

The Coal Refuse Reclamation to Energy Industry

Environmental and Economic Impact Analysis
Update

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Submitted to Appalachian Region Independent Power Producers
Association (ARIPPA)

About Econsult Solutions, Inc.

This report was produced by Econsult Solutions, Inc. (“ESI”). ESI is a boutique consultancy providing analysis and insights at the intersection of economics, planning, and public policy. We leverage the skills and experience of our team to help our clients find practical solutions to their complex challenges. Based in Philadelphia, ESI serves clients nationwide. ESI’s government and public policy practice combines rigorous analytical capabilities with a depth of experience to help evaluate and design effective public policies and to benchmark and recommend sound governance practices.

The Coal Refuse Reclamation to Energy Industry

Pennsylvania Environmental and Economic Impact Analysis

Private Activity, Public Benefit

Pennsylvania's coal mining legacy has left the Commonwealth with significant environmental liabilities, including 764 coal refuse piles. For decades, Pennsylvania's coal refuse reclamation to energy industry has addressed these liabilities by **removing coal refuse, using it as fuel to generate energy, and rehabilitating mining-affected lands.**

Pennsylvania's Coal Refuse Plants

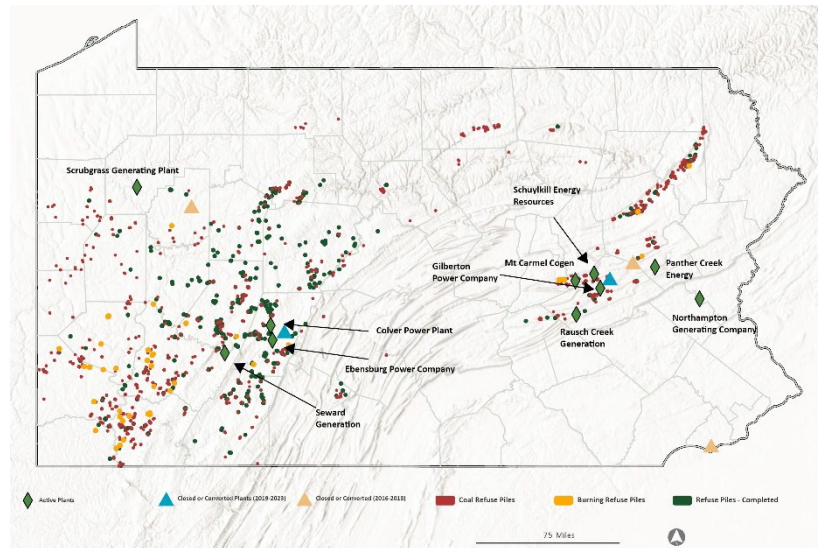
Focused Upon Environmental Remediation

- > 257 million tons of refuse consumed to date
- > 1,210 miles of polluted streams restored
- > 8,070 acres of land restored

Current Coal Refuse Inventory

764 Total Coal Refuse Piles in Pennsylvania

- > Covering 8,001 acres
- > Weighing 211 million tons
- > 44 piles actively burning



Stineman
Cambria County, Pennsylvania



Industry reclamation of the Stineman site restored the area and stopped acidic material from draining into the South Fork of the Little Conemaugh River after rainfall. A 1.6-mile walking and biking trail was also completed as part of the reclamation project. The project received a Governor's Award for Environmental Excellence in 2022, one of numerous environmental awards bestowed on the industry.

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The Business of Remediation

Coal refuse reclamation as an industry functions by **funding the removal of refuse coal and remediation of impacted sites through the sale of electricity.**

This private industry generates “positive externalities” for Pennsylvania, delivering benefits to the environment, the Commonwealth, and the public at large. Factors such as variable electricity prices and increasing costs can force plants to operate seasonally or to cease operations. When these plants cannot operate, Pennsylvania loses both environmental and economic benefits.

South Branch Blacklick Creek Cambria County, Pennsylvania

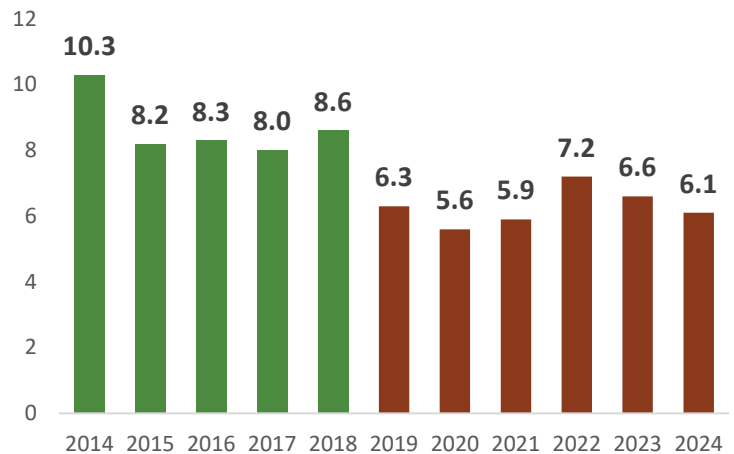


“We’ve got fish in the water now. People weren’t fishing here before. This is a good news story.”
- Cambria County Commissioner Tom Cherinsky

Valuation of Environmental and Public Benefits

The reduction in environmental hazards generates significant and quantifiable benefits to the Commonwealth each year. Improvements in water quality, air quality, public health and safety, and land values from continuing the removal of coal refuse piles at current levels generate an estimated \$1.2 billion in value over a 20-year period, or \$62 million a year in value to Pennsylvania.

Coal Refuse Consumed by Pennsylvania Plants (Millions of Tons)



Environmental Benefits

The removal of coal refuse piles and the reclamation of mining-affected lands has demonstrated environmental and public benefits, including water quality, public health and safety, air quality, and land value.

Coal refuse piles can cause many harmful effects to society and the environment. Piles can combust, releasing uncontrolled emissions. Water interacts with piles to form sulfuric acid causing acid mine drainage, which degrades water quality and threatens drinking water and aquatic life. Recent research provides evidence that coal refuse reclamation to energy production results in net improvements in air quality, reducing greenhouse gas emissions. The coal refuse reclamation to energy industry is imperative in preventing the ongoing environmental and societal damage that would otherwise require significant and costly efforts from the Commonwealth to prevent.

\$1.2 B in 20-Year Enviro / Public Benefits



Water
Quality
\$452M



Public Health
and Safety
\$184M



Air
Quality
\$444M



Land
Value
\$162M

The Coal Refuse Reclamation to Energy Industry

Pennsylvania Environmental and Economic Impact Analysis

Avoided Remediation Activity

At its current reduced capacity, the industry consumes about 6.6 million tons of coal refuse and remediates 203 acres of land per year. Historically, the industry has removed 257 million tons of coal refuse, restored thousands of acres of land, restored 1,200 miles of polluted streams, and has treated billions of gallons of polluted drainage water each year. **Absent the activities of the industry, the responsibilities and costs for the range of environmental and safety hazards associated with coal refuse falls on the Commonwealth.**



\$98 M - \$281 M in annual avoided cost to the Commonwealth

Avoided Public Cost

State clean-up efforts incur additional costs for disposal not required by the more comprehensive industry efforts. Further, state efforts produce no revenue from energy generation to offset the environmental remediation and reclamation costs. As a result, it is cost prohibitive for the state to remediate sites to the same standard as the industry.

Based on recent project bids, state costs for removal and disposal of coal refuse can run up to \$41 per ton (in addition to land remediation costs). Replicating the annual removal of 6.6 million tons of refuse and remediation of 203 acres would cost the state \$98 million annually under the most favorable conditions, and **\$281 million annually including typical disposal costs**. Addressing all identified piles across the state would cost \$3.2 - \$9.1 billion at this rate.

Swoyersville



Spotlight on Northampton Generating Company (NGC)

In collaboration with a host of industry partners, NGC led Phase 1 of an Abandoned Mine Reclamation project in Swoyersville, removing a four-million ton coal refuse pile. The project leveraged funding from both federal and private sources. Eastern Pennsylvania Coalition for Abandoned Mine Reclamation is now engaged with the borough's recreation board to plan for the repurposing of a portion of the site's acreage into athletic facilities, while NGC looks to move forward with the next phase.

Economic Benefits

The industry also represents a major source of economic activity and family-sustaining employment. The industry produces \$697 million in annual economic benefit, supporting 2,200 full-time equivalent (FTE) jobs annually.

These benefits are concentrated in Pennsylvania's coal communities that face existing challenges in generating economic opportunities for residents.

\$697 M in Annual Economic Impact



\$389M
Direct
Expenditures



\$155M
Earnings
Supported



\$16M
State
Taxes/Fees

2,200 FTE Jobs from Economic Impact

The Coal Refuse Reclamation to Energy Industry

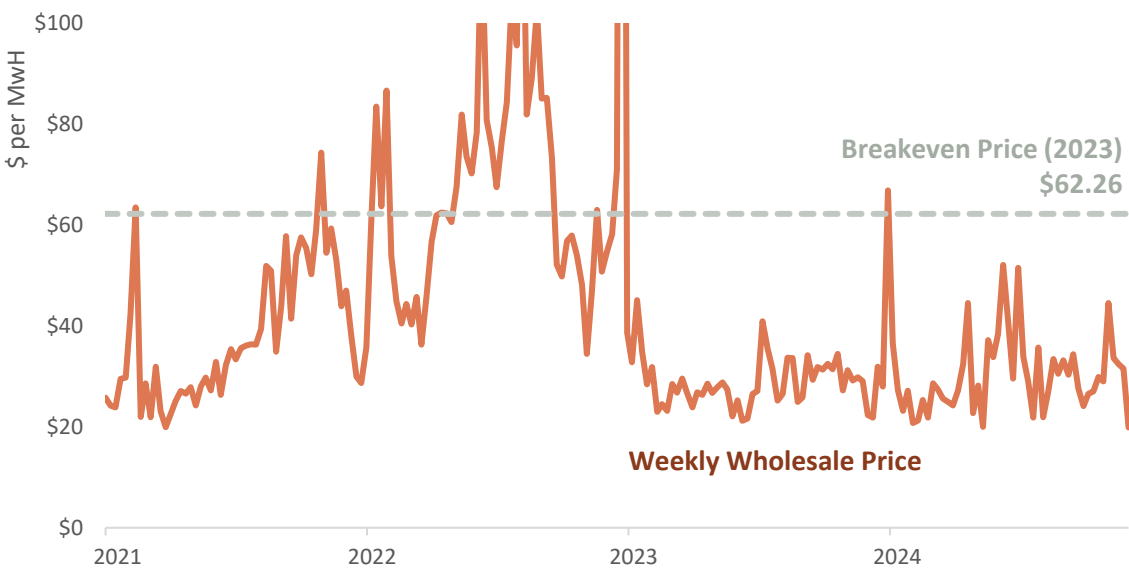
Pennsylvania Environmental and Economic Impact Analysis

Corrective Revenue Streams Support a Critical Industry

For more than three decades, the coal refuse reclamation to energy industry has provided a solution to refuse piles and their associated negative effects. While annual activity levels have decreased with the number of plants, the industry continues to produce meaningful and measurable benefits to the Commonwealth’s residents, economy, and environment.

The fundamental challenge is that while the industry's business model remains an efficient means of environmental remediation, market conditions frequently fail to generate sufficient revenue to cover operating costs. The future viability of the industry is highly vulnerable to fluctuations in energy prices, capacity payments, and increasing costs. Costs have continued to rise in recent years, widening the gap between revenues and operating costs.

