MASS ACQUISITION OF EARLY SITE PERMITS FOR COAL-TO-NUCLEAR REPOWERING

A PROPOSAL

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EXECUTIVE SUMMARY

This report proposes an approach to assist with repowering existing fossil fuel sites, with higher priority given to those sites en route to retirement. The approach leverages proactive planning and policy formulation, promoting revitalization without exclusively focusing on climate change concerns. In pursuit of clean energy alternatives, nuclear energy emerges as a prominent candidate to replace baseload energy from fossil fuels. As the imperative for low-carbon energy technologies gains momentum, the opportunity to reconfigure carbon-intensive power generation sources necessitates action beyond a "no-action" stance.

The coal-to-nuclear repowering (C2N) approach proposes to replace retiring coal-fired power plants (CPPs) with advanced nuclear reactors, utilizing viable existing infrastructure for power generation and transmission. This initiative aligns technological, social, and economic considerations, presenting a comprehensive response. However, the current barrier hindering implementation of this initiative is regulatory uncertainty.

Presently, legacy regulatory processes create friction rather than incentive for CPP owners considering engaging in C2N repowering projects. A key challenge is the regulatory process to acquire early site permits (ESPs). The current ESP pathway is lengthy and costly, which may discourage developers due to uncertainties and prolonged timelines. This report addresses this challenge and proposes a streamlined approach.

The Breakthrough Institute proposes a U.S. Department of Energy (DOE)-led program aimed at alleviating regulatory uncertainty. This program would assess retiring CPP sites nationwide, categorizing and prioritizing them based on local need for power, remediation, viability of existing infrastructure, and demand for workforce transition. Under the Energy Policy Act of 2005, the DOE can apply for an ESP to conduct site-specific evaluations of a location with potential for a nuclear power plant before the actual construction and operation of the facility begin. This process allows the DOE to assess the suitability of the site and address any potential safety and environmental concerns in advance. The proposed program targets eligible sites with transferable workforces and essential infrastructure, helping to facilitate a seamless transition for C2N projects. In the proposed program, the DOE's role will be to mass-acquire ESPs for multiple eligible C2N sites and subsequently to transfer those permits to utility companies and developers to recover the costs.

The program presents a strategic solution to catalyze but not to own the repowering of fossil fuel sites through regulatory innovation. By mitigating regulatory uncertainties and leveraging existing resources, the proposed program will propel the transition towards cleaner and sustainable energy sources, addressing the imminent challenges of energy transition and environmental preservation.

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ACRONYMS

ANR GEIS	Generic Environmental Impact Statement for Advanced Nuclear Reactors
BTI	Breakthrough Institute
C2N	coal-to-nuclear repowering
CATEX	categorical exclusion
CFR	Code of Federal Regulation
CGS	Coronado Generating Station
COL	combined license
CP	construction permit
CPP	coal-fired power plant
DOE	U.S. Department of Energy
EA	environmental assessment
EIA	U.S. Energy Information Administration
EIS	environmental impact statement
EPRI	Electric Power Research Institute
ESP	early site permit
GEIS	Generic Environmental Impact Statement
LWR	light-water reactor
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NGP	natural gas plant
NRC	U.S. Nuclear Regulatory Commission
OL	operating license
PPE	plant parameter envelope
RAI	request for additional information
SDC	standard design certification
SRP	standard review plan

INTRODUCTION

Reshaping the energy landscape in the U.S. to cleaner, more reliable, carbon-neutral energy technologies means addressing the gap in energy-reliant sectors and employment because of the decommissioning of coal-fired power plants (CPPs). Nuclear and geothermal energy technologies are the sole clean energy candidates with the capability to most effectively repurpose brownfield[1] sites or retiring CPP sites by leveraging viable existing infrastructure. There are socioeconomic advantages to siting nuclear power plants at retired CPPs, especially for disadvantaged communities: improved environmental conditions, job creation, and new economic opportunities. The Inflation Reduction Act of 2022 marks a historic milestone in U.S. climate legislation, providing financial support, comprehensive programs, and attractive incentives to expedite the shift toward a clean energy-driven economy. This act, with many of its provisions in effect in January 2023, is poised to facilitate substantial deployment of clean energy sources to repurpose coal plant sites for communities most impacted by the transition.

Repowering retiring coal plants with nuclear power plants leverages the reduced capacity size and nearly twice the capacity factors of the CPP being replaced [1] [2]. Moreover, re-siting CPPs with nuclear power takes advantage of such key CPP infrastructure advantages as proximity to cooling water sources, integration with transmission networks, and safe distances from local populations [2]. It is noteworthy, however, that some proposed advanced reactors cooled by liquid metal, gas, or molten salt will require significantly less water and may have more flexible siting potential. A U.S. Department of Energy (DOE) study investigated the benefits and challenges of converting CPPs to nuclear plants and found that building at a brownfield site would have 15% to 35% less capital costs than a greenfield construction project [3]. Because of the existing infrastructure at CPP sites, the coal-to-nuclear repowering (C2N) approach benefits from cost optimization.

