Assessing Energy-Related Redevelopment Options for Pennsylvania's Retired Coal Power Plants

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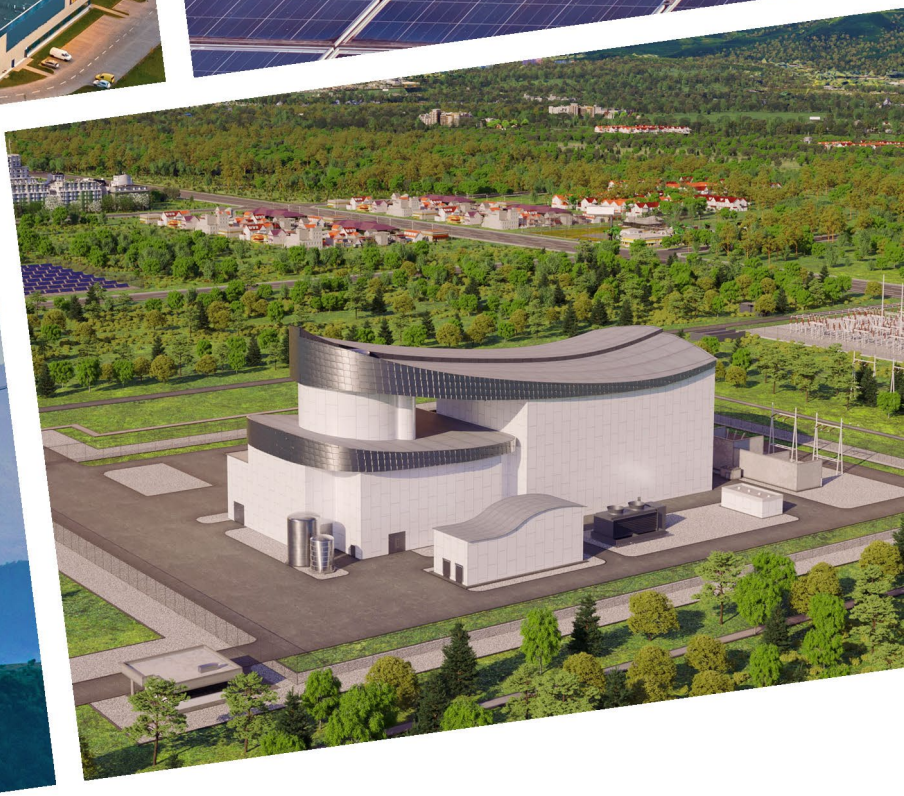

U.S. DEPARTMENT OF
ENERGY

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Visit the project website for additional resources: https://www.pnnl.gov/projects/coal-redevelopment.

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Summary

Within the last two decades, most of Pennsylvania's coal power plants have retired. While these closures present socioeconomic challenges to the surrounding communities and technical challenges to the electric system, they also offer potential for site redevelopment to new, economically promising uses like clean energy and energy-related industry. Pennsylvania is relatively unique in its number of retired and retiring coal power plants and the availability of legacy infrastructure that could be redeveloped.

This assessment focuses on energy-related redevelopment options for ten coal power plants in Pennsylvania that have retired since 2012. Using a geospatial approach, four redevelopment options are evaluated at a high level across the ten sites: 1) solar photovoltaic energy (plus energy storage), 2) wind energy (plus energy storage), 3) energy-related industry, and 4) nuclear energy. These options were selected due to their alignment with federal and state financial resources and availability of data.

The assessment reveals trends across the sites and the state as a whole. The solar and wind energy resource potential in the vicinity of all sites are within the ranges of operating and planned solar and wind generators in the state, indicating that resource potential should not be a limiting factor for solar or wind redevelopments. All sites have multiple modes of transportation infrastructure nearby that could benefit diverse end uses, but especially energy-related industrial uses. All sites have nearby electrical transmission infrastructure that could be beneficial for both exporting energy to the grid (solar, wind, or nuclear) or importing energy for on-site consumption (energy-related industry).

The availability of federal and state financial support could further enable redevelopment options for the sites and uses assessed. With the passage of the Bipartisan Infrastructure Law in 2021 and Inflation Reduction Act in 2022, billions of dollars are available to assist in transitioning infrastructure to new and clean uses. Energy Infrastructure Reinvestment financing from the Department of Energy is a unique resource that can support coal power plant redevelopment and associated site remediation for certain redevelopment pathways. At the state level, several programs are dedicated to readying sites for new economic development opportunities.

This assessment aims to raise awareness of redevelopment options for Pennsylvania's retired and retiring coal power plants and the financial resources that can support these transitions. It aims to serve as a basis for stakeholder discussions and starting place for further detailed assessments and public input that can consider factors like community preferences and economic development potential.

Acronyms and Abbreviations

AEC	Alternative energy credits
AEPS	Alternative Energy Portfolio Standards
BIL	Bipartisan Infrastructure Law
DCED	Department of Community and Economic Development
DOE	Department of Energy
EIA	U.S. Energy Information Administration
EIR	Energy Infrastructure Reinvestment
EPA	U.S. Environmental Protection Agency
GW	gigawatts
IRA	Inflation Reduction Act
ITC	Investment tax credit
PJM	Pennsylvania-New Jersey-Maryland
PNNL	Pacific Northwest National Laboratory
PTC	Production Tax Credit

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1.0 Introduction

Coal-fired power plants in Pennsylvania—and across the country—have been retiring in recent years. These closures present challenges to the surrounding communities and the electric grid. They are simultaneously an opportunity for redevelopment to new uses. These retired and retiring plants often have favorable attributes such as access to transportation infrastructure, open land, and nearby workforce that make them suitable for new uses like clean energy generation and manufacturing.

This assessment focuses on energy-related redevelopment options for Pennsylvania's retired coal power plants and is organized into three main sections:

1. Background on the status of Pennsylvania's coal power plants, the redevelopment process, and redevelopments underway in the state.
2. A geospatial assessment of ten plants considering four energy-related redevelopment options evaluated against a given site's geospatial characteristics.
3. An overview of financial resources at the federal and state levels that could generally support the redevelopment options contemplated in the assessment.

The Pennsylvania Department of Community and Economic Development (DCED) has previously analyzed five retired coal power plants in detail and published a series of playbooks evaluating possible redevelopment options (Table 1).

Table 1. Plants previously analyzed by the Pennsylvania Department of Community and Economic Development.

Plant name	EIA plant ID	Nameplate capacity (MW)	Retirement year	Link to DCED playbook
Cromby Generating Station	3159	188	2011	Cromby Playbook
FirstEnergy Bruce Mansfield	6094	2741	2019	Bruce Mansfield Playbook
FirstEnergy Mitchell Power Station	3181	299	2013	Mitchell Playbook
Sunbury Generation LP	3152	438	2014	Sunbury Playbook
Titus	3115	225	2013	Titus Playbook

Note: DCED = Pennsylvania Department of Community and Economic Development; EIA = U.S. Energy Information Administration; MW = megawatt.
Source: DCED n.d.

This assessment focuses on ten retired power plants that were not previously assessed by DCED (Table 2, Figure 1). New regional energy dynamics and new federal financial resources for coal redevelopment have also arisen and motivate the current assessment. The assessment excludes plants with a nameplate capacity less than 10 MW, dedicated industrial plants, and plants where there is already new development (e.g., natural gas-fired generating units) on-site. The assessed sites currently have different statuses—some power plants have been demolished to ready the sites for redevelopment, while other power plants appear to stand on-site much as they were when operational. Recent satellite imagery for each site is provided in the assessment to help discern the status.

Table 2. Retired coal power plants in this assessment.

Plant name	EIA plant ID	Nameplate capacity (MW)	Retirement year
Cambria Cogen	10641	98	2019
Cheswick Power Plant	8226	637	2022
Elrama Power Plant	3098	510	2014
FirstEnergy Armstrong Power Station	3178	326	2012
Hatfield's Ferry Power Station	3179	1728	2013
Homer City Generating Station	3122	2012	2023-2024
Kline Township Cogen Facility	50039	59	2018
Piney Creek Project	54144	36	2014
Portland (PA)	3113	255	2013
Wheelabrator Frackville Energy	50879	48	2020

Note: EIA = U.S. Energy Information Administration; MW = megawatt.

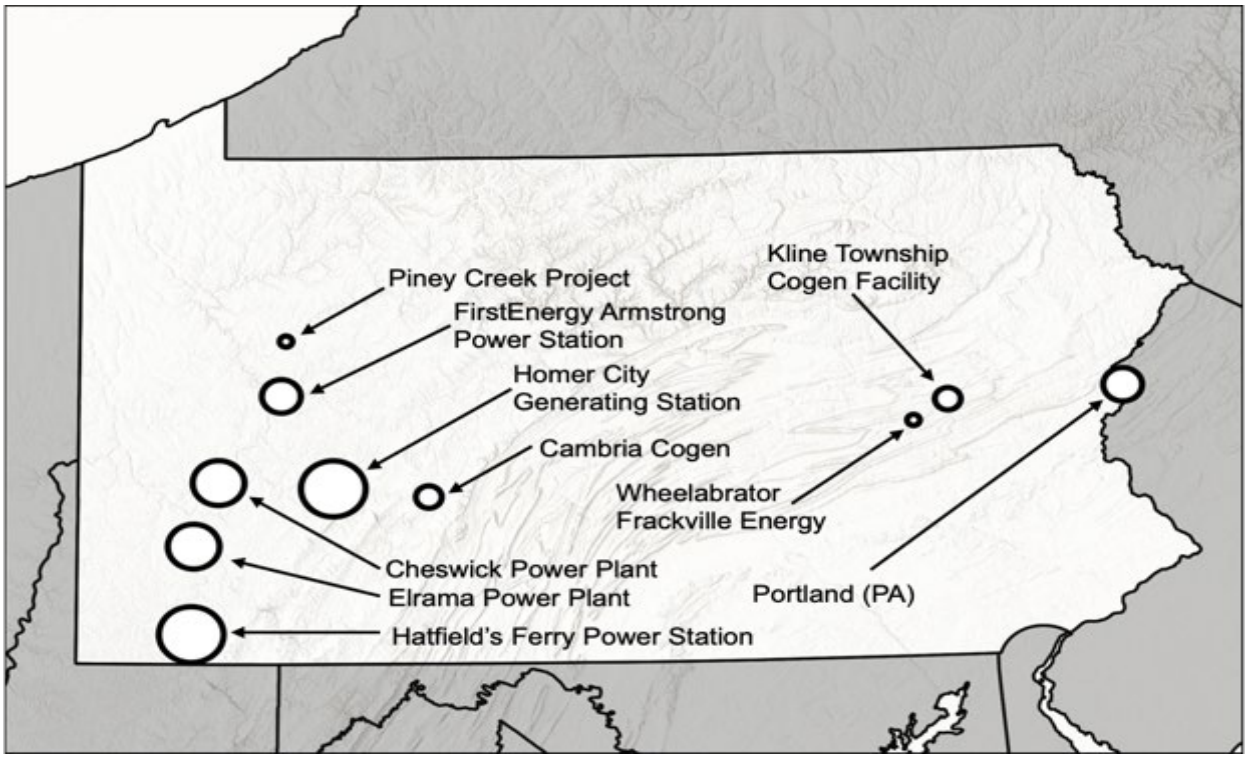


Figure 1. Retired coal power plants assessed. Marker size is scaled to nameplate capacity, ranging from 36-2012 MW.

This assessment considers four energy-related redevelopment options across each of the plant sites:

1. Solar photovoltaic energy (plus energy storage)
2. Wind energy (plus energy storage)
3. Energy-related industry
4. Nuclear energy

These redevelopment options are based on expected alignment with federal financial resources, available data, and Pacific Northwest National Laboratory's (PNNL's) recent analytical focus (PNNL 2024). They are examined in the context of an expected increase in electricity demand and in the context of new federal financial resources. Solar, wind, and nuclear energy redevelopments would provide energy back to the grid or other on-site uses. Energy-related industry could be a number of uses; activities such as manufacturing and recycling of electric vehicles, batteries, and other clean energy technologies are expected to be synergistic with a buildout of clean energy and compatible with currently available federal financial resources. An assessment could also be conducted from a different perspective, like economic development, which could include additional options and additional site assessment factors.

Coal redevelopment to new forms of energy generation may be especially relevant given an expected increase in demand for power from loads like data centers, electric vehicles, and heat pumps. Pennsylvania's electric grid is located within a regional grid operated by the Pennsylvania-New Jersey-Maryland (PJM) Interconnection (Figure 2), which has identified a long-term need to procure additional resources to account for this expected load growth and announced coal power plant retirements. PJM expects to add 15-30 gigawatts (GWs) of installed capacity by 2030, almost entirely renewable energy and storage (PJM 2023). The grid interconnection points that retiring coal power plants leave behind are expected to be a valuable asset for adding new forms of electricity generation back to the grid.

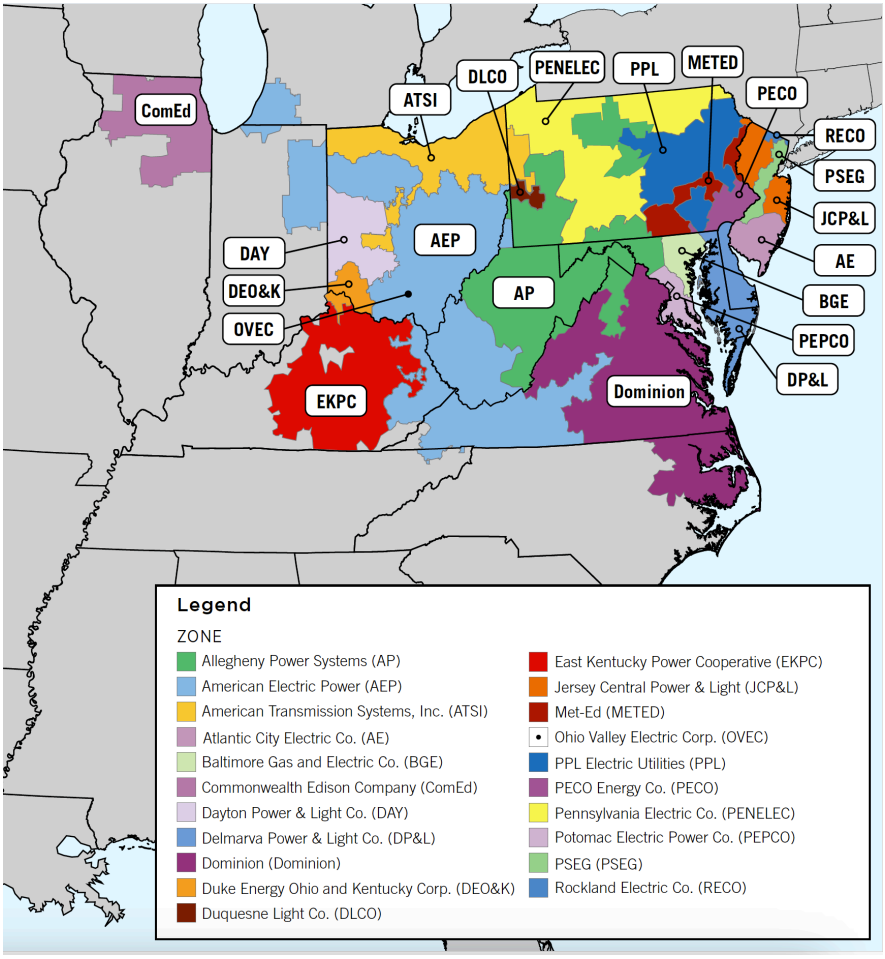


Figure 2. PJM territory and its transmission zones. Source: adopted from PJM.