Weekly Wholesale Energy Sale Price per MWh, 2021-2024



Sustaining Benefits Through Public Partnership

The Tier II Alternative Energy Credit and Coal Refuse Energy and Reclamation Tax Credit have emerged as a critical revenue component to support continued operation of Pennsylvania’s coal refuse reclamation industry. In 2023, Alternative Energy Credits accounted for 57% of industry revenues, stabilizing the industry in the midst of significant challenges. Without these revenue sources, the industry and the public benefits it contributes would face a severe threat to sustainability, as recent wholesale energy prices have remained far below the breakeven level for the industry. The continued rise of costs in 2024 and 2025 has further exacerbated this issue, greatly threatening the sustainability of the industry.

Estimated Industry Revenues and Costs per MWh, 2023

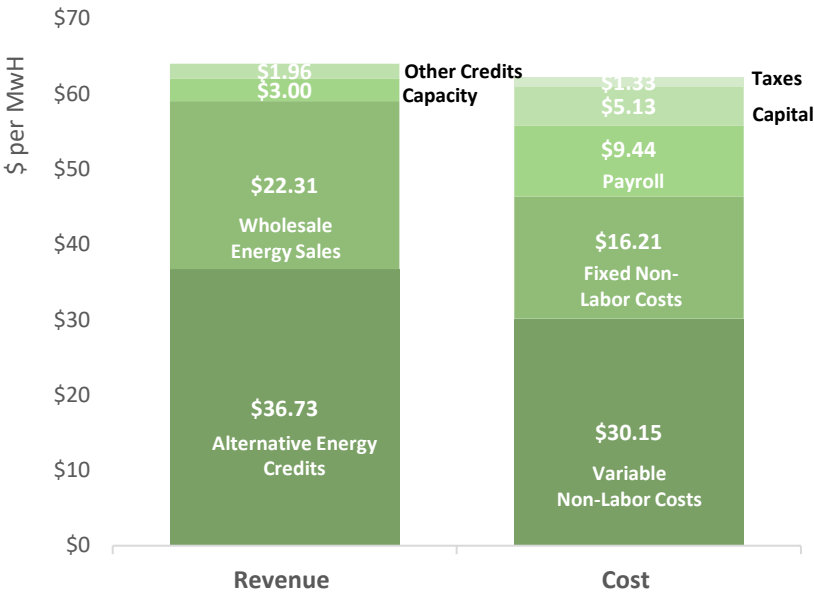


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1. Industry Overview

CHAPTER SUMMARY:

- Pennsylvania's coal mining legacy has left the Commonwealth with significant environmental liabilities, including 211 million tons of coal refuse piles identified by PA DEP, 5,500 miles of waterways impacted by acid mine drainage, groundwater pollution, and air pollution caused by coal refuse fires.
- For more than three decades, the coal refuse reclamation to energy industry has helped the Commonwealth address these liabilities by removing piles, reusing the coal refuse to generate energy, and restoring mining affected lands.
- Revenues from energy generation alone are insufficient to cover reclamation and restoration costs within the current market. State policy support has been essential to enabling these operations to continue, allowing the Commonwealth to capture the associated environmental and social benefits.

1.1. Legacy Liabilities from Pennsylvania's Coal Mining History

Pennsylvania's historic coal mining legacy poses current environmental and economic challenges for the Commonwealth. Over more than two centuries of mining activity, Pennsylvania produced more than 17 billion tons of coal from its bituminous region in the central and western parts of the Commonwealth and the anthracite region in the northeast. While this production helped power America's industrial and military might, over 80% of the production was before modern day disposal standards (the Surface Mining Control and Reclamation Act of 1977, for example). This has left behind environmental liabilities for current and future Pennsylvania residents.

Central to these challenges are the hundreds of coal refuse piles scattered across the Commonwealth's landscape. These mounds of "waste coal" and other mining refuse were discarded during mining and coal cleaning processes, primarily before the implementation of comprehensive environmental regulations. According to the Pennsylvania Department of Environmental Protection's (PA DEP) latest inventory, there are currently 764 identified coal refuse piles across Pennsylvania containing 211 million tons of refuse. This represents a modest reduction from the 772 piles and 221 million tons documented in 2019, largely due to the continued efforts of the coal refuse reclamation to energy

industry.¹ These refuse piles produce significant ongoing environmental and social damage, with effects on air quality, water quality, public safety, and property values.

For more than three decades, the coal refuse reclamation to energy industry has provided a solution to refuse piles and their associated environmental impact. The industry operates through a complete "fuel cycle" - removing coal refuse piles, using the material as fuel in specially designed power plants to generate electricity, and then utilizing the resulting alkaline ash to remediate and reclaim the formerly blighted sites. This process has demonstrated success in improving water quality, eliminating public safety hazards, and restoring land to productive use.

This approach to environmental remediation is economically efficient compared to other remediation approaches because it generates revenue (through energy generation and sales) to partially offset the cost of coal removal and site remediation. However, due to market design failures at the federal, state, and regional transmission organization level, recent and current energy market conditions do not enable plants to fully recover the cost of this activity through energy sales alone. To bridge this gap, Pennsylvania has implemented supportive policy designed to make industry operations viable, enabling the Commonwealth to continue to enjoy the environmental and economic benefits that this work generates. The Coal Refuse Energy and Reclamation Tax Credit provides up to \$8 per ton of refuse coal used, while qualification as a Tier II resource under the Alternative Energy Portfolio Standards (AEPS) program generates additional revenue through alternative energy credits (AECs).

The financial outlook for the industry has shown recent signs of improvement due primarily to stronger AEC pricing. As qualified Tier II alternative energy sources under Pennsylvania's AEPS program, coal refuse facilities have benefited from weighted average credit prices rising from historic lows of \$0.10-0.30 per credit between 2013-2020 to nearly \$30 per credit in recent reporting periods. The increase in Tier II credits relevant to the coal refuse industry follows a trend of increases for many alternative and renewable energy credits. AEPS Tier I credit prices and PJM Renewable Energy Credit (REC) prices both rose considerably since 2020; AEPS Tier I credits rose from \$10.62 to \$31.01 by the 2023-24 compliance year, and PJM Tier I REC prices rose from \$8.74/megawatt hour (MWh) to \$30/MWh in the same time.^{2,3} This represents a meaningful supplement to plant revenues from energy sales and Coal Refuse Energy and Reclamation Tax Credits.

However, significant challenges remain. Market disruptions stemming from abundant natural gas supply from the Marcellus Shale formation and various energy subsidies continue to impact wholesale electricity prices. Meanwhile, regulatory requirements continue to evolve and add to the regulatory burden of the industry, often without fully accounting for the positive environmental externalities provided by the industry. While improved AEC pricing has helped stabilize operations at remaining

¹ This dataset is acknowledged by PA DEP to be incomplete. Many pre-existing sites may remain unidentified, and refuse sites abandoned after 1977 have not been systematically added to the inventory. Independent studies of specific regions have consistently identified additional sites beyond those in the official database, suggesting the true scale of the challenge may be substantially larger.

² Power Advisory, July 8, 2023. <https://www.poweradvisoryllc.com/reports/rec-ord-high-price#:~:text=PJM%20Tier%20I%20REC%20prices,gas%20also%20play%20a%20role.>

³ PAPUC, Pennsylvania AEPS Historical Pricing. <https://pennaeps.com/pennsylvania-aeps-historical-pricing/>

facilities, the industry's capacity to address Pennsylvania's coal refuse liability remains below historic peaks due to past plant closures and ongoing cost pressures.

The fundamental challenge is that while the industry's business model remains an efficient means of environmental remediation, market conditions frequently fail to generate sufficient revenue to cover operating costs. Concurrently, federal resources for abandoned mine reclamation, which are funded through fees on current coal mining operations, continue to decrease as coal production declines. Continued support through programs like Alternative Energy Credits and Coal Refuse Energy and Reclamation Tax Credits remains vital to recognizing the public benefits delivered by the industry and preventing further reductions in remediation capacity.

1.2. Industry Landscape

Pennsylvania's coal refuse reclamation to energy plants are specialized power generation facilities that use waste coal as fuel while helping to remediate legacy environmental problems. These facilities employ circulating fluidized bed (CFB) boiler technology, which allows them to efficiently use lower-quality waste coal that was previously discarded during the mining process. The plants are strategically located throughout Pennsylvania's historic coal regions, with facilities in both the bituminous coal region of western Pennsylvania and the anthracite coal region in the northeast.

Current Coal Refuse Quantities

764 Coal Refuse Piles in Total

- 44 Burning Refuse Piles
- Covering 8,001 Acres of Land
- Weighing 211 million Tons

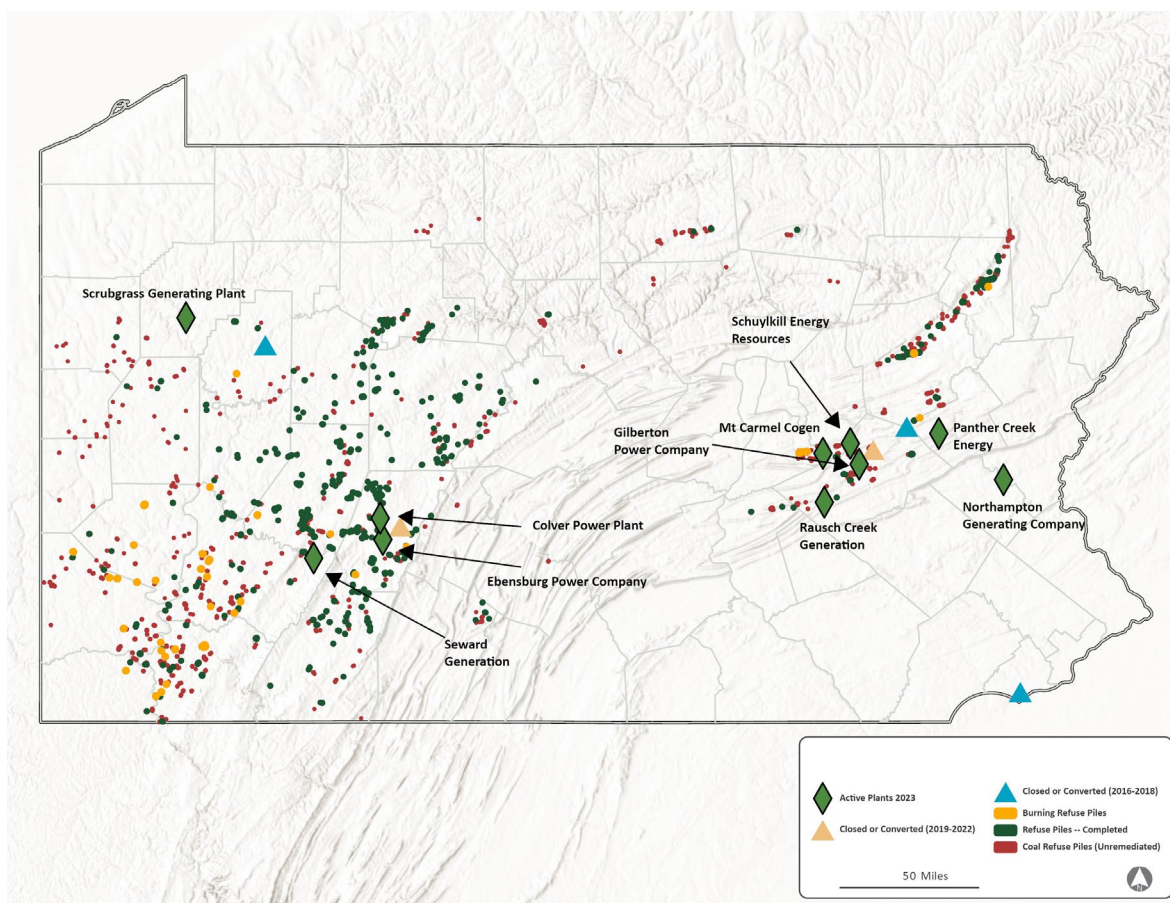
Source: PA DEP, ARIPPA

The location of these facilities is directly tied to their environmental mission. Plants were intentionally sited near concentrations of coal refuse piles to minimize transportation costs and maximize their ability to address environmental hazards. This has resulted in most facilities being located in rural areas that were historically centered around coal mining activity. The plants typically operate within 35-50 miles of multiple refuse sites to maintain economic viability while cleaning up multiple locations. Protecting existing plants to ensure their continued operations and environmental remediation is critical, given that the costs of building a new CFB poses overnight costs of over \$4,000 per kilowatt of capacity.

