	5	$2.07 billion
	Free Internet Access to Low-income Families	$557 million	5	$2.78 billion
Build Climate-Resilient, Clean Water Infrastructure Using Low-Carbon and PA-Made Materials Clean Drinking Water Repairing Dams	Bridge Repair	$2.92 billion	7	$20.4 billion
	Clean Drinking Water	$3.91 billion	7	$27.4 billion
	Dam Repair	$433 million	7	$3.03 billion

APPENDIX: JOB CREATION SUMMARY

Recommendations	Project Type	Direct Jobs Per Year	Direct Jobs By 2030
Energy			
Transform Pennsylvania's Energy Economy by Building 54.5 Gigawatts of Renewable Energy by 2035 with Gold-Star Labor Standards	40 GW Solar	11,000	77,000
	10 GW Onshore Wind	1,900	13,300
	4.5 GW Offshore Wind	2,400	16,800
Tap Into Renewable Energy Potential by Retrofitting Pennsylvania's Non-Powered Dams for Hydroelectric Energy	400 MW Hydroelectric Power	1,600	11,200
Address Methane Leakage by Establishing a Large-Scale Program to Cap Pennsylvania's Abandoned and Orphaned Oil and Gas Wells	Plugging All 27,000 Documented Abandoned Wells	75	525
Expand and Modernize Pennsylvania's Power Grid Using Union Labor	2.97 TW-Mi Intraregional Transmission	860	6,020
	10.67 GW Distribution Peak Capacity	2,300	16,100
	12.3 GW Energy Storage	150	1,050
Industry			
Reduce Pennsylvania's Industrial Emissions While Maintaining Union Jobs	Net-Zero Industrial Facilities	8,000	56,000
Buildings			
Adopt a Carbon-Free Keystone State Act to Jumpstart a Just Transition Through Building Decarbonization in Pennsylvania	Decarbonize State Facilities	330	2,310
	Decarbonize Low-Income Residential Homes	10,000	70,000
Incentivize Union-Built Zero-Emission Affordable Housing	New Construction of Net-Zero Affordable Housing	76,000	532,000
	Retrofits of Existing Affordable & Public Housing	1,300	9,100
Make Pennsylvania Homes Safer, Healthier, and More Efficient Through an Amended Whole-Home Repairs Program	Whole-Home Repairs Program	1,100	7,700
Adopt a Whole-School Repairs Act to Make Pennsylvania Schools Safe, Healthy, and Sustainable	Whole-School Repairs Act	4,100	28,700
Transport			
Construct High-Speed Rail Infrastructure in the Northeast Corridor	High-Speed Rail in Mid-Atlantic North region	10,000	70,000*
Electrify and Transformatively Expand Pennsylvania's Public Transit by 2035; Invest in a Retraining Program for the Electric Vehicle Transition	Transition Public Transit Buses & Paratransit Shuttles	71	497
	Transition Passenger Rail	130	910
Decarbonize Pennsylvania's Last-Mile Trucking by 2030 While Expanding Worker Protections in the Larger Logistics, Distribution, and Warehousing Sector	Decarbonize Heavy-Duty Freight Trucks	570	3,990
	Decarbonize Freight Rail	8,900	62,300
Agriculture			
Establish Pennsylvania's First Agricultural Workers' Rights Act to Strengthen Worker Power and Incentivize Emissions Reduction	Increase Funding for the Agriculture Energy Efficiency Rebate Program	27	189
Create a Circular Biofuel Economy to bolster land use retention, renewable energy, and domestic production	Anaerobic Digesters on Large PA Dairy Farms	180	1,260
Infrastructure			
Expand High-Speed Broadband Access by 2028 to 1.3 Million Digitally Excluded Households Using Local, Union Jobs	Broadband Infrastructure	23,360	116,800
Build Climate-Resilient, Clean Water Infrastructure Using Low-Carbon and PA-Made Materials	Bridge Repair	28,000	196,000
	Clean Drinking Water	18,000	126,000
	Dam Repair	2,700	18,900

**Includes direct, indirect, and induced jobs in the Mid-Atlantic North region (NEC Commission, n.d.b).*

APPENDIX: EMISSION REDUCTION SUMMARY

Recommendations	Project Type	Total Emissions Reduction
Energy		
Transform Pennsylvania's Energy Economy by Building 54.5 Gigawatts of Renewable Energy by 2035 with Gold-Star Labor Standards	40 GW Solar	86,300,000 $MTCO_2$/year by 2035
	10 GW Onshore Wind	
	4.5 GW Offshore Wind	
Tap Into Renewable Energy Potential by Retrofitting Pennsylvania's Non-Powered Dams for Hydroelectric Energy	400 MW Hydroelectric Power	
Address Methane Leakage by Establishing a Large-Scale Program to Cap Pennsylvania's Abandoned and Orphaned Oil and Gas Wells	Plugging All 27,000 Documented Abandoned Wells	107,000 $MTCO_2$/year by 2035
Expand and Modernize Pennsylvania's Power Grid Using Union Labor	12.3 GW Energy Storage	5,730,000 $MTCO_2$/year by 2040
Industry		
Catalyze Pennsylvania to Become a Renewables Recycling Powerhouse	Solar Panel Recycling	8,990 $MTCO_2$/year by 2050
	Wind Blade Recycling	1,380 $MTCO_2$/year by 2050
Reduce Pennsylvania's Industrial Emissions While Maintaining Union Jobs	Net-Zero Industrial Facilities	25,400,000 $MTCO_2$/year by 2035
Buildings		
Adopt a Carbon-Free Keystone State Act to Jumpstart a Just Transition Through Building Decarbonization in Pennsylvania Adopt a Carbon-Free Keystone State Act to Jumpstart a Just Transition Through Building Decarbonization in Pennsylvania (Residential)	Decarbonize State Facilities	167,000 $MTCO_2$/year through 2030
	Decarbonize Low- and Moderate-Income Residential Homes	4,340,000 $MTCO_2$/year through 2040
Incentivize Union-Built Zero-Emission Affordable Housing	Retrofits of Existing Affordable & Public Housing	774,000 $MTCO_2$/year through 2030
Make Pennsylvania Homes Safer, Healthier, and More Efficient Through an Amended Whole-Home Repairs Program	Whole-Home Repairs Program	49,300 $MTCO_2$/year through 2030
Adopt a Whole-School Repairs Act to Make Pennsylvania Schools Safe, Healthy, and Sustainable	Whole-School Repairs Act	1,100,000 $MTCO_2$/year partially reduced through 2030
Transport		
Construct High-Speed Rail Infrastructure in the Northeast Corridor	High-Speed Rail in Mid-Atlantic North region	15,500 $MTCO_2$/year by 2035
Electrify and Transformatively Expand Pennsylvania's Public Transit by 2035; Invest in a Retraining Program for the Electric Vehicle Transition Electrify and Transformatively Expand Pennsylvania's Public Transit by 2035; Invest in a Retraining Program for the Electric Vehicle Transition (Transition Passenger Rail)	Transition Public Transit Buses & Paratransit Shuttles	9,740,000 $MTCO_2$/year by 2035
	Transition Passenger Rail	1,420 $MTCO_2$/year by 2035
Decarbonize Pennsylvania's Last-Mile Trucking by 2030 While Expanding Worker Protections in the Larger Logistics, Distribution, and Warehousing Sector Decarbonize Pennsylvania's Last-Mile Trucking by 2030 While Expanding Worker Protections in the Larger Logistics, Distribution, and Warehousing Sector (Freight Rail)	Decarbonize Heavy-Duty Freight Trucks	7,650,000 $MTCO_2$/year by 2035
	Decarbonize Freight Rail	842,000 $MTCO_2$/year by 2035
Agriculture		
Create a Circular Biofuel Economy to bolster land use retention, renewable energy, and domestic production	Anaerobic Digesters on Large PA Dairy Farms	647,000 $MTCO_2$/year by 2035

APPENDIX: METHODOLOGY

Please note all estimates for recommendations are based on the best currently available data. Inflation adjustments for cost and jobs estimates in this report were made using the GDP Implicit Price deflator. All final costs are reported in 2023 dollars. Before jobs estimates were created, costs were adjusted for inflation to the dollar year of the multiplier. Cost estimates and job creation estimates may shift due to changes in technology and global markets. Any implementation of these recommendations in new policies should follow an additional review process to account for these changes. For questions on methodology please contact Avalon Hoek Spaans, Assistant Director of Research, ah679@cornell.edu.

ENERGY

RECOMMENDATION:

Transform Pennsylvania's Energy Economy by Building 54.5 Gigawatts of Renewable Energy by 2035 with Gold-Star Labor Standards

Future Electricity Demands

A high electricity demand growth scenario with 100% net-zero electricity generation by 2035 was chosen from the National Renewable Energy Laboratory's (NREL's) model based on the ***2023 Standard Scenarios Report: A U.S. Electricity Sector Outlook*** (Gagnon et. al., 2024; NREL, n.d.a). The scenario includes a projected compound electricity demand growth rate of 2.8% from 2024-2050, consistent with 100% nation-wide decarbonization by 2050. The scenario provides estimated grid loads, resource capacity, and generation data every two years from 2024-2050. Recommended levels of renewable energy buildout were then calculated to account for all baseload electricity needs in 2035, allowing generation from fossil fuel sources with carbon capture and storage (CCS) technology to provide surplus and maintain Pennsylvania's status as an energy exporter (Gagnon et. al., 2024).

Onshore and Offshore Wind

Capacity: The 10 GW onshore wind recommendation for 2035 was determined from the difference between land-based wind capacity from 2022 to 2036 in the NREL 2022 Standard Scenarios Report (Gagnon et. al., 2023).