There are also currently multiple forms of federal financial support for redeveloping coal power plants to the new uses examined in this assessment. Energy Infrastructure Reinvestment (EIR) financing from the Department of Energy (DOE) is a $250 billion program for retooling, repowering, repurposing, or replacing energy infrastructure like retired and retiring coal power plants. EIR financing can generally be combined with clean energy-related tax credits that were created or extended by the Inflation Reduction Act (IRA) of 2022. The IRA also created geospatially defined energy communities, including communities with a recently retired coal power plant, where certain clean energy projects can receive a tax credit bonus. Additional federal and state financial support is discussed in Financial resources.

This assessment uses a geospatial approach that can help evaluate the relatively large number of retired plants in Pennsylvania. Approaches like this may support broader regional assessments that consider additional plants. One tradeoff is that the level of detail in the analysis is reduced for each plant, compared to the DCED playbooks. A detailed follow-up analysis could be conducted for specific plants, which could involve examining additional site-specific attributes and gathering stakeholder input to adjust the assessment criteria.

This assessment aims to raise awareness of redevelopment options and serve as a basis for further discussion. It aims to complement DCED's playbook studies and pre-development work that is likely underway at some of the plant sites. Additional site-specific factors such as the history and current state of each site, the preferences and characteristics of the surrounding community, and the local economic conditions should be considered in follow-on assessments.

2.0 Background: Coal Power Plant Retirement and Redevelopment

This section provides background on the status of coal power plants in Pennsylvania, the coal plant redevelopment process, and redevelopment options that have been contemplated or are underway in the state.

2.1 Pennsylvania Coal Power Plant Fleet Status

Most of Pennsylvania's coal power fleet has retired in the last two decades. Some plants have re-powered to run on fuels like natural gas, some continue to operate but have announced that they will soon stop burning coal, and some remain operational with no announced plans to retire or redevelop. The ten plants that are the focus of this assessment have retired and could potentially be redeveloped to new uses. Figure 3 summarizes Pennsylvania's coal fleet status.

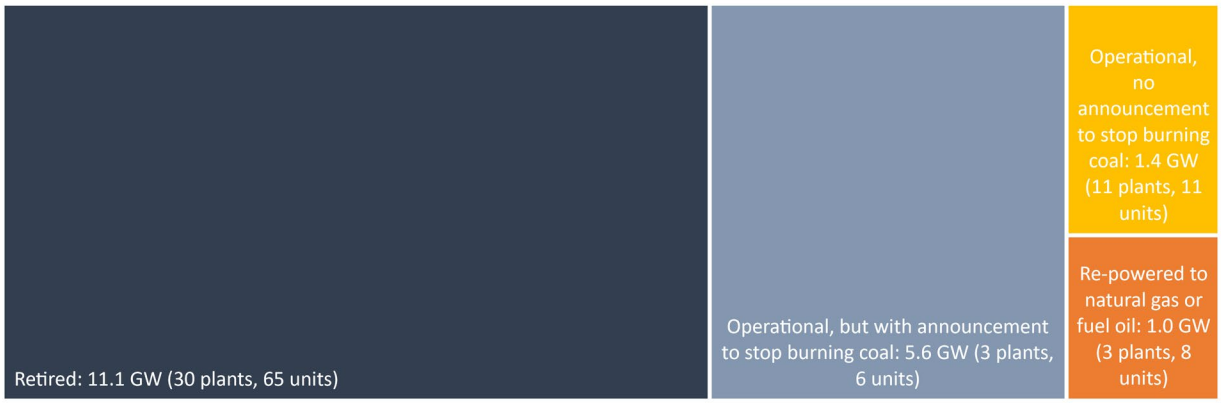


Figure 3. Summary status of coal-powered generating capacity in Pennsylvania. Data compiled from sources in text below.

Since 2002, 30 coal-fired power plants (composed of 65 individual generating units) have retired. Collectively, they represented over 11 GW of electric generating capacity. Figure 4 shows the timeline of these retirements, based on data from the EIA.

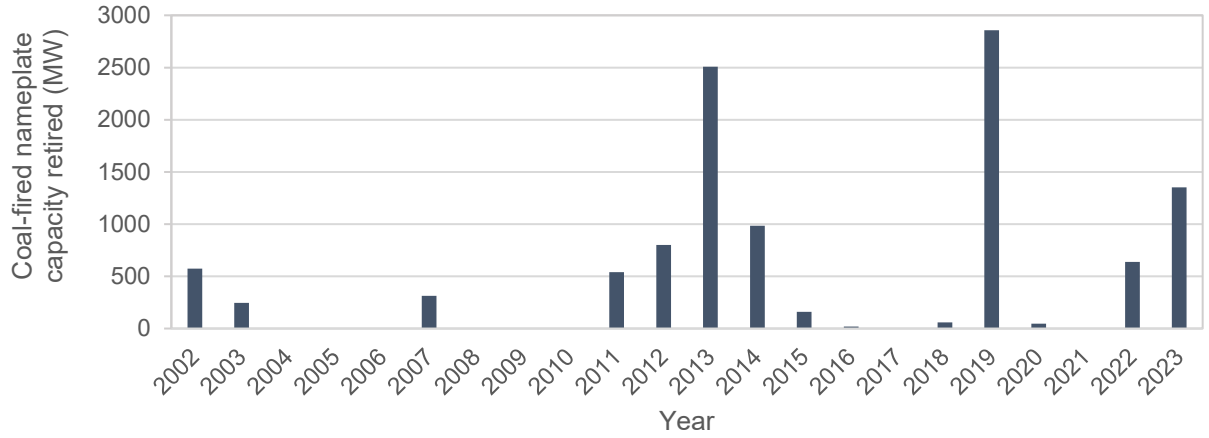


Figure 4. Timeline of retired coal-fired nameplate capacity. Source: EIA 2023.

Three large conventional coal power plants remain operational in Pennsylvania: Keystone, Conemaugh, and Talen Energy Montour. The Keystone and Conemaugh plants have announced that they will retire their coal-fired units by the end of 2028 at the latest (Rubinkam 2021). The Talen Energy Montour plant plans to stop burning coal by the end of 2025 (Global Energy Monitor 2023). Collectively these plants represent 5.6 GW of capacity across 6 units.

Three former coal-powered plants have already converted to natural gas or fuel oil. They represent about 1 GW of capacity across 8 units. Because these plants re-powered directly to new fuels, they do not appear as retirements in EIA data. These coal-to-natural gas conversions are reflective of a larger trend across Pennsylvania, where increased production of natural gas has made it cheaper than coal for generating electricity. Over the period from 2001 to 2021, the share of natural gas-fired electricity generation in Pennsylvania rose from 2% to 51%, while coal's share fell from 57% to 12% (EIA 2023).

A further 11 plants remain operational with no announced plan to stop burning coal. Collectively they represent 1.4 GW of capacity across 11 units. Ten of these plants are powered by waste coal, which is low-quality coal left over from mining. Burning waste coal is a phenomenon largely concentrated in Pennsylvania—there are only four waste coal power plants in the United States outside of Pennsylvania. Waste coal power plants can contribute to surface remediation by providing a means of waste coal disposal. Waste coal plants within Pennsylvania can also benefit from selling alternative energy credits under the state's Alternative Energy Portfolio Standards Act. In general, waste coal plants are also smaller and newer than their conventional counterparts. These factors likely mean waste coal power plants have a unique set of retirement and redevelopment factors.

2.2 Redevelopment Process

Coal power plant redevelopment can be generally described by the process in Figure 5:

Figure 5. General processes in coal power plant redevelopment. Adapted from Lessick et al. (2021).

The DCED playbooks for the Mitchell and Cromby plants estimated that redevelopment could generally take about 30 months. This estimate included about five months of construction planning to make a site near shovel-ready, and about 18 months for construction activities. Additional time was estimated for stakeholder engagement and acceptance of a redevelopment plan. Certain end uses would likely require additional construction time and the total time is expected to vary widely based on individual circumstances.

Though retired and retiring coal power plants often have attractive attributes (discussed below), redevelopment projects can be complex and expensive. Decommissioning and demolition can cost tens of millions of dollars (EPRI 2004) and remediation can also cost multiple millions of dollars (EPA 2016).

An early understanding of redevelopment options can help guide the remediation process, since the required level of remediation often differs by end use (EPA 2016). Some infrastructure from the original plant may also be retained for certain end uses.

2.3 Site Attributes

A coal power plant's redevelopment options depend on the combination of the site attributes and the requirements of the new use. The local community, workforce, and economic conditions are also important in determining which redevelopment option is implemented.

Retired and retiring coal power plants often leave behind a combination of physical and non-physical assets that may be valuable for redevelopment. Table 3 lists examples representative of the Pennsylvania power plants evaluated in DCED's playbooks.

Table 3. Representative examples of assets at retired and retiring coal power plants in Pennsylvania.

Physical assets	Non-physical assets
• Electrical switchyard/substation • Electrical transformers • Access to transportation infrastructure (commonly road, rail, and port) • Bulk loading and unloading facilities • On-site wastewater treatment • Leveled land • Office buildings • Maintenance facilities	• Adjacent workforce • Permits, e.g., water withdrawal • Favorable zoning for certain end uses

Some site factors can be either an asset or a constraint, depending on the end use. For example, easements for rights-of-way across the site may be beneficial for some uses (such as maintaining a rail line), but can hinder development for other uses. Local community familiarity with the retired or retiring coal power plant can also be an asset or a challenge, depending on the intended redevelopment use. Local stakeholders around the Bruce Mansfield and Titus plants expressed preferences for industrial redevelopment options, whereas stakeholders near the Cromby plant expressed preferences for redevelopment options that did not involve heavy industry. These cases highlight the importance of local stakeholder engagement in shaping redevelopment options.

2.4 Redevelopment Options Considered in DCED Playbooks

The DCED playbooks analyzed redevelopment options in detail for five plants, considering the site attributes, local economic and labor conditions, and views of interviewed stakeholders. In total, 18 types of redevelopment options were contemplated across five plants (Table 4).

Table 4. Redevelopment options contemplated across five coal power plants evaluated in DCED playbooks.

	Coal power plant				
Contemplated redevelopment option	Bruce Mansfield	Cromby	Mitchell	Sunbury	Titus
Natural gas-fired power generation	✓	✓	✓	✓	✓
Manufacturing or recycling	✓		✓		✓
Solar photovoltaic power generation	✓	✓		✓	
Natural gas-related processes	✓		✓		
Industrial park		✓	✓		
Rail transportation facility		✓			✓
Energy storage	✓				✓
Combined heat and power	✓				✓
Refrigerated storage			✓		✓
Residential		✓			

Contemplated redevelopment option	Coal power plant				
	Bruce Mansfield	Cromby	Mitchell	Sunbury	Titus
Office park		✓			
Logistics center				✓	
Wood waste recycling facility				✓	
Hydroponic greenhouse				✓	
Data center				✓	
Green hydrogen	✓				
Recreation					✓
Biomass energy					✓

All playbooks contemplated replacement energy generation. Natural gas-fired generation was contemplated for all, and solar photovoltaic generation was contemplated for three sites. Certain redevelopment options were highly site-specific; for example, the Cromby site was considered for a commuter rail station given its proximity to an existing light rail line. Constraints were noted for some sites; for example, the Bruce Mansfield site lacks a direct connection to a natural gas line and the Cromby site lacks access to major highways.

All playbooks considered multiple options and, in some cases, contemplated combining them on a single site. Some options appear readily combinable. For example, the waterfront access and open lands at several sites suggest that passive recreation could be integrated with new uses. On-site land use can also be maximized by installing solar panels on building rooftops.

2.5 Redevelopments in Pennsylvania

Redevelopments appear to be underway at several Pennsylvania coal power plant sites:

- The Bruce Mansfield site has been acquired by an environmental liability transfer company and is being marketed as an industrial park that could host a variety of uses (Frontier Group of Companies n.d.).
- The Cheswick site has also been acquired by an environmental liability transfer company that is contemplating renewable energy, battery energy storage, and other industrial uses (Charah Solutions 2022).
- The Hatfield's Ferry plant has been partially demolished in preparation for redevelopment, where energy- or water-intensive industrial uses are contemplated (FirstEnergy 2023).
- The Elrama site has been acquired by a redeveloper and the original plant has been demolished (Guidotti and Linder 2023; Litvak 2022).
- The Portland site has been acquired by a redeveloper and is being marketed as a commercial and industrial park (Gagiuc, 2023).

Several retired and retiring coal plants are in the process of developing solar energy. Talen Energy has announced plans for 20-MW solar arrays on closed coal ash ponds adjacent to the

Sunbury and Holtwood[1] plants (Talen Energy n.d.-a, n.d.-b). A 100-MW array is planned on lands adjacent to the operating Montour power plant[2] (Talen Energy 2020). The planned developments all involve multiple parcels of land, rather than contiguous arrays on a single parcel (Figure 6). Solar photovoltaic has been successfully constructed on closed coal ash landfills elsewhere in the U.S. (EPA 2023a) and on other Pennsylvania brownfield[3] sites like landfills (EPA 2023b).