Figure 1.1 below highlights the current landscape, and recent developments, of the industry within the Commonwealth. Key elements include:

- 764 unremediated coal refuse piles covering 8,001 acres of predominantly rural land, with heavy concentrations in the northeastern and southwestern corners of the Commonwealth,
- 44 actively burning coal refuse piles, tagged as causing increasingly hazardous public health effects and negative environmental impacts by the Pennsylvania Department of Environmental Protection, and
- A sampling of 441 remediated coal refuse piles covering a total of 3,811 acres of successfully restored land.

Figure 1.1: Pennsylvania Coal Refuse Piles and Reclamation to Energy Plants



Source: ArcGIS Pro (2024); ARIPPA (2023)

1.3. Public Benefits from Industry Activity

The coal refuse reclamation to energy industry generates substantial environmental and economic benefits for Pennsylvania that extend far beyond the direct financial returns from electricity generation. Understanding this distinction between market revenues and broader societal benefits is crucial for evaluating the industry's role and the rationale for public policy support.

This section summarizes key aspects of the industry that are detailed throughout this report.

Industry Activity (Section 2)

The total generation capacity of Pennsylvania's remaining coal refuse plants is approximately 1,200 megawatts (MW). While this represents a relatively small portion of Pennsylvania's total electricity generation, the environmental benefits these facilities provide by removing and remediating coal refuse piles make them strategically important for addressing the Commonwealth's legacy mining challenges. Over the past three years, industry plants have consumed an average of 6.6 million tons of coal refuse annually.

Environmental Benefits (Section 3)

The industry's environmental impact begins with the removal of coal refuse piles, which pose multiple hazards to nearby communities. These piles can spontaneously combust, releasing uncontrolled emissions and toxic compounds. They generate acid mine drainage that pollutes streams and groundwater, and their unstable nature creates public safety risks. Through their operations, coal refuse plants have removed over 257 million tons of waste coal to date, restoring more than 8,000 acres of land and improving water quality in over 1,200 miles of previously impaired streams.

These environmental benefits compound over time, as remediated sites continue to deliver improved outcomes year after year. This creates a cumulative positive impact that grows as more sites are addressed. The monetized value of these environmental benefits - including improved water quality, reduced health and safety risks, and enhanced land value - is estimated at \$62 million annually averaged over a twenty-year horizon (as detailed in Section 3).

Economic Benefits (Section 4)

The industry is also a significant economic driver, particularly in rural communities that have struggled with the decline of traditional mining activity. Current operations generate approximately \$697 million in annual economic impact within Pennsylvania, supporting nearly 2,200 jobs with \$155 million in wages and benefits. This activity produces approximately \$16 million in state taxes and fees annually (as detailed in Section 4).

The communities where these plants operate face significant economic challenges common to former coal mining regions. Many of these areas have experienced population decline and show indicators of economic disadvantage. In this context, coal refuse plants serve as important economic anchors for their host communities. In addition, the environmental benefits of remediation improve quality of life in nearby communities that have historically suffered from the environmental impacts from the Commonwealth's coal mining legacy.

Public Benefits: Addressing Pennsylvania's Legacy Liability (Section 5)

While environmental and economic benefits from industry activity are substantial, they are largely "positive externalities" that do not translate into direct revenue for the plants. The primary income stream for facilities comes from selling electricity into the PJM Interconnection's wholesale electricity market, where prices are largely set by natural gas generation and have often fallen below the break-even point required for coal refuse plants to cover their operating costs. This creates a fundamental mismatch between the private market economics of plant operations and their broader public value.

To bridge this gap, Pennsylvania has implemented the Coal Refuse Energy and Reclamation Tax Credit to subsidize activity, while qualification as a Tier II resource under the Alternative Energy Portfolio Standards program generates additional revenue through energy credits. However, these support mechanisms still capture only a portion of the total societal benefit delivered by the industry.

Another way to conceptualize these public benefits is through the costs the Commonwealth would bear to clear and remediate coal refuse sites to the same environmental standards as the industry. In economics terms, this is defined as the "avoided cost" from industry activity.

The coal refuse reclamation to energy industry offers an important benefit to the Commonwealth, which would otherwise require significant spending to address coal refuse piles without it. Based on recent project bids, state-funded cleanup efforts would cost between \$98 million and \$281 million annually to match the current level of industry activity (see Section 5).

This higher cost structure results from several factors:

- 1) State cleanup requires costly landfill disposal of refuse material, while the industry productively uses it as fuel,
- 2) The industry generates revenue from electricity sales to offset costs, while state cleanup is purely an expense, and
- 3) The industry's integrated approach addresses environmental impacts at their source, avoiding long-term treatment costs.

This avoided cost analysis suggests that supporting the industry through tax credits and alternative energy credits is highly cost-effective compared to the alternative of direct state intervention. Even with enhanced support mechanisms, the public cost is far below what would be required for equivalent environmental remediation through direct state activity.

2. Industry Activity

CHAPTER SUMMARY:

- The coal refuse reclamation to energy industry removes 6.6 million tons of coal refuse annually to generate energy sold in the PJM marketplace.
- Current market conditions feature depressed wholesale prices due to competition from natural gas and other sources, necessitating other revenue sources for plants to cover their costs and make operations and environmental activity viable.
- Alternative energy credits were the largest source of revenue for member plants in 2023, generating \$256 million.

Ten coal refuse reclamation to energy facilities are currently operating within Pennsylvania. The Appalachian Region Independent Power Producers Association (ARIPPA) was established in 1989 as a non-profit trade association for this industry.⁴ While a variety of factors have resulted in decreased production quantities in recent years, production levels have stabilized, and member plants continue to provide consistent impacts as a source of energy generation, environmental benefits, and local employment.

2.1. Historic Activity Levels

Since its inception 35 years ago, the network of plants situated in Pennsylvania alone have consumed over a quarter billion tons of waste coal and repurposed 206 million tons of ash byproduct to reclaim 8,070 acres of environmentally degraded land. Additionally, the plants' cumulative efforts have restored over 1,200 miles of hazardous waterways statewide.

Historic Industry Activity

257 million tons of refuse consumed

206 million tons of beneficial use ash

> 1,210 miles of polluted streams restored

> 8,070 acres of land restored

Source: PA DEP, ARIPPA

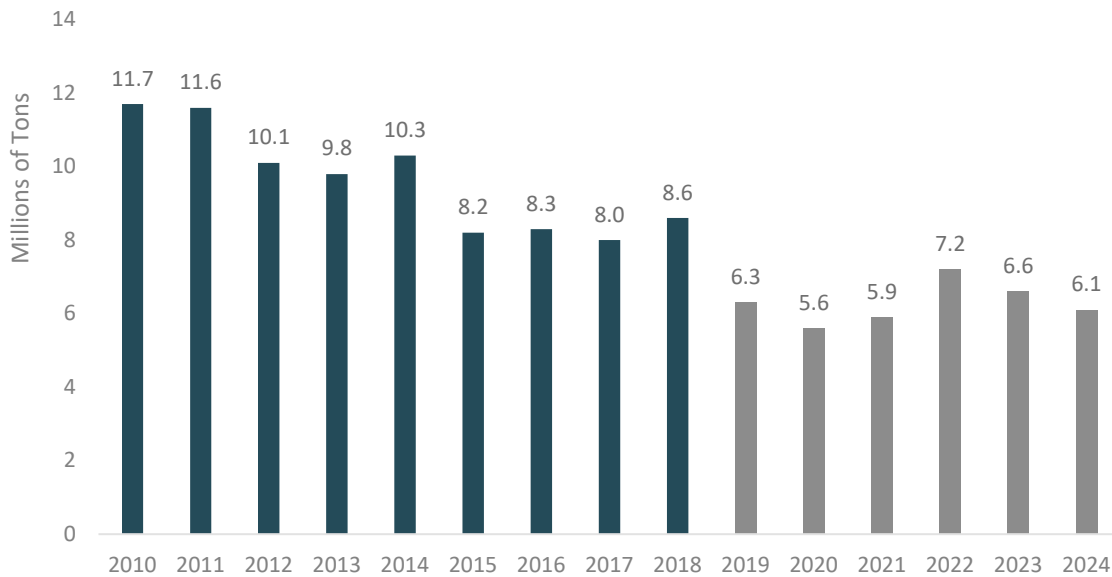
As a private enterprise needing to sustain a profitable framework, the coal refuse energy production industry faces a host of challenges, ranging from economic and financial fluctuations to political and legal opposition/obstacles. These challenges have acted as barriers to productivity over the past several years, leading to the closure of some industry plants which has caused a reduction in the annual level of industry activity.

⁴ ARIPPA was originally formed as the Anthracite Region Independent Power Producers Association.

Figure 2.1 shows annual consumption levels of coal refuse by Pennsylvania plants.

- Annual production by Pennsylvania plants decreased by 44% from 11.7 million tons in 2010 to 6.6 million tons in 2023.
- The most recent five-year (2020-2024) annualized average of 6.3 million tons is 28% below the previous five-year (2015-2019) annualized average of 7.9 million tons.
- Production levels have stabilized and grown slightly within the last five years through the activity of the ten plants currently in operation.

Figure 2.1: Tons of Coal Refuse Consumed by PA Plants, 2010-2024 (Millions)



Source: ARIPPA (2024)

2.2. Industry Economics

While remediation of coal refuse piles produces a broad range of environmental and social benefits, individual plants are private businesses that are responsive to the financial conditions in their marketplace. Reviewing the composition of industry costs and revenues provides context for the role of the Commonwealth's alternative energy credits and production tax credits in the economic viability of plants that remain active.

Market Conditions

Power-generating companies rely on two primary market-based revenue sources:

- 1) **Wholesale Energy** sales to producers that function as the providers to the customer base/households of a given geographic market; and
- 2) **Capacity Payments** received from energy service providers in exchange for a guarantee to supply adequate quantities during periods of peak consumer demand.

Wholesale energy sales are directly related to the actual quantities of energy delivered. By contrast, capacity payments received are a function of potential consumer demand in a worst-case scenario or extreme climate conditions and predicted future needs. Both revenue streams are a vital component of a power producer's financial viability.

Current conditions in the PJM Interconnection market serving Pennsylvania do not provide sufficient revenue to cover costs for coal refuse plants. Weekly wholesale energy prices averaged around \$30 per MWh in 2023 and 2024, well below the levels experienced in 2022 (see Figure 2.2).⁵ Meanwhile, estimated "breakeven prices" to recover costs of production for member plants (reviewed later in this section) grew from \$39 in 2019 to \$62 in 2023 due to increases in cost inputs. Prices have continued to rise since 2023, further expanding the gap between wholesale revenue and operating costs. When wholesale prices lag production costs, uninterrupted operational activity relies more heavily on capacity payments and governmental interventions, such as tax credits and other subsidies.