NREL's model does not include a baseline prediction for offshore wind in Pennsylvania, though other studies show the total offshore wind capacity deployable in Pennsylvania's Lake Erie waters more than 3 nautical miles offshore is 4,483 MW (Musial et al., 2016). The capacity factor for Pennsylvania's Lake Erie offshore wind of 48.75% was derived from the median of the current technology and advanced research technology scenarios in NREL's Great Lakes Wind Energy Challenges and Opportunities Assessment (Musial et al., 2023). Energy generation from OSW is projected to be 19,144,651 MWh in 2035.

Cost: Costs for wind installations were determined using the Annual Technology Baseline (ATB) model (NREL, 2023c; NREL 2023d). Class 7 and 5 were chosen for onshore and offshore wind respectively. These classes were chosen based on the wind speed range for the state (7-10 m/s) and the median wind speed for the Lake Erie region within state borders (8-8.5m/s) assuming hub heights of 80-100m and 90 m respectively (EERE, n.d.d; EERE, 2020b; EERE, 2020c; Schwartz et al., 2010). The costs for land-based wind and offshore wind are calculated to be $13.63 billion and $17.52 billion respectively (2021 dollar year). The costs for onshore and offshore wind are $1.28 billion and $1.64 billion per year respectively after adjusting the cost to a 2023 dollar year (Federal Reserve Bank of St. Louis [St. Louis Fed], 2024a). Note that this cost may shift due to improvements in wind turbine technology, changes in supply chain and available materials, and scale and pace of implementation (NREL, 2023b).

Jobs: A multiplier of 1.7 direct jobs per $1 million in spending for Wind Energy was used (Pollin et al., 2021b). Due to lack of data, it was assumed that the direct jobs multiplier for offshore wind was equivalent to onshore wind.

Solar

Capacity: In NREL's projections, the capacity factor for distributed solar was 17.74%, and the capacity factor for utility scale solar was 22.27% (NREL, n.d.a). The additional recommendation of 13 GW of distributed solar capacity and 27 GW of utility-scale solar capacity was calculated to cover Pennsylvania's remaining baseload needs in 2035. The ratio of distributed solar to utility solar above NREL's projections was determined using a median of the PA DEP's ***Pennsylvania's Solar Future Plan*** report scenarios A and B (PA DEP, 2018). Existing solar capacities were derived from Solar Energy Industries Association data (Solar Energy Industries Association, 2023).

Cost: The PA DEP's ***Solar Future Report*** recommends a 50-50% split between the installation of residential and commercial rooftop capacity (PA DEP, 2018). The distribution of rooftop solar is estimated to be 6.5 GW residential and 6.5 GW commercial. The recommended capacities are below the estimated total technical potential for rooftop solar in PA, which is 29.6 GW for small building rooftops and 14 GW for large building rooftops (Gagnon et al., 2016). Costs for solar installations were found using the ATB model for commercial, residential, and utility PVs. The solar irradiance for Pennsylvania was identified to be below 4.25 kWh/m2/day (Roberts et al., 2018). Class 8 and 9 were selected for each of the three solar PV implementations as these panels are built for a solar irradiance range of 3.75 to 4.25 kWh/m2/day. The capital costs for commercial, residential, and utility PVs was found to be $1,754/kW, $2,859/kW, and $1,291/kW respectively (NREL, 2023a; NREL, 2023e; NREL, 2023f). Costs were estimated to be $11.4 billion for commercial PVs, $18.6 billion for residential PVs, and $34.9 billion for utility PVs – a total of $64.8 billion (2021 dollar year). The cost for solar development is $6.09 billion/year after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 2.1 direct jobs per $1 million for Solar Energy in spending was used (Pollin et al., 2021b).

Emissions: Installing this recommended renewable energy capacity will generate a total of 131,503 GWh in electricity which has the theoretical potential to reduce emissions of existing fossil fuel power plants which in 2022 generated 111,758 gigawatt hours (GWh) of electricity and emitted emitted 86,300,000 metric tons (MT) carbon dioxide equivalent (CO_2e) per year (U.S. EPA, 2024b).

RECOMMENDATION:

Tap Into Renewable Energy Potential by Retrofitting Pennsylvania's Non-Powered Dams for Hydroelectric Energy

Cost: Pennsylvania was estimated to have a potential of 679 MW of Non-Powered Dam (NPD) retrofit hydroelectric capacity (Hadjerioua et al., 2012). Out of the top 75 candidate dams for retrofit across the nation, Pennsylvania has 8, which together total 404.7 MW of capacity (Hadjerioua et al, 2012).

Based on a data set of 1,485 Pennsylvanian dams, approximately 16.9%, 29.4% and 53.7% of dams were identified to have heights in ranges of 50-100+ ft, 25-50 ft, and 1-25 ft, respectively (U.S. Army Corps of Engineers, n.d.). Classes 2, 3, and 6 were chosen for the NPD categories based on the height and capacity ranges in the ATB model, costing $5,898, $6,020, and $7,292 per kW respectively (2021 dollar year) (NREL, 2023b). Scaling costs for each dam category, the

total cost for hydroelectric power generation and NPD retrofits would be $2.6 billion after adjusting to a 2023 dollar year (St. Louis Fed, 2024a). The cost is subject to variations in the individual nameplate capacities and head heights for NPD retrofit candidates, representing a broad expectation of cost rather than a representation of any individual project (NREL, 2023b).

Jobs: A multiplier of 7.3 direct jobs per $1 million in spending for Dams was used (Pollin et al., 2021b).

Emissions: The electricity generated from 400 MW of hydroelectric power is calculated to be 1,283 GWh per year in 2035 based on a calculated 36.6% capacity factor (NREL, n.d.a). This electricity generation contributes 1.2% to the emission reduction of 86,300,000 $MTCO_2e$ determined in the recommendation ***Transform Pennsylvania's Energy Economy by Building 54.5 Gigawatts of Renewable Energy by 2035 with Gold-Star Labor Standards.***

RECOMMENDATION:

Address Methane Leakage by Establishing a Large-Scale Program to Cap Pennsylvania's Abandoned and Orphaned Oil and Gas Wells

Cost: A total of 27,263 documented abandoned wells (20,451 abandoned and 6,812 orphaned) have been identified so far in Pennsylvania (PA DEP, n.d.l). An average cost of $36,000/well (based on the median cost per well for plugging 500,000 orphan wells in the United States) was used for a moderate costing scenario with a 2019 dollar year (Raimi et al., 2020). The cost to plug all documented wells by 2035 is $95.9 million per year after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 0.9 direct jobs per $1 million in spending for Closing Orphan Wells was used (Pollin et al., 2021b).

Emissions: The U.S. EPA reported 6.505 million MT CO_2e from a total of 2,932,440 abandoned oil wells due to methane and direct carbon emissions across the United States (U.S. EPA, 2023b). Additionally, the U.S. EPA reported 1.803 million $MTCO_2e$ emissions due to methane and CO_2 released nationally from 798,278 abandoned gas wells in 2021 (U.S. EPA, 2023b). About 1,739,533 and 439,407 out of the oil and gas wells recorded by the U.S. EPA were unplugged, and were calculated to contribute to 99.82% and 99.7% to methane emissions compared to plugged wells when accounting for the reported methane emissions for each well category (U.S. EPA, 2023b). Based on the emissions and population of unplugged wells only, the average $MTCO_2e$ per well annually was calculated to be 3.733 for unplugged oil wells and 4.096 for unplugged gas wells. Assuming an even mix of abandoned oil and gas wells in Pennsylvania, then emissions are estimated to be 3.914 $MTCO_2$/well. Plugging 27,263 abandoned wells in PA would reduce the equivalent of 106,714 $MTCO_2e$ annually by 2035.

RECOMMENDATION:

Expand and Modernize Pennsylvania's Power Grid Using Union Labor

Cost: It is assumed that out of the 11.69 TW-mi intra-region expansions developed by PJM, Pennsylvania would see 25.4% of intra-region transmission line development based on the grid-installed capacity of Pennsylvania relative to PJM (46,977 MW / 184,833 MW) (U.S. DOE, 2023; PJM, 2023). Therefore, it is calculated that Pennsylvania would have at most 2.97 TW-mi of transmission expansion by 2040. The total costs for the intra-region transmission upgrades are expected to be $4.46 billion (2014 dollar year), which is about $1,502 per MW-mi assuming new transmission lines are high-voltage and the normalized construction costs for alternating current (AC 345 kilovolts) versus direct current lines (DC 500 kilovolts) will be equal for projects less than 500 miles in length (DeSantis et al., 2021). The peak load distribution capacity in 2040 is expected to be 40,007 MW, which is 10,665 MW higher than the 29,342 MW peak reported for 2020 (Larson et al., 2021). The Pennsylvania Public Utility Commission estimates a baseline peak load distribution of 29.3 GW for 2023 (PA Public Utility Commission, 2023). The costs for 10,665 MW peak distribution load expansion by 2040 are $12.4 billion in 2018 dollar years (Larson et al., 2021). The distribution and transmission upgrades cost $872 million and $332 million per year after adjusting to a 2023 dollar year (St. Louis Fed, 2024a).

The recommendation to the PA DEP was that the deployment of new battery storage should be 25% of solar capacity and 5% of the expected peak demand (Burgess et al., 2021). The battery storage capacity needed based on the recommendation Transform Pennsylvania's Energy Economy by Building 54.5 Gigawatts of Renewable Energy by 2035 with Gold-Star Labor Standards, solar capacity would be 10.27 GW by 2035 (about 10.3 GW). The battery storage capacity need based on a projected peak distribution load in 2040 of 40,007 MW would be another 2 GW (Larson et al., 2021). Energy storage is estimated to cost $825 million (2020 dollar year), based on the DEP's Energy Assessment report which cited capital costs of $56 - $67 per kW for stand-alone battery storage (Burgess et al., 2021). Total costs for grid expansions by 2040 are expected to be $953 million (2023 dollar year), as energy storage will cost $56.1 million per year up to 2040 (St. Louis Fed, 2024a).

