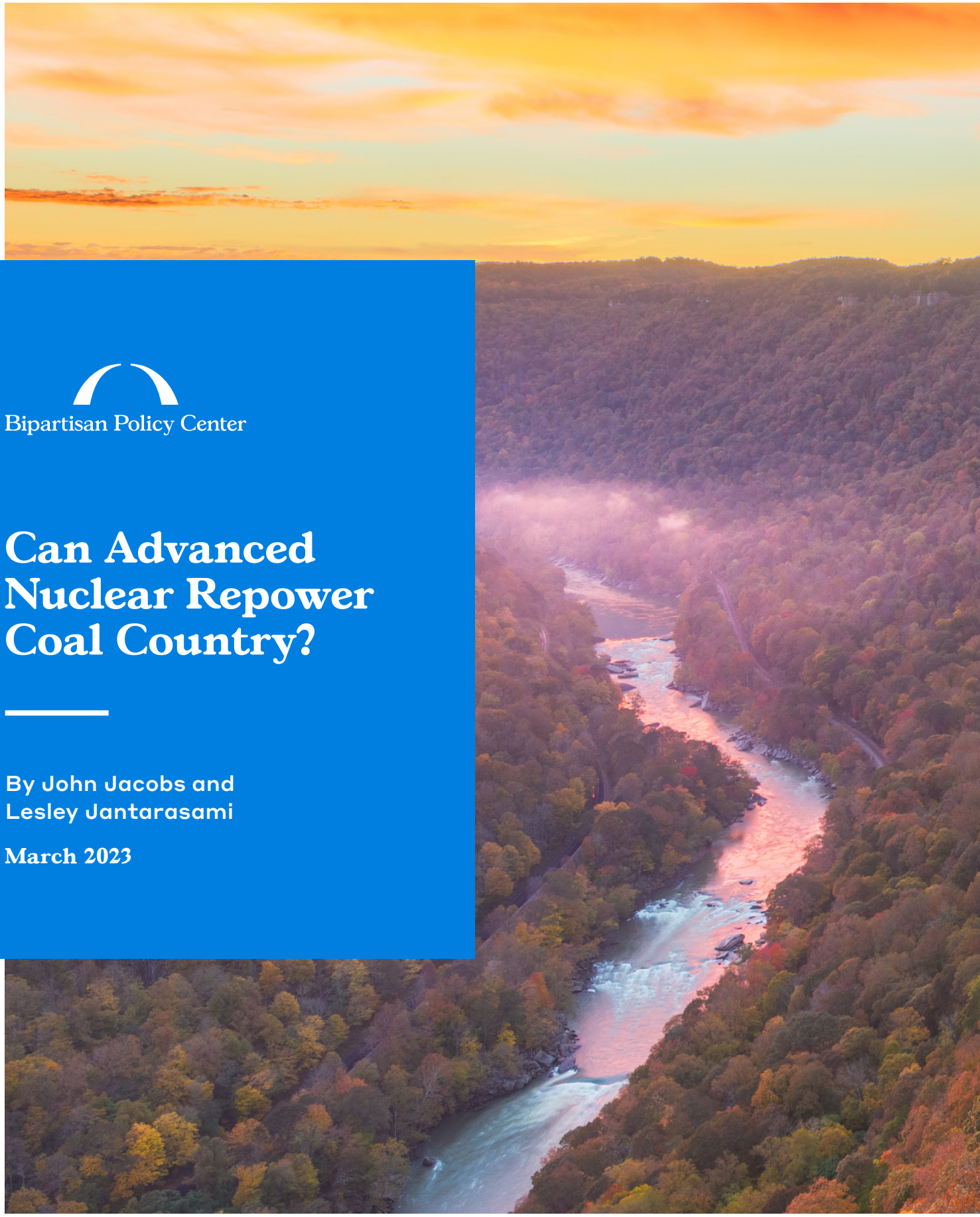

Bipartisan Policy Center

Can Advanced Nuclear Repower Coal Country?

By John Jacobs and
Lesley Jantarasami

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AUTHORS

John Jacobs

Lesley Jantarasami

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1. Executive Summary

With nearly a quarter of the U.S. coal-fired fleet scheduled to retire by 2029, replacing retiring coal power plants with advanced nuclear, specifically small modular reactors (SMR), has been put forth as a strategy to maintain local employment and economic opportunities for existing energy workers and communities, while simultaneously pursuing national climate goals. The Nuclear Regulatory Commission's (NRC) recent and groundbreaking certification of the country's first SMR design pushes the technology closer to maturity. As SMRs shift toward commercial deployment, identifying the existing opportunities and hurdles is vital to create a pathway for future coal-to-nuclear transition projects.

This report analyzes the benefits and challenges of a coal-to-nuclear transition and highlights recent legislation that may hasten such a transition.

SMRs Unlock New Possibilities:

- **80% of evaluated coal plants have the basic characteristics needed to be repowered by an SMR**, according to a Department of Energy study analyzing recently and soon to be retired coal plants.
- **SMRs have flexible power output levels,** allowing SMR developers to match the output of a retiring coal plant and capacity restrictions of equipment, unlike the fixed capacity of traditional nuclear plants.
- **Small land usage** required for nuclear plants combined with SMRs' unique flexibility to scale power generation make the footprint of SMRs suitable for replacing a retiring coal plant.

Potential Benefits of Coal-to-Nuclear Projects:

- **Nuclear energy provides firm, dispatchable clean energy,** maintaining grid reliability while pursuing climate goals.
- **77% of coal plant jobs are transferable to nuclear plants** with no new workforce licensing requirements.
- **Net increase of more than 650 jobs** could be created in regions where SMRs repower retiring coal plants.
- **Jobs at nuclear plants provide higher wages** compared to coal plants, which would boost local tax revenue.
- **SMRs can reuse coal plant transmission infrastructure,** reducing SMR construction cost and avoiding some permitting challenges.
- **SMRs can reuse coal plant electrical equipment and steam-cycle components**, which, combined with reuse of transmission and administrative buildings, can reduce SMR construction cost by 17% to 35%.

Challenges to Address:

- **Coal plant retirement and SMR operation dates must be aligned** for a smooth workforce transition and to prevent existing transmission and water infrastructure from being utilized by another project.
- **NRC licensing and technological infancy** create uncertainties for SMR construction timelines.
- **23% of coal plant positions require extensive retraining or licensing** to transfer to a nuclear plant, including operators, senior managers, and technicians.
- **Coal plant equipment reutilization may be limited** due to coal plants having multiple, smaller units with less capacity than what's needed for an SMR.
- **Some states have laws restricting new nuclear development**, which can limit overall coal-to-nuclear opportunities.

Recent Policy Progress:

- **Inflation Reduction Act** includes tax credits that make advanced nuclear projects and new energy investment in coal communities more attractive to investors.
- **Fission for the Future Act,** included in the bipartisan CHIPS and Science Act, authorizes $800 million to support coal-to-nuclear projects.
- **Some states overturned bans on new nuclear,** including Montana, West Virginia, and Connecticut.

2. Introduction

America's energy system is in the midst of a transition to cleaner and more efficient energy sources. This herculean effort to replace our existing energy technologies offers enormous economic promise in terms of new energy sector jobs and domestic manufacturing. But the American energy transition cannot continue to leave displaced workers with no immediate job prospects. The United States must ensure that economic prosperity and opportunity are shared with "energy communities"[1] across the country, including coal workers and communities that have powered this nation for over a century.