Average Weekly PJM Wholesale Energy Price (per MWh)

- 2021: \$37.62
- 2022: \$72.32
- 2023: \$29.73
- 2024: \$30.23

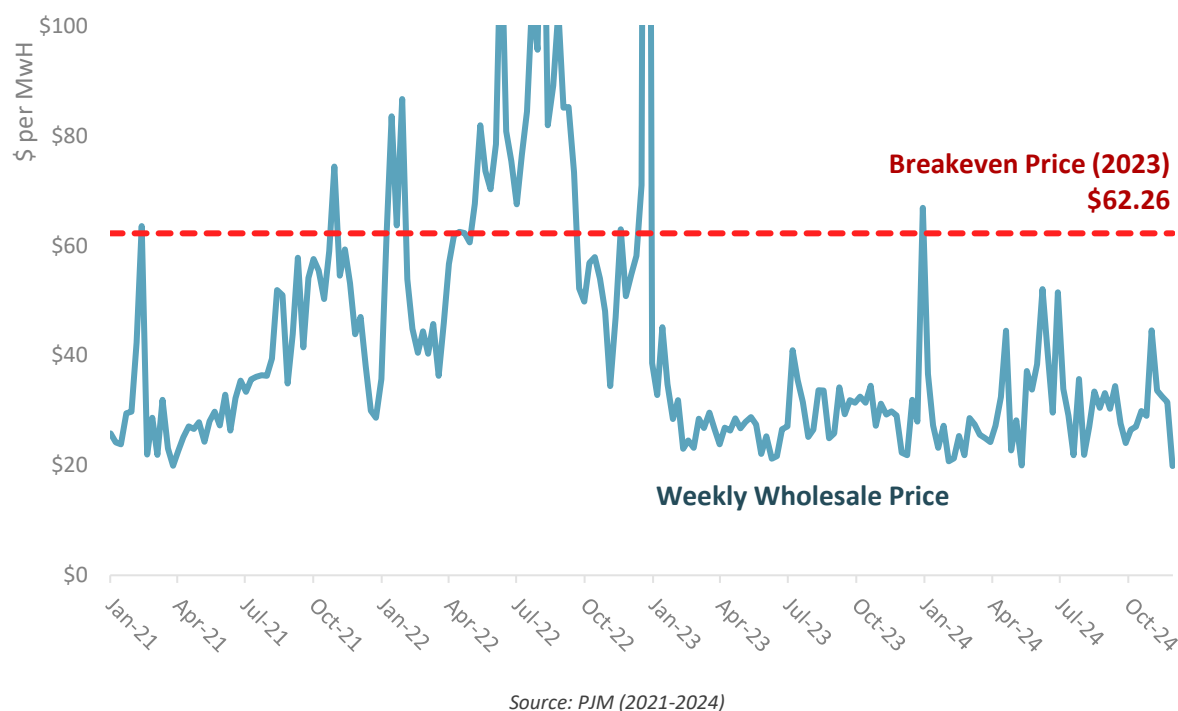
Source: PJM

Breakeven Prices for ARIPPA Member Plants (per MWh)

- 2019: \$39
- 2023: \$62

Source: ESI Analysis of Plant Data

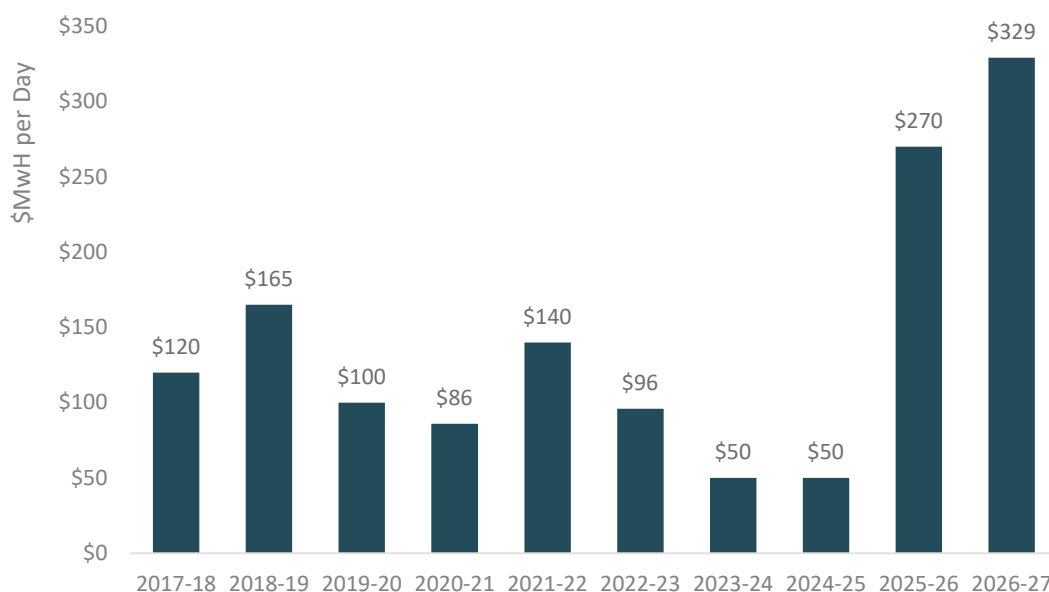
Figure 2.2: Weekly Wholesale Energy Sale Price per MWh, 2021-2024



⁵ Wholesale energy prices spiked at multiple points during the 2022 calendar year, reaching a peak weekly average of \$337 per MWh. Aside from a price increase in late December 2023, the weekly average price per unit of energy has remained below the cost to generate one unit of energy.

Capacity payments have also been below typical levels in recent years (see Figure 2.3). The residual auction price per MW-day from 2023 to 2025 of \$50 represents the lowest price in the past 10 years. However, 2025-26 pricing is at an elevated level of \$270, which is 64% above the pre-COVID high, representing a 28% increase in real terms.

Figure 2.33: Capacity Payments per MWh, 2017-2027⁶



Source: PJM (2025)

Going forward, the Federal Energy Regulatory Commission's (FERC) recent approval of a capacity payment "collar" will guarantee a range for capacity payments over the next two auction periods. The proposal establishes a floor of \$175/MW-day and a cap of \$325/MW-day, guaranteeing capacity payments stay notably above the depressed price levels seen in recent years.⁷

Plant Revenues

Variability in pricing and lower price levels for both wholesale sales and capacity payments in the past two years have increased the importance of additional revenue mechanisms in keeping plant operations viable. With market revenue lessened, alternative energy credits accounted for more than half (57%) of plant revenue in 2023. Cost information reviewed below shows clearly that industry operations would not have been viable without this revenue source.

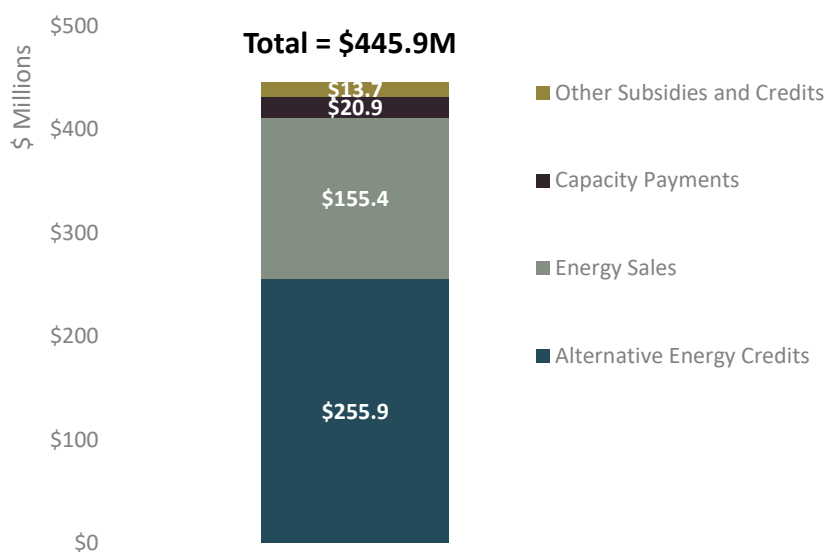
⁶ Capacity payment amounts reflect the determinations of the base residual auction (BRA) which typically takes place three years in advance of energy delivery from service providers to customer households. However, the BRA setting capacity payments for June 2025 through May 2026 occurred on July 17, 2024.

⁷ "FERC approves PJM capacity auction price cap, floor" Utility Dive, 2025. <https://www.utilitydive.com/news/ferc-pjm-interconnection-capacity-auction-price-cap-collar/745979/>

Based on aggregated data from a member survey, the ten member plants in Pennsylvania are estimated to have generated nearly \$446 million in revenue in 2023. This revenue breaks down by source as follows (see Figure 2.4):

- \$256 million in alternative energy credit receipts,
- \$155 million in wholesale energy sales,
- \$21 million in capacity payments from energy service providers, and
- \$14 million in production tax credits and other smaller sources.⁸

Figure 2.44: Estimated Industry Revenues, 2023 (\$M)



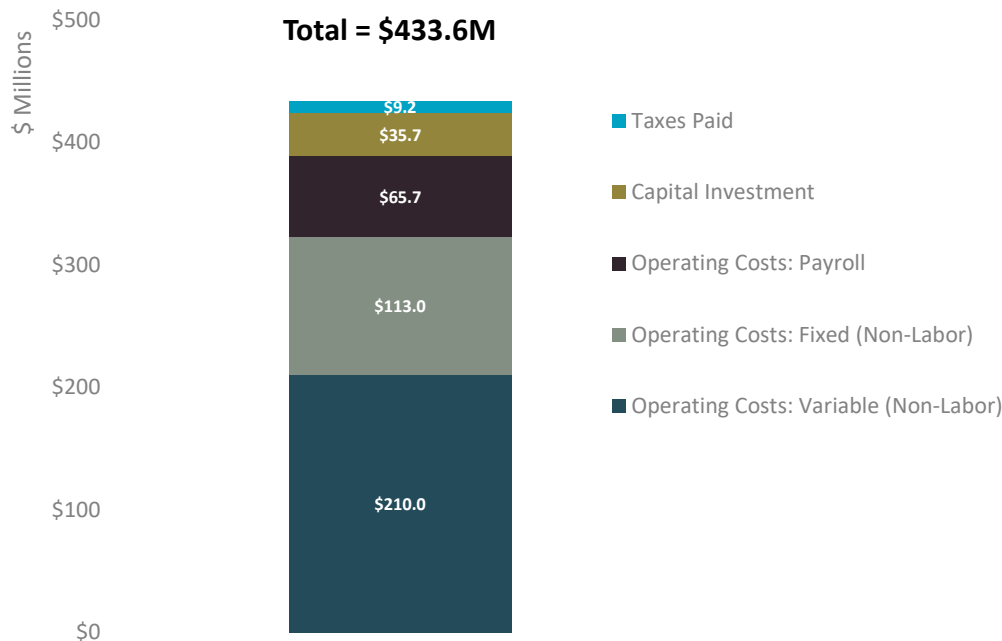
Source: ARIPPA Member Survey (2024)

Plant Costs

Energy production is a cost-intensive industry, with a range of skilled personnel and investments required for operations. Based on aggregated data from a member survey, the ten member plants in Pennsylvania are estimated to have total costs of \$434 million in 2023 (see Figure 2.5).

⁸ This revenue does not include the alternative energy credits.

Figure 2.5: Estimated Industry Expenditures, 2023 (\$M)



Source: ARIPPA Member Survey (2024)

These costs can be broken down in a number of ways that help illustrate the cost structure of the plants relative to their revenue streams.

Fixed costs represent investments such as personnel, equipment, and administration that do not directly vary (in the short term) with the level of energy production. These costs are estimated at \$179 million for 2023, with \$66 million comprised of payroll costs that supported an average salary in excess of \$81,000.

Variable costs are those expenses throughout the supply chain and processing that are associated with each unit of energy production. In the case of the coal refuse industry, transportation is the largest component of the cost structure, representing \$61 million in costs in 2023. Transportation costs have increased over time as member plants have consumed fuel and remediated the sites closest to their location and now must go further afield to find new sources of coal refuse. Diesel tax rates directly impact plant costs of remediation, and diesel tax rates are higher in Pennsylvania relative to neighboring states.⁹

Capital costs to maintain and enhance the functionality of the plant and equipment totaled \$36 million in 2023.¹⁰

Taxes totaled \$9 million in 2023 (see Figure 2.6).