Proactive planning for repowering fossil-fueled power plants is critical to positive community outcomes. According to a 2022 study conducted by the Breakthrough Institute (BTI), one could expect between 146 and 254 deployments of advanced reactors in the U.S. largely after 2035 [1]. But in any one site conversion scenario, it is important to consider how long a C2N site transition could take. The BTI study estimated a 16-year delay in converting a retired fossil-fired power plant site to a nuclear power plant site. Because of this large time gap, the study recommended that planners start preparing for new nuclear projects years in advance of the projected fossil-fired power plant retirement. In other words, to avoid the delay, C2N projects should initiate groundwork required at CPP

[1] A previously developed site for industrial or commercial purposes and thus requiring further development before reuse.

sites that will be retiring in a few years. One way of streamlining the transition could be the issuance of early site permits (ESPs) before CPP retirement.

An ESP is a permit that affirms the safety, environmental protection, and emergency preparedness of one or more sites to house a nuclear power plant [4]. ESPs are reviewed by the U.S. Nuclear Regulatory Commission (NRC) to address site safety issues, environmental protection issues, and plans for coping with emergencies, *independent* of the review of a specific nuclear plant design [5]. While an ESP applicant is not required to specify a plant design, the applicant is required to provide sufficient surrogate-design details that bound the various designs under consideration. Providing the necessary design envelope information is critical for the NRC to decide on the qualification of the site and the potential environmental impact [4]. An ESP can be granted by the NRC for one or more sites independent of a construction permit or a combined license and can last up to 20 years with the potential for renewal of up to 20 years.

The 2022 BTI study found that to reach 99% decarbonization by 2050, the U.S. power sector landscape must primarily consist of a mix of renewables and nuclear technologies (Figure 1) [1]. Over the next three decades in all four scenarios examined, both the installed capacity and total generation experienced significant growth. Achieving the level of clean energy needed to decarbonize the energy sector will mean potentially licensing not a handful but hundreds of new reactors to meet the needs of the nation. This projection shows that it's essential to rethink and transform the regulatory process, moving beyond minor efficiency enhancements that fail to tackle the core problems. Exploring possibilities for simplifying the ESP review through standardization can lead to a quicker transition toward decarbonization. Doing so can help alleviate the expected regulatory challenges and uncertainties, while also helping achieve global net-zero objectives.

Figure 1: Electricity generation by technology type for each model scenario for 2025-2050 [1]

2. SIGNIFICANCE

2.1 Tangible Benefits to Communities

The C2N effort is far-reaching in impact. Consequently, areas critical for the successful wide-scale transition from fossil-fired power generation to advanced nuclear energy generation need consideration. Nuclear energy offers significant economic, safety, and environmental advantages over fossil fuels [2], [6]—[8]. Several studies have examined the impact of nuclear facilities on nearby communities based on factors such as property values, economic growth, taxes, public services, schools, jobs, and community development [2], [5]—[7]. These research findings indicate that nuclear facilities have positive effects on the surrounding communities. They contribute to a substantial portion of total employment in the county where the plant is located and surrounding counties, and taxes and fees from these facilities fund a significant portion of county and school district budgets. Additionally, communities near nuclear plants tend to have higher home values and family incomes compared to those farther away [7]. Residents living close to operational nuclear power plants generally hold a favorable view of the plants and their operation history. In contrast, communities near coal plants often experience lower income levels and property values [7]. Although the retirement of fossil fuel power plants is gradual, repurposing those existing plants to nuclear power plants, especially those housing small modular reactors, presents an opportunity for environmental improvements and economic benefits for local communities. The Idaho National Laboratory, as part of the Gateway for Accelerated Innovation in Nuclear initiative, conducted a comprehensive study on repurposing the Coronado Generating Station (CGS) in St. Johns, Arizona, utilizing nuclear technology [9]. The study meticulously compared the economic impacts of nuclear alternatives with the CGS, evaluating diverse replacement scenarios in terms of output, employment, labor income, and value-added. The results revealed direct impacts of $155.5 million, with a NuScale-12 module generating a substantial $450 million in direct output. Moreover, indirect and induced impacts were projected to potentially reach an impressive $672.6 million. Notably, nuclear replacements exhibited slightly higher output multipliers attributed to elevated labor-to-capital ratios. Specifically, the CGS had an output multiplier of 1.43, while nuclear replacements demonstrated an average of 1.5, indicating a heightened level of economic activity per unit of electricity generated.

3. OBJECTIVES

The purpose of this report is to highlight some regulatory challenges that threaten a smooth and timely C2N transition, as well as to propose potential solutions to address those challenges. In a recent report, the DOE investigated the benefits and challenges of converting retiring CPPs to nuclear plants [3]. The study assessed the eligibility of CPPs, both retired and operating, for siting large light-water reactors (LWRs) or advanced reactors. Our report builds on this DOE study by further refining the C2N transition priority by primarily focusing on streamlining regulatory reviews of ESPs for currently operating CPPs that have planned retirement timelines.

