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Using National-Scale Data to Inform Coal Power Plant Redevelopment and Coal Community Revitalization Planning

September 2023

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Executive Summary

In the United States, individual coal plants have high variation in their construction and operation. Coal plants commonly have multiple units, with different commissioning ages, operational position, and maintenance conditions—even multiple fuels. These units may be in changing states of utilization, with variation in productivity depending on economic contexts. Coal plants themselves may be temporarily off-line, mothballed, retired, or decommissioned due to owner/operator portfolios or market conditions, and the current posture of the plant may be difficult to ascertain without local news sources (Tarekegne et al. 2021). Anticipated dates of plant closures are prospectively represented to regulators and to the Energy Information Administration (EIA), but may also experience uncertainty due to the engineering, environmental, economic, and social complexity of closing a very large power plant. As noted in this report, closure of the first unit to the last within a single plant may span more than 20 years.

Because of these complex factors, tracking and predicting the position of our nation's coal fleets on a national scale is deeply important. In developing a case for federal datasets and an approach to building and curating these data, this report identified that data must have high fidelity at the plant-level to be meaningful in aggregate. Plant-scale detail is also a match for its application: national priorities in federal investment range from economic revitalization for coal power plant communities, to maintaining reliable electric grid operations.

This document is organized into a statistical review of coal plant retirements, past and prospective, in the United States; trends in the relationship between closures and existing federal investment programs for community revitalization; and potential methods for supporting site redevelopment through advanced geospatial analysis based on federal data.

Key findings include:

- Coal power plant retirements cannot necessarily be represented with binary on-off data points. The complete retirement of individual generating units within a single plant can take years or even decades. This is not readily represented in national-scale datasets and analyst effort is required to determine the story of a given power plant composed of multiple generating units and update the collective story of retiring coal as new planned power sources are listed and more coal generators get official retirement dates, often monthly.

- Given the timelines observed in past generator retirements, and the expected shorter timeline of generator retirements in the future, there will be a relatively rapid shift in affected communities, requiring expedient research and tool development as more stakeholders in more places look to take advantage of clean redevelopment opportunities.

- Transparent tools and datasets can help support decision-making around coal power plant redevelopment. Equipping these tools with social and economic data, such as employment opportunities and available workforce, can help inform community-level decision-making around local or regional redevelopments.

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1.0 What do we know about coal plant retirements?

Over the last twenty years in the US, over 128 gigawatts of coal-powered generating capacity have retired, representing 40% of all coal-powered generation since 2002 (EIA 2023), with further retirements announced for the near future. While the story of each coal plant's retirement is unique, a detailed analysis of past and future retirements can provide insights into what is yet to come for the various communities tied to coal.

Coal power plants commonly consist of multiple generating units. Individual generating units within the same plant can each have their own retirement date registered with the US Energy Information Administration (EIA). Final plant closure occurs when a plant's last generating unit retires and no other units are listed as planned for the future. A final retirement from coal occurs when the plant's last generating coal unit retires. The time between the first unit retirement and last unit retirement within the same plant is commonly less than a year, but in some cases can span multiple years or even decades (Figure 1). Coal plant closures are therefore not always a binary on-off representation. There are further nuances: individual generators can run on different fuels (not just coal) and produce combinations of heat and electricity. These characteristics affect an overall plant's redevelopment options and the community's transition pathways.

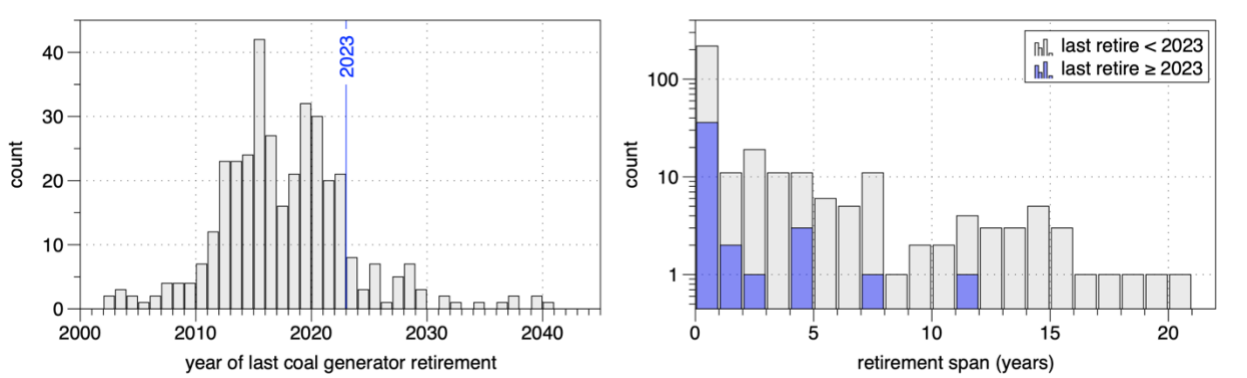

Figure 1. Yearly coal plant retirements, where coal made up 100% of electricity generation. The left graph shows the year the last on-site coal generator did retire or is scheduled to retire, with data on the 364 plants spanning 2002–2040 and 44 plants spanning 2023–2040. The right graph shows the timespan between when the first and last on-site coal generator retired, with the majority of retirements taking less than a year but a few historic and future examples taking much longer (PNNL).