⁹ In July 2023, the diesel tax rate in Pennsylvania was \$0.785/gallon, compared to \$0.47/gallon in Ohio, \$0.08/gallon in New York, and \$0.243/gallon at the national level.

¹⁰ As capital investment varies significantly from year to year, \$35.7 million reflects the annualized average of the three most recent years reported in the ARIPPA member survey to account for deviations from typical capital spending in a given year.

Figure 2.6: Aggregate Plant Costs (\$M) by Category, 2023

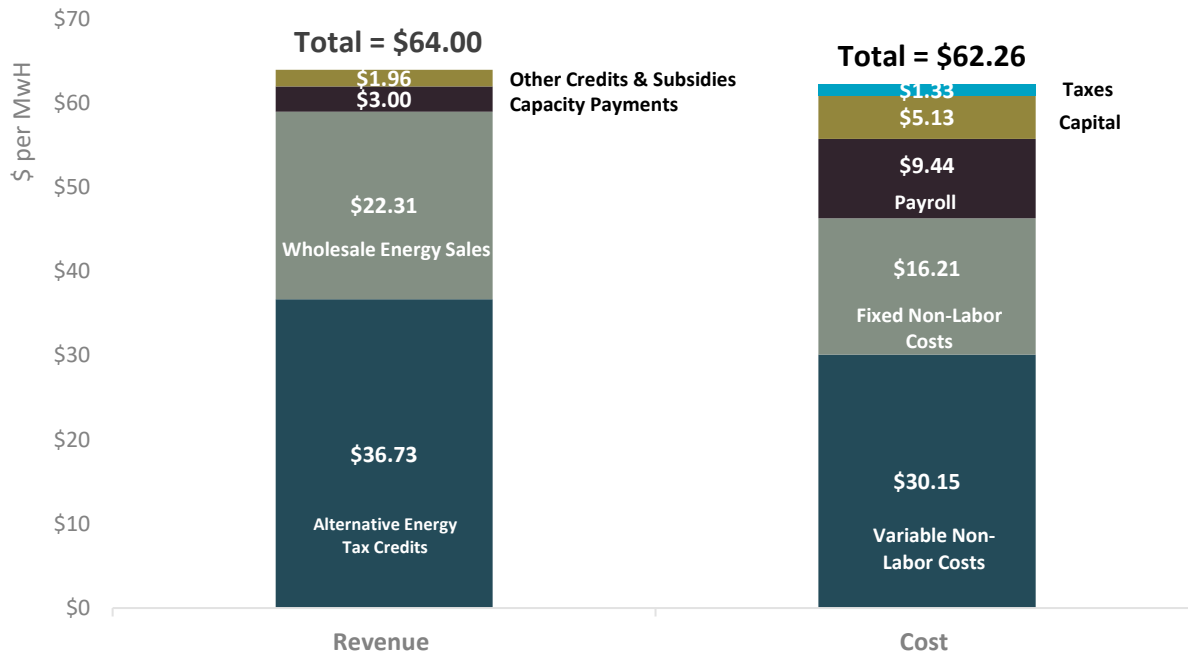
Cost Category	2023 Annual Cost (\$M)	Share of Total
Fixed Costs	\$178.7	41%
Payroll	\$65.7	15%
Non-Payroll	\$113.0	26%
Variable Costs	\$210.0	48%
Transportation	\$61.1	14%
Mining	\$58.2	13%
Limestone Moving	\$32.2	7%
Maintenance (non-plant)	\$16.8	4%
Land Reclamation	\$11.4	3%
Other Costs	\$30.3	7%
Capital Costs	\$35.7	8%
Taxes	\$9.2	2%
TOTAL	\$433.6	

Source: ARIPPA Member Survey (2024)

Highlighted in Figure 2.7, aggregated revenues slightly exceeded aggregated expenditures for the 2023 calendar year.

Comparing revenues and costs, the revenue generated per energy unit of \$64.00 cleared the total cost of \$62.26 per energy unit in 2023 (see Figure 2.7). This represents a profit margin of just under 3%, or an aggregated profit of \$12 million across the ten plants (\$446 million in revenue compared to \$434 million cost). It is important to note that the costs above represent 2023 cost levels. Inflation, as well as specific operating dynamics (e.g. increasing transportation needs, as mentioned above), will continue to drive costs up and impact industry operations.

Figure 2.7: Estimated Industry Revenues and Costs per MWh, 2023



Source: ARIPPA Member Survey (2024)

It is worth noting that plant energy production costs have increased considerably over the previous study period. Figure 2.8 compares average fixed and variable cost categories for 2018 versus 2023 to show the effects of rising costs. While labor costs have declined, significant increases in both fixed costs and variable costs have raised overall operating costs. Site costs are nonlinear due to the closest and cheapest piles being remediated first, indicating that in the future, plant costs will continue to rise and outpace inflation.

Figure 2.8: Comparison of Production Costs per Megawatt, 2018 and 2023¹¹

Cost Category	2018 Annual Cost (\$/MWh)	2023 Annual Cost (\$/MWh)	Percent Change
Fixed Costs	\$23.10	\$25.60	10%
Payroll	\$12.10	\$9.40	(28%)
Non-Payroll	\$11.00	\$16.20	32%
Variable Costs	\$22.90	\$30.10	24%
Transportation	\$5.40	\$8.90	38%
Mining	\$9.40	\$8.40	(13%)
Limestone Moving	\$2.60	\$4.60	44%
Maintenance (non-plant)	\$1.80	\$2.40	25%
Land Reclamation	\$2.70	\$1.60	(65%)
Other Costs	\$1.10	\$4.40	75%
TOTAL	\$46.00	\$55.70	21%

Source: ARIPPA Member Surveys (2015, 2018 and 2023)

Under these economic conditions, plant operations remain viable despite low wholesale energy prices. However, this viability is only possible due to the additional revenue sources beyond energy sales and capacity payments, most importantly revenue from the Alternative Energy Credits provided under Pennsylvania's AEPS program.

¹¹ Note that capital costs and taxes paid are not included in these annual cost comparisons.

3. Environmental and Public Benefits

CHAPTER SUMMARY:

- The removal of coal refuse piles and reclamation of impacted sites has demonstrated benefits including improved air quality, water quality, public health and safety, and land value.
- These benefits are largely “positive externalities” that accrue to individuals or society at large rather than to the plants themselves.
- The environmental and public benefits produced by industry removal and remediation are estimated at an annual value of \$62 million over a twenty-year horizon.
- Alternately, industry activity can be valued based on an “avoided cost” of \$98 to \$281 million per year for the Commonwealth to directly undertake removal and remediation to the same volume and standard.

The primary benefits to the Commonwealth from the coal refuse reclamation to energy industry come from the environmental and social impacts of removal and remediation of coal refuse piles. This section analyzes and quantifies these benefits through two frameworks:

- **Social Benefit:** We assess the environmental and social benefits of industry remediation—the positive externalities from removing coal refuse piles, including better water quality, reduced air emissions, improved public safety, and increased land values. The value of these benefits is “monetized” through standard economic frameworks.
- **Avoided Cost:** As an alternative framework, we quantify the avoided public costs if the Commonwealth were to perform remediation at the same volume and level of quality as the industry. This compares the industry approach against alternatives like landfill storage or direct government cleanup. Recent project bids show that taxpayers would face substantially higher costs to achieve similar environmental outcomes.

These frameworks demonstrate that while market revenues may not fully sustain the industry, the broader benefits justify policies supporting the viability of these plants so that the Commonwealth can capture these environmental and public benefits.

3.1. Social Benefits from Industry Remediation

The impacts of successful remediation efforts continually carried out by the established network of member plants extend across the Commonwealth, resulting in measurable benefits to the Commonwealth’s residents and the environment in which they live.

Academic and industry research support that the successful remediation of coal refuse piles holds positive environmental and societal value, which can be attributed to the following categories:

- Improved water quality,
- Avoided emissions and improved air quality,
- Public health and safety enhancements, and
- Increased land values (direct value).

These benefits are not adequately captured by standard business models or financial analysis, because they are “externalities” that are not captured by the plants themselves but rather accrue to individuals or society at large. ESI employs standard economic techniques used on cost-benefit analysis to approximate and quantify the economic value of projected environmental and societal benefits.

This model was originally developed for ESI’s 2016 analysis of the economic and environmental benefits of ARIPPA member plants, updated for a 2019 study update.¹² The current model has expanded on previous versions, adding in analysis of air quality impacts based on findings from studies conducted by TRC and Lehigh University. The model uses a 20-year time horizon and techniques including social benefit (emissions and safety), avoided cost (water quality and fire safety), and direct value (land value), to monetize various categories of benefits.

The following sections estimate the cost savings provided by the industry at current activity levels. These calculations serve as a forecast of costs that the Commonwealth would bear if member plants were to cease operations.

Emissions Savings

Coal refuse piles pose a number of threats to public health and safety, including air quality impacts. Coal dust from piles is swept up in the wind and deposited across nearby communities, creating adverse effects. Coal refuse piles can ignite spontaneously or through human intervention (like garbage burning). Once ignited, fires often continue to burn for decades, since the coal refuse provides a nearly inexhaustible fuel supply. Further, “methods to extinguish or control AML [abandoned mine land] fires...are generally expensive and have a low probability of success” according to a report from the U.S. Department of the Interior’s Bureau of Mines, which terms these fires “a serious health, safety and environmental hazard.”¹³

Burning piles create a range of uncontrolled negative atmospheric impacts, including smoke, minute dust particles, and the release of combustion gases and greenhouse gases, including carbon monoxide, carbon dioxide, hydrogen sulfide, sulfur dioxide, ammonia, sulfur trioxide, sulfuric acid, and oxides of nitrogen. These pollutants can be fatal to vegetative life and negatively impact human health. A study by the U.S. Environmental Protection Agency (EPA) established that concentrations of sulfur dioxide can increase illness rates and hospital admissions for older persons with respiratory disease, increase

¹² Econsult Solutions, Inc. “Economic and Environmental Analysis of Pennsylvania’s Coal Refuse Industry”. September 2016. ; Econsult Solutions, Inc. “The Coal Refuse Reclamation to Energy Industry: A Public Benefit in Jeopardy”. June 2019.

¹³ Kim, A. and Chaiken, F., U.S. Department of Interior Bureau of Mines, “Information Circular 9352: Fires in Abandoned Coal Mines and Waste Banks,” 1993.

absenteeism from work, accentuate the symptoms of patients with chronic lung disease, and increase daily death rates.¹⁴

These uncontrolled emissions stand in contrast to the removal and use of coal refuse as a fuel source under highly controlled and regulated conditions. Coal refuse reclamation to energy plants use limestone injection to control acid gas and fabric filter systems to reduce filterable particulate matter emissions. In addition, these plants have made considerable investments to meet ever-evolving state and federal emissions standards. The industry as a whole maintains a near flawless compliance record, with all coal refuse plants historically qualifying under the Mercury and Air Toxics Standards (MATS) regulations as low emitters of filterable particulate matter and non-mercury hazardous air pollutant metals.

Until recently, direct study on the comparative environmental impact of using coal refuse for energy instead of leaving refuse coal in situ was largely unavailable. Recent research provides compelling evidence that the operation of coal refuse reclamation to energy facilities results in net improvements in air quality.