Jobs: A multiplier of 3.0 direct jobs per $1 million in spending for Electrical Grid Upgrades was used (Pollin et al., 2021a).

Emissions: Emissions assume battery storage has the potential to reduce existing peaker plant emissions where a total of 51 fossil-fuel peaker plants were identified in Pennsylvania using the Peaker Plant Mapping Tool (Clean Energy Group, 2023). The nameplate capacity for peaker plants is 8.4 GW, with total energy outputs of 6.623 GWh after considering the individual capacity factors and runtime hours for each plant (Clean Energy Group, 2023). The total annual emissions associated with these plants is 5.732 million $MTCO_2e$ (Clean Energy Group, 2023). The capacity factor for battery storage is greater than peaker plant capacity factors of 0.1-20% (Burgess et al., 2021; Clean Energy Group, 2023).

INDUSTRY

RECOMMENDATION

Catalyze Pennsylvania to Become a Renewables Recycling Powerhouse

Cost: The end-of-life for solar panels is expected to be 25 years, with all currently installed panels expected to reach EOL by 2050 (Chowdhury et al., 2020). The total pre-existing capacity for panels connected to the grid and queued panels awaiting connection is 15,426 MW (PJM, 2023). The average wattage for a rooftop solar panel is 0.3 kW/unit (Allen, 2023). The initial cost to process solar panels in a new recycling program is expected to be at most $28 per module (Walzberg et al., 2021). Costs for this program may decrease to $18 per module by 2050 (Walzberg et al., 2021). Assuming similar mechanical properties between rooftop and utility modules, the cumulative cost of recycling is expected to be $1.44 billion for 51.42 million panels (2020 dollar year). The average cost per year up to 2050 would be $61.6 million after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Grid-connected and queued wind capacity is approximately 466 MW and 741 MW respectively (PJM, 2023). In Pennsylvania alone, 53,367 MT of end-of-life wind turbine blades will become waste by 2050 (Cooperman et al., 2021). Blade teardown, shredding, and segmentation are expected to cost $30-$34/kW, $99.21 per MT, and $27.56 per MT, assuming median heights of 90m for installed hub heights and 100m for queued hub heights (Cooperman et al., 2021). Using a weighted average based on installed versus queued turbine capacity, the teardown cost is about $32.46/kW. Transportation costs are estimated to be $0.08 per kilometer (km) per ton and an average transport distance of 25 km is assumed for new recycling facilities (Cooperman et al., 2021). The total cost for recycling 53,367 MT of in-state wind turbine blades is expected to be $46.1 million (2019 dollar year). This is equivalent to $2 million per year up to 2050 after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Emissions: The medium material composition for wind blades was assessed from ranges of blade material data on a kilogram (kg) per MW basis (Cooperman et al, 2023). Percentages of blade material composition were determined from each median material mass divided by the total median material mass for blades from the study. Percentages were multiplied by the 53,367 MT end-of-life blades expected by 2050 (Cooperman et al., 2021).

Masses for each material were inputted into the EPA Recycled Content Tool in order to determine the emission reductions from salvaging material in the recycling process versus landfilling blades (U.S. EPA, n.d.e). It is assumed that more turbine blades utilize polymer foam over balsa wood and that polyethylene terephthalate (PET) is the most common polymer of choice (Ireland, 2022). Surrogate materials of PET, mixed plastics, and glass were chosen from the calculated blade compositions of 9.4% polymer foam, 26.4% glass fibers, and 64% carbon fibers. Material recovery rates are assumed to be the same between actual blade materials and the modeled surrogate materials. Additionally, the end-use for materials may differ depending on recoverability, as the carbon dioxide emission reduction is 16% compared to landfill methods if polymer resin and glass fiber are used to create cement (Cooperman et al., 2021). Under the assumptions of the EPA Recycled Content Tool, a total of 37,295 $MTCO_2e$ is expected to be reduced, or the equivalent of 1,381 $MTCO_2e$ per year over 27 years compared to non-recycling waste methods.

Residential solar panels weigh approximately 40 lb per unit while commercial and utility units may weigh at least 50 lb (Allen, 2022). Solar glass contributes to about two-thirds of the total mass for silicon-based PV modules (Cooperman et al, 2023). Assuming a median panel weight of 45 lb, about 699,711 MT of solar glass are calculated to be recycled from 1,049,567 MT of solar panels. Using the EPA Recycled Content Tool with a glass surrogate material, emission reductions from recycled solar glass are estimated to be 242,714 $MTCO_2e$ – approximately 8,989 $MTCO_2e$ per year for 27 years. This is likely an underestimate because it does not account for emissions from the solar panel construction process, which can be reduced by using refurbished panels or materials recovered from the recycling process. Additionally, 99% of silver and 85% of aluminum and electrical cables are expected to be recoverable from the solar recycling process, which can result in additional emission reduction savings (Peplow, 2022).

RECOMMENDATION:

Reduce Pennsylvania's Industrial Emissions While Maintaining Union Jobs

Cost:

Electrification

Low-temperature industries are able to electrify heating and drying processes with heat pumps (Saini et al., 2023). Paper and allied products, bulk chemicals, and food and kindred products are significant low-temperature industries in Pennsylvania and are projected to use 113 petajoules (PJ), 150 PJ, and 27.1 PJ of energy by 2035 (Larson et al., 2021). The energy demand for pulp/paper production is 4,088 KWh/MT thermal and 682 KWh/MT electric, about 86% heat and 14% electric (Hasanbeigi et al., 2023). Chemical manufacturing and food processing industries used 57% and 54% of energy for process heating in 2018 (Pennsylvania Technical Assistance Program, n.d.). The energy demand for pulp & paper, bulk chemicals, and food products process heating is calculated to be 26,901 GWh, 23,750 GWh, and 4,065 GWh for 2035. Heat pump capital costs range from €500-1500 per thermal kW at an average operating temperature of 160°C (Saini et al., 2023). Using a median cost of $1,079 per kW and converting the GWh of heat to thermal kW, the capital costs for new heat pump systems is $6.74 billion (2022 dollar year) for the three energy-intensive low-temperature industries after currency exchange (Forbes, 2024a). Actual costs may vary depending on individual facility needs, as the bulk chemicals industry can have a wide range of operating conditions and may require additional electrification equipment.

Pennsylvania's high-temperature steel industry could be electrified through the widespread use of electric arc furnaces (Hasanbeigi et al., 2023). The costs for this system are £68 per MT of liquid steel, or $84.48 per MT steel (Pimm et al., 2021; Forbes, 2024b). Pennsylvania has three large-scale steel facilities that already utilize electric arc furnaces and produce 2.8 million tons of steel annually (Global Energy Monitor, 2023). The remaining 2.9 million MT of large-scale steel production are manufactured with blast furnaces in the U.S. Steel Edgar Thomson steel plant near Pittsburgh, which is responsible for the majority of emissions in the industry (Global Energy Monitor, 2023; Regional Carbon Capture Deployment Initiative, 2021a). Electrification of 2.8 million MT of annual steel production would cost $250 million if using a hydrogen-reduced iron electric furnace system (2020 dollar year).

Efficiency and Fuel Switching

High-temperature industries, such as the cement industry, are capable of using high-oxygen combustion methods paired with CCS to increase energy efficiency and capture remaining emissions (Cormoş, 2022). Capital costs of producing cement with an oxy-fuel CCS system range from €110-119 per MT, or about $123.55 per MT of cement (Cormoş, 2022; Forbes, 2024a). Decarbonizing Pennsylvania's 4 million MT of annual cement production would cost $494 million (2017 dollar year) (Portland Cement Association, 2016).

Another industrial decarbonization pathway is the use of hydrogen for high-temperature processes, such as furnaces in the glass industry (Gärtner et al., 2021). The capital costs for retrofitting glass furnace systems with hydrogen equipment, including on-site electrolyzers, is €1200 per thermal kW (Gärtner et al., 2021). Energy consumption for the glass industry in Pennsylvania is projected to be 11.7 PJ/year by 2035 (Larson et al., 2021). Energy used for heat processes is expected to be 78% or 9.1 PJ, based on the 1465 kWh/MT thermal demand and 416 kWh/MT electric demand for conventional glass container production (Hasanbeigi et al., 2023). Accounting for local hydrogen production and heat loss from the furnace, the efficiency of the new system is about 40% (Gärtner et al., 2021). Retrofitting 687,985 kW of glass furnaces with hydrogen fuel systems would cost $891 million (2019 dollar year), after currency exchange (Forbes, 2024a).

Carbon Capture

After accounting for the decarbonization of steel and cement facilities, the remaining emissions for metal, mineral, and refinery industrial facilities in Pennsylvania is 6.7 million MTCO2 (U.S. EPA, 2023e). Carbon emissions from the flue gas of high-temperature industrial processes could be captured with CCS units. Capital costs for carbon capture and storage infrastructure in the Midwest were estimated by the Global CCS Institute to be $1 billion to $6 billion for units capturing 12-18 million MTCO2 and storing via pipeline networks of 285-1,944 miles (Cevikel & Thomas, 2023). The weighted average cost of these proposed projects is calculated to be $256 per MTCO2. Assuming the infrastructure required for carbon storage network piping in Pennsylvania will be the same as Midwest capture hubs, then the cost for industrial CCS is estimated to be $1.7 billion (2022 dollar year). The required amount of pipeline constructed for Pennsylvania's carbon capture storage systems will need to be assessed in coordination with any DAC projects sequestering carbon.