With nearly a quarter of the U.S. coal-fired power plant fleet scheduled to retire by 2029,[2] replacing retiring coal plants with advanced nuclear reactors has been put forward as a strategy for maintaining local employment and economic opportunities for existing energy workers and communities, while also maintaining energy affordability for American households by reutilizing existing power plant and transmission infrastructure. Small modular reactors (SMR), one of the many types of next generation advanced nuclear reactors, promise to make reactors smaller, cheaper, even safer, and more flexible, making nuclear energy a more viable option for many communities. The Nuclear Regulatory Commission's (NRC) recent and groundbreaking certification of the country's first SMR design pushes the technology closer to maturity, which will be hastened by ongoing SMR demonstration projects.[3] As these advanced nuclear technologies shift toward commercial deployment, identifying the existing opportunities and hurdles is vital to create a pathway for future coal-to-nuclear transition projects.

The next era of energy production is already underway as market forces have compelled utilities to shift to cleaner and cheaper energy alternatives, with U.S. coal consumption peaking in 2006.[4] The shift away from coal has displaced tens of thousands of coal power plant workers, with the industry losing more than 12% of its workforce between 2019 and 2021 alone.[5] In the coming decades,

1 The Inflation Reduction Act provides tax credits for clean-energy projects within "energy communities." These communities are not well defined, but the intent of the language is to incentivize clean energy investment in communities with a sizable fossil fuel industrial presence. Daniel Raimi and Sophie Pesek, *What Is an "Energy Community"?*, (Resources for the Future, September 7, 2022), Available at: https://www.resources.org/common-resources/what-is-an-energy-community/

2 "Nearly a quarter of the operating U.S. coal-fired fleet scheduled to retire by 2029," EIA, November 2022, Available at: https://www.eia.gov/todayinenergy/detail.php?id=54559#

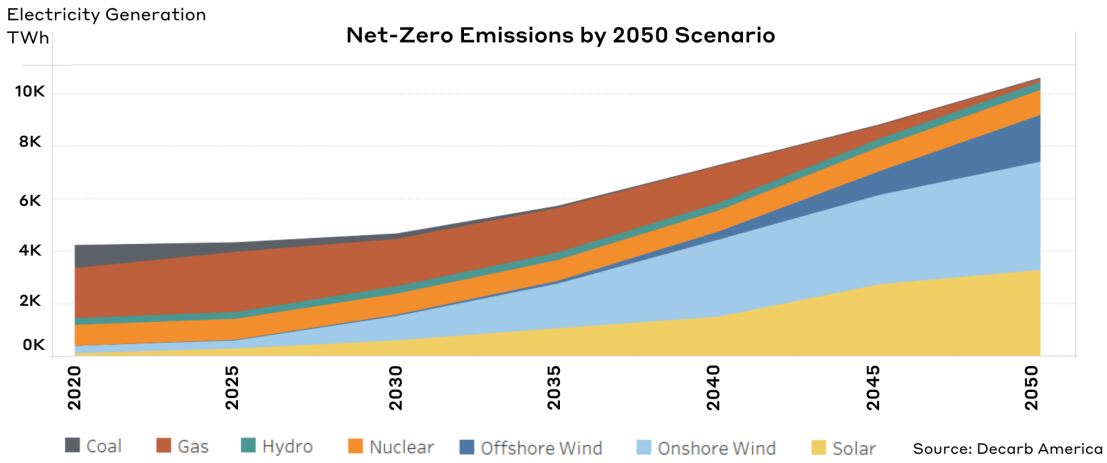
3 "NRC Certifies First U.S. Small Modular Reactor Design," DOE Office of Nuclear Energy, January 20, 2023, Available at: https://www.energy.gov/ne/articles/nrc-certifies-first-us-small-modular-reactor-design

4 "Coal explained," U.S. Energy Information Administration, last modified June 6, 2022, Available at: https://www.eia.gov/energyexplained/coal/use-of-coal.php

5 *United States Energy & Employment Report 2022*, (US DOE, June 2022), 29, Available at: https://www.energy.gov/sites/default/files/2022-06/USEER%202022%20National%20Report_1.pdf

further job displacement in the coal industry will mount. Under a business-as-usual scenario without new clean energy policies, modeling by Decarb America, a joint research initiative between the Bipartisan Policy Center and other climate-focused research groups, estimates domestic coal plant electricity production will decrease from 899,000 megawatt hours (MWh) today to 173,000 MWh in 2050 (Figure 1).[6] If the United States is to reach net-zero emissions by 2050, the loss in coal power plant production and associated economic impacts will be even more substantial. Under a net-zero emissions scenario where new clean energy incentives are enacted, electricity production from coal will decrease to just 6,500 MWh by 2040 and phased out almost entirely by 2050.[7]

Figure 1



With the recent passage of the Inflation Reduction Act of 2022 (IRA), the net-zero by 2050 scenario is beginning to look more plausible. New tax credits for nuclear power and clean energy make coal less cost competitive, likely hastening coal plant retirements and making advanced nuclear projects more attractive to investors. Additionally, other provisions included in the IRA and the recently passed Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022 provide funding and financing specifically for projects that seek to reutilize fossil fuel infrastructure for clean energy projects. Collectively these provisions make it attractive for stakeholders and investors to identify pathways for new nuclear projects to efficiently repurpose existing resources while utilizing the unique energy sector skills of coal workers to accelerate and maintain a reliable and resilient clean energy grid.

6 "Pathways To Net-Zero Emissions And Energy Infrastructure Needs For A Net-Zero Economy," Decarb America, October 2021, Available at: https://decarbamerica.org/technical-results/

3. Benefits of Advanced and Small Modular Nuclear Reactors

- Nuclear energy provides 24/7 firm, dispatchable clean energy, making it possible to maintain grid reliability while pursuing climate goals.
- SMRs are available at a variety of power output levels, enabling developers to match the power output of the retiring coal plant and providing operators with sufficient flexibility based on demand.
- The small land usage required for nuclear power plants combined with SMRs' unique flexibility to scale its power generation, also decreasing the plant's size, make the footprint of SMRs suitable for replacing a retiring coal plant.

a. Nuclear Helps Fill the Void of 24/7 Clean Power

Like coal power plants, nuclear reactors provide dispatchable energy available 24/7 regardless of weather conditions, time of day, or the season. Renewables have a vital and substantial role to play in a decarbonized energy grid. Yet, it is essential to complement their variability with the construction of firm power capable of filling the gaps and maintaining reliability. Over the coming decade, the United States is expected to retire 140,000 MWh of firm power, the vast majority coming from retiring coal plants, while only adding 46,000 MWh of firm power, mostly from natural gas.[8] Every lost unit of coal generation does not need to be replaced by a unit of firm power from another source. But, to ensure grid reliability, it is vital to maintain a certain level of firm power in our energy mix. According to Decarb America modeling, under a net-zero by 2050 scenario that relies heavily on renewables, the United States will still need to maintain over 1.4 million MWh of firm power, or about 13% of the nation's total electricity generation.[9] Additionally, maintaining extensive firm power in the national energy mix mitigates the need to overbuild renewable energy capacity in order to maintain reliability, reducing the overall cost of the system and

8 "Dispatchable generation capacity, net additions by technology in the Stated Policies Scenario, 2030", IEA, October 26, 2020, Available at: https://www.iea.org/data-and-statistics/charts/dispatchable-generation-capacity-net-additions-by-technology-in-the-stated-policies-scenario-2030

9 Based on Decarb America's Net-Zero High Electrification/High Renewable Scenario.

therefore energy costs for households.[10] Unlike replacing coal with other fossil generation sources, nuclear power's lack of greenhouse gas (GHG) emissions and dispatchable energy allows the country to simultaneously pursue its climate goals while increasing energy reliability.