From 2002 to 2022, 320 power plants utilizing coal have retired all coal-burning units. According to the latest available data (EIA 2023), 44 more power plants are scheduled to completely retire from coal before December 2040; 42 of those are shutting down the plant completely as they have no other source of fuel other than coal. Retiring a plant's coal generators is not always an immediate event. As shown in Figure 1, a pre-2023 coal plant retirement took an average of two years to retire all coal-burning generators between first scheduled and last scheduled (min=0 years, max=20.2 years). Currently announced retirement dates indicate that from 2023 to 2040, generator retirement is planned to happen more quickly, with a projected future plant average of 0.8 years (min=0 years, max=11 years). Still, there are 182 plants with an on-site coal generator without a planned retirement date (EIA 2023).

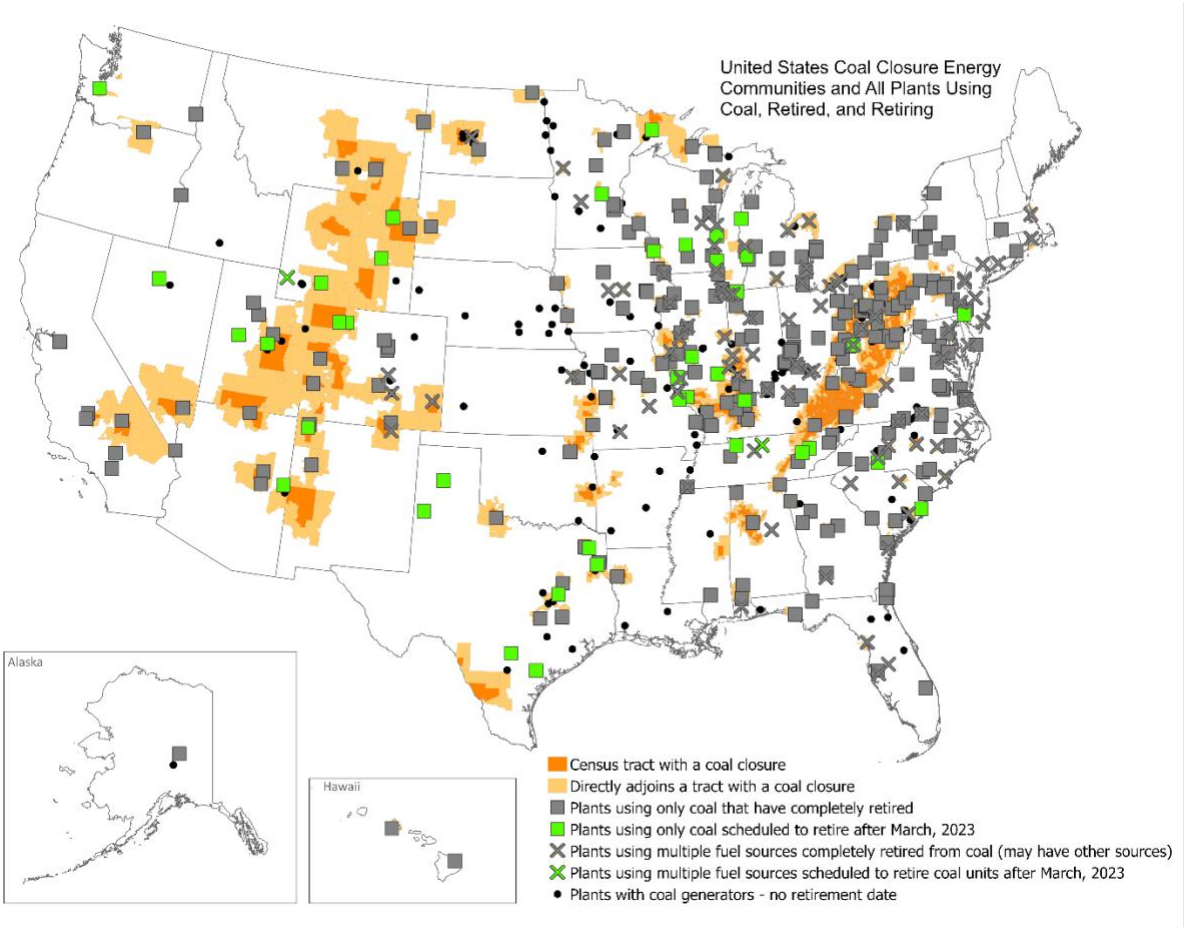

Figure 2. Map of all power plants using coal—retired, soon-to-retire, or not yet scheduled-to-retire coal generators. Whether plants use only coal as a source or use multiple fuel sources is also indicated (PNNL).

It is also not uncommon for a coal-fired power plant to utilize multiple fuel types on-site. For example, Big Bend Power Station in Hillsborough County, Florida uses conventional steam coal (nameplate capacity is 486 MW), natural gas-fired combined cycle (1,241 MW), natural gas combustion turbine (70MW), natural gas steam turbine (446 MW), and a solar photovoltaic system (20 MW). Prior to a major reconfiguration in 2022, Big Bend had four coal generators with a nameplate capacity almost four times today's value; with retirements in 2022 and 2023, one conventional steam coal generator will be left. During this retrofit period, petroleum generation was also retired, and natural gas generators were introduced. These technological changes are documented monthly by the EIA[1] and provide the basis for a storyline of technological changes for a power plant. National-scale data can be readily extracted from this monthly dataset for generating units with a nameplate capacity greater than one MW, including energy storage.