CCS could be used to capture 9.2 million $MTCO_2$ from miscellaneous large industrial facilities (U.S. EPA, 2023e). Based on the carbon balance for alternate reduction pathways, an additional 1.7 million $MTCO_2$ should also be captured with direct air capture methods. Levelized costs for liquid sorbent direct air capture methods range from $190 to $220 per $MTCO_2$ for a 25 year project lifetime, with the CAPEX contributing to about 55% of the cost (IEA, 2022). Assuming the high-electricity cost scenario and a 25 year project life, the median capital cost of installing direct air capture is $2,819 per $MTCO_2$. The costs for reducing 10.9 million $MTCO_2$ with direct air capture are $30.7 billion or $2.56 billion by 2035 (2020 dollar year).

Total Industrial Decarbonization Costs

Total costs for the set of industrial decarbonization pathways analyzed is $46 billion after adjusting cost data to a 2023 dollar year (St. Louis Fed, 2024a). These costs can vary depending on the individual decarbonization methods chosen by facilities in response to tax credits, inter-regional carbon capture coordination, and cost trends for individual technologies (Regional Carbon Capture Deployment Initiative, 2021a).

Jobs: A multiplier of 2.4 direct jobs per $1 million in spending for Industrial Efficiency, Including Combined Heat and Power was used (Pollin et al., 2021a).

Emissions: According to the U.S. EPA's (2023e) Facility Level Information on Greenhouse Gases Tool, about 25.5 million $MTCO_2e$ are emitted by large-scale facilities in Pennsylvania that release at least 20,000 $MTCO_2e$ and are not classified as power plants, petroleum/natural-gas systems, or waste treatment facilities (U.S. EPA, 2023e). About 67,455 $MTCO_2e$ are from dairy and farm processes. After subtracting facilities outside of the scope, the total emissions reduction aimed for the remaining Pennsylvania industrial facilities is 25.43 million $MTCO_2e$.

BUILDINGS

RECOMMENDATION:

Adopt a Carbon-Free Keystone State Act to Jumpstart a Just Transition Through Building Decarbonization in Pennsylvania

Decarbonize Pennsylvania State Government Facilities

Cost: To achieve a 100% emissions reduction among commonwealth-owned buildings by the end of 2030, Pennsylvania will have to allocate funding for a mix of deep energy retrofits (DERs), and technological upgrades to decarbonize its existing fossil fuel district energy systems. Assisted by the Penn State Facilities Engineering Institute (PSFEI), the Pennsylvania Department of General Services (PA DGS) releases annual energy and utility usage reports that include comprehensive data on commonwealth-owned buildings (Pennsylvania Department of General Services [PA DGS], n.d.), with the most recent publicly accessible report released for the 2019-2020 fiscal year (PSFEI, 2020). Given the impact of the COVID-19 pandemic, however, energy and utility usage data from the *Energy and Utility Usage Report, Fiscal Year 2018–2019* was used for the purpose of the following calculations, and is assumed to be most similar to present and future energy and utility usages (PSFEI, 2019).

The majority of the commonwealth's buildings listed in the *Energy and Utility Usage Report, Fiscal Year 2018–2019* are located in its capital city, Harrisburg, and approximately half of those buildings are part of the Pennsylvania State Capitol Complex (PSFEI, 2019). The entirety of the Capitol Complex has its heating needs met by a district energy system owned and operated by Cordia Energy (Cordia, n.d.). Specifically, Energy Center Harrisburg LLC, a cogeneration plant located in downtown Harrisburg, generates steam for heating purposes which is delivered to customers through a network of insulated underground pipes (U.S. EPA, 2023j). The system also contains a chilled water facility that provides cooling to four buildings that are not part of the Capitol Complex (Cordia, n.d.). The profile of Harrisburg's district energy system can be found on Cordia's website: total capacity is listed as 370,000 lb/hour steam, 3,900 tons of chilled water, and 12 MW of electricity (Cordia, n.d.).

While each *Energy and Utility Usage Report* tabulates which buildings comprise the Capitol Complex, what is tabulated is less inclusive than what the City of Harrisburg details as being part of the Capitol Complex (PA DGS, n.d.; PA General Assembly Capitol Visitor Services, 2020). For this reason, the Rachel Carson and State Records buildings (which were not tabulated as part of the Capitol Complex in the *Energy and Utility Usage Report, Fiscal Year 2018–2019)* were included as part of the Capitol Complex in this cost estimate (PSFEI, 2019).

Ball State University's geothermal district energy project is a suitable analog to the proposed decarbonization of the district energy system in downtown Harrisburg. The University decarbonized its existing district energy system, replacing the campus' coal-fired boilers, natural gas-fired boilers, and chilled water equipment with four industrial heat pump chillers with cooling capacities of 2,500 tons each (Ball State University, 2019). Muncie, Indiana (where Ball State University is located) and Harrisburg are also in the same climate zone (U.S. EIA, 2023e). The system provides heating and cooling to 5.5 million ft^2 among the interconnected buildings, and the entire project cost a total of $82.9 million, coming out to approximately $15/$ft^2$ (Ball State University, 2019; Ball State University, n.d.).

At minimum, the PA Capitol Complex (with the Rachel Carson and State Records buildings included) comprises approximately 5.16 million ft^2 of building space (PSFEI, 2019). It is assumed that the scale (system capacity and building area served) of the proposed geothermal district energy system in Harrisburg is comparable to Ball State's geothermal district energy system. It is important to note, however, that the Cordia district energy system in Harrisburg also serves a number of buildings ***not*** owned by the Commonwealth (Cordia, n.d.). The use of this area in the following calculation provides a minimum cost estimate for the decarbonization of Harrisburg's district energy system:

$$2{,}499{,}042\ ft^2\ \times 18\frac{\$}{ft^2} = \$44{,}982{,}756\ (2019\ dollar\ year)$$

Given that this cost estimate is based on a total project cost, it is assumed that this value includes the purchase ***and*** comprehensive installation costs (borehole drilling, pipework, etc.) of industrial heat pumps.

DERs were recommended for state-owned buildings included in the *Energy and Utility Usage Report, Fiscal Year 2018–2019*, but not connected to the Harrisburg district energy system. Cost estimates for DERs were taken from the *Retrofit Market Analysis* (Urban Green Council [UGC], 2019). While not explicitly stated in the *Retrofit Market Analysis*, it is assumed that DER costs include electrification of heating equipment and appliances – in line with many organizations' (such as the Rocky Mountain Institute) definitions of DERs (UGC, 2019; Clark et al., 2021). The high-end estimate of $18/$ft^2$ for commercial building DERs was used for the following calculation (UGC, 2019). The remaining buildings listed in the *Energy and Utility Usage Report, Fiscal Year 2018–2019* have a combined area of 2,499,042 ft^2 (PSFEI, 2019). The DER cost for these state-owned facilities is then estimated to be:

$$2{,}499{,}042\ ft^2\ \times 18\frac{\$}{ft^2} = \$44{,}982{,}756\ (2019\ dollar\ year)$$

Jobs: A multiplier of 4.4 direct jobs per $1 million in spending for Building Retrofits was used (Pollin et al., 2021b).

Emissions: Decarbonizing the Energy Center Harrisburg LLC cogeneration plant will reduce annual emissions by 32,344 $MTCO_2e$ (U.S. EPA, 2023j). The total energy usage of Pennsylvania state facilities, minus the Capitol Complex (including the Rachel Carson and State Records buildings), is 200,449 MMBTU (PSFEI, 2019). Assuming natural gas is the primary heating fuel for these facilities, the emissions multiplier is 52.91 $kgCO_2e$ per million BTU (U.S. EIA, 2023c). Decarbonizing these facilities is calculated to reduce 10,606 $MTCO_2e$ in natural gas combustion emissions per year.

Decarbonize Pennsylvania's State System of Higher Education (PASSHE)

Cost: According to their campus maps and websites, most PASSHE universities have central plants on their campuses (PASSHE, n.d.). Unless reported otherwise, PASSHE universities with existing central plants on campus were assumed to have their heating needs met by fossil fuel-powered district energy systems. For these universities, we estimated the cost of decarbonizing existing district energy systems with ground-source industrial heat pumps capable of both heating and cooling.

In the absence of available energy and utility data for university campuses, geothermal district energy system costs were calculated one of two ways:

(1): If universities had publicly reported cumulative square footage data (referred to as "total building area" in Table A.1) for their respective campus buildings, system costs were estimated based on the average cost-per-square-foot of Ball State University's geothermal district energy project (Ball State University, n.d.). Dividing the total project cost of $82.9 million by the total building area served, the cost of Ball State's geothermal district energy system comes out to $15/ft^2 (Ball State University, 2019; Ball State University, n.d.). Reported campus square footages were then multiplied by this value to obtain estimated costs.

(2): In cases where square footage data was unreported for a campus, a total building area was estimated. An average individual building area was calculated for each PASSHE university with reported square footage data. These areas were then averaged together, coming out to 33,884 ft^2. To obtain total square footage estimates, this value was then multiplied by the total number of buildings for each remaining PASSHE university campus. The total number of buildings per campus was either reported directly by the university, or estimated from campus maps. In Table A.1, the resulting total building area estimates are referred to as "calculated." Cost estimates were then performed in the same manner detailed above.

Square footage data was found for six PASSHE universities: East Stroudsburg University, Kutztown University, West Chester University, Slippery Rock University, Pennwest California, and Pennwest Clarion. In 2010, the East Stroudsburg University campus comprised 1,026,272 net ft^2 of building area (East Stroudsburg University, 2010). The Kutztown University campus currently comprises 2.5 million ft^2 (Kutztown University, n.d.). In 2013, the West Chester University campus contained 3 million ft^2 of occupied building space (West Chester University, 2013). In 2007, the Slippery Rock University campus contained 1,679,109 existing assignable square feet among its buildings (Slippery Rock University, 2007). Pennwest California's campus comprises 1,844,648 gross square feet of building space (California University of Pennsylvania, 2022). In 2015, Pennwest Clarion's campus had 1,035,666 net assignable square feet of building space (Perkins Eastman, 2015). It is important to note the variability in the way these areas were reported (net square feet, gross square feet, net assignable square feet, etc.). For the purpose of this cost estimate, these differences were not taken into account.