The innovations of SMR technology make nuclear facilities smaller, more flexible, cheaper, and even safer. For communities interested in replacing aging coal power plants, SMRs would allow them to preserve a heritage of providing American households with reliable electricity and expand economic prosperity in the region.

b. Small Footprint and Flexible Output of SMRs

The average footprint of a recently retired coal power plant is considerably smaller than that of a traditional nuclear power plant, despite the fact that both use approximately the same number of acres per megawatt (MW) of electricity produced.[11] Unlike traditional nuclear plants, SMRs can be scaled up or down to match the electricity output of the outgoing coal plant, also reducing the land usage of the facility. For example, NuScale, the nuclear company that recently received NRC certification for its SMR Natrium design, states that their SMR is able to customize generation capacity from 4-modules (308 MW) to 6-modules (462 MW) to 12-modules (924 MW).[12] The advantages of nuclear's small land usage for coal-to-nuclear projects is even more clear when compared to renewable technologies. Per 1,000 MWh, solar requires 68 sq. miles, wind requires 268.9 sq. miles, while the average nuclear plant requires only 1.1 sq. miles.[13]

A recent study by the Department of Energy on the viability of a coal-to-nuclear transition reinforces the advantage of this reduced footprint, modular design, and flexible power output. Of the 394 retired and currently operating coal power plants analyzed by the study, 80% were found to be amenable for advanced nuclear reactors, including SMRs, while only 22% were amenable for traditional nuclear reactors.[14] The study states that this vast divergence is due to advanced reactors' ability to better match the land usage and power output of coal plants compared to traditional 1 GW nuclear plants. TerraPower's first of a kind coal-to-nuclear demonstration project highlights this advantage for SMRs. In 2030, the 448 MW Naughton coal power plant in Wyoming will be fully retired and

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10 Christopher TM Clack et al., *Advanced Nuclear Power in The United States Can Support A Transition To a Clean Economy*, (Vibrant Clean Energy, July 2022), Available at: https://www.vibrantcleanenergy.com/wp-content/uploads/2022/06/PressRelease_AdvNuclear.pdf

11 Barrett Anderson et al., *The Footprint of Energy: Land Use of U.S. Electricity Production*, (Strata, 2017), 1, Available at: https://docs.wind-watch.org/US-footprints-Strata-2017.pdf

12 VOYGR Power Plants. (NuScale Power). Available at: https://www.nuscalepower.com/en/products/voygr-smr-plants

13 *Gone with the Steam*, 15

14 Hansen et al., *Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants*, (DOE, September 13, 2022), 5, Available at: https://fuelcycleoptions.inl.gov/SiteAssets/SitePages/Home/C2N2022Report.pdf

replaced by the Natrium nuclear demonstration plant, which includes a 345 MW sodium-cooled fast reactor with a molten salt energy storage system that can temporarily boost output up to 500 MW and provide operators with more flexibility based on demand.[15]

As discussed later, some of the benefits of a coal-to-nuclear project can still be realized if the nuclear plant is constructed near rather than at the site of an outgoing coal plant, including reutilization of transmission, road, and building infrastructure, as well as opportunities for an existing energy sector workforce. However, SMRs' modularity and reduced footprint increases their ability to be constructed at the site of coal plants, consequently increasing the reutilization of more coal plant infrastructure, which increases potential cost savings of the project.

15 "TerraPower selects Kemmerer, Wyoming as the preferred site for advanced reactor demonstration plant", TerraPower, November 16, 2021, Available at: https://www.terrapower.com/natrium-demo-kemmerer-wyoming/

4. Estimated Savings of Repurposing Coal Plant Infrastructure for Nuclear

- Depending on the infrastructure reutilized, nuclear plants constructed at the site of outgoing coal plants can potentially reduce costs by up to 15% to 35%, compared to a standalone greenfield nuclear project not affiliated with a coal plant.
- If a nuclear project is sited near the retiring coal plant and only reutilizes transmission, road, and administrative building infrastructure, it can still reduce total construction costs by 10% and avoid some permitting challenges associated with new transmission projects.

a. Retrofitting Coal Power Plant Infrastructure

At a minimum, coal-to-nuclear projects can reutilize land surrounding the coal power plant, transmission infrastructure and connection to the grid, and administrative buildings.[16] Depending on the design of both the outgoing coal plant and the incoming nuclear plant, components such as cooling water delivery systems, heat sinks, site fire protection, switchyards, and other equipment can be retrofitted for use at the nuclear plant. Unlike nuclear plants, coal plants typically have more than one unit, which in combination produce the plant's nameplate capacity. Two 250 MW units have multiple, smaller components with reduced capacity than the components of a single 500 MW unit. Retrofitting undersized coal plant components for an SMR may prove more costly and troublesome than it is worth. SMR's ability to scale power output to match the existing infrastructure capacity may help alleviate this issue by ensuring the plant does not exceed the capacity of the most valuable infrastructure, such as transmission, electrical equipment, and cooling systems. Demonstration projects and future studies can provide a better understanding of the extent these components can be reutilized for nuclear plants.[17]

Like transmission, water access comes with permitting and siting challenges, making reutilization of water infrastructure valuable. For example, even though the Natrium reactor will be constructed near rather than at the Naughton coal

16 Hansen et al., Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants, 29

17 We are also aware of a forthcoming Clean Air Task Force study of the technical and economic feasibility of matching coal plant equipment and SMRs, which will help ground estimates using data from three SMR vendors and existing coal plants.

plant, as the coal plant retires, the Natrium nuclear plant will still leverage the existing Naughton water cooling tower, water pipelines, and other water infrastructure.[18] Additionally, while challenging, steam-cycle components could be retrofitted for the incoming nuclear plant if it were built at the site of the coal plant. These components include turbine infrastructure, condensing systems, and feed heating systems. While reutilizing this infrastructure offers one of the greatest cost-saving opportunities for a nuclear plant, capacity constraints, compatibility, licensing issues, and the components simply being at the end of their life cycle could hamper the feasibility of reusing the steam-cycle components.

Lastly, reutilizing coal plant components creates an opportunity cost. Shutting down a coal plant unit, or the entire plant, to remove system components that will be used in a future nuclear plant creates a revenue gap in between the closure of the coal plant and opening of the nuclear plant. The value of reutilizing these coal plant components needs to be weighed against the lost revenue of shutting down the coal plant or unit early to remove the components.

b. Reutilizing Transmission

Building out new high-voltage transmission lines are notorious for permitting and siting challenges. Land usage for transmission lines is granted at the state level, but the projects often cross multiple states and have benefits spread across the nation. This creates a mismatch between who approves a project and who realizes the benefits.[19] One example of this mismatch is the Grain Belt Express, a 500 kilovolt (kV) high-voltage transmission project to bring wind energy from Kansas to Indiana, crossing through Missouri and Illinois.[20] The Missouri Public Service Commission blocked the project in 2017 after determining that it did not provide sufficient benefits to Missouri, delaying the buildout.[21] Even after the commission reversed course and approved the project in 2019, it still faces uncertainty as local opposition groups try to prevent its construction. Transmission projects like the Grain Belt Express, estimated at $2 billion, are also expensive.[22] On average, high voltage transmission lines (lines over 100 kV) cost $3.9 million per mile.[23] Using existing transmission

18 "Frequently Asked Questions," Natrium, n.d., Available at: https://natriumpower.com/frequently-asked-questions/