The monthly EIA dataset captures operating and retired generators, as well as generators with planned retirement dates. Figure 3 aggregates the per-generator data using the March 2023

[1] "Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860)" accessible at: https://www.eia.gov/electricity/data/eia860m/

data, including planned retirements through Dec. 2030. The majority of retired[1] generator capacity was conventional steam coal, though it still comprises about 15% of the operating nameplate capacity today. Deployment of renewables and storage dominates planned capacity additions: solar photovoltaic (50%), battery (18%), onshore wind (13%), and offshore wind (5%). The only fossil fuel generator type planned to see more than 5% of nameplate capacity additions is natural gas combined cycle (9.5%). No new coal generators are planned.

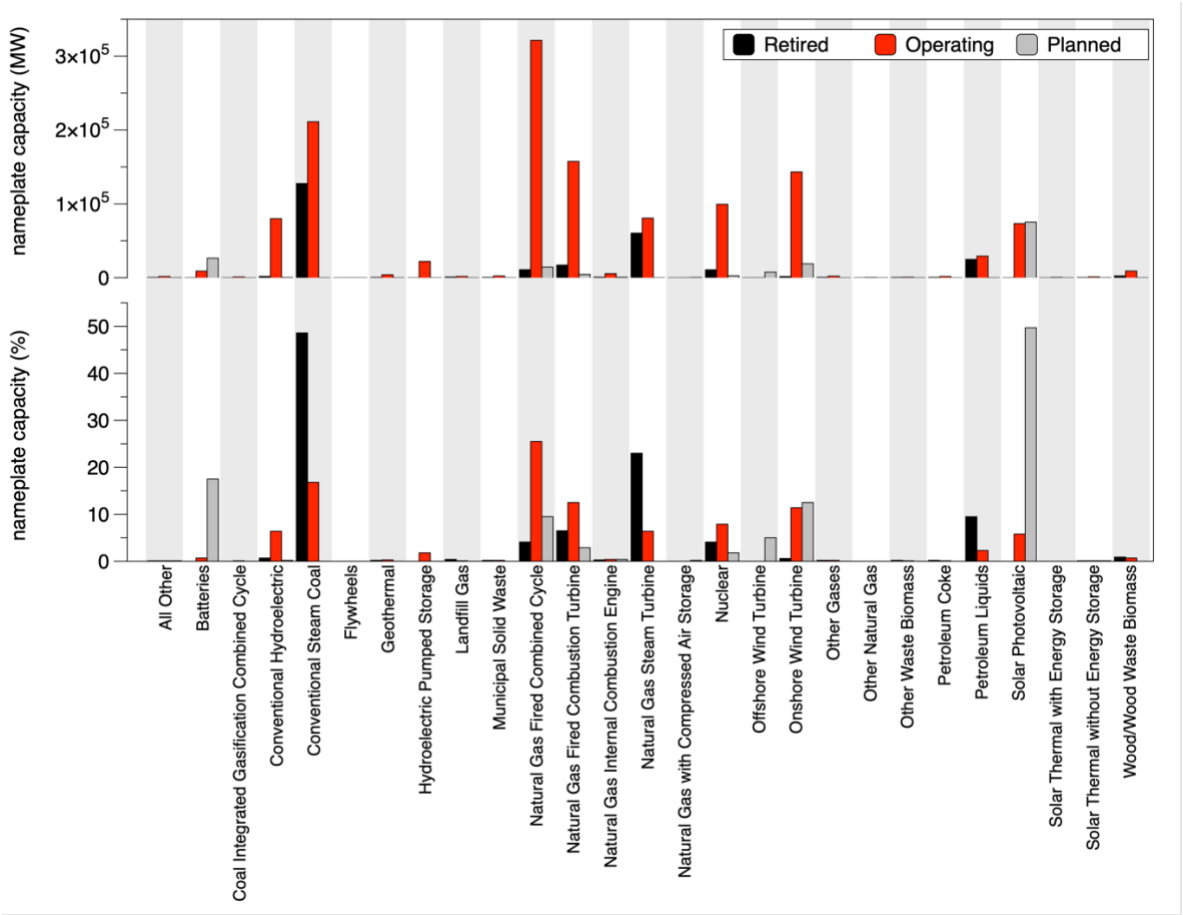

Figure 3. Nameplate capacity per technology, based on the March 2023 data release of the EIA's 860 M dataset. The lower plots showing percentages are only applicable to the retired, operating, or planned grouping. For example, conventional steam coal comprises about 50% of retirements, and solar photovoltaic comprises about 50% of all planned additions, but these are not equivalent (127,540 MW conventional steam coal retired; 75,337 MW solar photovoltaic planned) (PNNL). Retirement data goes back to 2002. Planned facilities are those that are expected to be grid connected, greater than one MW, and operational within ten years (for coal and nuclear) or five years (for other energy sources).