While West Chester University was reported to have 3 million ft^2 of building space, 1.2 million ft^2 of West Chester University's campus is already served by an existing geothermal district energy system (West Chester University, 2021). Therefore, West Chester University's cost estimate is for expanding its existing geothermal district energy system to meet the heating and cooling needs for the remaining 1.8 million ft^2 of building space on campus.

Table A.1 (PASSHE Geothermal District Energy Cost Estimates)

PASSHE University	Total Number of Buildings	Total Building Area ($\overline{built}$)* *calculated	Average Building Area ($\frac{ft^2}{building}$)	Cost Estimate (2009 USD)
East Stroudsburg University	54	1,026,272	19,005	$15,394,080
Kutztown University	60	2,500,000	41,667	$37,500,000
Cheyney University	30	1,016,520*	N/A	$15,247,800
West Chester University	70	3,000,000	42,857	$27,000,000
Slippery Rock University	60	1,665,981	27,766	$24,989,715
Indiana University PA	65	2,202,460*	N/A	$33,036,900
Pennwest California	40	1,844,648	46,116	$27,669,720
Pennwest Clarion (Clarion Campus)	40	1,035,666	25,892	$15,534,990
Shippensburg University	40	1,355,360*	N/A	$20,330,400
CU Bloomsburg	55	1,863,620*	N/A	$27,954,300
CU Lock Haven	30	1,016,520*	N/A	$15,247,800
CU Mansfield	30	1,016,520*	N/A	$15,247,800
TOTAL	**574**	**19,543,567**	**33,884 (AVG.)**	**$275,153,505**

Universities without a central plant were assumed to have no existing district energy infrastructure. Estimated costs were then calculated for decarbonizing heating and cooling on these campuses via networked geothermal systems. Cost values for networked geothermal calculations were taken from the *Geothermal Networks 2019 Feasibility Study,* where values were differentiated between residential and commercial building types, as well as low-, medium-, and high-density land areas (prototypical street segments) (Buro Happold, 2019). For the purpose of these calculations, college campuses were classified as medium-density, mixed-use land areas (consisting of both residential and commercial buildings). For universities with networked geothermal potential, large buildings (lecture halls, dining halls, dormitories, athletic facilities, etc.) were classified as "commercial," whereas college/university-owned houses were classified as "residential" buildings. Excluding incentives, the average geothermal conversion cost of a commercial building in a medium-density, mixed-use land area is assumed to be $73,917 (Buro Happold, 2019), whereas the average conversion cost of a residential building is $7,552 (Buro Happold, 2019).

It is important to clarify that "conversion costs" as listed in Tables IV-4 and IV-5 of the *Geothermal Networks 2019 Feasibility Study* include energy efficiency retrofits, individual heat pump units, and new appliances (Buro Happold, 2019).

Table A.2 (Networked Geothermal Conversion Costs – Adapted from Geothermal Networks 2019 Feasibility Study)

Included Work	Residential Conversion Cost per Unit	Commercial Conversion Cost per Unit
Energy Efficiency Retrofit	$1,250-$2,500	$10,167-$15,833
GSHP Conversion	$2,354-$6,979	$30,500-$91,333
New Appliances	$771-$1,250	N/A
Averaged Total	**$7,552**	**$73,917**

Installation costs, as detailed in the *Geothermal Networks 2019 Feasibility Study,* contain the following: borehole drilling, drilling rig setup and breakdown where applicable, loop piping and installation, circulation pumps, service connections to buildings, public right-of-way (ROW) work including street closures, project design and engineering, permits and approvals, and contractor overhead, profit, and contingency (Buro Happold, 2019).

Table A.3 (Networked Geothermal Installation Costs – Adapted from *Geothermal Networks 2019 Feasibility Study*)

System Characteristics	Vertical Ground Source Heat Pump
Total Installations	203
Avg. Building Size	3,596 ft^2
Avg. Heating Capacity	4.8 tons
Avg. System Cost per Capacity	$13,343
Avg. System Cost per Square Foot	**17.8 $/ft²**

The following equation was used to calculate total networked geothermal system costs (conversion and installation):

$$Total\ Cost\ = (\$7{,}552x) + (\$73{,}917y) + (\$17.8z)$$

where y is the estimated number of residential campus buildings, y is the estimated number of commercial campus buildings, and f is the estimated total campus building area (e.g., the space that would be heated/cooled by the geothermal district energy system). Three PASSHE universities (Millersville University, Pennwest Clarion – Venango Campus, and Pennwest Edinboro) have no central plants on their respective campuses (Millersville University, n.d.; PennWest University, n.d.). Therefore, it is recommended to decarbonize these campuses with networked geothermal systems.

Table A.4 (PASSHE Networked Geothermal Cost Estimates)

PASSHE University	Estimated Total Buildings	Total Building Area (ft^2)* *calculated	Estimated Residential Buildings	Estimated Commercial Buildings	Estimated Networked Geothermal System Cost (2019 USD)
Millersville University	50	1,694,200*	20	30	$32,525,295
Pennwest Clarion - Venango	9	304,956*	N/A	9	$6,093,465
Pennwest Edinboro	32	1,084,288*	3	29	$21,466,561
Total	**91**	**3,083,444**	**23**	**68**	**$60,085,321**

Total Costs: Total costs to decarbonize state facilities is $86.6 million per year after adjusting to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 4.4 direct jobs per $1 million in spending for Building Retrofits was used (Pollin et al., 2021b).

Emissions: Ten non-net-zero Pennsylvania Universities with both building area and net emissions data were reported to have a total of 312,618 $MTCO_2e$ for a total of 30,248,165 ft^2 (University of New Hampshire Sustainability Institute [UNHSI], 2023). From the sample size, the average emissions per building area was calculated to be 0.0084 $MTCO_2e/ft^2$. It should be noted that the emissions per square foot for universities can vary between 0.0008 to 0.01 $MTCO_2e/ft^2$ based on the sample size (UNHSI, 2023). The total square footage for campuses cost for district and network geothermal was estimated to be 25,281,868 ft^2 based on reported gross square footage data and square footage per building for campuses with building area (UNHSI, 2023; East Stroudsburg University, 2010; Kutztown University, n.d.; West Chester University, 2013; California University of Pennsylvania, 2022). The emissions associated with these campuses is estimated to be 213,353 $MTCO_2e$ per year, which can be reduced by 44% or 72% depending on the replacement of air-source heat pumps and electric resistance heating with air conditioning systems (Cross et al., 2011). A moderate emissions reduction is expected to be 123,745 $MTCO_2e$ based on the median of these percentages. Note that these emissions are likely an overestimate, as most universities are reporting net square footage while the emissions trend relies on gross square footage data (UNHSI, 2023). Total emissions reductions for state government facilities and universities is 166,695 $MTCO_2e$/year by the end of 2030.

LMI Community Decarbonization with Utility-Scale Thermal Energy Networks

Cost: According to the most recent available data from the U.S. Census Bureau (2022b), there are 5,193,727 households in Pennsylvania. Of these households, 44% (2,285,240) are classified as low- and moderate-income (LMI) (Rewiring America, 2021). Approximately half (51%) of all households in Pennsylvania use natural gas as their primary heating fuel, or an estimated 2,648,801 households, 1,165,472 of which are estimated to be LMI (U.S. EIA, 2023g; U.S. CB, 2022a).

$$2{,}648{,}801\ households\ \times\ 0.44\ =\ 1{,}165{,}472\ LMI\ households$$

Networked geothermal systems can only meet about a third of annual heating and cooling loads in high-density, mixed use areas (Buro Happold, 2019). Households from counties with population densities greater than 2,000 persons per square mile and less than 100 persons per square mile, (with the exceptions of Pike, Lycoming, and Armstrong counties with population densities between 90 and 100 persons per square mile), were therefore classified as unsuitable for networked geothermal systems (Geiger, 2022).

Using county population data, as well as the average Pennsylvania household size of 2.42 persons, it was estimated that 1,298,141 households cannot feasibly have their heating and cooling loads met by networked geothermal systems (U.S. CB, 2022d; Geiger, 2022). These households were subtracted from the total number of households, and it was again assumed that 51% of the remaining households use natural gas as their primary heating fuel (U.S. EIA, 2023g). The number of LMI households currently using natural gas, and suitable for connection to networked geothermal systems was then estimated as:

$$874{,}170\ households\ \times \left(1{,}700\ \frac{ft^2}{household}\right) \times \left(17.8\ \frac{\$}{ft^2}\right) = \$26{,}452{,}384{,}200$$

This estimate was then multiplied by the average residential networked geothermal conversion cost of $7,552 (excluding incentives) as provided by the *Geothermal Networks 2019 Feasibility Study* (Buro Happold, 2019).

$$874{,}170\ households\ \times \left(1{,}700\ \frac{ft^2}{household}\right) \times \left(17.8\ \frac{\$}{ft^2}\right) = \$26{,}452{,}384{,}200$$

The median home size in Pennsylvania is assumed to be 1,700 ft^2 (St. Louis Fed, 2024b). The average installation cost for networked geothermal systems is assumed to be \$17.80/ft^2 (Buro Happold, 2019).

$$874{,}170\ households\ \times \left(1{,}700\ \frac{ft^2}{household}\right) \times \left(17.8\ \frac{\$}{ft^2}\right) = \$26{,}452{,}384{,}200$$

DERs were recommended for LMI households in counties classified as unsuitable for networked geothermal systems. The cost of a DER for a residential building is assumed to be \$12/ft^2 (UGC, 2019).

$$300{,}000\ housing\ units\ \times\ 1{,}035\ \frac{ft^2}{unit} = 310{,}500{,}000\ ft^2$$

The total cost for networked geothermal installations, geothermal conversions, and DERs is estimated to be \$38.99 billion (2019 dollar year). The cost is \$2.69 billion per year after adjusting to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 4.4 direct jobs per \$1 million in spending for Building Retrofits was used (Pollin et al., 2021b).