A 2023 study conducted for ARIPPA by TRC demonstrates that abandoned coal refuse piles in Pennsylvania and West Virginia continuously emit significant quantities of numerous air pollutants through both weathering and spontaneous combustion.¹⁵ This analysis found that for every ton of coal refuse remediated, there is an annual reduction of 5.3 tons of carbon dioxide (CO₂) equivalent, as these facilities prevent the ongoing emission of methane—a greenhouse gas 25-28 times more potent than CO₂—from abandoned piles that would otherwise act as "forever emitters" of pollution at ground level where communities live and breathe.

This conclusion is reinforced by a further study by Lehigh University, which employed different methodologies but reached similar conclusions.¹⁶ By comparing a range of emission factors for coal plants and in situ pile conditions, this research determined that unabated coal refuse piles emit 1.9 to 5.1 times more greenhouse gases than when the same material is processed through coal refuse reclamation to energy facilities. Both studies provide empirical evidence that the controlled combustion of coal refuse in properly equipped facilities represents an environmentally superior alternative to the uncontrolled, unregulated emissions that continue from abandoned coal refuse piles throughout the Appalachian region.

This study uses this research as a basis to develop a monetized estimate for the net reduction in air emissions achieved through the use of coal refuse for energy. Following from the structure of the 2023 TRC research, this study assumes that any in situ refuse coal has a realistic risk of combusting. To value this avoided risk, this study compares the emissions produced from using coal refuse for energy to the emissions produced if that coal were to combust in situ.

¹⁴ Industrial Research Laboratory, United States Environmental Protection Agency, "Source Assessment: Coal Refuse Piles, Abandoned Mines and Outcrops, State of the Art," 1978.

¹⁵ Fraser, R. and Fennell, P. "Net Air Emissions Benefits from the Remediation of Abandoned Coal Refuse Piles". TRC Companies. March 2023.

¹⁶ Romero, C. "Comparison of the Impact on Greenhouse Gas Emissions between Unabated Coal Refuse Piles and Reclamation-to-energy Power Plants". Lehigh University: Energy Research Center. January 2023.

Social Benefit Value

Using information from the TRC study on the rate of coal refuse burning in situ, it is estimated that combusted waste coal will burn over 20 years, and the surface of the coal piles will generate additional emissions through weathering and oxidation. Applying this framework to the annual amount of coal refuse remediated by the industry in 2023 (6,578,086 tons) results in a net lifetime savings of 26.1 million tons of carbon dioxide equivalent. Using data from the EPA, annual carbon dioxide equivalent emissions from all Pennsylvania coal refuse plants in 2023 was 7.7 million tons.¹⁷ Comparing the magnitude of these emissions profiles clearly indicates that use and remediating is the environmentally preferable course of action over leaving coal refuse piles in situ by a significant margin. This result is decently in line with the results of the Lehigh University study, which estimated net lifetime savings between 13 million and 58 million tons of carbon dioxide equivalent. To value this impact, a conservative CO₂ equivalent value of \$23 per ton was used.¹⁸ A 3% discount rate was used to compare the upfront immediate value of coal refuse burned for energy to the impact over time of leaving that coal refuse in situ. This framework results in a net present value of \$22.2 million in avoided lifetime CO₂ equivalent emissions resulting from the 6.6 million tons of coal refuse remediated by the industry in 2023. This is expressed as a “one-time” benefit because it captures the lifetime value of emissions savings for each quantity remediated; however, if an equivalent quantity of coal refuse was removed in the subsequent year, this level of value would compound for the emissions savings associated with the removal of this set of piles.

Water Treatment Savings

In addition to the degradation of air quality, waste coal pollutes the Commonwealth’s rivers, streams and other bodies of water. Through the process of acid mine drainage (AMD), the mineral composition of coal refuse interacts with precipitation and surface-level water to form sulfuric acid. This chemical reactant can, in turn, infiltrate free flowing rivers and streams, impacting not only the water quality, but also threatening the health of the animal and plant life that it supports.

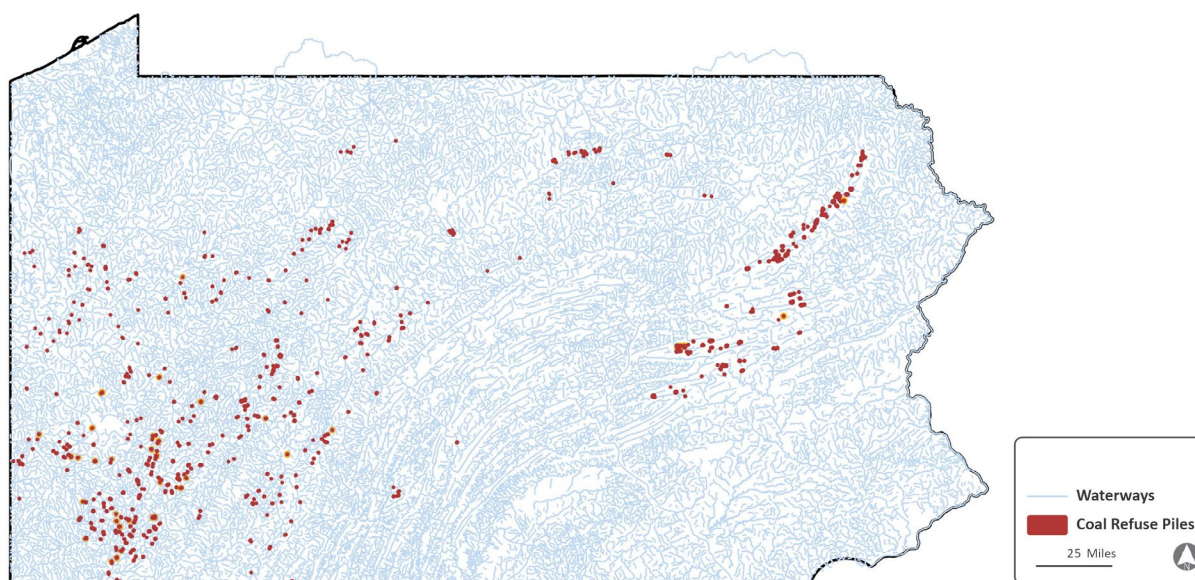
Pennsylvania hosts a vast network of waterways, from large rivers to smaller creeks and streams. These natural resources sustain critical ecosystems and flow through land inhabited by the Commonwealth’s 13 million residents and diverse wildlife. Not only does AMD and other polluting activity affect those living in close proximity to abandoned coal refuse sites, but it also poses downstream statewide health risks through the interconnectedness of the region’s network of waterways. The Commonwealth’s more than 960,000 miles of waterways are featured in the figure below. Over 5,500 miles of this network are directly impacted by coal refuse sites and other abandoned mines that are located in the Commonwealth’s southwestern and northeastern quadrants.¹⁹

¹⁷ Emissions and Generation Resource Integrated Database (eGRID), <https://www.epa.gov/egrid>

¹⁸ Systems Change Lab, weighted average direct carbon price. <https://systemschangelab.org/finance/price-greenhouse-gas-emissions-and-other-environmental-harms>

¹⁹ PA Department of Environmental Protection. “2024 Pennsylvania Integrated Water Quality Report”. <https://storymaps.arcgis.com/stories/7af67824d6924b88b544dbad302ebc4f>.

Figure 3.1: Pennsylvania's Waterways Network



Source: PA DEP (2024); ArcGIS Pro (2025); Econsult Solutions (2025)

In addition to responsive treatments conducted to improve the quality of affected rivers and streams, remediation of existing refuse coal presents an alternative and potentially more cost-effective intervention strategy. Unlike alternative methods of managing coal refuse, remediation permanently removes the source cause of the pollution, which, independent of cost considerations, may be an even better approach in terms of harm reduction.

Current and previous mining activity poses a threat to water quality, as well as the animal and plant life that it supports. Remediation stands as a readily available and effective intervention, with research providing evidence that it is an optimal alternative to post-contamination treatments and other reactive tactics, both in terms of harm reduction and cost savings. Over 35 years, the industry has restored more than 1,200 miles of the Commonwealth's vital waterway network.

Avoided Cost Value

Academic research supports the cost savings of this particular energy reclamation process. In examining the Grant Town Power Plant in West Virginia, Dr. Paul Ziemkiewicz measures the impact of both elements of the two-tiered reclamation process, estimating the magnitude of acidity reduction for coal refuse removal and beneficial ash replacement.²⁰ Due to only evaluating one facility's impact, the Ziemkiewicz analysis calculates its impacts on a scale about ten times smaller than that of Pennsylvania's statewide industry.²¹ Therefore, the ESI framework applies ratios for both tons of coal refuse removed, and tons of beneficial ash replacement to scale up benefit levels to align with current

²⁰ Ziemkiewicz, P., "Acid Load Reduction Resulting from Operation of the American Bituminous Power Partners, L.P. Grant Town Power Plant." April 28, 2016.

²¹ The Grant Town plant consumed 550,000 tons of coal refuse and produced 450,000 tons of beneficial ash in the year studied.

industry levels.²² At its current levels and coal removal (6.6 million tons) and restorative ash produced (5.1 million tons), it is estimated that the industry eliminates over 3,600 metric tons of acid loadings per year. Additionally, the model maintains its annual rate of a \$500 treatment cost as its factor for avoided cost per ton of acid loading. After accounting for inflation, the current industry level (3,615 tons) yields a cost savings of \$2.2 million in year one.²³ Assuming that industry activity continues at the same level each year, that activity will eliminate additional water treatment services with an estimated cost savings to the Commonwealth of \$2.2 million each year, with this value accumulating over time.

Fire Control Savings

Similar to the benefits of the remediation approach over reactive treatment of water resources described above, the industry's removal of a coal refuse pile eliminates it as a potential fire risk as it no longer exists in the landscape. When lit, coal refuse fires are difficult to contain (due to the combustible nature of the coal refuse), resulting in significant safety risks and costs for fire control.²⁴

Avoided Cost Value

While academic research informed the modeled water quality cost savings, the framework uses data provided by the PA DEP's Bureau of Abandoned Mine Reclamation (BAMR) to calculate annual cost savings to the Commonwealth. As no new data on coal refuse pile induced fires has been presented since the release of the 2019 study update, the current framework relies on the recalculations for annual activity levels to estimate the Commonwealth's annual avoided fire response resources. As size of piles varies quite widely, and the emergency service response costs are largely determined by the amount of space that a given pile occupies, average cost incurred by these fire departments is calculated per acre (\$117,700). The current stock of unremediated coal refuse piles averages just over 11 acres at each site, resulting in an estimated cost savings of \$1.3 million per fire commanding emergency response services. Conservatively assuming only one fire occurs each year, the industry's annual reclamation rate of 3% reduces the likelihood of a fire event occurring, yielding an annual cost savings value of approximately \$41,000. Adjusted for inflation, the cost savings from pile removal performed by the industry is estimated at \$48,700 per year.

Health and Safety Savings

Each unaddressed coal refuse pile poses multiple threats to the elements of its immediate environment, especially in the case of disruption by natural or human events. For instance, a collapsing pile may trigger a landslide with the potential to damage and destroy the land, infrastructure, and property of its surrounding area. These events decrease the values of private assets and public amenities and oftentimes require costly repair, restoration, and replacement services.

The detrimental impact of these lasting byproducts of historic mining activity are not limited to the public health hazards and societal costs previously identified. These unnatural landmasses attract

²² To combine these values, an "overlap adjustment" of 50% is conservatively applied to account for situations where beneficial ash is returned to the original site where coal refuse was remined, thus combining to remediate the same waterway. Annual acid loading savings quantities accumulate into future years, because remediation that takes place in a given year delivers benefits in subsequent years.

²³ Ziemkiewicz, P.F., Skousen, J.G. & Simmons, J., "Long Term Performance of Passive Mine Drainage Systems," 2003.