[1] EIA 860 records generators that have retired since 2002 (https://www.eia.gov/electricity/data/eia860/)

2.0 Energy communities

Coal communities will be especially affected by these power plant technological changes and retirement decisions. In 2021, President Biden's Executive Order 14008 established the Interagency Working Group (IWG) on Coal and Power Plant Communities and Economic Revitalization,[1] alongside other community-support measures. The IWG is identifying, coordinating, and delivering federal funding to support energy communities—communities with strong ties to fossil-fuel employment and economic activity. The IWG has currently identified 173 open or planned funding opportunities and 22 tax credits that could benefit energy communities. Some opportunities, such as Energy Infrastructure Reinvestment financing from the Department of Energy, can support both site remediation and redevelopment in a single transaction (Eisdorfer et al. 2023). These resources can enable energy communities to achieve economic revitalization through redevelopment options, among other strategies.

2.1 Energy community tax credit bonus

A key opportunity is the energy community tax credit bonus created by the Inflation Reduction Act of 2022. This bonus provides up to an additional 10 percentage points on investment tax credits, or up to an additional 10 percent on production tax credits for certain energy projects sited in qualifying energy communities as defined by the IRA. Energy communities can be areas with recent coal-fired electric generating unit retirements or coal mine closures, certain thresholds of fossil-related employment or tax revenues, or brownfields.

Qualification under the coal closures category is spatially determined, based on census tracts and adjacent census tracts where coal-burning units have retired since December 31, 2009, or coal mines have closed since December 31, 1999 (Figure 4). Coal Closure Energy Communities may overlap with the other qualifying energy community layers.

[1] https://energycommunities.gov/

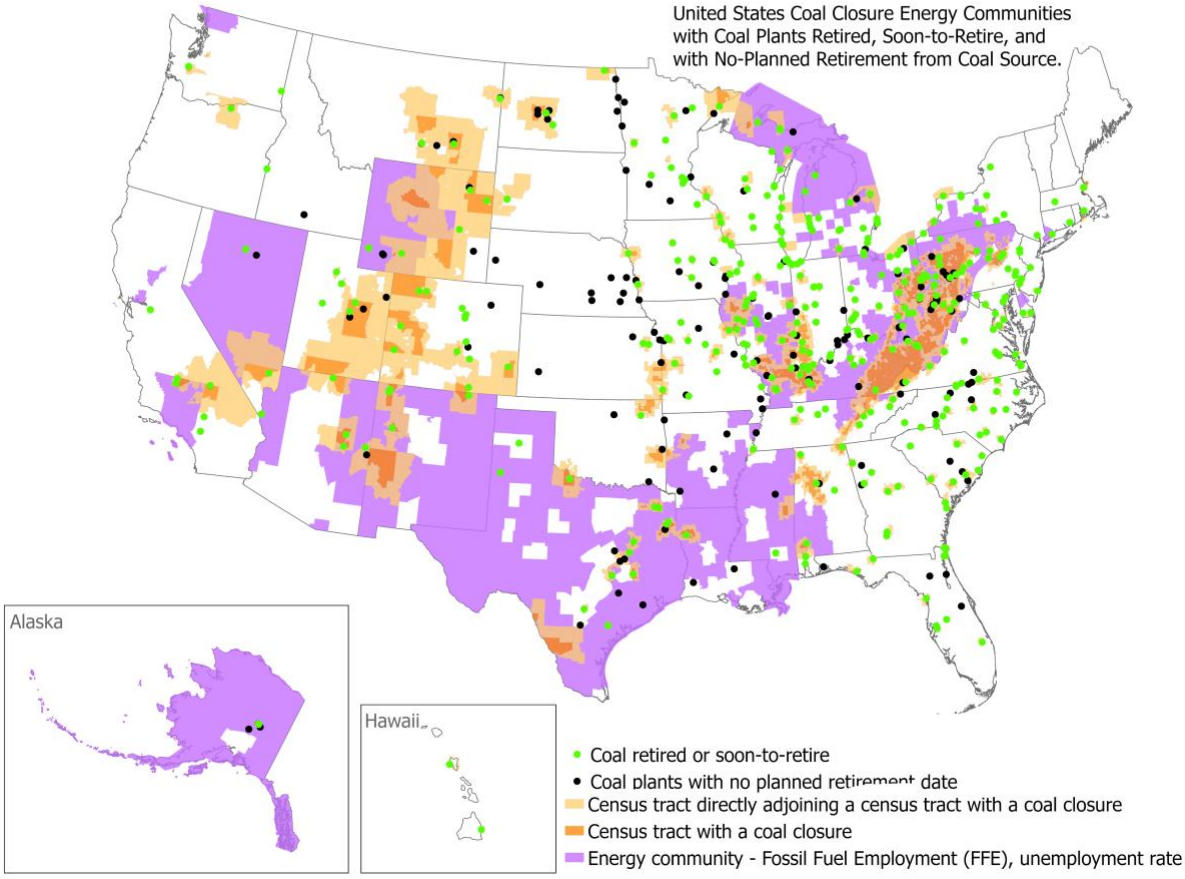

Figure 4. Map of retired or retiring US coal power plants 2015 - 2030 and currently identified Coal Closure (orange) and Other Energy Communities (purple) (PNNL).