Emissions: Assuming natural gas as the primary fuel source for households applicable for geothermal retrofits, then the estimated emissions per million BTU of fuel is 52.91 kg CO_2e (U.S. EIA, 2023c). The annual amount of fuel used by homes utilizing natural gas is reported to be 70.4 million BTU per household in Pennsylvania (U.S. EIA, 2023b). Converting 874,170 LMI households to geothermal systems would reduce the equivalent of 61,541,568 million BTU of natural gas fuel, reducing emissions of 3,256,164 $MTCO_2$e from natural gas. DERs for 291,302 households are calculated to reduce 1,085,062 $MTCO_2$e in emissions, assuming all households receive electric heating systems and switch from using natural gas. A total emissions reduction of 4.341 million $MTCO_2$e/year is therefore expected.

RECOMMENDATION:

Incentivize Union-Built Zero-Emission Affordable Housing

Cost: In Pennsylvania, there is a deficit of 267,074 available/affordable rental units (National Low Income Housing Coalition [NLIHC], 2021). For this calculation, it is assumed that all new-build, net-zero affordable housing units will be located in multi-family buildings. It also assumed that new-build, net-zero multi-family buildings are ***entirely*** comprised of affordable units. This means that this cost estimate does not include any potential ongoing state subsidies that would be required to maintain the affordability of the new units once completed. As such, this calculation provides an order-of-magnitude cost estimate, and should be considered a baseline minimum expected cost for the recommended work.

Among multi-family buildings in the Northeast United States, the average rental unit area is 1,035 ft^2 (U.S. CB, 2019). Assuming that the area of newly constructed multi-family units will, on average, be the same as existing units:

$$300{,}000\ housing\ units\ \times\ 1{,}035\ \frac{ft^2}{unit} = 310{,}500{,}000\ ft^2$$.

We assume a cost of \$325 per square foot for new-build, net-zero, small multi-family housing as provided by Daedalus Projects, Inc. (Integral Group, 2019).

$$163{,}629\ housing\ units\ \times\ 1{,}035\ \frac{ft^2}{unit} =\ 169{,}356{,}015\ ft^2$$

The cost per year for net-zero small multi-family housing is \$17.2 billion/year after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

According to the most recent available data, there are 163,629 existing available/affordable rental housing units in Pennsylvania (NLIHC, 2021). Assuming that the majority of available/affordable rental housing units are in multi-family buildings, the estimated total square footage of available/affordable rental units in PA is:

$$163{,}629\ housing\ units\ \times\ 1{,}035\ \frac{ft^2}{unit} =\ 169{,}356{,}015\ ft^2$$

The cost of a DER for a residential building is assumed to be \$12 per square foot (UGC, 2019).

$$\$1{,}886{,}320{,}356\ -\ \$813{,}043{,}960 =\ \$1{,}073{,}276{,}395\ (2023\ dollar$$

The cost to perform DERs for the entirety of Pennsylvania's affordable rental housing stock is estimated to be \$341 million/year after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 4.4 direct jobs per \$1 million in spending for Building Retrofits was used (Pollin et al., 2021b). A multiplier of 5.5 direct jobs per \$1 million in spending for Construction was used (Bivens, 2019).

Emissions: In a study on building energy use in Northwestern Pennsylvania, Horsey et al. (2023) reported emissions from 10,455 multifamily households totaling 49,470 $MTCO_2$e (Horsey et al., 2023). The average emissions per multifamily household is calculated to be 4.73 $MTCO_2$e per year (Horsey et al., 2023). It is important to note that emissions inherently vary depending on the energy usage of individual households, and total building square footage. DERs for 163,629 affordable housing units is calculated to reduce 773,965 $MTCO_2$e in annual emissions, assuming all households receive electric heating systems.

RECOMMENDATION:

Make Pennsylvania Homes Safer, Healthier, and More Efficient Through an Amended Whole-Home Repairs Program

Cost: The median home size in Pennsylvania is estimated to be 1,700 ft^2 (St. Louis Fed, 2024b). Setting a budget of \$300 million per year covers the cost of repairs for households per year based on an average repair cost of \$2,920 per household and a residential retrofit cost of \$12 per square foot (Divringi et al., 2019; UGC, 2019). In total, about 90,051 homes are expected to be repaired through 2030 under this budget.

Jobs: A multiplier of 4.4 direct jobs per \$1 million in spending for Building Retrofits was used (Pollin et al., 2021b).

Emissions: The PA DEP reports that, in 2019, Pennsylvania's residential sector was responsible for emitting 19.91 million $MTCO_2e$ from petroleum, natural gas, and other fuel use (PA DEP, 2023b). According to the most recent available data from the U.S. Census Bureau (2022d), there are 5,193,727 households in Pennsylvania. It is then estimated that, on average, a household will emit 3.83 $MTCO_2e$ annually. DERs for 90,051 homes, assuming these homes are upgraded to electric heating systems, will reduce emissions by an estimated 344,895 $MTCO_2e$.

RECOMMENDATION:

Adopt a Whole-School Repairs Act to Make Pennsylvania Schools Safe, Healthy, and Sustainable

Repairs and DERs for Title I Schools

Cost: In January 2017, the School District of Philadelphia released a comprehensive facility condition assessment (FCA) (Parsons, 2017). Per the FCA, the total estimated repair cost for the school district, which comprises 308 schools, was $4,502,429,767 (Parsons, 2017). On a per-school basis, repair costs come out to $14,618,278. We assume this repair cost for all K-12 schools throughout the state.

Pennsylvania contains 1,787 Title I schools (National Center for Education Statistics [NCES], 2021). To repair all Title I schools from 2024 through 2040 would require an estimated allocation of $1,546,097,922 per year (2017 dollar year). This is equivalent to $1.886 million/year after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a). Note this may be an underestimate if Title I schools in the state have greater repair needs from chronic disinvestment.

The total recommended year-over-year allocation from PlanCon, Public School Facility Improvement Grant, and School Environmental Repairs Programs is $813,043,960. Annually through 2040, the total remaining need for the repair of Title I schools is then:

$$\$1{,}886{,}320{,}356 - \$813{,}043{,}960 = \$1{,}073{,}276{,}395\ (2023\ dollar\ year)$$

Jobs: A multiplier of 4.4 direct jobs per $1 million in spending for Building Retrofits was used (Pollin et al., 2021b).

Emissions: Annual emissions for K-12 buildings in Pennsylvania were reported to be 1,733,386 $MTCO_2e$ (New Buildings Institute, 2021). Assuming the same carbon footprint for all K-12 schools, the emissions for 1,798 Title I schools is estimated to be 1,101,282 $MTCO_2e$ as they represent 64% of the total 2,830 K-12 schools in Pennsylvania (NCES, 2021; PA Department of Education, n.d.). School repairs will not be able to completely reduce emissions, but will increase the energy efficiency of the repaired buildings, thus contributing to total emissions reduction.

TRANSPORT

RECOMMENDATION:

Construct High-Speed Rail Infrastructure in the Northeast Corridor

Cost: High speed rail infrastructure development could cost up to $18 billion in the Mid-Atlantic North region by 2035 (NEC Commission, 2021b). This would be equivalent to $1.5 billion per year for 12 years.

Job Creation: High speed rail infrastructure development will create more than 173,000 direct, indirect, and induced jobs in the Mid-Atlantic North region by 2035 (NEC Commission, n.d.b). This is equal to 10,000 jobs per year, or about 70,000 jobs by 2030.

Emissions: The Northeast Corridor project will create 132 route miles of high-speed rail tracks by 2035 (NEC Commission, 2021a). The reported weighted average carbon footprint for the proposed C35 NEC rail-line is 0.22 $lbCO_2e$ per passenger-mile traveled (NEC Commission, 2021a). Carbon reductions from increased rail ridership are calculated to be 1.44 lbs per passenger-mile traveled based on the difference in emissions between rail and non-rail alternatives per passenger-mile (NEC Commission, 2021a). The Pennsylvania Passenger Rail Program reported 91,212,842 passenger miles in the fiscal year of 2021 to 2022 (PA Department of Transportation [PennDOT], 2023a). The NEC project is expected to increase services and daily revenue round trips by 26% in the Mid-Atlantic North region (NEC Commission, 2021b). Based on these statistics, the carbon reductions from 23,715,339 new passenger-miles by the project in 2035 will be 15,490 $MTCO_2e$/year.

RECOMMENDATION:

Electrify and Transformatively Expand Pennsylvania's Public Transit by 2035; Invest in a Retraining Program for the Electric Vehicle Transition

Transition Public Transit Buses and Paratransit Shuttles

Cost: Pennsylvania transport authorities reported a total of 127,390,703 revenue miles for all transit systems (PennDOT, 2023a). About 2,688 diesel/gasoline motor buses and 435 compressed natural gas buses were identified from the fleets of transit agencies (PennDOT, 2023a). The typical purchase price range for a battery electric bus is $579,000 to $1.2 million, with a baseline cost of $887,308 per bus (Johnson et al., 2020). Installation costs for electric vehicle supply equipment is $17,050 per bus charging station, with the assumption that one charger will be allocated per depot-charged vehicle (Johnson et al., 2020). Replacing a total of 3,103 transit buses with electric buses costs $2.75 billion for vehicles and $52.9 million for charger installations (2018 dollar year).