19 Alexandra B. Klass and Elizabeth J. Wilson, *Interstate Transmission Challenges for Renewable Energy: A Federalism Mismatch*, (Vanderbilt Law Review, 2012), Available at: https://scholarship.law.vanderbilt.edu/vlr/vol65/iss6/10/

20 Corina Rivera-Linares, *Grain Belt Express will likely seek regulatory approval in Illinois in 2021*, (TransmissionHub, December 21, 2020), Available at: https://www.transmissionhub.com/articles/2020/12/grain-belt-express-will-likely-seek-regulatory-approval-in-illinois-in-2021.html

21 Liza Reed, *Transmission Stalled: Siting Challenges for Interregional Transmission*, (Niskanen Center, April 14, 2021), Available at: https://www.niskanencenter.org/transmission-stalled-siting-challenges-for-interregional-transmission/

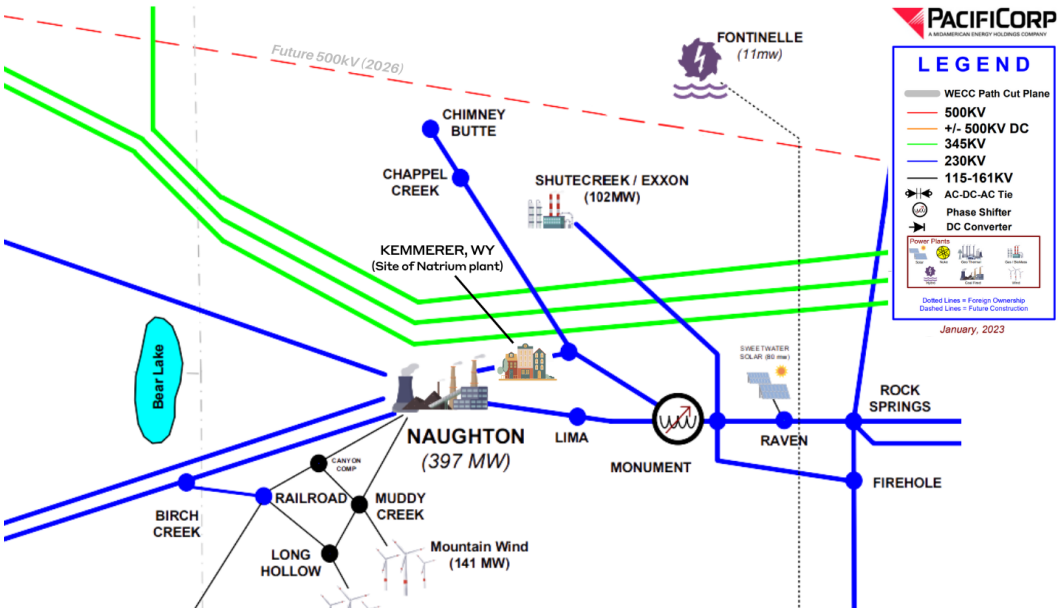
22 Rivera-Linares, *Grain Belt Express*

23 Daniel DeSantis, et al., *Cost of long-distance energy transmission by different carriers* (iScience, December 17, 2021), 4, Available at: https://www.cell.com/action/showPdf?pii=S2589-0042%2821%2901466-8

lines can help decrease lengthy permitting and cost challenges, making coal power plant sites incredibly appealing for continued energy generation.

As seen in Figure 2, existing transmission infrastructure near the Naughton coal plant in Wyoming is extensive.[24] Multiple 230 kV and 345 kV transmission lines cross hundreds of miles near where the Natrium plant will be constructed, with an additional 500 kV line that began construction in June 2022. The Wyoming, Colorado, and Utah section of the new 500 kV line is expected to cost $2.2 billion.[25] Additionally, the same switchyard infrastructure is required for both the coal and nuclear plants, allowing for reutilization that would save tens of millions of dollars.[26] Even if the Natrium nuclear plant does not utilize the Naughton plant's transmission hookup infrastructure, it is immensely valuable to be located near the existing transmission lines. For small coal plants with limited or no infrastructure capable of being retrofitted due to the technology reaching the end of its life cycle or being outdated, the nearby transmission alone might offer enough value to consider constructing a nuclear plant near or at the site.

Figure 2



24 PacifiCorp Main Grid Transmission Map, (PacificCorp, 2023), Available at: http://www.oasis.oati.com/woa/docs/PPW/PPWdocs/PacifiCorp2023_v1.pdf

25 Mary Powers, *Western Transmission Projects Pushed to Link New Power Sources*, (ENR Mountain States, May 31, 2022), Available at: https://www.enr.com/articles/54209-western-transmission-projects-pushed-to-link-new-power-sources

26 George Griffith, *Transitioning Coal Power Plants*, (Idaho National Laboratory, December 2021), 12, Available at: https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_54812.pdf

c. Overall Cost Savings

According to the DOE study, whether its sited at or near the retiring coal plant, any coal-to-nuclear project is assumed to reutilize the coal plant's transmission, transformer, road, and administrative building infrastructure, reducing total cost of the project by an estimated 10% compared to a greenfield nuclear project with no association to a coal plant.[27] Building from there, if a project reutilizes electrical components and the coal plant's heat sink, the savings increases to a range of 15% to 25%. If the nuclear project reuses all of the above-mentioned infrastructure plus the coal plant's steam-cycle components, the cost savings range jumps up to 17% to 35%. Reusing coal plant infrastructure also requires costs associated with removal and requalification[28] of equipment and facilities, as well as site remediation to remove contaminants, which have been factored into these estimates.

27 Hansen et al., Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants, 2

28 Requalification of coal plant equipment is the process of reanalyzing and licensing components for use in the nuclear plant.

5. Transferring the Worker Skills of the Coal Power Plant Industry to Nuclear

- About 77% of coal power plant positions analyzed—including mechanics, maintenance, electricians, and security—are transferable to nuclear plant positions with no licensing or experience requirements.
- The other 23% of positions—including operators, senior managers, and technicians—require licensing, four years of nuclear plant experience, or extensive retraining, which will limit overall workforce transferability in some areas.[29]

There is a misconception that nuclear plants primarily employ nuclear engineers. In fact, the majority of current nuclear plant workers have a similar skillset to other energy sector workers. The skills that many coal workers possess are transferable and valuable to nuclear facilities. NuScale analyzed coal-to-nuclear workforce transferability and found that 39 coal power plant positions would have a comparable counterpart at a NuScale nuclear plant, with only 9 of those positions having licensing and experience requirements.[30] This finding is not surprising. Aside from boiling water in different ways, nuclear and coal plants generate electricity in the same manner.

Examples of highly transferable positions include transitioning coal outage managers to nuclear generation and planning managers, coal boilermakers and steam fitters to nuclear plant mechanics, coal shift engineers to nuclear staff technical advisors, environmental board operators to nuclear radwaste operators, coal yard specialists and handlers to nuclear site support craftsman, and security guard roles. Many senior management positions would also be transferable between the plants, though some require up to four years of nuclear plant experience before transitioning to a similar role.