2.2 Future energy communities

The energy community landscape is expected to evolve with future coal retirements and other factors. Future coal retirements may come from both currently announced retirements and new generator retirement announcements. New coal-fired generating unit retirements that occur while the energy community tax credit is in force are expected to qualify for the coal closure definition of the energy community tax credit bonus, with the qualifying census tracts updated annually to reflect newly identified retirements.[1] This could lead to an expansion of census tracts eligible for the tax credit bonus (Figure 5). Some units with announced retirements are already located within Coal Closure Energy Communities. These retirements are expected to add to existing coal-closure related challenges in these communities. A significant number of coal-fired power plants have no announced retirement date. Table 1 summarizes the distribution of these statuses.

[1] https://energycommunities.gov/energy-community-tax-credit-bonus-faqs/

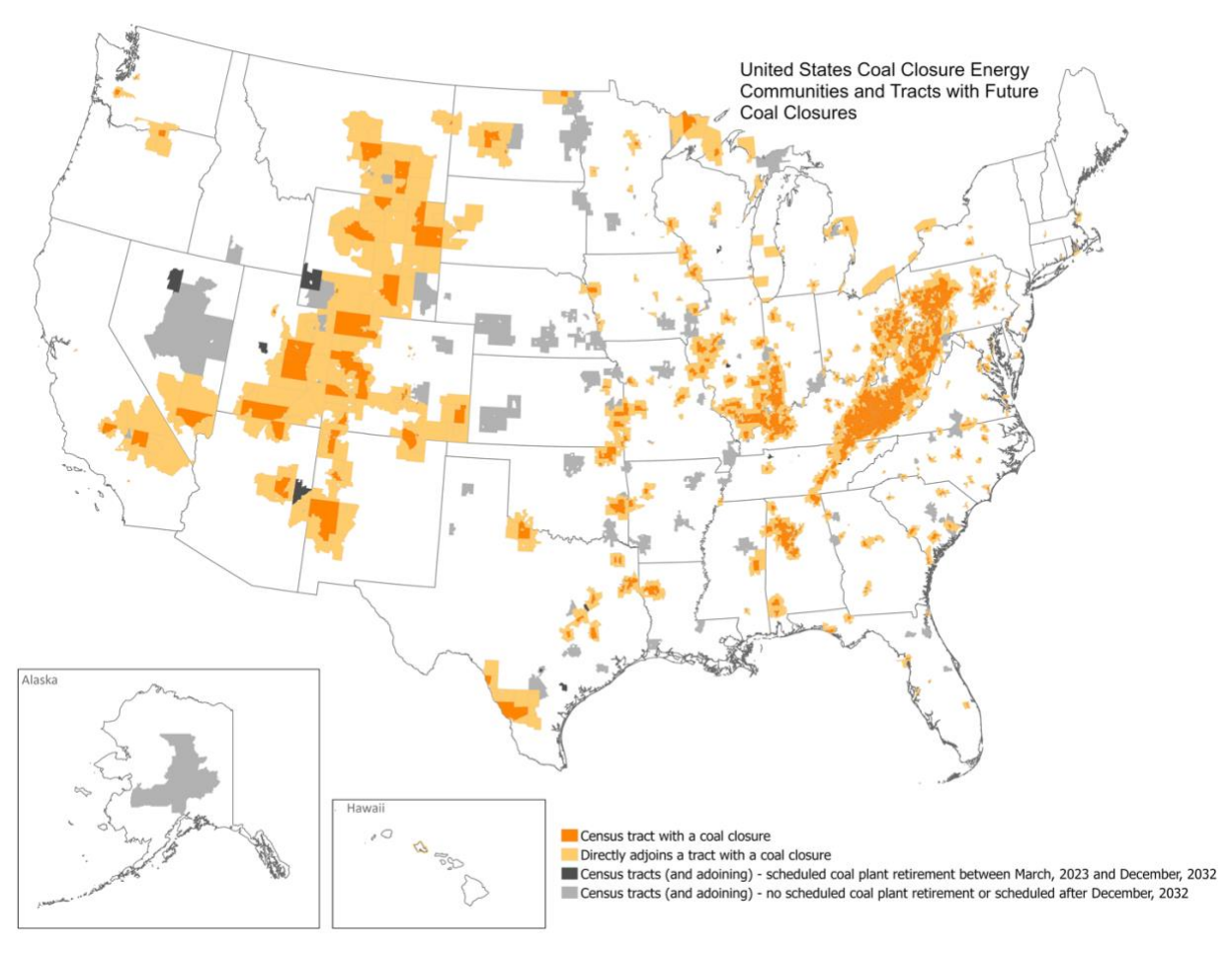

Figure 5. Coal Closure Energy Communities based on current, announced, and potential retirements (EIA, PNNL).

Table 1: Coal power plants and units relative to energy community status

Status	Count
Coal power plants that have retired all coal-fired electric generating units and are currently within a Coal Closures Energy Community	303
Plants with scheduled-to-retire coal-fired units currently outside of a Coal Closures Energy Community	14
Plants with scheduled-to-retire coal-fired electric generating units already within a Coal Closures Energy Community	30
Coal-fired power plants with no currently scheduled retirement date	182

The Inflation Reduction Act tax credits are expected to provide at least a ten-year window of opportunity to coordinate the interplay between the evolving energy community landscape and clean energy redevelopment opportunities. Given the timelines observed in past generator retirements, and the expected shorter timeline of generator retirements post 2023, this will entail relatively rapid movement that requires expedient research and tool development as more stakeholders in more places look to take advantage of clean redevelopment opportunities.