Additionally, 1,456 gasoline paratransit vehicles and eight compressed natural gas paratransit vehicles were identified from transit agencies (PennDOT, 2023a). Assuming the capital costs for electric shuttle buses and other forms of paratransit transportation are equivalent to electric transit buses, the total costs for replacing 1,464 paratransit vehicles is $1.32 billion after considering the cost of charger installations (2018 dollar year). The total costs for new electric transit and paratransit buses is $412 million annually for 12 years after adjusting to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 0.2 direct jobs per $1 million in spending for High Efficiency Autos was used (Pollin et al., 2021b).

Emissions: The average per-passenger fuel economy is about 3.26 miles per gasoline gallon equivalent (GGE) for transit 3.3 buses and approximately 7.1 miles per GGE for paratransit shuttles (Alternative Fuels Data Center [AFDC], 2020b). These are equivalent to 3.7 and 8.0 miles per diesel gallon respectively (AFDC, 2020b). The national average vehicle miles (VMT) for buses and paratransit vehicles is about 43,647 and 29,429 VMT per vehicle (AFDC, 2020a). Assuming the fleet of 2,688 gasoline/diesel buses and 1,456 gasoline/diesel shuttles primarily rely on diesel fuel, the expected emissions for these vehicles would be 5.41 million and 4.30 million MTCO2e/year respectively based on an average of 12,546 g CO2e emitted per diesel gallon burned (AFDC, 2021a). CO2e emissions from compressed natural gas buses were assessed by the U.N. Climate Technology Centre & Network to be 1040-1440 grams per vehicle kilometer (UN. Climate Technology Centre & Network, n.d.). The CO2 emissions from all Pennsylvania CNG transit vehicles is calculated to be 38,359 MTCO2e per year based on the median of the emissions range from U.N. Climate Technology Centre & Network (n.d.) and the average annual vehicle miles from the U.S. DOE AFDC (2021). Total emission reductions from replacing CNG and diesel transit vehicles is projected to be 9.74 million $MTCO_2e$/year by 2035.

Transition Passenger Rail

Cost: A total of 16 miles of non-electrified commuter rail tracks were identified (SEPTA, 2015). Based on the route-miles of electric rail infrastructure and cost predictions for the electrification of Boston commuter rails, the average cost for commuter rail electrification is calculated to be $3.60 million (TransitMatters, 2021). Using this average, the total costs for electrification infrastructure for 16 rail miles would be $57.6 million (2021 dollar year). This is equivalent to $5.4 million annually by 2035 after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

SEPTA purchased 15 electric locomotives for its passenger rail system in 2018 for a total cost of $154 million (Brasuell, 2018). Additionally, SEPTA has a fleet of 351 electric Silverliner railcars in Philadelphia (Philadelphia Transit Vehicles, n.d.). SEPTA still has 45 Comet-model push-pull trains in the transit system that are not decarbonized yet (Philadelphia Transit Vehicles, n.d.). The total cost for 45 new electric passenger railcars in Pennsylvania is $4.15 billion assuming ACS-64 model electric locomotives are purchased (2018 dollar year), which cost $10.26 million per railcar in SEPTA's agreement with Siemens AG (Brasuell, 2018). This is equivalent to $413 million annually after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a). Total costs for transit rail electrification and electric commuter rail cars is $470 million annually by 2035 (2023 dollar year).

Jobs: A multiplier of 2.8 direct jobs per $1 million in spending for Rail was used (Pollin et al., 2021b).

Emissions: The average fuel economy for a transit railcar is 141.4 passenger miles per gasoline gallon equivalent (AFDC, 2022). In 2019, 465,744,543 passenger miles were reported for SEPTA's total regional railroad system (SEPTA, 2020). Based on the 929 total reported regional trains in SEPTA's fleet in 2021, it is estimated that the average passenger miles per train is 501,340, including light rail systems (PennDOT, 2023a). The addition of 45 electric locomotives has the potential to reduce 8,469 gasoline gallon equivalents based on an estimate of 22,560,2845 new passenger miles for the new fleet. This is equivalent to a reduction of 1,418 $MTCO_2e$/year based on an emissions rate of 8.887 $kgCO_2e$ per gasoline gallon (Office of Transportation and Air Quality, 2023).

RECOMMENDATION:

Decarbonize Pennsylvania's Last-Mile Trucking by 2030 While Expanding Worker Protections in the Larger Logistics, Distribution, and Warehousing Sector

Heavy-Duty Freight Trucks

Cost: The U.S. Federal Highway Administration defines any vehicles Class 7 and above as Heavy Duty Vehicles (HDV), which includes large delivery trucks and tractor-trailers exceeding 26,000 lbs (Federal Highway Administration Office of Operations, 2020). There are a total of 73,189 registered ARP Trucks in the state, of which 71,862 are a weight class of 26,000 lb and above (PennDOT Bureau of Motor Vehicles, 2022c). This represents the majority of Pennsylvania freight trucks responsible for inter-state transportation, as heavy duty transport vehicles are required to be registered with the Apportioned Registration Program if they travel in two or more states (PennDOT Driver & Vehicle Services, n.d.). The average manufacturer suggested retail price for battery electric Class 8 long-haul vehicles is $500,000 (Basma et al., 2023). The expected cost for replacing all inter-state HDV transport vehicles with Class 8 electric trucks is calculated to be $35.9 billion (2022 dollar year). This prediction is an overestimate as 4,590 of the existing HDV transport fleet are Class 7 trucks and the costs for electric trucks are expected to decrease over time (PennDOT, 2022c; Basma et al., 2023).

Electric HDVs will require Direct Current Fast Chargers (DCFCs), which cost $10,000-$40,000 per single port or about $4,000-$150,000 for public charging station installation costs (PennDOT, 2022a). The majority of new DCFC locations are expected to support four charger ports (PennDOT, 2022a). Using a medium installation cost of $77,000 per station and assuming the accommodation of one port per truck in the fleet, then the estimated costs for providing charging stations for electric freight HDVs is $1.38 billion (2021 dollar year). These costs may be an overestimate as the replacement of pre-existing diesel stations with electric vehicle stations may become more cost effective (Basma et al., 2023). The total costs are estimated to be $39.4 billion, or about $3.28 billion per year for 12 years after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 0.2 direct jobs per $1 million in spending for High Efficiency Autos was used (Pollin et al., 2021b).

Emissions: The national average vehicle miles traveled for Class 8 trucks is estimated to be about 62,751 miles per year (AFDC 2020a). Additionally, the average fuel economy for diesel powered Class 8 trucks is approximately 6 miles per gallon (AFDC, 2020b). The U.S. EPA reports that an average of 10,180 grams CO2e is emitted per diesel gallon burned by the average passenger vehicle (Office of Transportation and Air Quality, 2023). Assuming the Pennsylvania fleet of HDV freight trucks primarily relies on diesel fuel and the emissions per burned diesel gallon are independent of vehicle size, then the emissions per truck would be 106,468 kg CO_2e. Emission reductions are calculated to be 7.65 million $MTCO_2e$/year by 2035 after replacing 71,862 diesel HDV trucks with electric trucks.

Freight Rail

Cost: The total length of freight rails reported by Pennsylvania is 5,760 railroad miles (PennDOT, 2023b). The normalized cost for electric locomotive infrastructure, such as chargers and catenary systems, is $4.8 million per track mile (Cambridge Systematics Inc., 2012). Electric trains are estimated to cost $5 million per straight-electric locomotive and $8 million per dual-mode locomotive (Cambridge Systematics Inc., 2012). Approximately 960,200 freight carloads left from PA in 2021, equivalent to about 3.4% of the total 27,885,000 outbound carloads in the U.S. (American Association of Railroads, n.d.). The total number of Class I freight locomotives in the U.S. identified by the end of 2020 was 23,544 (Bureau of Transportation Statistics, n.d.). The estimated number of Class I freight locomotives in Pennsylvania is 811 based on the state contributing to 3.44% of carloads in 2021 (Bureau of Transportation Statistics, n.d.; American Association of Railroads, n.d.). Using the median of the electric locomotive cost range of $5 million to $8 million, the costs for replacing 811 freight trains would be $5.3 billion (Cambridge Systematics Inc, 2012). The total costs for freight rail electrification were calculated to be $32.9 billion (2011 dollar year). Annual costs to decarbonize freight rail by 2035 are $3.67 billion after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 2.8 direct jobs per $1 million in spending for Rail was used (Pollin et al., 2021b).

Emissions: After considering the CO_2 equivalencies for carbon dioxide, nitrous oxide, and methane emitted from non-passenger line haul locomotives in Pennsylvania, freight train emissions were calculated to be 841,937 $MTCO_2e$ from 105 non-point sources (U.S. EPA, 2023a).

AGRICULTURE

RECOMMENDATION:

Establish Pennsylvania's First Agricultural Workers' Rights Act to Strengthen Worker Power and Incentivize Emissions Reduction

Cost: The three types of projects funded by the agriculture energy efficiency rebate program include upgrades to ventilation, lighting, and refrigeration equipment (PA DEP, 2023a). At least 48.15% of these projects were identified as lighting upgrades (PA DCED, n.d.b). The U.S. DOE assessed that a total of 42%, 74%, 64%, 53%, 98%, and 89% of the poultry broiler, poultry layer, dairy, hog, supplemented greenhouse, and high intensity sole source farms utilized non-LED lighting systems (EERE, 2020a). Assuming the national percentages of farms with energy inefficient lighting holds true for Pennsylvania's 53,157 farms, then 12,487 of these farms are in need of lighting upgrades in Pennsylvania (U.S. Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2023). Based on the need for new lighting systems and assuming these farms are in need of upgrades for other equipment as well, the PA DEP should scope at least 1,015 new applicants per year by 2035 for the rebate program.