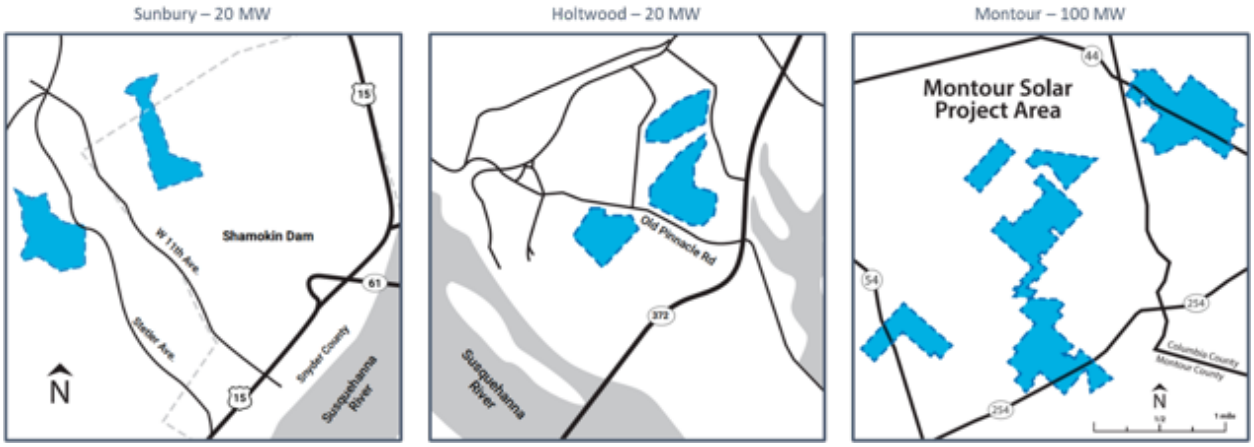


Figure 6. Solar photovoltaic arrays (blue regions) under development adjacent to coal power plants. Images compiled from Talen Energy (2020, n.d.-a, n.d.-b).

Though no wind power was found to be directly part of a coal power plant redevelopment in Pennsylvania, wind power has been deployed on coal mine lands in Pennsylvania. The Casselman and Highland wind power projects are both located on former coal mine lands and demonstrate the potential for wind development on brownfield sites (EPA 2023b).

3.0 Geospatial Assessment

This section describes the geospatial assessment approach, then presents an assessment at the state level, then an assessment for each of the ten plant sites. Trends are then synthesized and discussed.

[1] The Holtwood plant retired in 1999 and does not appear in the EIA retirement data. The main power plant site has already been redeveloped to support expansion of a nearby hydroelectric facility. Source: PPL Corporation, 2010. *PPL Holtwood Celebrates Past, Present and Future of Hydroelectric Power* https://www.prnewswire.com/news-releases/ppl-holtwood-celebrates-past-present-and-future-of-hydroelectric-power-92679194.html.

[2] The Montour plant currently has one unit capable of burning coal and plans to cease burning coal by the end of 2025. Source: McDevitt, 2021. *Talen Energy agrees to protect Montour Preserve as part of coal phase-out plan*. StateImpact Pennsylvania. Retrieved March 2024 from https://stateimpact.npr.org/pennsylvania/2021/03/05/talen-energy-agrees-to-protect-montour-preserve-as-part-of-coal-phase-out-plan/.

[3] The U.S. Environmental Protection Agency (EPA) generally defines a brownfield as “a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.” https://19january2017snapshot.epa.gov/brownfields/brownfield-overview-and-definition_.html.

3.1 Redevelopment Options Assessed

This assessment considers four energy-related coal power plant redevelopment options:

1. Solar photovoltaic energy (plus energy storage)
2. Wind energy (plus energy storage)
3. Energy-related industry
4. Nuclear energy

These options were selected mainly because they are generally compatible with a number of currently available federal financial resources. The emphasis on energy generation technologies also reflects the context of anticipated growth in regional electricity demand. Energy storage is considered as an option for pairing with solar and wind since it can unlock additional economic and grid benefits. Energy storage can also be deployed in stand-alone form. Energy-related industry is meant to encompass uses like manufacturing and recycling of electric vehicles, batteries, and other clean energy technologies. It may also be possible to combine multiple uses at a given site. Additional redevelopment options beyond the four assessed here are possible and may be incorporated in future assessments.

3.2 Assessment Approach

Each retired coal power plant site has characteristics that determine how well it could match with a given redevelopment option. Site characteristics were gathered from national-scale datasets for the parameters in Table 5. References are provided in Appendix: Data sources.

Table 5. Parameters from national-scale datasets considered in this assessment.

Socioeconomics	Infrastructure	Land features	Resource potential
• Population density • Social vulnerability index • Fossil-related employment	• Electric generator capacity • Distance to port • Distance to rail • Aggregate distance to electrical infrastructure	• Land use: forested • Land use: open water • Land use: developed • Land use: agricultural • Land use: barren • Topographical variation/rigidity	• Wind resource potential • Solar resource potential • Adjacent installed renewable energy • Adjacent planned renewable energy

The assessment takes the perspective of the retired coal power plant site evaluating potential redevelopment options, rather than a given redevelopment option seeking an optimal development site. This approach is a pivot from several existing energy-related site selection studies. Coal power plant redevelopment also raises consideration of social and economic factors that are not always considered in energy-related siting studies and are not always readily translatable into site scoring criteria. This assessment therefore did not develop a scoring rubric for site selection, though a more structured framework could be developed with further stakeholder consultation.

The assessment begins with a state-level view of solar and wind resource potential, then proceeds to site-specific assessments of the four redevelopment options across the ten

selected sites. The narrative for each plant site describes how the site characteristics interact with the redevelopment options. A vicinity map and recent satellite image also allow for a visual assessment of nearby infrastructure and site characteristics like surrounding population density and land use. General considerations for each redevelopment option are described below.

3.2.1 Solar

When deployed on the ground (rather than on rooftops), solar arrays generally require relatively level sites with slopes less than 5-10% (Koritarov et al. 2013). The land cover type also affects solar deployment potential: barren lands and pasture areas are very amenable, whereas forested lands are less amenable (Koritarov et al. 2013). Floating solar is an emerging technology that may be applicable in some cases like storage ponds (IRENA 2019). The annual potential output of a solar project is generally determined by the solar resource potential, measured in average annual average kilowatt hours (kWh) per square meter per day or year. The resource potential does not vary greatly on fine geographic scales, so the value for a given site can generally be expected to be representative of the adjacent lands. The coal-related solar developments underway in Pennsylvania (Figure 6) demonstrate that solar may occupy the retired plant site and adjacent lands.

3.2.2 Wind

Wind energy developments require adequate wind speeds. In contrast to solar energy potential, wind energy potential can vary greatly on fine geographic scales. Utility-scale wind farms also generally occupy large sites. Large-scale wind development would likely require using some adjacent land beyond the site of the coal power plant itself. Pennsylvania's largest wind farm consists of 88 turbines spread over a 9,000 acre site (BP 2013). The coal power plant sites considered in the DCED playbooks averaged about 380 acres. This assessment therefore considers the maximum wind resource potential within a 10-mile radius of the plant site—considered "local" to the plant site—in order to consider potential development beyond the plant parcel. Like solar energy, wind power developments are very compatible with barren and pasture lands (Koritarov et al. 2013). Unlike solar, wind development is somewhat tolerant of forested land cover, since the footprint of turbine towers is relatively small compared to the total plant area, and wind turbine height can exceed treetop height. Wind developments also benefit from proximity to major transportation infrastructure for the construction phase, given the size of components and construction equipment.

3.2.3 Energy-related Industry

Compared to energy resources like solar and wind, site suitability for energy-related industry is less straightforward to determine from national-scale datasets. Site factors considered important for energy-related industry may include access to transportation infrastructure, access to energy infrastructure like an electrical substation or natural gas line, and available local workforce. Natural gas infrastructure is therefore indicated on the site-specific maps below. In the absence of a detailed local study, population density may provide a proxy for the availability of local workforce. The characteristics of the local population are also important. Some communities have also previously expressed a desire to site job-creating installations near population centers. Areas with high social vulnerability index and high shares of fossil employment may particularly benefit from job-creating installations like energy-related manufacturing. On-site energy generation and storage could be combined with industrial uses, and therefore geospatial values like the solar resource potential are still an important consideration.

3.2.4 Nuclear Energy

Nuclear energy has a unique set of both physical and regulatory site requirements. A key factor is population density in the surrounding area. Current regulatory siting guidance indicates that the average population density in a 20-mile radius should be less than 500 people per square mile. This is approaching the density of urban areas, which are generally defined as having a core population density of 1000 people per square mile and surrounding density of 500 people per square mile (USDA 2024). Advanced nuclear reactors may have reduced requirements in the future and a population density of 500 people per square mile over a 4-mile radius has been explored previously in an informational site screening study (Hansen et al. 2022). Surface water coverage indicated in national geospatial datasets may provide a proxy for the cooling water that nuclear power plants are expected to require. Nuclear power plants may be able to tolerate slopes of 12-18%, but have several other geologic and topographic constraints like landslide risk and seismic risk (not evaluated in the current assessment).

Like energy-related industry, nuclear power plants have the potential to create a significant number of well-paying jobs and local tax revenues. A nuclear power plant is expected to provide more jobs than a similarly sized coal power plant, though some job types will differ (DOE Office of Nuclear Energy 2024). This job creation potential suggests that nuclear power plants could be a favorable redevelopment option for coal power plant sites with a high fossil energy employment score.

3.2.5 Energy Storage

Site factors were not directly assessed relative to energy storage, since battery energy storage facilities are expected to be relatively adaptable to a given site and require relatively little land. Smaller sites that may have limited redevelopment potential for other uses may therefore be an especially good fit for energy storage. A grid-scale lithium-ion battery facility, a technology type that typically provides about four hours of storage at its rated power capacity, might fit on the order of 25 MW power capacity (100 MWh energy capacity) units per acre of land (EIA 2024). Other forms of grid-scale energy storage exist and may have different spatial requirements.

3.3 State-level Assessment

Pennsylvania has numerous operating solar, wind, and nuclear generators. Mapping the retired coal power plants against this backdrop shows that several are located near areas with concentrations of solar or wind generators (Figure 7). There is a concentration of wind farms in the southwestern part of the state near the Homer City plant (#1), the Cambria plant (#4), and the Hatfield’s Ferry plant (#8). The Kline Township plant (#5) is located near two operating solar generators in the eastern part of the state and the Cheswick plant (#2) is near a concentration of solar generators in the far western part of the state.

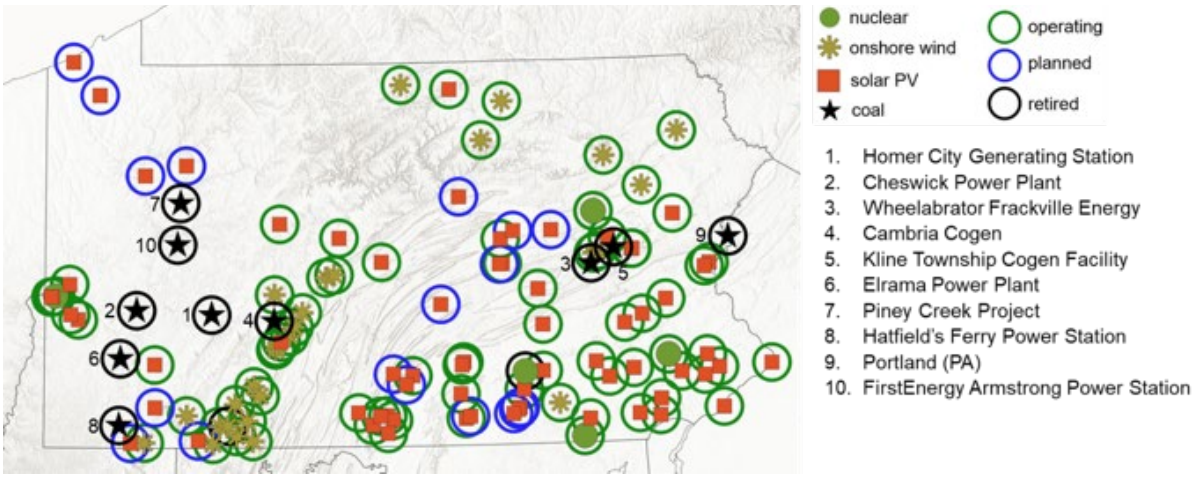
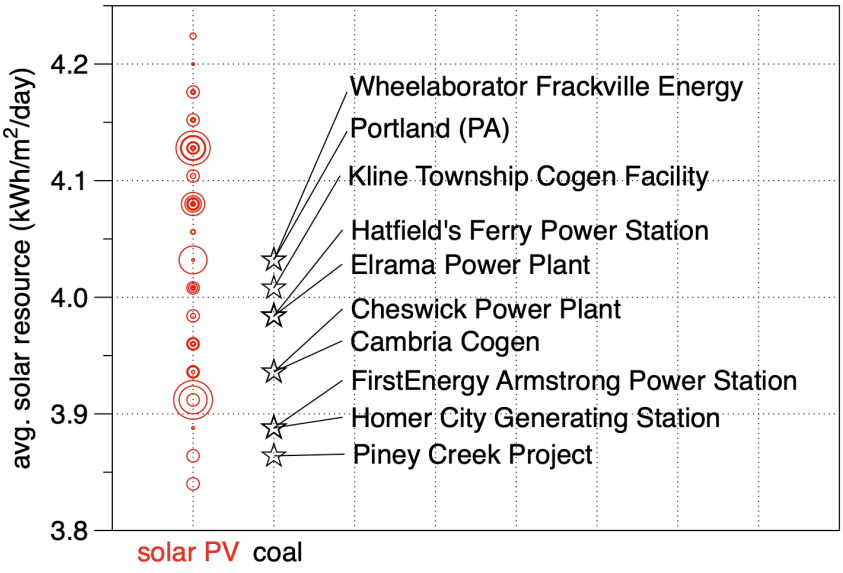


Figure 7. Several retired coal power plants are located near planned or operational renewable generators.

The presence of operating or planned renewables near a retired coal power plant site may indicate that the site has suitable conditions for renewable energy development. These conditions may be a combination of local support, land features, and renewable energy resource potential (solar irradiance or wind speed).