Examining past and announced retirements reveals that earlier closures generally had smaller overall plant capacity, while currently announced future retirements are generally for larger plants, with most over one gigawatt in capacity (Figure 6). This trend may have implications for the electricity system, as the removal of a large plant likely entails significant changes to power system dynamics. Retiring coal plants create a resource gap that will likely be filled by generators with very different characteristics. In addition to the implications for resource adequacy—ensuring that there is always enough supply to meet demand—the new resource characteristics affect grid control and procedures for recovering from disruptions. Analysis can help identify in advance how these effects could be mitigated by deployment of clean energy generation and storage.

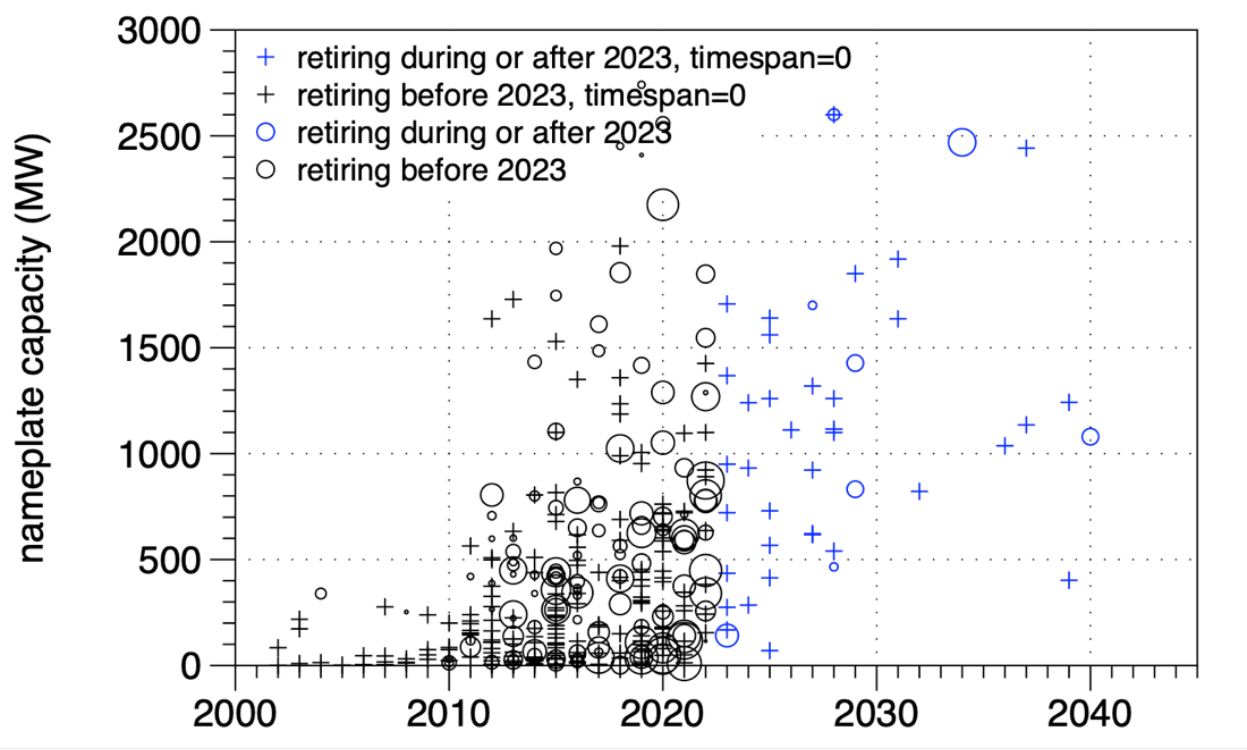

Figure 6. Retiring coal power plants by the retirement year of the last on-site generator and the nameplate capacity, with the circle size representing the timespan of the retirement. The timespan between the first and last on-site generator retirement is in some cases 0 months, identified above as the cross. The circles are scaled to represent longer timespans, such as the coal plant set to retire in 2034 with a retirement timespan of 11 years. There are generally fewer future announced retirements, but of those, several have a large nameplate capacity and are expected to retire all units at the same time (PNNL).

Plants located near other plants in the planning phase of development would benefit from analysis of electricity demand, potential scope and type of coal plant redevelopment, and population attributes related to the future energy workforce. The proximity of these power sources to one another could create questions from system planners and other stakeholders about feasibility of plant operations, electric grid dynamics, workforce value in the local population, and other aspects of plant/grid technology and community landscape/population attributes. For example, natural gas is prominent in the electricity generation sector, but solar, batteries, and wind figure strongly in the *planned* capacity additions (Figure 3).

While employment and tax revenues related to coal plant operations were considered in the communities identified by the IWG and the energy community tax credit bonus, more social considerations will likely emerge as stakeholder feedback informs our current understanding and the energy community landscape continues to evolve spatially and technically. Workforce will be a key consideration for redevelopment opportunities. Geospatial analysis can help inform where workforce synergies can arise from co-locating redevelopment opportunities with localized employment data, education opportunities, and demographic attributes.