²⁴ Note that these costs for fire control are above and beyond the emissions impacts of burning piles, which are captured within the air emissions calculations presented above.

daring and dangerous recreational activity, especially in serving as a navigable and challenging course for motorized vehicles, such as popular all-terrain vehicles (ATVs). The dangerous nature of the activity itself, as well as the instability of these non-permanent masses of coal refuse, proximity to open pits, potential rockslides, and subsidence, can lead to serious injury and fatalities.

Social Benefit Value

In order to estimate a value for the likelihood of severe injury and death for coal refuse mining and recreational activity at inactive sites, the framework uses the following inputs:²⁵

- Value of a Statistical Life (VSL): \$13,000,000²⁶
- Number of Coal Refuse Mining Fatalities (Annual Average): 0.2²⁷
- Number of severe ATV injuries at Coal Refuse Sites (Annual Average): 135²⁸

Applying these assumptions to the annual rate of coal refuse pile reduction produced by industry activity results in a societal cost savings value of approximately \$826,900.

Value to Landholders

Reclamation activity further benefits Pennsylvania and its residents through two positive externalities related to land:

- Enhanced usability of the land covered with coal refuse, and its related materials and chemicals, prior to successful restoration efforts.
- Increased property value of residents owning land adjacent to a former coal refuse site.

Direct Value

To date, the industry has reclaimed more than 8,000 acres of formerly compromised land, returning it to the environment and for developmental use. As coal refuse consumption levels, and the supply of its beneficial ash byproduct, have decreased in recent years, the current model uses an annual average of 203 acres reclaimed.

Agricultural land values in Pennsylvania increased from \$5,600 to \$8,630 per acre over the most recent five-year period, yielding a \$1.7 million value annually.²⁹

Benefits to homeowners and landowners in the vicinity of restored sites can also be quantified. Maintaining consistency with the 2019 model's framework, benefits are applied only to those properties located within one-quarter mile of a restored site. Furthermore, a conservative 5% value increase is afforded those properties that meet this metric. Adjusting the average of the 2019 property

²⁶ Kearsley, A. "HHS Standard Values for Regulatory Analysis, 2024". ASPE: Office of Science and Data Policy". January 2024.
<https://aspe.hhs.gov/sites/default/files/documents/cd2a1348ea0777b1aa918089e4965b8c/standard-ria-values.pdf>.

²⁷ US Department of Labor: Mine Safety and Health Administration. "Coal Fatalities for 1900 through 2023".
<https://arlweb.msha.gov/stats/centurystats/coalstats.asp>.

²⁸ Zhang, C. "2022 Report of Deaths and Injuries Involving Off-Highway Vehicles with More than Two Wheels". May 2023.
<https://www.cpsc.gov/s3fs-public/OHV-Annual-Report-2022.pdf>.

²⁹ US National Agricultural Statistics Service. "NASS Highlights: 2023 Agricultural Land: Land Values and Cash Rents". October 2023.
https://www.nass.usda.gov/publications/highlights/2023/2023landvaluescashrents_FINAL.pdf.

sample set for inflation, the estimated value added annually for this non-cumulative benefit is \$6.4 million. Taken together, the two land-related impacts are valued at \$8.1 million.

Aggregated Value of Environmental Benefits

The industry delivers sizable positive outcomes in the form of added societal benefits/externalities, increased value to private assets, diminishing the frequency of certain destructive environmental events and their negative impacts, and by reducing the financial costs incurred by government-funded treatments and interventions.

Aggregated values are shown in Figure 3.2 below:

- At an annualized average of \$62 million, these environmental and social benefits are valued at more than \$1.2 billion over a 20-year time horizon, growing from \$33 million in year 1 to \$91 million in year 20.
- Reductions in air emissions generate over \$444 million in value to society while the elimination of water treatment services saves the Commonwealth nearly \$452 million.
- Enhancements of public health and increases to property values are estimated to create approximately \$350 million in added value.

Figure 3.2: Annual Public Benefits / Avoided Costs (\$M)

Category	Effect	Year 1	Year 10	Year 20	Total	Average (Annualized)
Air Emissions	One-Time	\$22.2	\$22.2	\$22.2	\$444.2	\$22.2
Water Quality	Cumulative	\$2.2	\$21.5	\$43.0	\$451.7	\$22.6
Public Health & Safety	Cumulative	\$0.9	\$8.8	\$17.5	\$183.9	\$9.2
Land Value	One-Time	\$8.1	\$8.1	\$8.1	\$162.4	\$8.1
Total		\$33.3	\$60.6	\$90.8	\$1,242.2	\$62.1

Source: Econsult Solutions (2025)

3.2. Avoided Costs of Alternatives

In lieu of the coal refuse reclamation to energy industry's continued operations, the Commonwealth would have to explore other options to address legacy coal refuse piles and their associated environmental liabilities. An alternative is to commission the removal of piles, disposal of refuse, and remediation of waste coal sites to the same standard as the remediation performed by the industry. The cost associated with these efforts represents the "avoided cost" to the Commonwealth that is currently undertaken by the coal refuse reclamation to energy industry.

The reclamation and energy generation cycle is a cost-effective means of addressing coal refuse sites due to structural advantages:

- The need for permanent storage of refuse is eliminated and landfill costs can be avoided, as the refuse is instead repurposed as a fuel source. Permanent storage often represents the largest cost driver for remediation activity undertaken by the Commonwealth.

- The energy generation process creates revenue that offsets costs of operation, whereas the alternative of removal, disposal, and remediation is purely a cost to the Commonwealth.
- The industry addresses water quality impacts from their source with strict standards and regulations, rather than a lengthy water treatment program that requires upfront and ongoing operating costs.

Avoided Costs for Removal and Secure Landfilling

Project bids from recent years can provide a basis to estimate the avoided cost from other removal, disposal, and remediation efforts by the Commonwealth that are currently undertaken by the industry.

In 2016, PA DEP requested bids for removal, disposal, and remediation of a coal refuse pile in Ehrenfeld totaling 2.7 million tons of coal refuse and 62 acres. The contract was awarded to Rosebud Mining Company with a total project cost of \$26.2 million, including coal refuse removal and disposal, as well as site rehabilitation costs.³⁰ This total project cost was based on minimal disposal cost because Rosebud was able to relocate and repurpose the refuse in strip mining pits, and due to its ownership of and proximity to these strip mining pits, transportation and storage costs for the coal refuse were greatly reduced. Upon accepting this proposal, PA DEP noted that previous bids they had received in 2013 were cost prohibitive.³¹ Rosebud Mining Company was able to submit their competitive bid due to favorable circumstances that are not replicable for most other remediation efforts in the Commonwealth.

The Rosebud proposal is used as an illustrative example of a low-end cost remediation solution, and one that may be accessible to DEP based on limited funding, though it does not remediate waste coal to the same environmental standard as a more permanent remediation solution offered by the coal refuse reclamation to energy industry. High end cost estimates for removal, disposal, and remediation of coal refuse piles offer a solution that is more equivalent to the level of remediation offered by the coal refuse reclamation to energy industry, but these estimates are often cost prohibitive. While lower cost estimate proposals are sometimes available based on extenuating circumstances, these scenarios are rare and potentially less environmentally sound than higher end cost estimates.

The bid submitted by Rosebud showed a cost of \$11 per ton split evenly between removal and disposal costs and a rehabilitation cost of \$20,000 per acre.³² Other bids received had an average removal price of \$7.50 per ton, a disposal price of \$25 per ton, and a rehabilitation price of \$23,000 per acre.³³ Due to its unique removal and disposal solution, Rosebud was able to propose a much lower cost for removal and disposal than any other bidders. The averages of the other bids received are a more accurate

³⁰ Bids for removal and rehabilitation of the site were submitted publicly to PA DEP in November 2015 under contract number OSM 11(3041)102.1. Rosebud's winning bid included removal costs of \$12.22 million and rehabilitation costs of \$1.24 million for a total of \$13.46 million. In addition, disposal costs of \$5.14 per cubic yard for 2.478 million cubic yards of refuse totaled \$12.74 million, for an aggregate cost of \$26.2 million.

³¹ Former DEP Secretary John Quigley, quoted in: PR Newswire. "Pennsylvania DEP Awards Contract to Reclaim Long-Abandoned Ehrenfeld Mine Site in Cambia County. March 8, 2016.

³² Per unit costs for Rosebud are derived by dividing the volume of refuse and acreage of the site by the quoted cost. Costs submitted by three other bidders for removal and rehabilitation were uniformly higher.

³³ Bids for removal, disposal, and rehabilitation of the site were submitted publicly to PA DEP in August 2013 under contract number OSM 11(3041)101.1. The two submitted bids totaled \$59.8 million and \$98.2 million, respectively, driven by disposal costs of \$53.4 million and \$91.3 million, respectively, and the project was not awarded.

representation of the actual costs the Commonwealth would incur for a typical removal, disposal, and remediation effort.

Based on these bids and taking into account inflation to present value, the estimated cost of removal and disposal is \$14 per ton (for Rosebud) to \$41 per ton (in a more typical scenario), and rehabilitation costs range from \$26,000 to \$30,000 per acre. In order to maintain the current level of activity from the coal refuse reclamation to energy industry of 6.6 million tons of coal refuse consumed and 203 acres of land remediated each year, costs incurred to the Commonwealth would total approximately \$98 to \$281 million annually. Fully eliminating the refuse piles in the Commonwealth would cost approximately \$3.2 to \$9.1 billion.

4. Economic Benefits

CHAPTER SUMMARY:

- The annual economic impact of the industry is \$697 million within Pennsylvania, supporting nearly 2,200 jobs and generating \$15.9 million in state taxes and fees.
- This economic activity supports family-sustaining jobs, which yield average salaries for direct industry employees above \$81,000 per year.
- Plant operations are a driver of economic opportunity and employment in rural communities throughout the Commonwealth that have suffered from historic disinvestment.

4.1. Economic Impact

The coal refuse reclamation to energy industry is a critical driver of economic opportunity throughout rural communities in Pennsylvania. Industry plants are significant employers as well as significant purchasers for other suppliers. The direct expenditures by the plant on their payroll and supply chains create downstream opportunities for related industries including mining, transportation, and environmental remediation that further support jobs and opportunities in rural Pennsylvania.

Based on member surveys, it is estimated that the direct spending associated with plant operations of the ten member plants in Pennsylvania totaled \$389 million in 2023. Costs are categorized by salary/non-salary payments and fixed/variable costs for plant operations and related activities such as transportation, maintenance, and remediation.

Figure 4.1: Est. Direct Industry Operating Activity, 2023

Activity	Direct Spending
Plant Operations: Salaries	\$65.7
Plant Operations: Non-Labor Fixed Costs	\$113.0
Mining: Non-Labor Variable Costs	\$58.2
Trucking	\$61.1
Maintenance	\$16.8
Reclamation	\$11.4
Limestone	\$32.2
Other	\$30.3
TOTAL	\$388.7

Source: ARIPPA (2024), ESI (2025)

Expenditures by plants on payroll, operations, and services generate “spillover” effects within the state economy, stimulating business activity and supporting increased employment across a variety of sectors. The total economic impact of member plants is estimated as the sum of the direct plant operational expenditures, the indirect (supply chain) impacts from plant spending on goods and services with vendors, and the induced (labor income) effect as employees supported directly and indirectly by plant activities recirculated their income in the form of household spending.

Inclusive of these spillover effects, industry operations are estimated to have generated \$697 million in total economic impact in Pennsylvania in 2023 (see Figure 4.2). These operations supported nearly 2,200 full-time equivalent (FTE) jobs in the coal refuse reclamation industry, with just over half of those jobs representing direct positions within the plants. These direct and indirect jobs were associated with \$155 million in employee compensation (inclusive of both wages and benefits).