The renewable energy resource potential of each coal power plant site can be readily obtained from national-scale data. These values are given greater meaning when placed in the context of the resource potentials of operating and planned renewable generators in the state (Figure 8).

All coal sites assessed have renewable energy resource potentials comparable to those of operating and planned renewable energy generators in the state. The solar resource potential does not vary greatly on fine geographic scales and the on-site solar resource value is generally representative of the site and surrounding area. Wind speeds, however, are more variable, and wind project feasibility is more sensitive to the wind resource available. The wind resource potential of the retired coal power plant sites was therefore considered within a 10-mile radius of the site—a range considered to be “local.”



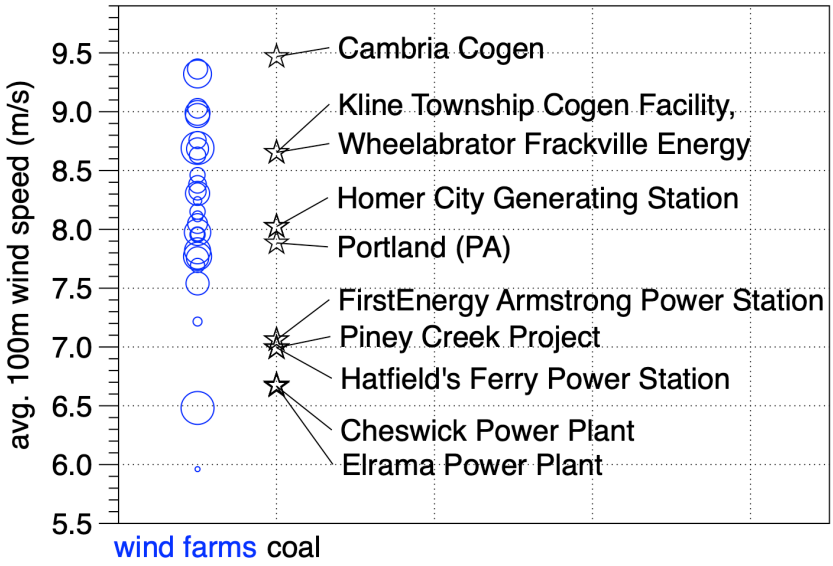


Figure 8. The renewable energy resource potential of retired coal power plant sites is comparable to the resource potential at operating and planned renewable energy generators in the state. Top panel: all assessed coal power plant sites have an on-site solar resource potential within the range of the potentials at operating and planned solar generators within the state. Bottom panel: all assessed coal power plant sites have a maximum windspeed within a 10-mile radius that is within or above the range of operating wind generators in the state. Colored circles are scaled relative to the nameplate capacity of the generators.

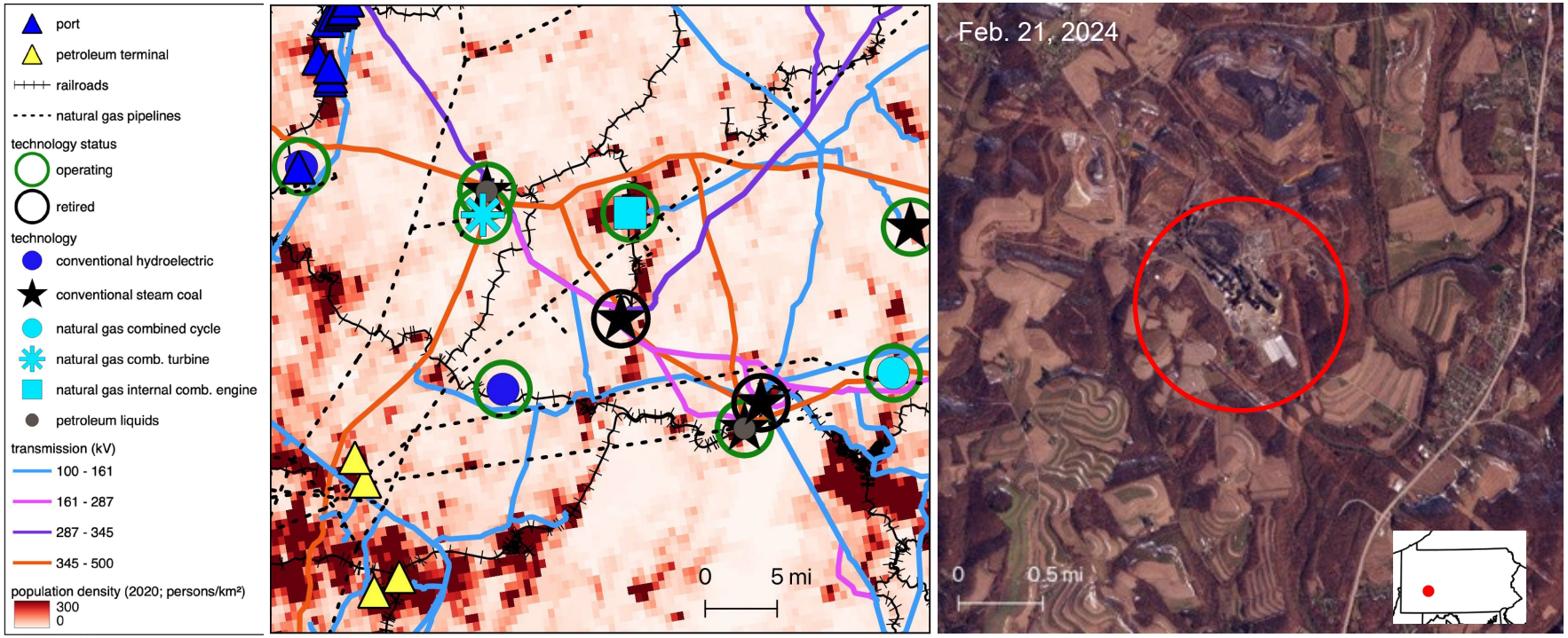
The local wind resource potential at the assessed sites indicates several sites are in the upper end of the range of operating wind farms. The Portland, Homer City, Kline Township, and Wheelabrator plants have local wind speeds comparable to most operating wind farms. The Cambria plant has the highest potential and is above the range of operating and planned wind farms. Figure 7 shows that this plant is located near a concentration of existing wind farms along the Allegheny Mountains. The mountainous regions of the state may generally be better suited for wind because ridgetops often have a high resource potential.

Sites with high renewable energy resource potential could potentially benefit from on-site development or adjacent development of renewable energy. They could also serve as points of interconnection to the electric grid for surrounding generators. There are currently no planned new wind farms in the state; if there is a future buildout, several of the assessed coal power plants may be favorably located to serve as wind-related logistics centers or manufacturing centers. Several existing wind farm sites have been re-powered with larger turbines. This activity could similarly be a logistics opportunity for nearby retired coal power plant sites.

In the following site-level assessments, the resource potential and adjacent renewable installed capacity are highlighted for several plants, alongside other geospatial considerations.

3.4 Site Assessments

3.4.1 Homer City Generating Station

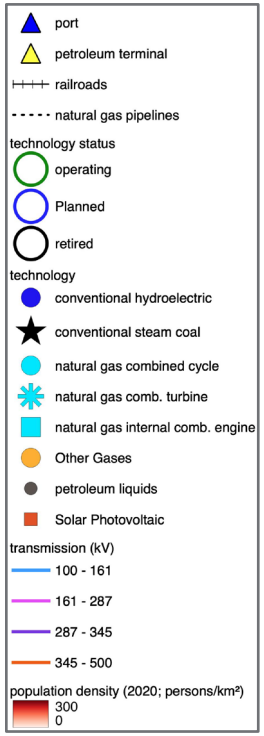


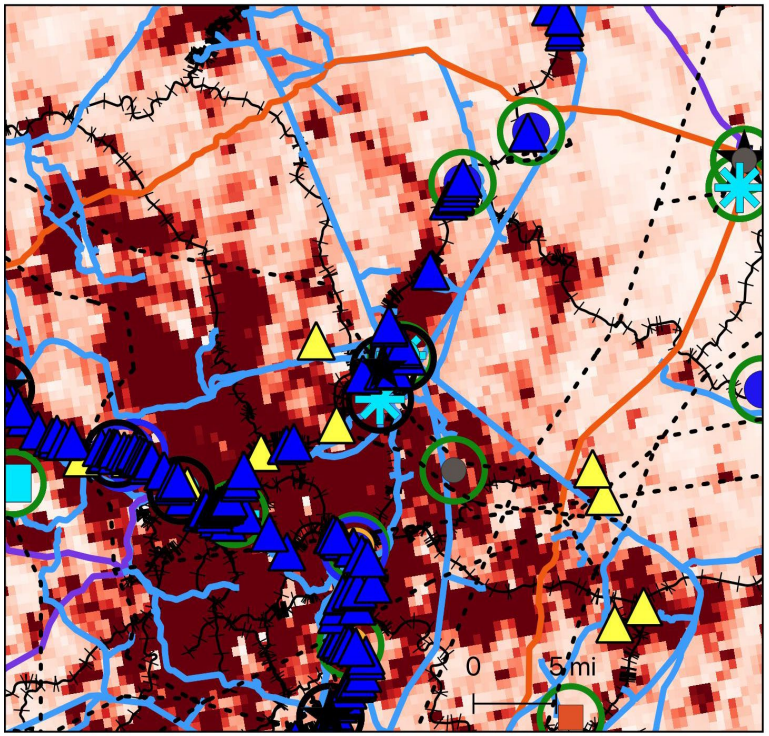
Homer City generating station had a 2012 MW nameplate capacity, and that large capacity requires careful consideration when planning for a replacement power source or other new use. There are eight operational renewable power generators within 20 miles of the facility, with 15 MW of generation capacity, potentially indicating favorable conditions for and familiarity with renewable energy. The area has a surrounding population of 466 people per square mile, meaning it could be suitable for redevelopment to nuclear energy. There are several voltage levels of electrical infrastructure that connect to the plant, potentially indicating that power could be transported both locally and long distance.

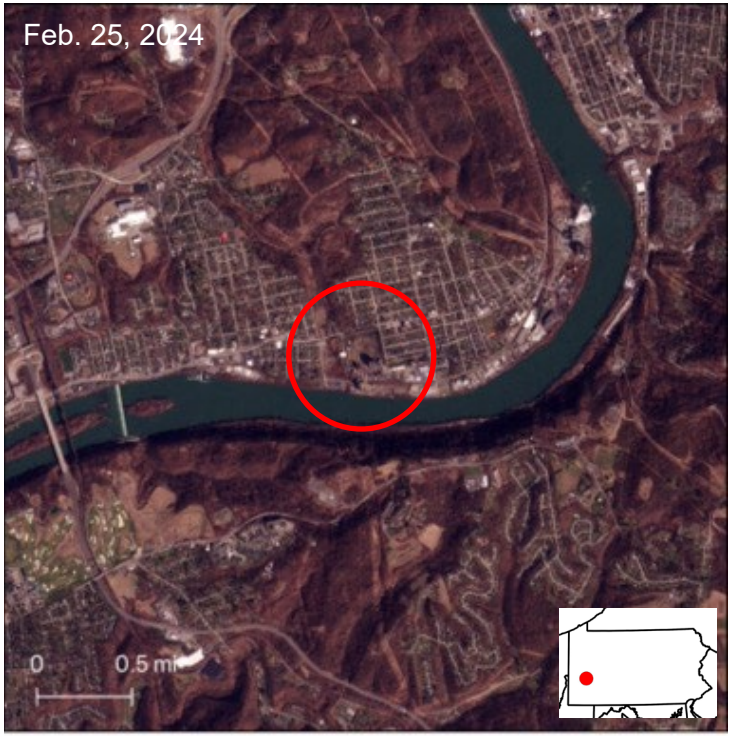
The region ranks 25th out of the top 70 fossil fuel employment regions in the U.S. Nearby apprenticeship programs could be important for future employment for the remaining population. The closest port is 29 miles from the facility, with a large network of waterways (39% open water within 20 miles). The site benefits from extensive rail access and several high-voltage transmission lines, as indicated on the site map.

The landscape around the plant is mostly undeveloped, forested, and relatively variable in comparison to flatter developed areas in the state. These factors could favor siting of wind turbines, whereas solar panels might fare better with flatter surfaces and less forest cover.