As NuScale notes, while there are many comparable positions between coal and nuclear plants, a knowledge and ability gap exists between the workforces, especially for roles requiring a Nuclear Operator License or nuclear chemical engineering experience. These types of specialized roles would only be available to former coal plant workers after extensive retraining and successful licensing. Figure 3 shows the lengthy career path of an experienced coal plant operator transitioning to a nuclear plant.[31]

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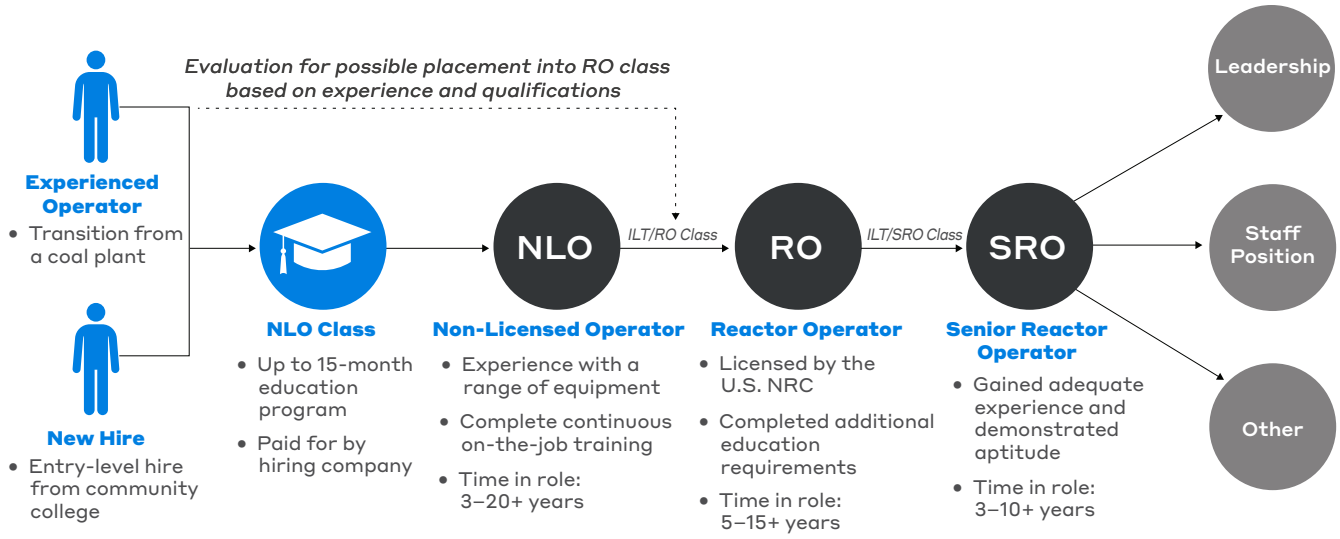
29 *Repurposing U.S. Coal Plant Infrastructure and Revitalizing Communities, (NuScale, 2021), 11, Available at: https://www.nuscalepower.com/-/media/nuscale/pdf/publications/nuscale-smr-technology-an-ideal-solution-for-coal-plant-replacement.pdf*

30 *NuScale SMR Technology*, 11

31 *Gone with the Steam*, 10

Figure 3



For other roles, such as security and previous coal employees working with reutilized coal plant infrastructure, for example, the steam turbine, generator, feedwater pumps and heaters, and electrical systems, the transition may require new training and professional development, but no new licensing or work experience requirements.

Higher wages for nuclear plant positions and a tight labor market for nuclear expertise incentivizes a workforce transition for both coal workers and nuclear companies. However, the extent of the transition could be limited if coal workers who need substantial retraining or licensing decide the burden is too high or if nuclear facilities seek out existing nuclear sector workers who already possess the necessary skills or licensing. Furthermore, the U.S. government's track record on retraining displaced workers is poor, with programs by both Democratic and Republican administrations making little progress since the 1980s.[32] Studies show that labor organizations and industry have had greater success training and retraining workers.[33] As discussed later, the bipartisan Fission for the Future Act signed into law places industry at the center of retraining efforts for coal-to-nuclear projects that receive grants, which may prove more effective than past efforts. Additionally, the availability of positions that need little retraining and no additional licensing is a positive sign that coal power plant workers can transfer to nuclear facilities. If nuclear plants retrofit or reutilize existing coal plant infrastructure, the coal workers currently managing and maintaining that infrastructure may be especially valuable.

32 Lola Fadulu, *Why is the U.S. so Bad at Worker Retraining?*, (The Atlantic, January 4, 2018), Available at: https://www.theatlantic.com/education/archive/2018/01/why-is-the-us-so-bad-at-protecting-workers-from-automation/549185/

33 Angela Hanks and David Madland, *Better Training and Better Jobs*, (Center for American Progress, February 22, 2018), Available at: https://www.americanprogress.org/article/better-training-better-jobs/

6. Timing a Coal-To-Nuclear Transition

- A smooth workforce transfer should have a good match between the retirement date for a coal plant and its repowering with an advanced nuclear reactor.
- Timeline flexibility is crucial to ensure relevant nuclear positions open as the coal plant retires.
- If a coal-to-nuclear transition lapses, leaving valuable infrastructure idle, transmission and water infrastructure could be snatched up by other projects.

a. Coordinating a Workforce Transition

Planning and timeline coordination are critical to allow a large portion of coal workers the opportunity to transition to positions at a nuclear facility. Ideally, for the workforce to transfer smoothly, the coal plant would scale down as the new nuclear facility begins to come online. If the coal plant operates longer than expected, an advanced nuclear facility may not be able to draw from the local power plant workforce. If timelines between the plants fail to matchup, whether due to a lack of coordination, cost overruns, or other unforeseen delays, coal plant workers could be left without an immediate nuclear plant position and may even leave the region or the energy sector workforce in search of opportunity.

Considering the history of nuclear plant construction overruns, finding good timeline matches could prove to be one of the most challenging aspects of the coal-to-nuclear workforce transition. With advanced reactor projects still in the demonstration phase, it is fair to say the technology is in its infancy. Until advanced nuclear reactor projects prove they are capable of consistently hitting deadlines, workforce transfer planning should build in flexibility to the coal plant retirement timeline. For example, the Naughton coal power plant is staggering the retirement of the plant's three units. Units 1 and 2 are slated for retirement in 2025[34] and Unit 3 in 2030.[35] The Natrium plant is planned to begin operation shortly after. The project estimates that construction of

34 Steve Ernst, *TerraPower Selects PacifiCorp's Retiring Naughton Plant as Site for Demo Reactor*, (California Energy Markets, November 19, 2021) Available at: https://www.newsdata.com/california_energy_markets/regional_roundup/terrapower-selects-pacificorps-retiring-naughton-plant-as-site-for-demo-reactor/article_90770f22-4999-11ec-a59a-cf219f278b2a.html

35 Timothy Gardner, *U.S.-backed high-tech nuclear plant in Wyoming delayed to 2030*, (Reuters, December 14, 2022), Available at: https://www.reuters.com/article/usa-nuclearpower-terrapower-delay-idAFL1N33414T

the Natrium plant will require 2,000 workers, positions that would open up as the Naughton plant begins retirement. A flexible retirement date that can be extended, should the nuclear plant experience further delays, would offer a buffer and prevent coal plant workers from being left to seek other employment opportunities. This flexibility is especially important considering other uncertainties specific to coal-to-nuclear projects, such as regulatory oversight and costs related to remediation efforts.

b. Added Uncertainty of Reactor Licensing

As the kinks of advanced nuclear reactor technology are ironed out during demonstration projects, the construction timelines and permitting process for future nuclear projects should become more consistent and predictable. The NRC can take upwards of three to six years to license a new nuclear reactor design for construction and operation.[36] Licensing of subsequent nuclear reactors of the same design will likely take less time as applicants and the NRC leverage lessons learned from the initial licensing process.