In 2023, the PA DEP offered $7,500 or up to 50% of costs for agricultural projects installing energy efficient equipment – accepting 26 applicants and covering $89,257 of costs (PA DEP, 2023a; PA DCED, n.d.b). The average funding per application was $3,433, with only one farm receiving the highest possible cost coverage of $7,500 (PA DCED, n.d.b). Therefore, it is assumed that the average total costs per project was $6,866 as the majority of state spending per application was capped off at half the total cost. Increasing the program funding cap to 80% per applicant would result in the state covering an average of $5,492 per application, with the remaining $1,373 of costs to be paid by the applicant or private investment. Increasing the rate of applications accepted per year from 26 to 1,041 would increase both state and private spending on energy efficient equipment by $7.01 million per year (2023 dollar year), totalling $84.1 million by 2035.

Jobs: A multiplier of 4.4 direct jobs per $1 million in spending for Building Retrofits was used (Pollin, 2021b).

Emissions: Emission reductions are dependent on the energy efficient technology pursued in each application. One pathway includes rebates for switching to LED light bulbs, which can save 50-75% energy compared to older fluorescent bulbs for Pennsylvania farms or about 25% in energy usage for lighting in livestock farms (PA DEP, 2023a; EERE, 2020a). Additionally, upgrading refrigeration systems with scroll compressors can decrease the system's energy usage by 15-20% (PA DEP, 2023a).

RECOMMENDATION:

Create a Circular Biofuel Economy to bolster land use retention, renewable energy, and domestic production

Scope and Cost: Data on herd-sizes, technology, and CO_2e reductions for dairy farms with established anaerobic bio-digesters was collected from the U.S. EPA's AgSTAR database (U.S. EPA, 2023f). It is assumed that the average fixed cost function for the anaerobic digester (ADs) will be the same regardless of reactor technology and that materials for construction will be consistent with existing reactors in the national database Cowley & Brorsen, 2018). Fixed costs for digesters are $2.590 million, $4.723 million, $8.084 million, and $15.084 million for ADs in farms with herd sizes of 500, 1.6k, 4.5k, and 15k animals respectively (Cowley & Brorsen, 2018). Fixed costs are highly dependent on farm sizes, with reactor costs per cow decreasing for larger dairy farms after calculations ($5,180, $2,958, $1,796, and $1,006 per cow for the above ranges respectively). Multiple herd sizes were examined based on the ranges presented in the PA Agricultural Statistics Annual bulletin (USDA NASS, 2023). The livestock count for these ranges exclude un-fresh heifers and any non-dairy livestock that may also be raised at the same farm (USDA NASS, 2023). Additionally, the total population of dairy cows has decreased from 527,000 to 468,000 between 2017 to 2022, which implies that the number of live-stock in the selected ranges may be smaller in the present (USDA NASS, 2023). It is assumed that these errors are more significant for small farms compared to large livestock farms, the former of which is excluded from the recommendation scope.

The top four ranges, consisting of 341 farms with 153,737 dairy cows, were selected in order to limit the scope of the recommendation to large livestock farms with milk cow populations of 200 or higher (USDA NASS, 2023). Out of these farms, approximately 24 farms with 18,277 cows already have ADs in Pennsylvania (U.S. EPA, 2023f). After considering farms with digesters in place, the cow populations and average herd size per farm for the 317 remaining farms were determined for each range between 200 and 2,500+. The total remaining headcount is 135,460 cows or about 25% of the 2017 dairy population (USDA NASS, 2023). Calculations for average cows, interpolated costs from data, and predicted total costs for each range are listed in Table A.4 below.

Table A.4 (Assessment of Digester Costs for Large Live-stock Dairy farms)

Category	Range 1	Range 2	Range 3	Range 4	All Ranges (1-4)
Milk Cow Range	2,500 or more	1,000 to 2,499	500 to 999	200 to 499	200 or more
Milk Cows	11,286	28,184	41,622	72,645	153,737
Dairy Cows in AD farms	0	6,225	8,917	3135	18277
Milk Cows left	11,286	21,959	32,705	69,510	135,460
% of Dairy Population 2017	2.14%	4.16%	6.20%	13.17%	25.67%
Farms	4	20	62	255	341
Farms with Digesters	0	4	13	7	24
Farms with no Digesters	4	16	49	248	317
Cows per farm in scope	2822	1372	667	280	5142
Average Digester cost per farm	$6,143,886	$4,288,874	$2,916,069	$1,451,862	$1,880,589
Total Cost for range (2014 Dollar year)	$24,575,542	$68,621,980	$142,887,373	$360,061,800	$596,146,695
Total Cost for range (2023 Dollar year)	$31,110,941	$86,870,693	$180,885,557	$455,813,400	$754,680,590
Cost per year (2025-2035)	$2,828,267	$7,897,336	$16,444,142	$41,437,582	$68,607,326

Average fixed costs for digesters per farm in each of the four ranges were determined from linear interpolation between reported costs, with Range 1 estimated from the costs for farms with 1600 and 4500 herd sizes. The total cost is $755 million, or approximately $62.9 million per year for 12 years after adjusting cost data to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 3.3 direct jobs per $1 million in spending for Low-Emissions Bioenergy was used (Pollin et al., 2021a).

Emissions: For all 24 Pennsylvania dairy farms that already have functional Anaerobic Digesters, an annual average of 4.78 $MTCO_2e$ reduced per dairy cow was calculated with a standard deviation of ± 2.24 $MTCO_2e$/cow (U.S. EPA, 2023f).

It is assumed that carbon emissions and respective reductions are proportional to herd-size population. It should be noted that variations in emission reduction are dependent on the type of reactor technology and the usage of biogas fuel, such as generation of electricity versus heat for cogeneration (U.S. EPA, 2023f). All reductions are assumed to be consistent with the AR5-100 year accounting method utilized by the EPA. Scaling the average emissions reduction per cow with the total 135,460 dairy cows in farms that will receive new digesters produces an estimated reduction of 647,360 $MTCO_2e$/ year.

INFRASTRUCTURE

RECOMMENDATION:

Expand High-Speed Broadband Access by 2028 to 1.3 Million Digitally Excluded Households Using Local, Union Jobs

Broadband Infrastructure

Cost: The Pennsylvania Broadband Development Authority (PBDA) evaluated the costs needed to upgrade 279,085 unserved and 54,048 undeserved addresses, a total of 333,133 locations in need of broadband infrastructure (PBDA, 2023). The state estimated the need for $2.07 billion in total funds for the action-plan, with contributions to the cost covered by PBDA Capital Project Funds and the Broadband Equity, Access, and Deployment program Funds (PBDA, 2023). This is equivalent to $414 million per year by 2028.

Internet Coverage

Cost: The total number of low-income households without broadband subscriptions was determined to be 205,278 for households earning less than $20,000 and 343,576 for households earning $20,000 - $75,000 annually (U.S. CB, 2022e). This represents 548,854 households earning less than 375% of the lowest census income category. The average monthly rate for internet subscriptions in the U.S. is about $69.70, $63.30 and $61.7 for Urban, semi-rural, and rural households earning less than $50,000 monthly (U.S. CB, 2018). Additionally, the average monthly rate for households earning more than $50,000 monthly is $79.9, $73.9, and $71.4 for urban, semi-rural, and completely rural regions respectively (U.S. CB, 2018). The PBDA reported that 82% of addresses lacking access to broadband are in rural areas (PBDA, 2023). Since the median of earnings from households earning $20,000 - $75,000 annually is about $48,000, the broadband subscriptions for these households are about $71.40-$79.90. After considering the number of households within the two income ranges and addresses in rural versus urban areas, the weighted average monthly rate was estimated to be $69.27 (2017 dollar year). Based on this estimate, the medium cost for internet subscriptions would be $557 million after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a). The total costs for five years of broadband internet coverage is $2.78 billion (2023 dollar year).

RECOMMENDATION:

Build Climate-Resilient, Clean Water Infrastructure Using Low-Carbon and PA-Made Materials

Bridge Repair

Cost: Repairing all bridges will require at least $18.15 billion of investment (2021 dollar year), or about $2.59 million per year for 7 years (PA State Council of ASCE, 2022). This is equivalent to $2.92 billion per year after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 11.1 direct jobs per $1 million in spending for Surface Transportation was used (Pollin et al., 2021b).

Clean Drinking Water

Cost: The EPA's 7th Drinking Water Infrastructure Needs Survey and Assessment outlines the individual costs to be $15.84 billion for distribution/transmission, $4.71 billion for treatment, $2.20 billion for storage, $691 million for source infrastructure, and $859 million for other drinking water infrastructure needs (2021 dollar year) (Office of Water, 2023). The total cost balance for these components is $27.37 billion after adjusting for inflation (2023 dollar year), which includes the costs for replacing 688,697 lead pipelines in Pennsylvania (Office of Water, 2023; St. Louis Fed, 2024a). The total costs for Pennsylvania's drinking water infrastructure needs are $3.91 billion per year if all necessary projects are funded by 2030.

Jobs: A multiplier of 5.2 direct jobs per $1 million in spending for Water/Wastewater was used (Pollin et al., 2021b).

Dam Repair

Cost: The rehabilitation of all dams with a rating lower than satisfactory is at least $2.88 billion (2022 dollar year) (Association of State Dam Safety Officials, 2023). Out of this cost, approximately $1.88 billion are for dams that have a High-Hazard Potential and must be prioritized (Association of State Dam Safety Officials, 2023). The costs for dam repair are $433 million per year by 2030 after adjusting the cost to a 2023 dollar year (St. Louis Fed, 2024a).

Jobs: A multiplier of 7.3 direct jobs per $1 million in spending for Dams was used (Pollin et al., 2021b).

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