3.4.2 Cheswick Power Plant

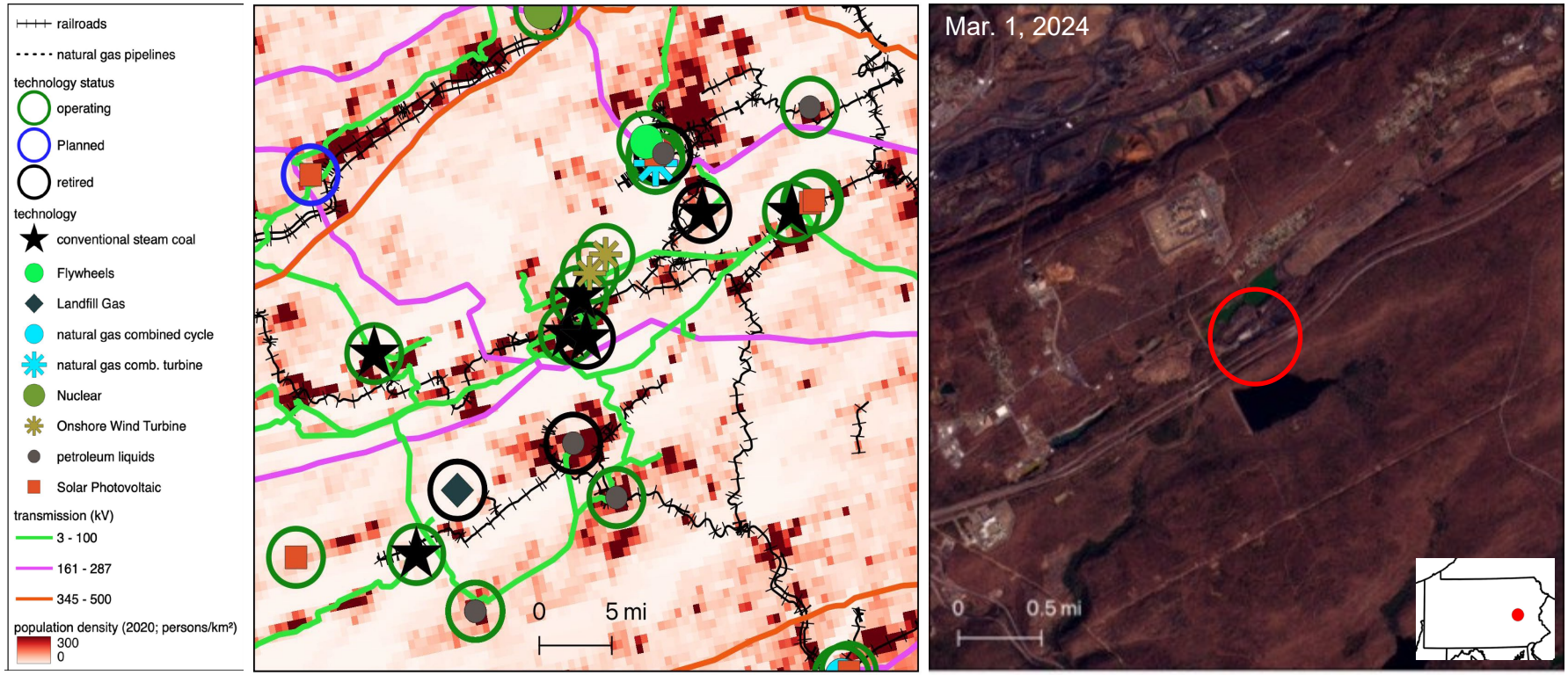






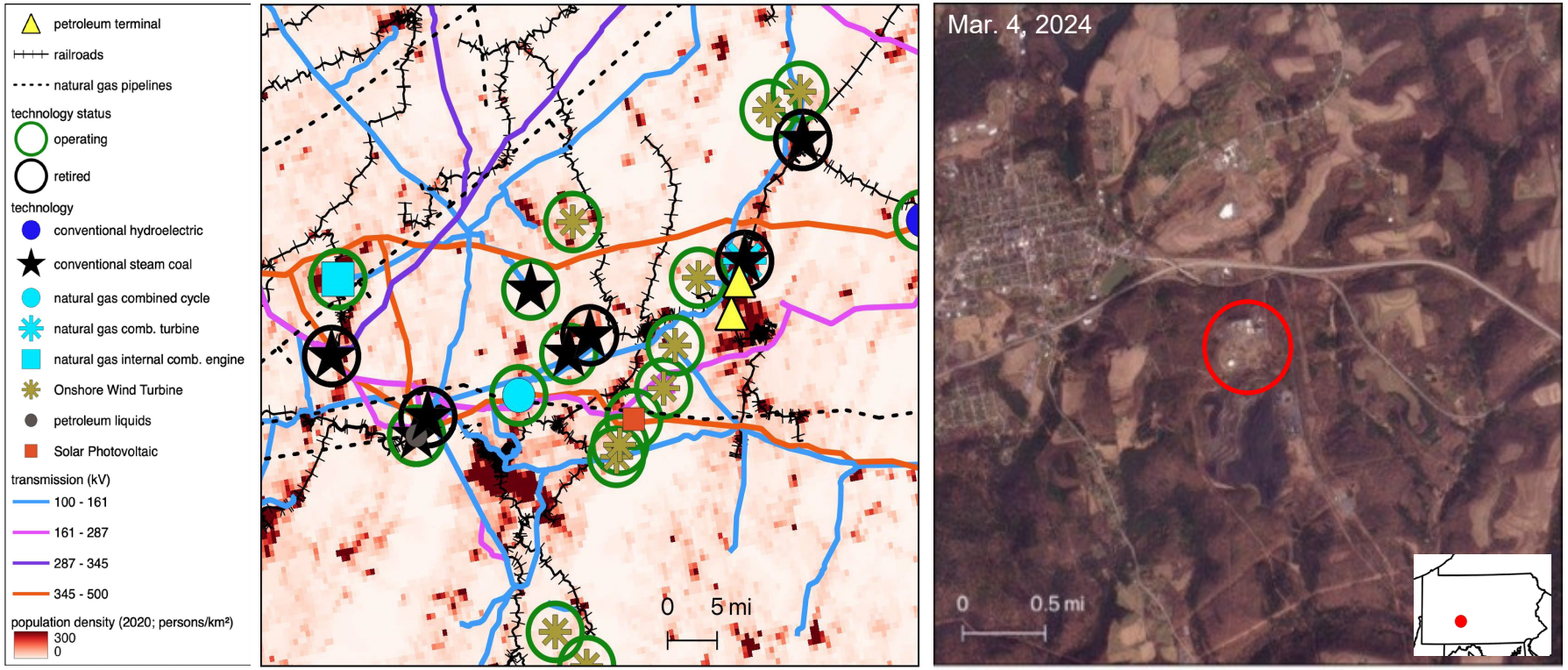
The Cheswick power plant had a nameplate capacity of 637 MW and retired in 2022. The site has been acquired by a redeveloper (Charah Solutions 2022) and satellite imagery shows that the plant infrastructure has been demolished in preparation for redevelopment. The site is relatively small and in a relatively developed setting. The population density within a 20-mile radius exceeds the recommended limit for nuclear power of 500 people per square mile. However, this surrounding population and development could favor energy-related industry that could reuse the on-site access to electric transmission and draw workforce from the surrounding community. The site has rail access and port access on the Allegheny River, additional factors that could favor energy-related industrial uses. The relatively compact site could also host energy storage, either stand-alone or connected to on-site solar photovoltaic. The site's low elevation variance would favor these uses.

3.4.3 Wheelabrator Frackville Energy



The Wheelabrator Frackville Energy plant was a waste coal plant with a nameplate capacity of 48 MW that retired in 2020. The plant and site are relatively small, like almost all other waste coal power plants in the state. Given the small size of the plant site, a compact use like stand-alone energy storage could be suitable. Satellite imagery indicates waste coal piles and other coal-related land use in the vicinity. Given the relatively small site area, these adjacent brownfields might be beneficial for expanding redevelopment like renewable energy near the site. The site has the second highest solar resource potential of the ten sites assessed; however, certain factors might favor wind development: the area has a high elevation variance and, apart from the brownfield sites, the surrounding land is mostly forested. Both of these factors favor wind over solar for larger-scale developments. There is also an operational wind farm just a few miles away. As the Casselman wind farm in Somerset County demonstrates, it is possible to develop wind farms on brownfield sites like coal mine lands. The site's interstate highway access could be beneficial for a use like energy-related industry. Among the sites assessed, this site's surrounding area has a relatively high social vulnerability index value, potentially indicating that redevelopments that create local jobs and revenues would be especially beneficial in this region.

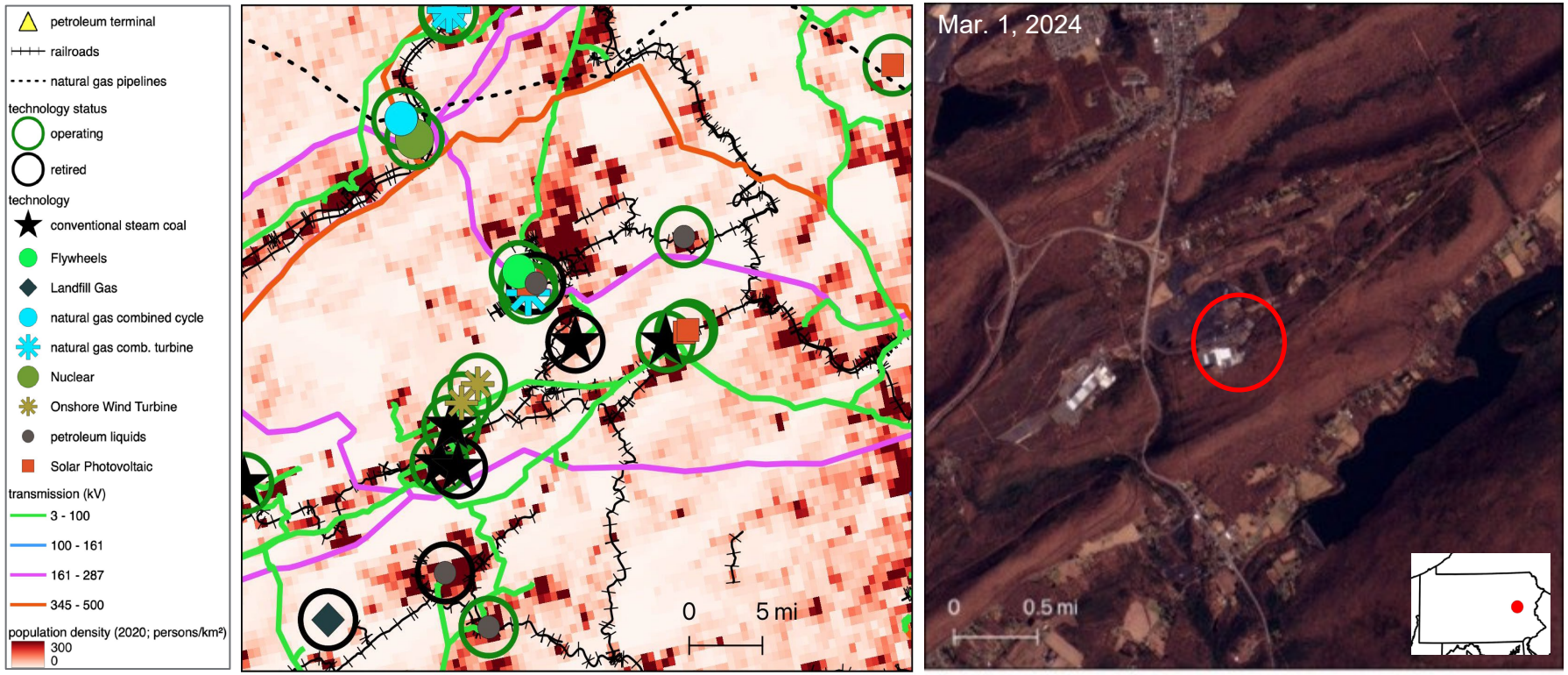
3.4.4 Cambria Cogen



Cambria Cogeneration Facility was a 98 MW waste coal plant that retired in 2019 in a rural area of 556 people per square mile. To the west of the plant are several operating coal power plants within 20 miles (Ebensburg Power Plant, Clover Green, and Seward). To the east are several wind farms (North Allegheny Windpower Project, Chestnut Flats, and Patton Wind) and some solar farms, though with lower capacity than the coal and natural gas power plants. The surrounding renewable installations suggest regional suitability for and familiarity with renewables. The nearby town of Ebensburg, centered among a rural community, could also potentially benefit from a small energy-related manufacturing facility that could employ local workforce. However, the site is located farther from a port (60 miles) or rail (0.5 miles) compared to similar plants in the state and there does not appear to be a sizable water body close to the facility.

The nearby electrical transmission infrastructure has a range of voltage levels which could mean that power is distributed both locally and transported to areas farther away from the plant. This range of voltages could make the site amenable to many redevelopment options and power needs. However, the high elevation variance and forest cover (50% of the land within 20 miles) makes it favorable for wind over solar.

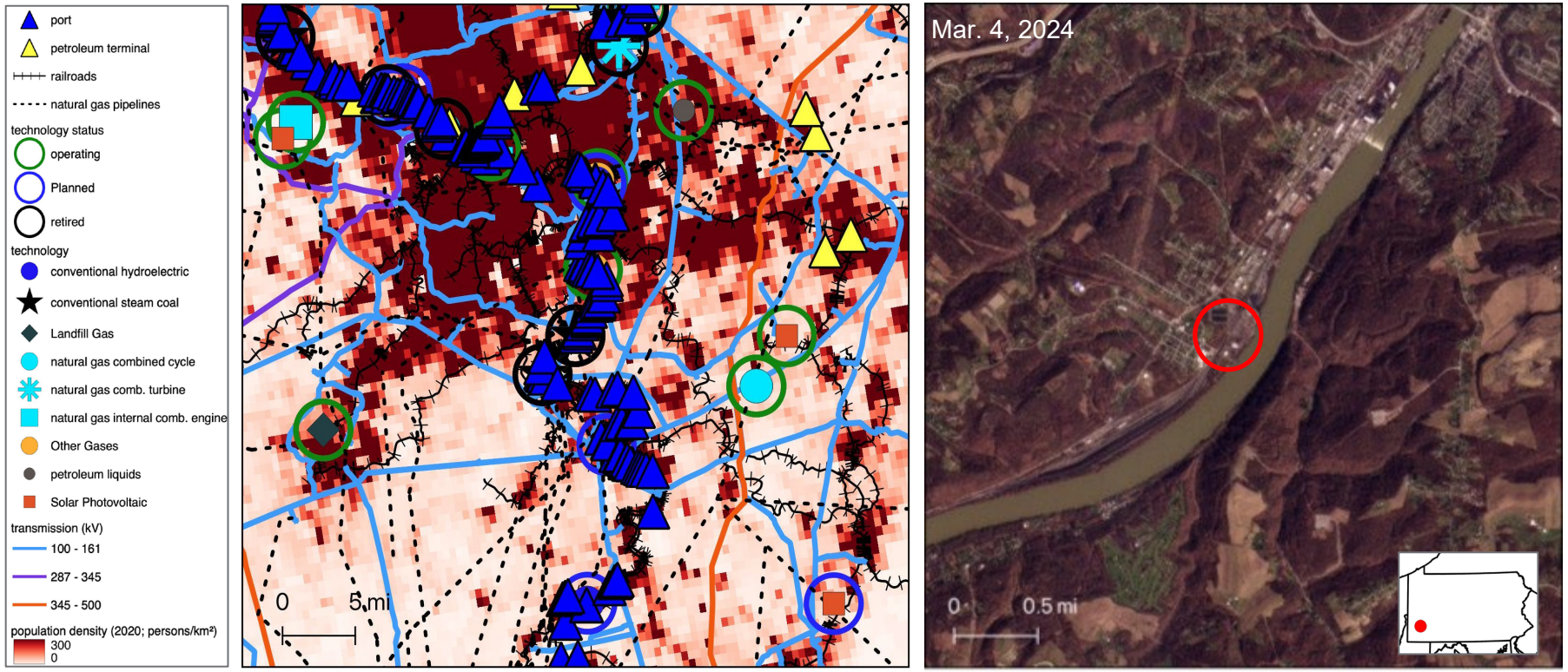
3.4.5 Kline Township Cogen Facility



Kline Township Cogen Facility was a 59 MW waste coal plant in a rural area (though with a relatively high overall population density of 624 people per square mile in a 20-mile radius). While there are still many operating coal plants and some petroleum liquid power installations in the same area, there is also a growing presence of solar (half a mile from the facility) and wind within 20 miles of the plant. The electrical transmission lines are on the lower end of the voltage scale, meaning power may be transmitted relatively close to the plant. The plant is relatively far away from a port, but has nearby access to rail.