As NuScale did with their SMR Natrium reactor, developers can also choose to have the NRC certify a standardized nuclear reactor design. The design certification process streamlines future licensing reviews by enabling the NRC to focus only on evaluating site-specific licensing issues.[37] By certifying an SMR reactor, the NRC has for the first time unlocked this efficiency gain for advanced nuclear projects, provided they use the already certified design. Certifying additional SMR designs will streamline the process further for the industry.

While certification of an SMR creates efficiencies regarding the reactor design, the NRC still needs to consider and license design methods for the full power plant. Like reactor certification, as SMRs become licensed, the base for already approved design methods for the projects will grow. The AP1000 design used for the Vogtle nuclear plant has been certified and licensed by the NRC, creating a base of approved methods future applicants have built off of beyond just the reactor design. Getting the initial SMR designs through the NRC's rigorous licensing process may prove daunting. But successful SMR licenses will help streamline the approval of future SMR projects. Increased NRC experience licensing demonstration reactors and other advanced nuclear reactors combined with a strong industry focus on reactor standardization may lead to faster and more predictable construction and operating licensing reviews by NRC.

c. Coordinating a Transmission and Infrastructure

36 Nuclear Regulatory Commission, *Generic Schedules*, (Nuclear Regulatory Commission, September 10, 2021), Available at: https://www.nrc.gov/about-nrc/generic-schedules.html

37 Nuclear Regulatory Commission, Nuclear Power Plant Licensing Process, NUREG/BR-0298, Revision 2, Available at: https://www.nrc.gov/docs/ML0421/ML042120007.pdf

Transition

As has been made clear, transmission infrastructure is enormously valuable. When coal plants retire, hundreds of millions of dollars of transmission lines must be repurposed so that ratepayers can benefit from their investment in the lines' construction.[38] With America's energy mix transitioning to cleaner sources, winning the rights to access that infrastructure will be highly competitive.[39] For example, one solar firm bought land rights near a New Mexico coal plant well before the plant's retirement in hopes of utilizing the transmission lines left behind.[40]

To realize one of the most compelling benefits of coal-to-nuclear projects, the timeline needs to match up so that the coal plant's transmission access is not snatched up by another project, which could also be an issue for the coal plant's water infrastructure. Losing transmission access could threaten nuclear projects that experience delays, causing a significant lapse between the coal plant retirement and nuclear operation. The buffer added by a flexible coal plant retirement timeline would help protect transmission access for the nuclear plant and ensure a smooth transition for workers.

38 Herman Trabish, *Shuttered coal plant fixer-uppers for sale all over the U.S.*, (Utility Dive, January 16, 2018), Available at: https://www.utilitydive.com/news/shuttered-coal-plant-fixer-uppers-for-sale-all-over-the-us/514213/

39 Will Wade, *Clean Energy Producers Are Eyeing Old Coal Plants—for the Wiring*, (Bloomberg Green, July 22, 2022), Available at: https://archive.ph/20210722184639/https://www.bloomberg.com/news/articles/2021-07-22/clean-energy-wants-to-tap-coal-s-power-infrastructure#selection-3645.0-3650.0

40 Karen Uhlenhurt, *Solar firm buying land rights near coal plants with eye toward transmission*, (Energy News Network, July 14, 2020), Available at: https://energynews.us/2020/07/14/solar-firm-buying-land-rights-near-coal-plants-with-eye-toward-transmission/

7. Regional Economic Considerations

- Nuclear plant wages are on average 15% higher than coal plant wages and 64% higher than the median U.S. hourly wage, providing economic stimulus and contributing to local indirect jobs from spending in the local community.
- The high wages of nuclear plant and construction jobs provide tens of millions of dollars to local tax bases, preventing a hollowing out of government services and a cycle of disinvestment following a coal plant closure.
- A recent DOE study estimates that a coal-to-nuclear transition would result in a net *increase* of more than 650 jobs to the region the plant is located in, with two-thirds of those jobs being indirect.[41]

a. Wages

One of the most compelling aspects of a coal-to-nuclear workforce transition is that the nuclear sector offers well-paid, stable, long-term jobs. The median hourly wage of a worker at a nuclear utility is $47, compared to $41 at a coal utility and the national median hourly wage of $27.[42] Additionally, 21% of the nuclear power generation segment is unionized compared to 15% of the coal sector and 10% of the national workforce.[43]

b. Tax Base and Local Revenue

When jobs are displaced, local governments lose their tax base. Retaining high-wage jobs is important to prevent the hollowing out of government services and a cycle of disinvestment. Investment in nuclear facilities can help fill the job and funding gap for the next phase of retiring coal plants. In 2019, NuScale and the Idaho Policy Institute evaluated the benefits of constructing and operating a six-unit SMR on the Idaho National Laboratory Site.[44] The study found that the 2,000 workers needed over four years to construct the project would earn

41 Hansen et al., Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants, 56

42 Jackie Toth, Jessica Lovering, and Suzy Baker, *Opportunities for Coal Communities Through Nuclear Energy: An Early Look*, (Good Energy Collective, December 2021), Available at: https://uploads-ssl.webflow.com/5f05cd440196dc2be1636955/622d09b5a0d195112ac726a1_Full%20Report_Opportunities%20for%20Coal%20Communities%20Through%20Nuclear%20Energy.pdf

43 *United States Energy & Employment Report 2021*, (US DOE, 2021), Available at: https://www.energy.gov/sites/default/files/2021-07/USEER%202021%20Executive%20Summary.pdf; *Union Members — 2021*, (US BLS, January, 2022), Available at: https://www.bls.gov/news.release/pdf/union2.pdf

44 Griffith, *Transitioning Coal Power Plants*, 19-20

$640 million, local taxes would increase by $37 million, and federal tax revenue would increase by $140 million. Once complete, the 360 permanent operational jobs would provide $48 million in local income, $3 million/year in local taxes, and $11 million/year in federal taxes.

c. Direct Job Impact

SMR plants and coal power plants have similar staffing requirements. TerraPower estimates the Natrium nuclear plant will require 250 employees to support day-to-day operations, compared to about 230 plant employees currently operating the Naughton coal power plant.[45] This estimate is similar to NuScale's estimate that their SMR plants will require 270 employees to support operations, general and outage maintenance, refueling, and security, which they state is nearly double the employees required for the average coal power plant per MW.[46] SMR employee requirements are substantially greater than its counterparts: the average solar facility only requires 36 permanent employees, 80 for an average wind facility, and 30 for an average natural gas facility.[47] Additionally, NuScale estimates that, while temporary, the construction of the plant will create another 1,600 jobs, providing an influx in local spending and tax revenue. With a similarly sized workforce and temporary construction jobs, Wyoming communities recognized the value of retaining well-paying energy sector jobs in the region when they solicited the Natrium power plant.[48]

d. Indirect Job Impact

High-earning workers spend their income in the local economy, providing businesses with customers and helping to create additional jobs. This indirect (and induced) impact of wages is known as the "multiplier effect," and it's unusually high for coal worker jobs due to the dramatically higher wages than other regional employment opportunities. A study by West Virginia University found that coal power plants employ 2,750 workers in the state, but generate an additional 6,500 jobs due to the high wages of plant workers and the overall revenue generated by the plant.[49] According to a hypothetical Midwestern case study conducted by DOE to evaluate the regional economic impact of a coal-

45 Toth, Lovering, and Baker, *Opportunities for Coal Communities*; Brady McCombs and Mead Gruver, *In tiny Wyoming town, Bill Gates bets big on nuclear power*, (AP, January 18, 2022), Available at: https://apnews.com/article/climate-technology-business-wyoming-bill-gates-19a36eb0bd65e0999d26c0cc122f6158