3.0 Criteria for redevelopment

The characteristics of each retiring coal plant and energy community will determine the types, forms, locations, and sizes of redevelopment options. The intersection between a site's characteristics and the desired redevelopment attributes can form selection criteria to help assess, sort, and prioritize these options. Feedback from various stakeholders (plant developers, local officials, energy experts, and others) can be used to further develop tools to answer immediate questions and pinpoint potential communities for a myriad of possible clean redevelopment opportunities with local benefits.

Richer GIS analysis of US national-scale datasets can reveal benefits and challenges that system planners and other stakeholders may have otherwise overlooked when planning for a redevelopment project. General topics are access to workforce, access to water or transmission assets, infrastructure for renewable energy redevelopment, or certain community characteristics. Additional redevelopment options (or selection criteria) can be created and further honed by performing deeper geospatial analysis around the social and technical data to reveal more local challenges and opportunities. This additional analysis can be performed using more sophisticated geospatial techniques and adding more information about the environmental and demographic characteristics at local scales. For example, Figure 7 illustrates wind and sunlight measurements scaled from geospatial analysis to emphasize the potential wind and solar power potential at locations matching those same natural resource characteristics at soon-to-retire coal plants.

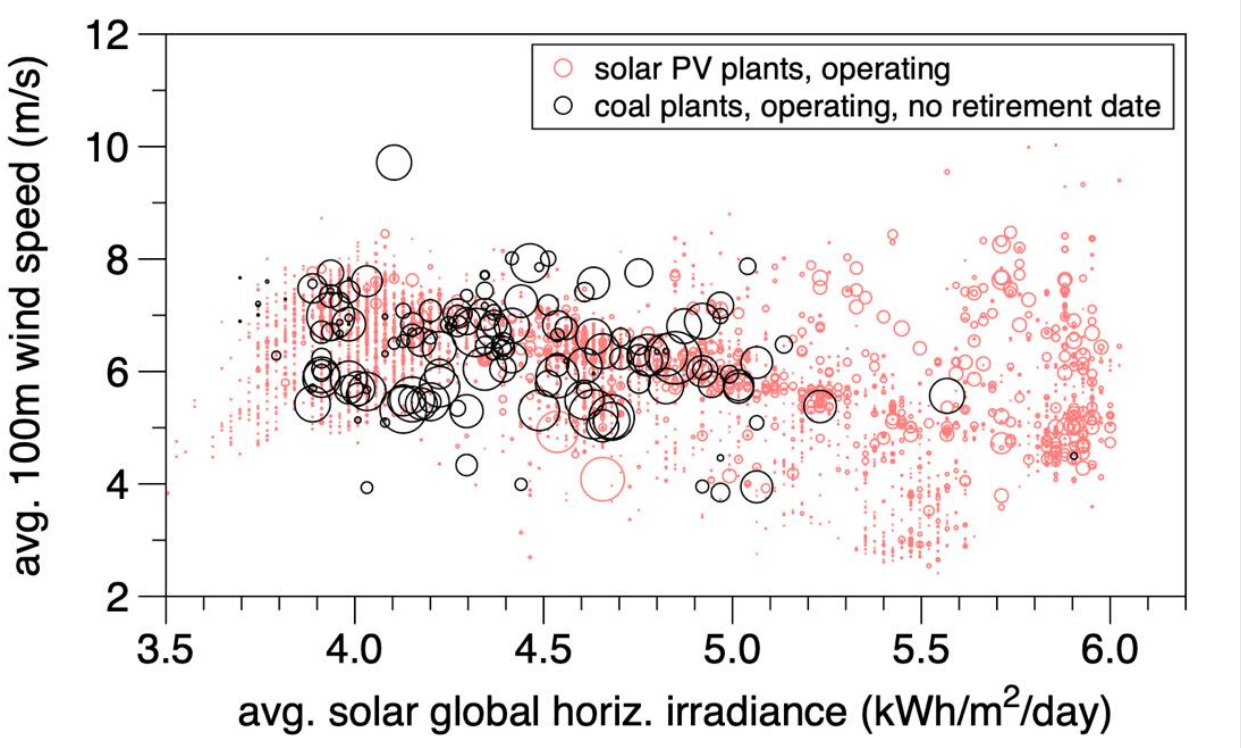

Figure 7. Solar resource at currently operating coal plants in comparison to currently operating solar power plants, with the circle size illustrating the nameplate capacity of the plant (National Renewable Energy Laboratory's National Solar Radiation Database v3, PNNL).

For example, the above type of analysis might prompt inquiries of:

- Coal plants that have recently closed (i.e., plants that are available for redevelopment opportunities).
- Connection to bulk electrical transmission. Coal plants have valuable points of interconnection that can be repurposed for significant time and cost savings for energy-related redevelopment. It may be possible for several renewable energy generators at or near the retiring plant to use the same point of interconnection.
- Solar irradiance on the property greater than 5.0 kWh/m^2/day (i.e., provides an estimate of the solar resource at the site and its potential to offset the reduced generation from coal).
- Location within 500 feet of a port.
- Location within 50 miles of apprenticeship programs specifically training interested local workers as electricians, industrial mechanics, or machine operators (i.e., provides local workforce opportunities in the new venture).
- Location within an official energy community (i.e., to assure an energy tax credit bonus).