The site is at the northern end of the Appalachian Mountains with very high elevation variance. The mostly forested land also has relatively high wind speeds and relatively low horizontal solar irradiance compared to surrounding plant areas, making it more favorable to wind installations.

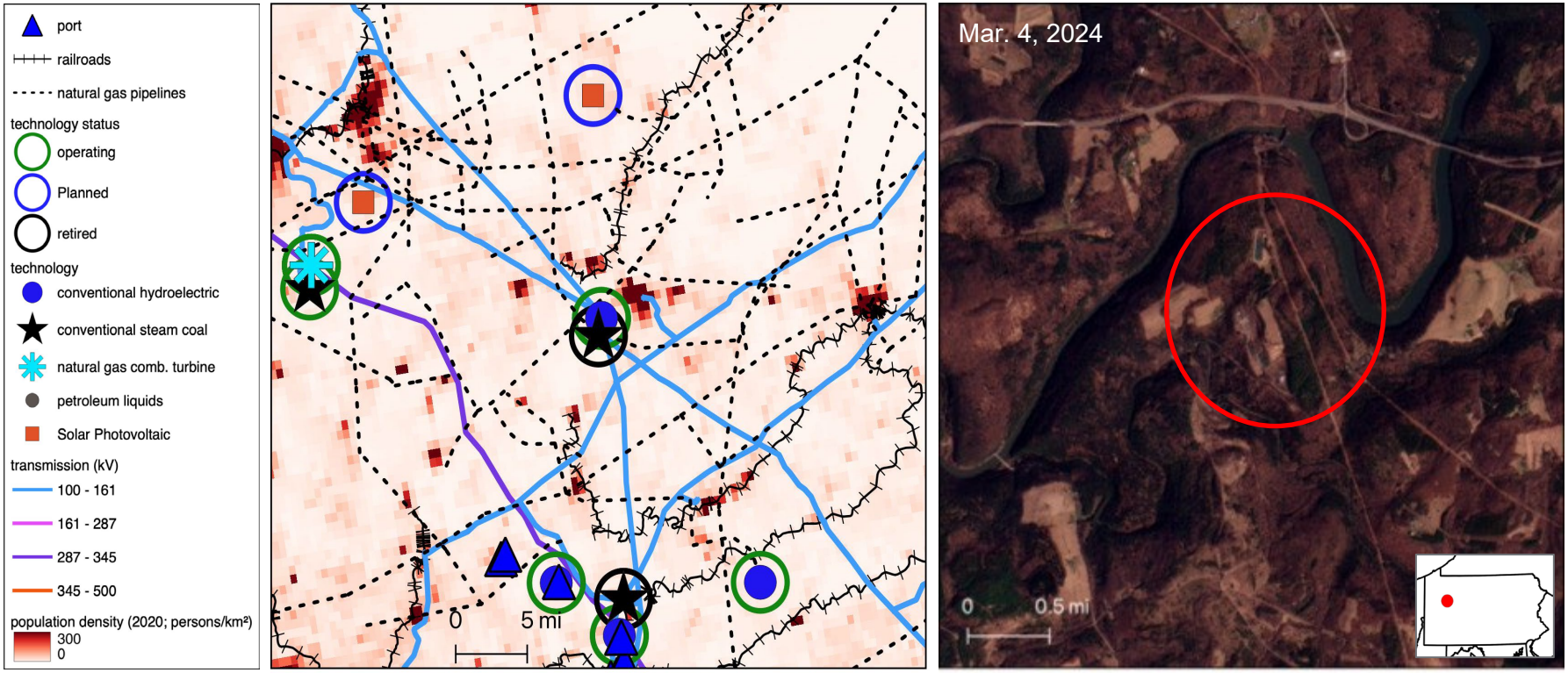
3.4.6 Elrama Power Plant



The Elrama Power Plant had a 510 MW nameplate capacity and retired in 2014. Satellite imagery shows the plant has been demolished and the site has been partially cleared for some form of redevelopment. The site is in a relatively developed area close to Pittsburgh and the surrounding population density within a 20-mile radius exceeds the current guideline value for nuclear power plants. The site has rail access and port access on the Monongahela River. These factors may make the site favorable for energy-related industrial uses.

Among the assessed sites, the Elrama site is in the middle of the rankings for solar resource potential. The low elevation variance would likely be amenable to solar development, but the relatively small site size could limit the capacity. The site has the lowest wind energy resource potential of those assessed.

3.4.7 Piney Creek Project

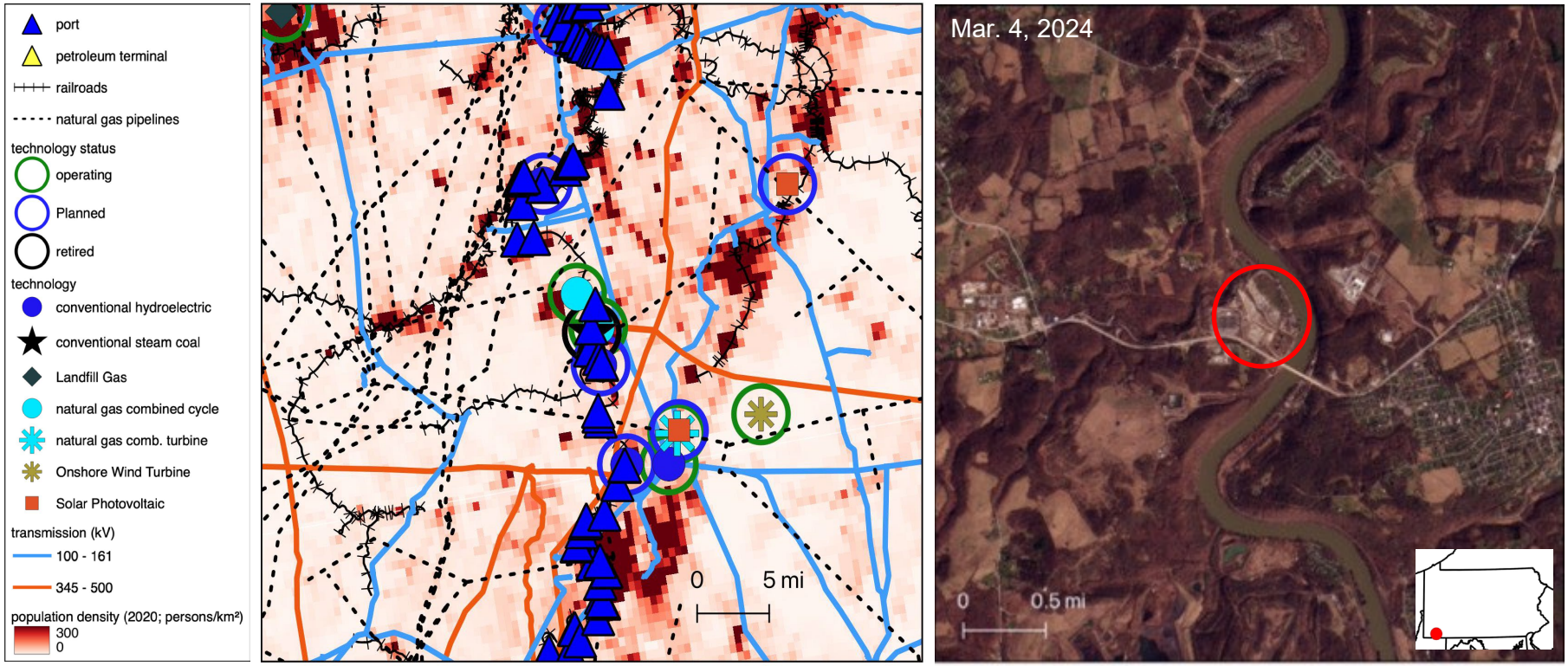


Piney Creek Project was a 36 MW waste coal power plant that retired in 2014. The site now has four operational renewable power generators within 20 miles of the facility with a combined nameplate capacity of 64 MW. There are two more planned renewable energy developments within 20 miles with a combined nameplate capacity of 40 MW. These adjacent operating and planned renewable generators indicate local familiarity with renewables in the area. Renewable energy development could bring jobs to this rural area with 155 people per square mile.

The transmission line size, counts, and voltage indicate that power is likely transmitted relatively long distances to more populated areas or distributed across larger areas of rural communities. The closest port is on the Allegheny River 16 miles from the facility, with a large network of waterways (35% open water within 20 miles). Rail transport is nearby (0.06 miles), though does appear to be directly connected to the facility.

The landscape around the plant is moderately variable in elevation compared to other plants in the state and is 38% forested, 4% developed, and 9% agricultural, meaning solar placement is possible, but wind installations potentially have a place on the higher, windier areas around the plant. The characteristics considered here generally seem to favor wind and solar power as redevelopment options.

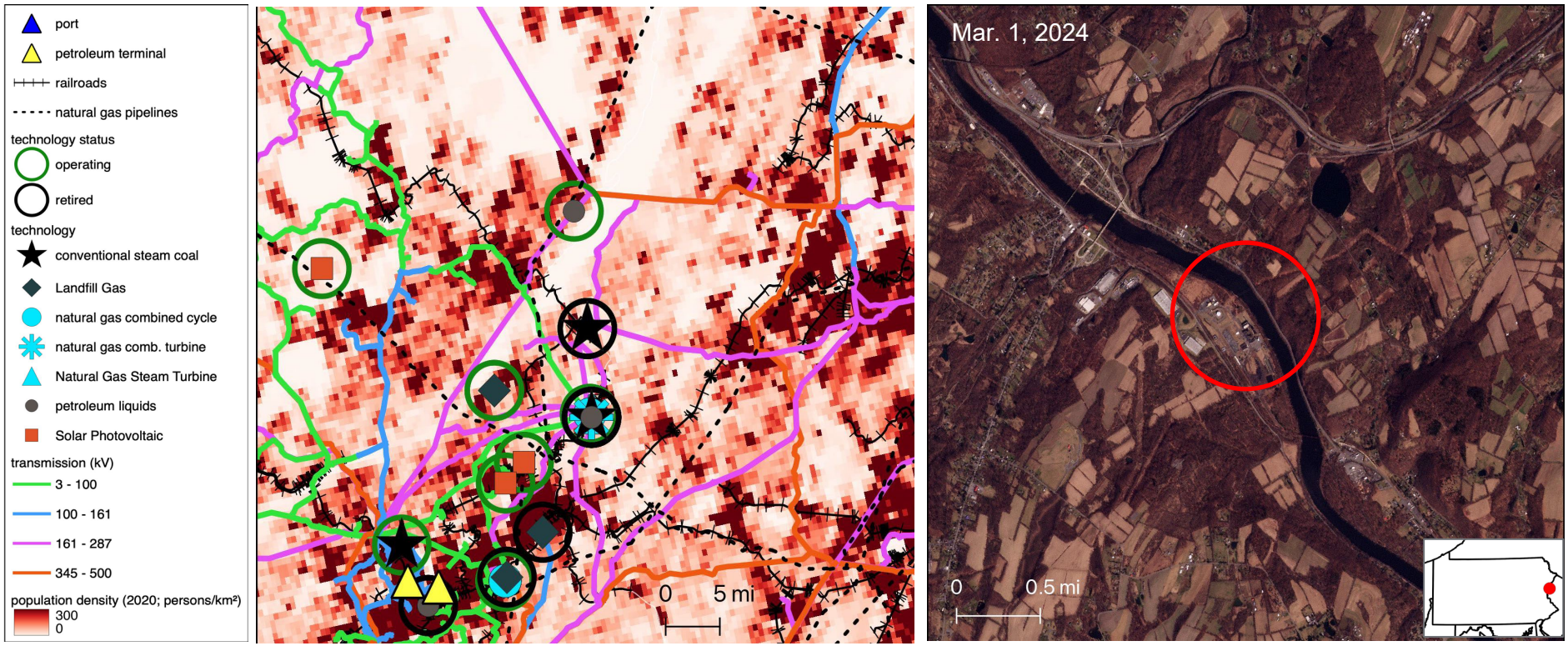
3.4.8 Hatfield's Ferry Power Station



Hatfield's Ferry Power Station had a 1728 MW nameplate capacity and retired in 2013. The plant was a large power source in a relatively rural region. Although similar to the retired Armstrong power plant in being sited on a river, it is different in its high capacity and its immediate neighboring operational plants (natural gas and a coal power plant in West Virginia). However, the planned power facilities within 20 miles of Hatfield are primarily hydroelectric along the river and some solar totaling 80 MW of nameplate capacity, indicating an uptake of these renewable options in the area.