46 *NuScale SMR Technology*, 7

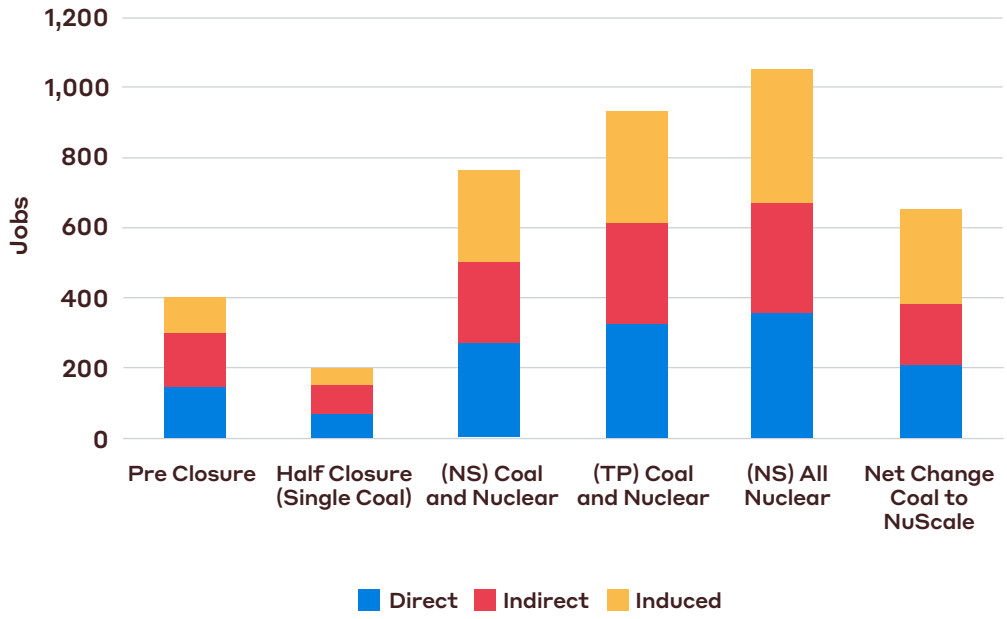
47 *Gone with the Steam*, 13

48 Ellen Gerst, *Wyoming Towns Eager to Host Next Generation Nuclear Reactor*, (Casper Star Tribune, June 16, 2022), Available at: https://trib.com/business/energy/wyoming-towns-eager-to-host-next-generation-nuclear-reactor/article_f73e3b4d-032f-5727-87a7-88bb3e23d890.html

49 Christiadi, Ph.D. and John Deskins, Ph.D., *The Economic Impact of Coal in West Virginia*, (West Virginia University, 2018), Available at: http://busecon.wvu.edu/bber/pdfs/Econ-Impact-Coal-2018.pdf

to-nuclear project, the high wages and staffing requirements of nuclear plants offer a similarly positive economic impact. As seen in Figure 4, the study finds that a coal-to-nuclear transition would provide a net increase of 653 jobs to the hypothetical region, with two-thirds of those jobs being indirect/induced.[50]

Figure 4



50 Hansen et al., Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants, 56

8. Suitable Locations for a Coal-to-Nuclear Transition

- 80% of the evaluated recently retired and soon to be retired coal power plants have the basic technological and geographic characteristics needed to be repowered by advanced nuclear reactors.
- Factors such as geographic vulnerability to natural disasters and a mismatch between the coal plant and nuclear plant's energy output limit opportunities to pursue coal-to-nuclear projects.
- State restrictions on nuclear construction and lack of local public support for new nuclear power plants limit the opportunities for coal-to-nuclear projects.

a. Geographic Opportunities

According to the Energy Information Administration, between 2022 and 2035, 28% of coal power plants, or 59 gigawatts (GW), in the U.S. will be retired.[51] As seen in Figure 5, these retirements sprawl across the country.[52] Each retiring coal power plant leaves behind a trained workforce, energy infrastructure, and unused transmission lines, creating an opportunity to identify sites suitable to be repowered with advanced nuclear.

As mentioned previously, DOE's 2022 study on the viability of a coal-to-nuclear transition found that 80% of coal power plants analyzed, including recently retired (retired after 2012) and currently operating plants, have the basic characteristics needed to host an advanced nuclear reactor within a 0.5-mile radius (500 acres) of the coal plant.[53] This translates to 125 retired coal plants and 190 operating coal plants amenable to a coal to SMR transition. This finding holds when considering a 1.0-mile radius (2,000 acres) from the coal plant, which was included in the study to observe how siting decisions may interface with population centers. Of the 315 coal plants amenable to advanced reactors that were analyzed in this study, 34% are located in the Midwest, 31% in the Southeast, 13% in the Southwest, 13% in the West, and 9% in the Northeast. Limitations on suitable sites include vulnerability to natural disasters (floods, earthquakes, landslides, etc.), safety hazard concerns for nearby populations,

51 *Of the operating U.S. coal-fired power plants, 28% plan to retire by 2035*, (EIA, December 15, 2021), Available at: https://www.eia.gov/todayinenergy/detail.php?id=50658

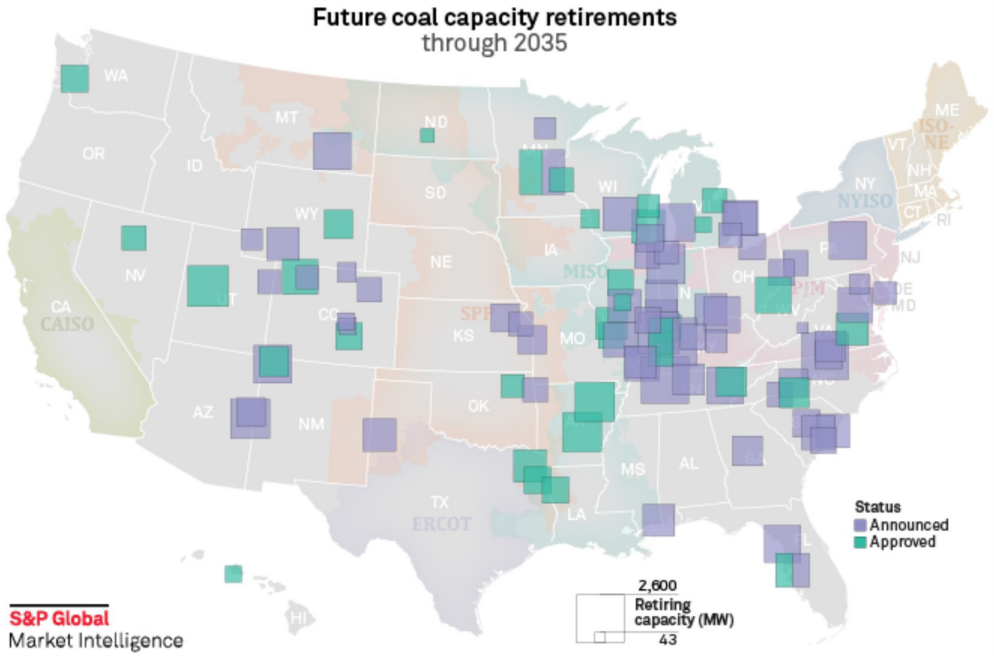
52 Taylor Kuykendall, Anna Duquiatan, and Darren Sweeney, *Slated retirements to cut US coal fleet to less than half 2015 capacity by 2035*, (S&P Global Market Intelligence, July 29, 2021), Available at: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/slated-retirements-to-cut-us-coal-fleet-to-less-than-half-2015-capacity-by-2035-65741012

53 Hansen et al., Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants, 5

slope of the terrain, and proximity to protected lands. The 190 currently operating coal plants that are suitable for an SMR transition generate 199 GW combined, more than double current U.S. nuclear energy capacity.