Figure 4.2: Statewide Industry Economic Impact, 2023

Impact Type	Pennsylvania
Direct Output (\$M)	\$389
Indirect and Induced Output (\$M)	\$308
Total Output (\$M)	\$697
Employment (FTE) Supported	2,180
Employee Compensation (\$M)	\$155

Source: ARIPPA (2024), IMPLAN (2025), ESI (2025)

It is worth noting that some of the power generated by these plants is exported outside of the Commonwealth, providing power and supporting activity in neighboring states. While this represents economic activity outside of Pennsylvania, it also represents an influx of wealth from those other states to Pennsylvania.

4.2. Tax Revenue Generated

The economic activity from industry plants also produces a significant volume of local and state economic activity. These revenues come in two forms:

- 1) Direct and spillover economic activity from the plants enhance various tax bases through the income, sales, and business profits that are created.
- 2) Member plants are subject to direct environmental taxes and fees that generate additional government revenue.

Tax revenue impacts from total economic activity are estimated by combining economic impact estimates developed above with fiscal modeling of the ratio between economic activity of various types and tax collections (i.e. effective rates).

- The economic activity from plant operations is estimated to have generated \$11.3 million in taxes through the Pennsylvania income tax (\$3.5 million), sales tax (\$5.7 million), and corporation tax (\$2.1 million) in 2023.
- In addition, plants reported paying \$4.6 million in state and local environmental taxes and fees.
- Combined, plant operations generated an estimated \$16 million in state and local taxes in 2023 (see Figure 4.3).

Figure 4.3: State and Local Tax Revenue Impacts (\$M)

Tax Type	Pennsylvania
Pennsylvania Income Tax	\$3.5
Pennsylvania Sales Tax	\$5.7
Pennsylvania Corporation Tax	\$2.1
State and Local Environmental Taxes and Fees	\$4.6
Total	\$15.9

Source: ARIPPA (2024), PA CAFR (2022), BEA (2021), ESI (2025)

4.3. Impact on Disadvantaged Communities

Pennsylvania’s coal refuse plants and its unremediated coal refuse piles are primarily situated within rural geographic areas, which host populations that generally face higher rates of economic and environmental hardship.³⁴ Member plants provide economic opportunity through their direct and spillover economic activity, with average salaries of more than \$81,000 per year for direct employees and millions spent each year on procurement of related services. The environmental benefits of plant activities as they consume and remediate coal refuse sites also enhances quality of life in the surrounding communities.

Spatial analysis shows that the 277 census tracts with unremediated coal refuse piles are disproportionately rural. Populations have lower educational attainment, are more likely to lack broadband internet connectivity, are more likely to be elderly, and have lower median home values than the statewide average (see Figure 4.4).

³⁴ According to the U.S. Census, census tracts reporting fewer than 5,000 residents and 2,000 household units are classified as rural geographies.

Figure 4.4: Indicators of Economic Disadvantage

	Without a Bachelor's	No Internet	Elderly	Rural Share of Census Tracts	Median Home Value
Statewide	66.0%	11.5%	26.5%	67.1%	\$266,800
<i>Distressed Tracts</i>	77.8%	15.3%	23.6%	70.2%	\$181,600
<i>Tracts w/ Refuse Pile</i>	76.6%	15.3%	30.5%	71.4%	\$257,600
<i>Tracts w/o Refuse Pile</i>	65.1%	11.1%	25.9%	66.7%	\$274,500

Source: American Community Survey, 5-Year Estimates (2023)

According to the Pennsylvania Department of Environmental Protection, 46% of the Commonwealth's current stock of unremediated coal refuse piles are located in disadvantaged block groups compared to 32% of block groups statewide. These economic and environmental indicators are consistent in demonstrating that the costs of Pennsylvania's coal refuse legacy are borne by disadvantaged populations within the Commonwealth.

5. Public Benefits: Addressing Pennsylvania's Legacy Liability

CHAPTER SUMMARY:

- The removal and remediation of coal refuse sites performed by coal refuse plants generates significant public benefits that fall outside of the direct monetary return captured by plants.
- Under current energy market conditions, plants are unable to recover their costs from energy sales alone and would be unable to continue operations without additional support.
- Policy supports that enable plants to continue their activity return benefits to Pennsylvania, improving current conditions and reducing long-term environmental liabilities.

Pennsylvania's coal mining history has left current and future residents with the significant environmental liability posed by 211 million remaining tons of coal refuse. The coal refuse reclamation industry provides an opportunity to address this public liability that generates energy, creates jobs, and improves environmental conditions. While the revenue generated by energy sales provides a significant offset to environmental remediation costs, under current market conditions there is generally a gap between industry costs and sales revenues. Pennsylvania's policy interventions have been essential to closing this gap, enabling plants to continue operations and the Commonwealth to reduce its environmental liability over time.

Current Market Conditions and Policy Support

Many of the environmental and economic benefits of plant activity are externalities that are not captured within the wholesale energy revenues or capacity payments received by the plants. The economics of the industry remain challenging for several reasons:

- Fixed and variable plant costs have increased with inflation in recent years, particularly for labor, maintenance, materials, and transportation,
- Wholesale energy prices have generally been well below breakeven costs in recent years (primarily due to competition from natural gas generation), averaging around \$30 per MWh on the PJM market in 2023 and 2024, and
- Capacity payments through PJM's market have fluctuated but generally do not fully compensate for fixed operational costs. Future capacity payments should be higher than recent years due to the introduction of the capacity payment "collar" but will still not compensate for operational costs.

Under these market conditions, additional revenues generated from the Coal Refuse Energy and Reclamation Tax Credit and from alternative energy credits available through qualification as a Tier II

resource under the Alternative Energy Portfolio Standards have been essential to making continued industry operations viable. In 2023, member plants generated more than half of total revenue through Alternative Energy Credits. Absent these credits, plant revenues would have been far below costs, illustrating the mismatch between revenues captured by the industry and the positive externalities that plant activity creates.

Lessons from Industry Contraction

In previous years, less favorable market conditions and low AEC levels have forced plants to idle and several to shut down permanently.

Since 2013, several coal refuse facilities have been forced to close or significantly reduce operations due to unfavorable economics, including:

- The permanent closure of four plants in Clarion, Schuylkill, and Cambria counties;
- The conversion of the Kimberly Clark Chester facility to natural gas; and
- Periods of seasonal idling at multiple facilities to avoid unprofitable operations during seasons with lower wholesale prices.

These closures and idlings directly impact workers as well as suppliers of these plants. More broadly, they have contributed to a reduction in the level of coal refuse consumed by Pennsylvania plants from 11.7 million tons in 2010 to 6.6 million in 2023. Each closure represents a permanent loss of reclamation capacity, as these specialized facilities are typically demolished once operations cease. The environmental reclamation activities these plants perform cannot be simply replaced without substantial cost to the Commonwealth to perform remediation in other ways.

The Path Forward

The environmental benefits of continued industry operation are substantial and cumulative. Each year of ongoing operations at current levels provides:

- Removal of millions of tons of coal refuse,
- Remediation of hundreds of acres of abandoned mine lands,
- Improvement of water quality in dozens of streams and watersheds,
- Elimination of air quality hazards, including uncontrolled emissions from smoldering, oxidizing, and weathering of piles, resulting in net reductions in greenhouse gas emissions, and
- Reduction of safety risks to communities near coal refuse piles.

While the economics of energy generation from this fuel source are challenging, the coal refuse reclamation to energy industry has proven itself as a cost-effective means of addressing the Commonwealth's legacy environmental liabilities, delivering environmental improvements at a fraction of the cost that would be required for direct public remediation. Without this activity Pennsylvania would face the prospect of either substantially higher public expenditures to address coal refuse piles or—more likely—the persistence of these environmental hazards and their associated cost. Pennsylvania's recent policy interventions have been effective to date in providing support to enable

continued operations of the industry, which in turn has provided the Commonwealth with significant environmental, social, and economic benefits.

Appendix A: Input-Output Methodology

In an interconnected economy, every direct dollar spent generates two spillover impacts:

- First, some amount of the proportion of that expenditure that goes to the purchase of goods and services gets circulated back into an economy when those goods and services are purchased from local vendors. This represents what is known as the **indirect effect** and reflects the fact that local purchases of goods and services support local vendors, who in turn require additional purchasing with their own set of vendors.
- Second, some amount of the proportion of that expenditure that goes to labor income gets circulated back into an economy when those employees spend some of their earnings on various goods and services. This represents what is known as the **induced effect** and reflects the fact that some of those goods and services will be purchased from local vendors, further stimulating the economy.

To model the impacts resulting from the direct expenditures, ESI developed a customized economic impact model using IMPLAN's input/output modeling system. Utilizing an industry standard approach, IMPLAN's input/output modeling system allows users to assess the economic and job creation impacts of industry-based events and public policy changes within a county or its surrounding area. IMPLAN has developed a social accounting matrix (SAM) that accounts for the flow of commodities through economics. From this matrix, IMPLAN also determines the regional purchase coefficient (RPC), or the proportion of local supply that satisfies local demand. These values not only establish the types of goods and services supported by an industry or institution, but also the high level at which they are acquired locally. This assessment determines the multiplier basis for the local and regional models created in the IMPLAN modeling system. IMPLAN takes these multipliers and divides them into 546 industry categories in accordance with the North American Industrial Classification System (NAICS) codes.

Explanation of Multipliers³⁵

The use and application of multipliers are intuitive. Multipliers, in their most basic form, are the result of an algebraic analysis expressing how two inputs are interconnected in the production of an output. The result of the equation generates a multiplier that is broken down into direct, indirect, and induced effects. In a generalized example: if the multiplier for good X to good Y is 3, then the direct effect of good X on Y is 1, with indirect and induced effects of 2. Essentially, every unit of good X supports 2 units of good Y.

When implemented on a large complex scale, such as that of the U.S. economy or any subsection of it, multiplier effects across industries can be complicated. However, the same general concept comes into play. Each industry has largely different and varied inputs into other industries. The quantity of the output is largely decided by the scale and efficiency of the industries involved. As a result, the sum of

³⁵ Lahr, Michael. "Input-Output Analysis: Technical Description and Application." Rutgers University Edward J. Bloustein School of Planning and Public Policy.

those inputs equates to an output product plus a value added/component. By arranging these inputs and outputs by industry in a matrix and performing some algebra to find the Leontief inverse matrix, each industry's effect on final demand can be estimated. Additionally, the direct, indirect, and induced effects can also be determined. Direct effects include direct purchases for production, indirect effects include expenses during production, and induced effects concern the expenditures of employees directly involved with production. Using building construction as an example, the direct effects would include materials, brick, steel, and mortar; the indirect effects would involve the steel fabrication and concrete mixing; and the induced effects would consider purchases by construction workers using their wages. While impacts vary in size, each industry has rippling effects throughout the economy. By using an input-output model, these effects can be more accurately quantified and explained.

IMPLAN is one of several popular choices for regional input-output modeling. Each system has its own nuances in establishing proper location coefficients. IMPLAN uses a location quotient to determine its RPC. This represents the proportion of demand for a good that is filled locally; this assessment helps determine the multiplier for the localized region. Additionally, IMPLAN also accounts for inter-institutional transfers (e.g., firms to households, households to the government, etc.) through its SAM multipliers. IMPLAN takes the multipliers and divides them into industry categories in accordance with the NAICS codes, allowing a comprehensive breakdown of a region's multipliers by industry to be shown.

Despite the usefulness of input/output modeling, there are some shortcomings to the system. Notably, input-output models ignore economies of scale. Input-output models assume that costs and inputs remain proportionate through different levels of production. Further, multipliers are not generally updated on a timely basis; most multipliers are prone to be outdated with the current economy. If the multipliers are sourced from a year of a recession economy, the multipliers may not accurately represent the flows from an economic boom period. Additionally, multipliers may not capture sudden legal or technological changes which may improve or decrease efficiency in the production process.

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