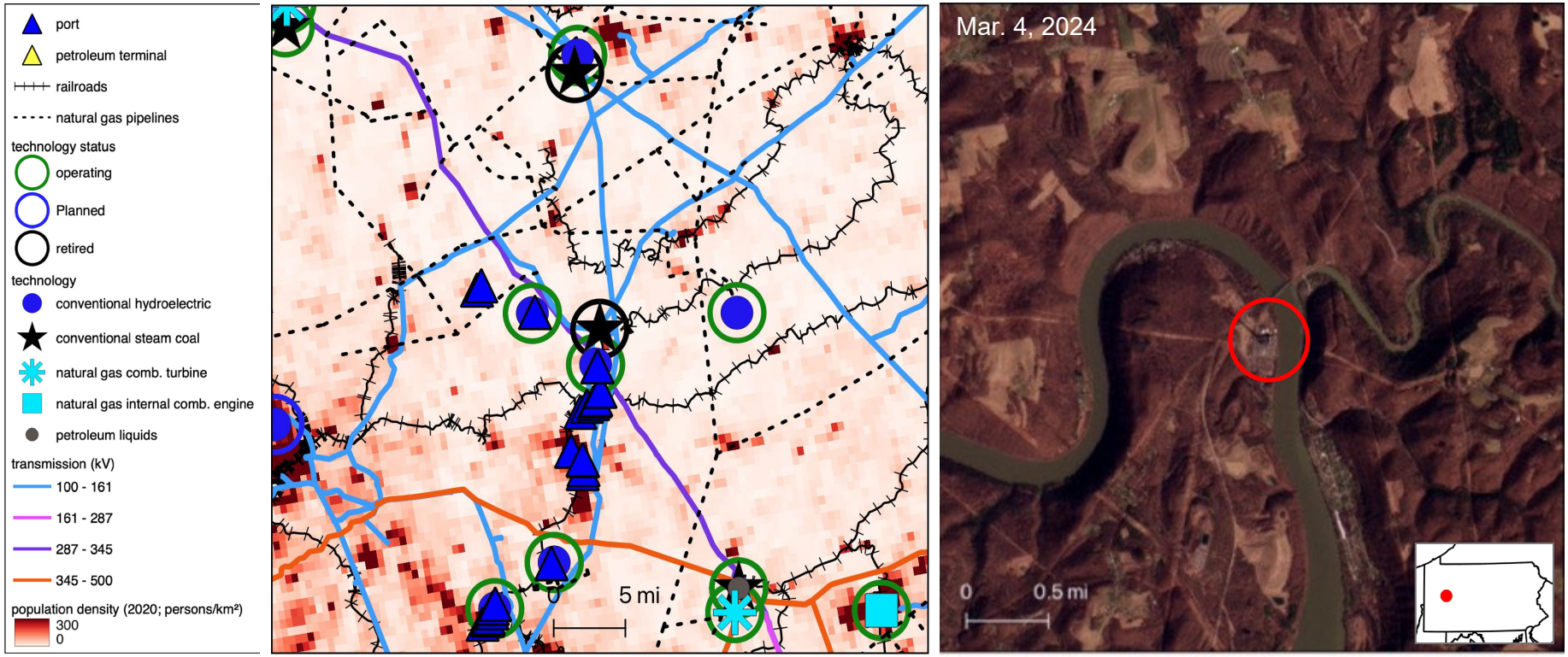
The plant region has a high social vulnerability index value and ranks 25th of the top 70 fossil fuel employment communities in the country. West of the plant are suburbs (like Little Chicago) and agricultural lands (8% land cover) that could benefit from a redevelopment option offering high employment. The site's access to the river, roadways, and rail transportation are further factors that might favor uses like energy-related manufacturing or nuclear energy. Solar power could also be suitable, as the site has a solar resource that is toward the upper end of the assessed range and has low elevation variance that could be amenable to solar siting. The area east of the plant has higher elevation variance and forested land cover (25%) more conducive to wind development than solar.

3.4.9 Portland (PA)



The Portland power plant had a nameplate capacity of 255 MW and retired in 2013. Satellite imagery indicates that the power plant structure is still standing. The site has been acquired by a redeveloper and is being planned as a commercial and industrial park (Gagiuc 2023). Given this potential development, this assessment considers potential energy-related co-uses at the site. The site has the highest solar resource potential of those assessed. The relatively high elevation variance might limit ground-mounted solar and favor rooftop solar on the proposed commercial and industrial buildings. Energy storage—either stand-alone or connected to solar—could also be an on-site option. A battery energy storage system could potentially benefit from the on-site electrical infrastructure and be compatible with other site uses, since battery energy storage has a relatively compact land footprint.

3.4.10 FirstEnergy Armstrong Power Station



FirstEnergy Armstrong Power Station was a 326 MW coal plant that retired in 2012 in a rural area (though with 606 people per square mile within a 20-mile radius). This plant is unique to the state in that it is located on the Allegheny River and surrounded by hydroelectric power installations totaling 85 MW of nameplate capacity. Port access is 2.5 miles downriver that provides a water source that could be appealing to energy-related manufacturing. The site has access to rail which could be useful for several redevelopment options. The rural population currently ranks 56th in the top 70 regions for fossil fuel employment, so redevelopment options that generate more local jobs could have more of a positive impact on the local population.

The solar irradiance and annual average wind speed are low compared to other retired coal plants assessed, but still within the range of operating and planned solar and wind farms in the state. The elevation variance is lower than other assessed coal plant sites. The surrounding land cover is 21% agricultural, but solar developments would still likely face challenges in the remaining forested areas. The available water could be beneficial to a use like nuclear energy, but the surrounding population density is above the currently recommended threshold.

3.5 Assessment Synthesis

The state-level assessment and series of site-level assessments reveal several trends:

Renewable energy resource potential for solar and wind at all assessed sites (within a 10-mile radius, for wind) is within or above the range of operating and planned solar and wind generators in the state. The resource potential should therefore not be a limiting factor for coal-to-solar or coal-to-wind redevelopments.

Wind energy potential is significant for the 10-mile area around several assessed sites. Other factors across several sites also tend to favor wind development: barren land such as brownfields, access to electrical infrastructure, and access to surface transportation infrastructure, which is needed for wind farm construction. The forested land cover and elevation variation at several sites also favor wind over solar. Several sites that could be amenable for wind could also be amenable for energy-related industry. Though there are no EIA-registered planned wind farms in the state, a future buildout could lead to wind-related manufacturing and logistics opportunities.

Solar energy potential is present at all sites, but the small size of several sites might limit the potential for utility-scale solar, especially if other uses are intended for a given site. Sites like the Portland plant in Mount Bethel that have announced plans for commercial and industrial development could take advantage of solar resource potential through rooftop solar. Smaller sites could still be significant for community-scale solar installations. Talen Energy's planned solar developments (Figure 6) indicate that solar can also be developed on lands adjacent to a coal power plant site and still take advantage of site assets like the electrical infrastructure.

Energy storage was originally contemplated in this assessment as a complement for wind and solar generation, but could be equally valuable as a stand-alone option. Smaller sites and sites with developed surroundings could still likely accommodate sizable battery energy storage systems. It also seems likely that tailoring brownfield remediation for energy storage might provide efficiencies compared to some other redevelopment options.

Access to transportation infrastructure is likely an important factor for many redevelopment options, and especially important for energy-related industry. All sites assessed have multiple forms of access. Almost all sites have rail on-site or nearby. Four sites are located on rivers and have direct port access. Additional sites have a port nearby. Port access could provide unique opportunities for transporting bulk materials or large pieces of equipment associated with certain energy-related industrial uses.

Access to electricity transmission infrastructure appears to be in place at all sites. All redevelopment options assessed are energy-related and could benefit from electricity transmission access, though in different ways. Solar, wind, and nuclear generators would benefit by being able to *export* energy to the grid, while energy-related industry would likely benefit from *consuming* bulk electricity from the grid. The presence of on-site generation like solar or on-site energy storage could affect these dynamics, too. The condition of a coal power plant's substation, precise transmission range, and the availability of power were not examined in this assessment, and it is not clear if they can be readily determined from open data sources.

Surrounding development at some sites could hinder expansive uses like utility-scale wind farms while favoring other uses like energy-related industry and energy storage. Plants like

Cheswick and Elrama are located in highly developed areas where workforce availability and industrial clustering potential could be high. Most sites have a relatively high surrounding population density; only three sites have surrounding population densities low enough to be within the current siting guidelines for nuclear power plants.

4.0 Financial Resources

This section summarizes financial resources that could generally support the redevelopment options assessed. Several federal- and state-level resources are highlighted, but the information provided may not be the latest. See the full guidance and regulations corresponding to each opportunity. Each project will have its own circumstances and set of appropriate financial resources.

4.1 Federal Resources

There are currently numerous and sizable federal resources that can generally support the redevelopment options assessed. With the passage of the Bipartisan Infrastructure Law (BIL) in 2021 and IRA in 2022, billions of dollars are available to assist in transitioning infrastructure to new and clean uses. This section focuses on funding that can be used for project deployment. Additional resources exist for community engagement, workforce development, and other forms of economic development.

Table 6 provides an indicative summary of relevant resources. The resource landscape is dynamic and each opportunity has its own considerations for timing, eligibility, and compatibility. The federal Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization maintains a Funding Clearinghouse that is updated weekly with relevant opportunities.

Table 6. General summary of federal financial resource coverage.

Financial resource		Site assessment	Site remediation	Solar energy	Wind energy	Energy storage	Energy-related industry	Nuclear energy
DOE Loan Programs Office	Energy Infrastructure Reinvestment		✓	✓	✓	✓	✓	✓
	Advanced Technology Vehicles Manufacturing						✓	
Tax credits	Section 48 investment tax credit			✓		✓		
	Section 48E investment tax credit (anticipated)			✓	✓	✓		✓
	Section 45 production tax credit				✓			
	Section 45Y production tax credit (anticipated)			✓	✓			✓

	Financial resource	Site assessment	Site remediation	Solar energy	Wind energy	Energy storage	Energy-related industry	Nuclear energy
	Section 48C Qualifying Advanced Energy Project Credit						✓	
	Section 45X Advanced Manufacturing Production Tax Credit						✓	
Select grant programs	EPA Brownfields Grants	✓	✓					
	DOE Advanced Energy Manufacturing and Recycling Grants						✓	

Note: The regulatory landscape is dynamic and not all details are shown. Consult the guidance for each opportunity for full information.
Source: IWG n.d.

4.1.1 EIR Financing

The DOE Loan Programs Office EIR financing is a flexible resource designed for situations like coal power plant redevelopment. It generally supports retooling, repowering, repurposing, or replacing existing energy infrastructure to a range of energy-related new uses (Figure 9). The coal redevelopment options assessed in this study are all expected to be generally compatible with these basic requirements. Additional requirements are described in the Title 17 Clean Energy Financing Program Guidance.

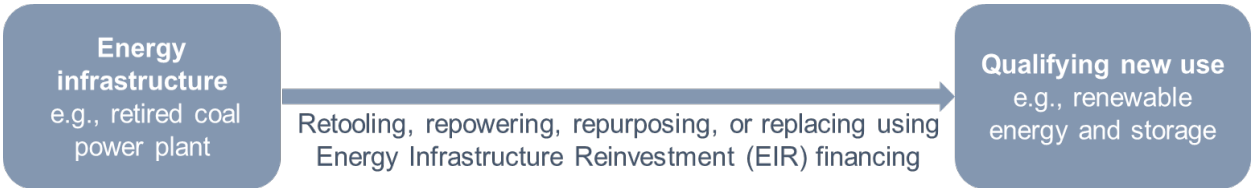


Figure 9. General description of Energy Infrastructure Reinvestment financing.

EIR was established with $250 billion in lending authority to commit through September 2026; time is of the essence for taking advantage of this opportunity. EIR can provide loan guarantees of commercial loans or of loans obtained from the Federal Financing Bank. EIR is relatively unique in its ability to support site remediation (associated with energy infrastructure redevelopment) and broad potential end uses. EIR is compatible with federal clean energy investment and production tax credits, but a given project cannot generally otherwise benefit from multiple forms of federal support. Projects seeking to use federal grants like EPA Brownfields Grants need to consider the timing and ownership arrangements if seeking to also use EIR on the same project.

4.1.2 Advanced Technology Vehicles Manufacturing Loan Program

The DOE Loan Programs Office Advanced Technology Vehicles Manufacturing Program supports manufacturing of low- and zero-emission vehicles and their components. The program has $40 billion total in lending authority available for commitment through September 2028.

4.1.3 Clean Energy and Manufacturing Tax Credits

The IRA extended, expanded, and created tax credits for clean energy and manufacturing. The two main energy credits are the Section 48 investment tax credit (ITC) and the Section 45 Production Tax Credit (PTC). In 2025, these will transition to technology-neutral tax credits generally available to technologies that generate electricity with zero greenhouse gas emissions.[1] The credits are expected to be in place through 2032, with possible extension. The IRA created a sliding scale for the credit value. The value of the base credit is multiplied fivefold for projects that meet prevailing wage and apprenticeship requirements. Bonuses are available for meeting domestic content requirements and for siting in energy communities (discussed below). The total value of the ITC across this sliding scale ranges from 6%-50%.[2]

The Section 48C Qualifying Advanced Energy Project Credit supports clean energy manufacturing, recycling, and minerals processing (DOE 2024). The program functions somewhat like a grant in that projects must apply for an allocation of credit, which can support up to 30% of qualifying investment.

The Section 45X Advanced Manufacturing PTC was established by the IRA and supports production of a range of clean energy-related components including solar panels, inverters, and batteries (DOE 2023). The value of the credit depends on the component produced.

4.1.3.1 Energy Community Bonus

The ITC and PTC have bonuses for siting projects in defined energy communities. The IRA defines three main types of energy communities (Table 7). Coal-fired generating units that have retired since 2010 enable the creation of an energy community in that census tract and adjacent census tracts. This means that the energy community qualifying area is larger than the plant site itself. This could be beneficial to investments like renewable energy on lands adjacent to a retired coal power plant. Figure 10 displays the broad coverage of current energy communities in Pennsylvania.

Table 7. IRA energy community definitions.

Type of energy community	IRA definition
Brownfields	A brownfield site (as defined in subparagraphs (A), (B), and (D)(ii)(III) of Section 101(39) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601(39)))
Fossil employment and tax revenues	A metropolitan statistical area or nonmetropolitan statistical area which (I) has (or, at any time during the period beginning after December 31, 2009, had) 0.17% or greater direct employment or 25% or greater local tax revenues related to the

[1] Energy storage is expected to be eligible for the Section 48E credit.

[2] Certain solar and wind projects under 5 MW can apply for an allocation of additional bonus credits under the Low-Income Communities Bonus Credit program.