An important limitation not considered in this study is state restrictions banning new nuclear construction. 12 states have such bans, including Illinois which is completely covered by expected retirements in Figure 5 and is pursuing a plan to close the state's entire coal power plant fleet by 2035.[54] These bans somewhat diminish the opportunities for coal-to-nuclear projects. Over the past couple of years, progress has been made at the state level to expand coal-to-nuclear opportunities. Montana and West Virginia, both states with sizable and retiring coal fleets, have taken action and overturned their bans on new nuclear construction. Connecticut also enacted a law to exempt expansion of the state's only nuclear plant from the state's ban on new nuclear construction.[55] If other states with similar restrictions and large fleets of retiring coal plants follow suit, such as Illinois, it would increase the number of opportunities to pursue coal-to-nuclear projects in regions that may benefit the most from such a transition.

Figure 5



54 Michael Hawthorne, *As legislature reconvenes, Illinois is poised to become the first state in the Midwest to ban coal-burning power plants*, (Chicago Tribune, June 15, 2021), Available at: https://www.chicagotribune.com/news/environment/ct-illinois-pritzker-coal-clean-energy-20210615-lgx35ouufjfsvgimmfoqa37qdu-story.html

55 Stephen Singer, *Nuclear power gets another look in 'all-of-the-above' energy approach as climate worries mount*, (Utility Dive, January 20, 2023), Available at: https://www.utilitydive.com/news/nuclear-power-smr-climate-irg-omnibus-spending/639484/

b. Public and Political Support

A 2022 study by The Good Energy Collective adds a political lens to the analysis on suitable locations for coal-to-nuclear projects. When narrowing down suitable sites, the study only looked at brownfield sites, rather than the 0.5-1.0-mile radius that DOE considered, and accounts for state nuclear restrictions and county level public support for new nuclear plants, as well as site vulnerability to natural disasters, terrain slope, and the power output of the outgoing coal plant (more than 300 MW but less than 1,000 MW). Of the 300 sites analyzed by the study, 79 coal plants were found to be a good fit to be repowered by an SMR.[56] If all 79 coal plants and their 71.5 GW of generation capacity were replaced with SMRs, it would increase America's nuclear energy capacity by 75%.

Narrowing down the list to sites in counties where a majority of the public supports new nuclear plant construction leaves 44 suitable coal plants. However, a recent study by the Potential Energy Coalition found that only 15% of coal-to-nuclear candidate communities are highly knowledgeable on nuclear energy. According to the study, as knowledge increases from "Not very knowledgeable" to "Very knowledgeable", support for nuclear energy projects increases from 8% to 78%.[57] These studies highlight how community outreach and local public support should be considered in conjunction with technological viability.

56 Jackie Toth, Jessica Lovering, and Suzy Baker, *Opportunities for Coal Communities Through Nuclear Energy: An Early Look*, 34

57 John Marshall, Nuclear Energy Institute conference presentation, (Potential Energy Coalition, June 2022).

9. Recent Congressional Progress

a. Fission for the Future

Enacted into law as part of the CHIPS and Science Act of 2022 is the Fission for the Future Act (S.3428/H.R. 7360), a bipartisan bill introduced in December 2021 by Sens. Joe Manchin (D-WV), Chairman of the Senate Energy and Natural Resources Committee, and John Barrasso (R-WY), Ranking Member of the Committee, and by Reps. Mike Doyle (D-PA) and Anthony Gonzales (R-OH). The Fission for the Future Act authorizes $800 million over five years to establish a Nuclear Reactor Grant Program within DOE to provide states, local governments, utilities, and private entities with financial assistance for advanced nuclear research, development, and demonstration projects, with prioritization given to projects in communities with retired fossil fuel plants. Additionally, the bill prioritizes applicants that establish traineeships to develop a U.S. nuclear workforce, which may support the training of coal power plant workers for roles in nuclear facilities. With support across the aisle from four Members of Congress representing the most coal-dependent states in the nation, Fission for the Future highlights considerable bipartisan interest in pursuing nuclear investment in regions that will be hit the hardest by upcoming coal plant retirements.

b. Inflation Reduction Act

The recently passed Inflation Reduction Act of 2022 includes new authorities under the 1706 Energy Infrastructure Reinvestment Financing provision that allows the DOE Loan Programs Office (LPO) to provide financing for projects that "retool, repower, or replace" retired energy infrastructure or enable currently operating infrastructure to avoid, reduce, utilize, or sequester GHGs. To carry out this authority, LPO was appropriated $5 billion through 2026 and provided $250 billion in loan authority. With this new authority, LPO can now provide debt financing to projects that seek to reutilize retiring coal plant infrastructure, including coal to nuclear and transmission repurposing projects. This authority also does not have the innovative technology requirement that other LPO programs include, increasing eligibility for coal to nuclear projects using already deployed reactor designs. Additionally, the

Inflation Reduction Act's technology neutral clean electricity production and investment tax credits are increased by 10% for projects located in an "energy community." If a nuclear project wants to maximize its tax credit, investing in coal communities is a way to do that.

The Fission for the Future Act can help create more straight forward, timely, and coordinated regulatory and planning pathways for coal-to-nuclear projects, while debt financing available through LPO's new Energy Infrastructure Reinvestment Financing authorities and new tax incentives help attract advanced nuclear projects to coal communities.

10. Conclusion

Over the past year, there have been many positive developments to support new nuclear investment in regions where remaining coal power plants are reaching the end of their lifecycle. These include passage of the Fission for the Future Act; LPO's new authorities and funding to invest in projects that repurpose fossil fuel infrastructure; Montana, West Virginia, and Connecticut's recent law change allowing new nuclear construction; impending coal to nuclear demonstration projects; and the NRC's first ever certification of an SMR design. With or without a coal-to-nuclear transition, the United States will need to grapple with workforce displacement as more affordable and cleaner energy sources are deployed. Investing in regions with existing fossil fuel generation is vital to ensuring that future coal sector displacement does not hollow out the economic viability of surrounding communities. To most effectively catalyze investment in these communities and curb workforce displacement, the business case for nuclear companies in these regions must be compelling.

Retrofitting otherwise stranded coal power plant assets is an intriguing opportunity for new SMR and advanced nuclear reactor projects to cut costs and reduce construction timelines. For projects constructed at the site of retiring coal plants, the 15% to 35% reduction in total construction cost translates to hundreds of millions of dollars saved on the project. Additionally, nuclear projects constructed near retiring coal plants can leverage existing transmission infrastructure, which is extremely expensive, arduous, and time-consuming to construct. With low community acceptance of new transmission infrastructure in many areas, the ability to reuse existing transmission lines should be valuable to stakeholders across the board.

While not a silver bullet for the approaching coal sector displacement, policymakers in states and communities reliant on the industry should evaluate the new workforce capacity building policy and new funding opportunities provided by recently passed legislation and identify regulatory changes, policies, and approaches that would incentivize nuclear sector investment. In some cases, this is as simple as removing long-standing state restrictions on new nuclear development. Nuclear investment can help create well-paying jobs, accelerate the deployment of firm clean energy, and maintain the heritage of energy production in Coal Country. America's existing energy workforce is an important asset that must be incorporated into the nation's clean energy transition.

1225 Eye St NW, Suite 1000
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