Using currently available GIS data, this query would return seven plants meeting these criteria, one of which just recently closed in November 2022.

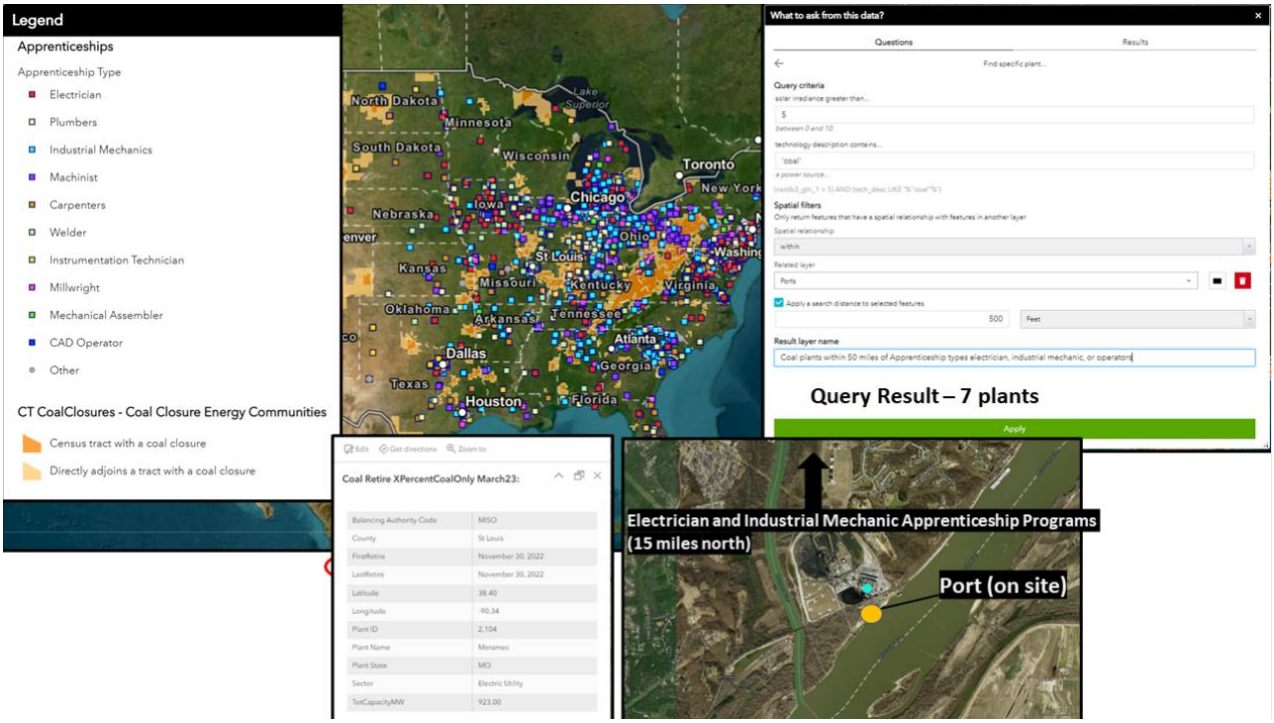

Figure 8. Currently available GIS data queried in an online interactive web-mapping tool showing retiring coal plants inside an official energy community, connected to bulk electrical transmission, with a solar irradiance on the property greater than 5.0 kWh/m^2/day, within 500 feet of a port, and within 50 miles of apprenticeship programs for skills needed to operate the site (PNNL).

Using modern web tools for running spatial queries, interested parties could look at community-level data related to employment needs, power demands, siting opportunities, or other community aspects in decision-making processes and public awareness (see Figure 8). This is one example that could be made by utilizing data about communities within the vicinity of retiring coal-fired plants. Data queried online could also be supplemented with community-driven insights to provide more granular analyses that support energy communities in understanding redevelopment options that align with local economic revitalization goals.

Regional analyses are also possible beyond understanding a localized coal plant retirement, such as the power plants operating nearby as well as those planned in the near future, and the socioeconomic considerations of nearby communities utilizing the electricity. From this perspective, the megawatt output of a plant, its location relative to interconnection points along the already existing transmission lines, or the surrounding area's wind or sun resource allow the immediate attributes of the plant to inform *localized* options for redevelopment. Additionally, after analyzing the spatial data *regionally*, it may become evident that other generation options are available or even preferrable. Perhaps the workforce within driving distance is more diverse than expected, or planned plants within the same electricity control area could partner with a redevelopment project to better use the power generated. There are additional opportunities for coal redevelopment planning as more coal plants register retirement dates and more communities are met with the challenges and opportunities of the energy transition. Consistent and up-to-date geospatial analysis can aid that transition as redevelopment opportunities get underway or arise new.

Given that the timelines and conditions involved in these transitions are complex—and unique to each coal plant story—future research could also leverage local- and regional-level data to support energy communities with relevant technical, financial, and educational tools. The expected shorter timeline of generator retirements post 2023 will spell a rapid shift in affected communities, each with distinct characteristics and redevelopment needs. Engaging communities with tools and resources early in the redevelopment process can inform swifter decision-making processes and enable more equitable outcomes.

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