Type of energy community	IRA definition
	extraction, processing, transport, or storage of coal, oil, or natural gas (as determined by the Secretary), and (II) has an unemployment rate at or above the national average unemployment rate for the previous year (as determined by the Secretary)
Coal closures	A census tract (I) in which (aa) after December 31, 1999, a coal mine has closed, or (bb) after December 31, 2009, a coal-fired electric generating unit has been retired, or (II) which is directly adjoining to any census tract described in subclause (I)

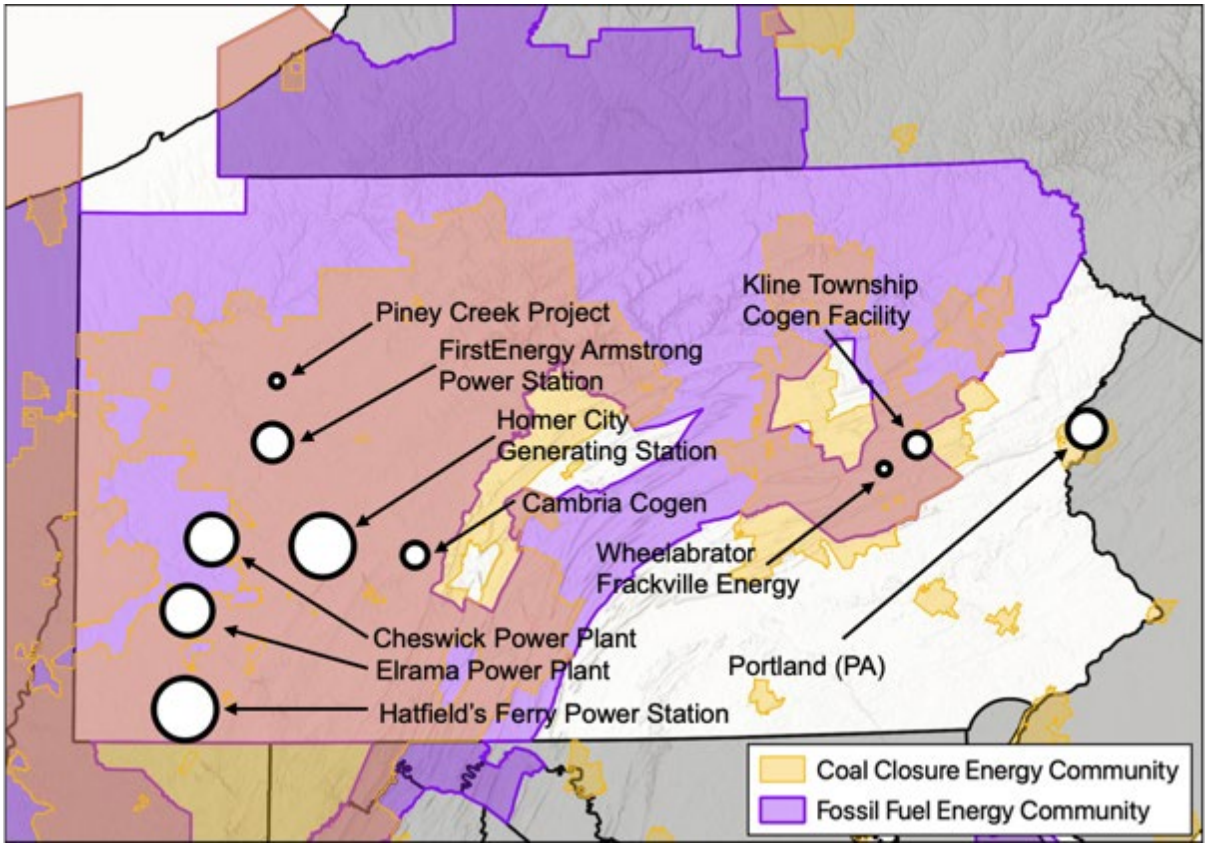


Figure 10. Coverage of current IRA energy community areas in Pennsylvania and retired coal power plants in this study. Coal power plant marker size is scaled to relative nameplate capacity. Energy community areas were adapted from the Department of Energy and National Energy Technology Laboratory (DOE and NETL 2023), with data from May 2023. Map should not be relied on for determining tax credit or grant eligibility.

Different financial resources have slightly different treatments of the energy community bonus (Table 8). For the ITC and PTC, siting in an energy community leads to a bonus credit. For the Section 48C credit, funding is set-aside for certain coal closure energy communities. And the DOE Advanced Energy Manufacturing and Recycling Grants use a definition of certain coal closure energy communities from the BIL to determine program eligibility. Each of these resources has a mapping tool indicating potentially qualifying areas.

Table 8. Energy community bonus treatment across several financial resources.

Financial resource	Treatment of energy community bonus
Section 48, 48E investment tax credit	Credit bonus of up to 10 percentage points for qualifying projects sited in energy communities as defined in IRA and indicated in the IRA energy communities mapping tool.
Section 45, 45Y production tax credit	Credit bonus of up to 10% for qualifying projects sited in energy communities as defined in IRA and indicated in the IRA energy communities mapping tool.
Section 48C Qualifying Advanced Energy Project Credit	At least $4 billion of the $10 billion in this program to be allocated to projects in certain energy communities defined in IRS Notice 2023-18 and indicated in the 48C mapping tool.
DOE Advanced Energy Manufacturing and Recycling Grants	Eligibility based on project siting in energy communities as defined in BIL Section 40209(a)(2) and indicated in the BIL Section 40209 mapping tool.

4.1.3.2 Elective Pay

The IRA created the elective pay mechanism, which allows certain entities to receive the value of certain tax credits even though they do not owe federal income tax. Entities eligible for elective pay include certain tax-exempt organizations and state and local governments and their agencies and instrumentalities.

Though elective pay effectively acts as a rebate of the value of the tax credit, the payment comes only after a project has registered and been placed in service. Other sources of funding are therefore needed to support up-front project implementation. Projects over 1 MW in size also need to meet domestic content requirements to receive the full value of the credit when using elective pay.

In the context of redevelopment opportunities for Pennsylvania's coal power plants, elective pay may be beneficial to county development agencies or nonprofit electric cooperatives interested in pursuing clean energy development.

Additional information on using elective pay can be found through the IRS webpage on elective pay and transferability.

4.1.4 EPA Brownfields Grants

EPA Brownfields Grants are part of a long-standing program that supports brownfield assessment and cleanup. Grants typically range from $500,000 to $2 million and can be used for single projects, multiple projects, or revolving loan funds. EPA's RE-powering America's Land Initiative demonstrates the potential for developing renewable energy on brownfield sites. Several projects have been developed on coal-related sites in Pennsylvania and elsewhere in the United States.

4.1.5 DOE Advanced Energy Manufacturing and Recycling Grants

The DOE has numerous grant programs. The Advanced Energy Manufacturing and Recycling Grants program is especially relevant for the coal-to-energy-related industry pathway explored in this assessment. The program supports small- and medium-sized advanced energy manufacturers and recyclers. It is aimed specifically at communities that have experienced the closure of a coal mine or coal power plant.

4.1.6 Other Federal Programs

The resources highlighted in this section are only a selection of many applicable federal programs. Several other agencies and programs may support the coal redevelopment pathways envisioned in this study:

- The U.S. Department of Agriculture has numerous energy-related lending and grant programs that may be relevant for coal redevelopment in rural areas.
- The U.S. Economic Development Administration can support planning and deployment of economic development projects.
  - The Public Works and Economic Adjustment Assistance program is a grant program that has previously supported energy-related projects.
  - Assistance to Coal Communities funding is dedicated to economic development and workforce development in communities with coal mining, coal power plants, and other coal-related activities.

4.2 State-level Resources and Policies

Pennsylvania has several state-level funding resources that can support coal redevelopments. These funds may be a valuable complement to federal funding sources.

- Business in Our Sites (BOS) grants and loans can support pre-development activities to make previously used land shovel-ready for redevelopment.
- The Industrial Sites Reuse Program provides grants and loans for environmental assessments and remediation at former industrial sites. Awards range from $200,000–$1 million.
- The Redevelopment Assistance Capital Program can support regional economic improvement projects that generate or maintain significant levels of employment or tax revenues. Prospective projects must first be authorized by the State Legislature.
- The Pennsylvania Strategic Investments to Enhance Sites (PA SITES) Program was established in 2023 with an initial round of $10 million in grant funding to help make sites shovel-ready for attracting businesses. Potentially eligible uses include improving transportation access or extending utilities to sites.

In addition to these funding opportunities, Pennsylvania's Alternative Energy Portfolio Standards Act (AEPS) may provide a revenue stream for qualifying clean energy redevelopments such as solar energy. Implemented in 2004, AEPS established a market-based credit trading system that requires retail energy providers to acquire alternative energy credits (AEC) for a certain percentage of their electricity sales (DSIRE 2023). Currently AEPS requires 8% of retail electricity to come from Tier 1 renewable sources, with a 0.5% carve-out for in-state solar sources. The weighted average price of 2022/2023 solar AECs was $42.48 per megawatt-hour (MWh), the highest since 2017 (Pennsylvania Public Utility Commission 2023). Other renewables in Tier 1 AECs, such as wind, had a weighted average AEC price of $23.68 per MWh in 2022/2023, the highest since the 2007/2008 compliance year. However, the price of these credits is expected to decrease given that the supply of solar AECs currently exceeds demand (Pillar & Mahoney 2023). HB 1467, a proposed expansion of the AEPS, could make coal-to-renewable pathways more economically compelling by increasing the Tier I goal from 8% to 30% by 2030 and the solar carve-out from 0.5% to 14%.

5.0 Conclusion

Pennsylvania has significant legacy infrastructure, including retired coal power plants. These sites have several attributes that can be beneficial for redevelopment into new uses. Redeveloping these retired power plants can bring economic benefits to surrounding communities and clean energy generation can support expected regional growth in electricity demand.

There is significant renewable energy resource potential at all assessed retired coal power plant sites. The solar and wind resource potential at these sites is comparable to the resource potentials at operating and planned solar and wind facilities in Pennsylvania. Wind energy emerges as an option with high potential given the windspeeds and the terrain features that favor wind over solar in several sites. A wind energy buildout in Pennsylvania could bring opportunities for related manufacturing and logistics, which could also be developed on retired coal power plant sites.

Several sites are relatively small or located in relatively densely populated areas. These may be better for accommodating concentrated uses such as battery energy storage or energy-related manufacturing. The transportation infrastructure present at all sites is expected to be particularly valuable for manufacturing-related uses. Several of Pennsylvania's retired coal power plants have port access that may be relatively unique and valuable compared to legacy assets in other regions.

It is an opportune time to assess these redevelopment opportunities in Pennsylvania. There are numerous retired coal power plant sites that appear available for redevelopment or are taking early steps toward specific new uses. There are currently significant federal and state resources for cleaning up sites and developing new uses. Federal clean energy tax credits and financing from DOE's Loan Programs Office can support a wide array of energy-related projects. The tax credits currently represent a long-term opportunity window, though Energy Infrastructure Reinvestment financing should be sought now to allow for meeting the September 2026 commitment deadline.

This assessment approached redevelopment options from the perspective of aligning site features with energy-related uses. Other perspectives could be taken, such as evaluating the economic development potential across a wider array of end uses. Deeper assessment for any of the sites should include an evaluation of the local community's interests.

6.0 Informational Resources

- PNNL coal-to-X fact sheets highlighting the four energy-related redevelopment options in this assessment
- PNNL and DOE funding resource guide: Utilizing the Inflation Reduction Act to Remediate and Redevelop Energy Assets and Sites
- Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization Funding Clearinghouse, updated weekly with relevant opportunities
- DOE information guide on Coal-to-Nuclear Transitions

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Appendix A – Data Sources

Dataset	Source
Social vulnerability index	Flanagan, B.E., Gregory, E.W., Hallisey, E.J., Heitgerd, J.L., & Lewis, B. 2011. A Social Vulnerability Index for Disaster Management. Journal of Homeland Security and Emergency Management, 8(1)
Population	Center for International Earth Science Information Network - CIESIN - Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4): Population Count, Revision 11. Palisades, New York: NASA Socioeconomic Data and Applications Center (SEDAC). Accessed March 2024. https://doi.org/10.7927/H4JW8BX5
Installed and planned electric generator capacities	US Energy Information Administration. 2023. Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860). Electricity, Analysis and Projections Spreadsheet data: U.S. Energy Information Administration. Accessed December 2023. https://www.eia.gov/electricity/data/eia860m/
Electric transmission infrastructure	HIFLD. 2023. Electric Transmission Lines. GIS data: Homeland Infrastructure Foundation-Level Data. Accessed November 2023. https://hifld-geoplatform.opendata.arcgis.com/datasets/bd24d1a282c54428b024988d32578e59/explore?location=35.948114%2C-95.655030%2C5.79
Electric infrastructure locality	PNNL calculation based on electric transmission line data from: HIFLD. 2023. Electric Transmission Lines. GIS data: Homeland Infrastructure Foundation-Level Data. Accessed November 2023. https://hifld-geoplatform.opendata.arcgis.com/datasets/bd24d1a282c54428b024988d32578e59/explore?location=35.948114%2C-95.655030%2C5.79
Land cover data	Dewitz, Jon. 2021. National Land Cover Database (NLCD) 2019 Products (ver. 3.0, February 2024) GIS Data set: U.S. Geological Survey. Accessed February 2024. https://doi.org/10.5066/P9KZCM54
Rail transportation infrastructure	HIFLD. 2022. NARN Rail lines. GIS data: Homeland Infrastructure Foundation-Level Data, U.S. Department of Transportation Federal Railroad Administration (November, 2022). Accessed November 2023. https://hifld-geoplatform.opendata.arcgis.com/datasets/geoplatform::north-american-rail-network-lines/about
Fossil fuel employment ranking	NETL. 2023. MSAs and Non-MSAs that only meet the Fossil Fuel Employment Threshold. GIS data: U.S. Census Bureau Statistical Areas (MSAs) analyzed for employment information by National Energy Technology Laboratory. Accessed 2023. https://arcgis.netl.doe.gov/server/rest/services/Hosted/MSAnMSA_FEE/FeatureServer/17
Elevation variance	U.S. Geological Survey, 2019, 3D Elevation Program 1-Meter Resolution Digital Elevation Model (published as updated February 2024), accessed February 2024. https://www.usgs.gov/the-national-map-data-delivery
Solar resource potential	Global Solar Atlas. 2020. Global Horizontal Irradiance. GIS data: Global Solar Atlas 2.0, a free, web-based application is developed and operated by the company Solargis s.r.o. on behalf of the World Bank Group, utilizing Solargis data, with funding provided by the Energy Sector Management Assistance Program. (Last modified April 5, 2020). Accessed November 2023. https://www.arcgis.com/home/item.html?id=f589564ae8d64ecba49bf2b486cfebfd
Wind resource potential	Draxl, C., B. M. Hodge, A. Clifton, and J. McCaa. 2015. “The Wind Integration National Dataset (WIND) Toolkit.” GIS data: National Renewable Energy Laboratory analysis derived outputs. Applied Energy 151: 355366. Accessed November 2023. https://nrel.github.io/rex/misc/examples.wind.html

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