4. CHALLENGES WITH THE REGULATORY PATHWAY FOR C2N TRANSITION

4.1 Licensing Process

There are two existing licensing pathways for C2N: a two-step process (acquiring a construction permit, followed by an operating license) under 10 Code of Federal Regulation (CFR) Part 50; and a one-step process (acquiring a combined license that authorizes both construction and operation) under 10 CFR Part 52 [10]. For either pathway, the process takes several years [11]. To facilitate expedited decarbonization through implementation of emerging nuclear technologies, it is imperative to modernize the regulatory licensing procedure. The NRC has introduced other permits that allow prospective applicants to begin certain aspects of the licensing process before filing a full application, including limited work authorizations, standard design certifications, and ESPs. The following sections will expound on ESPs and potential opportunities for review process improvement.

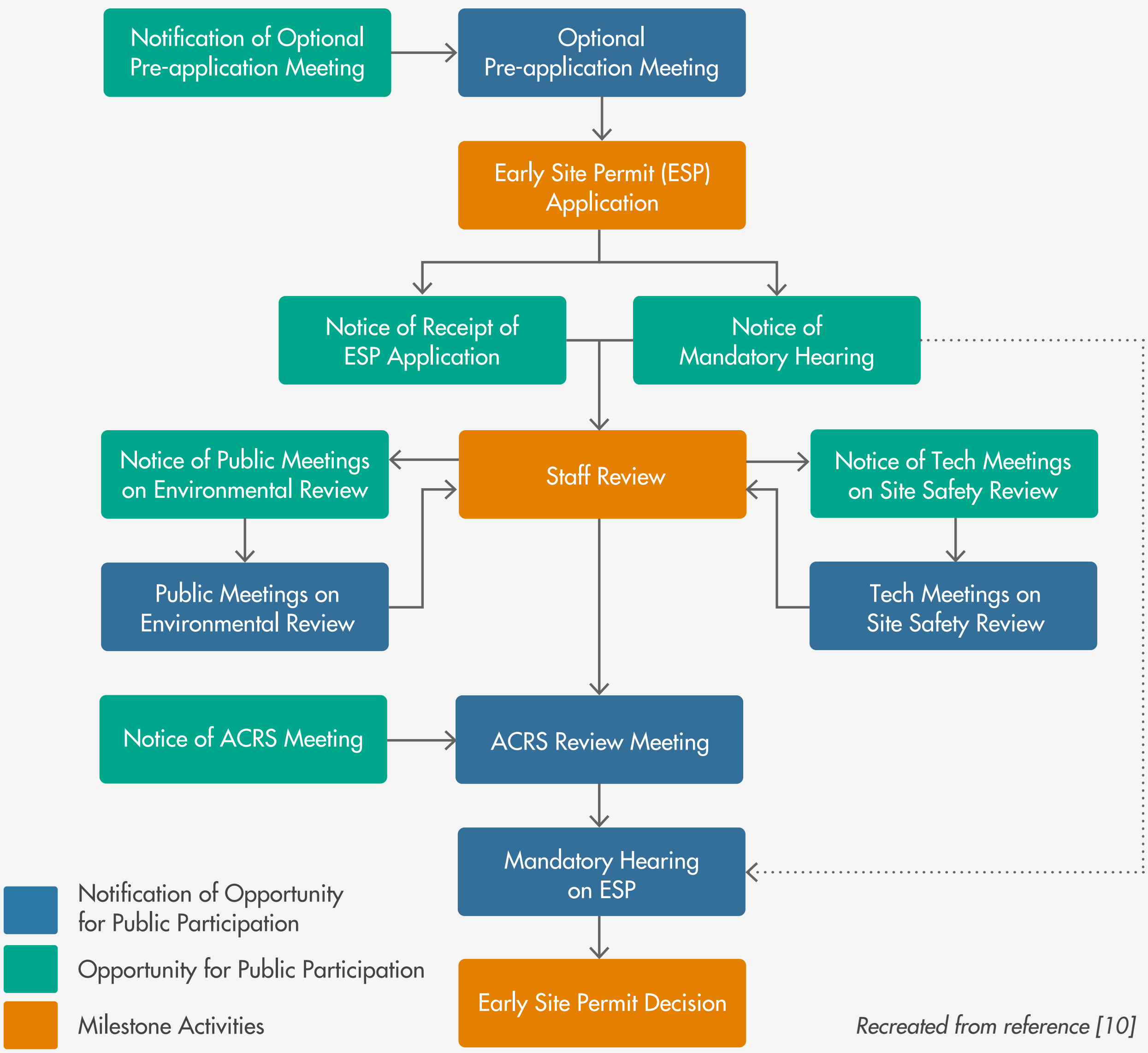
The NRC is currently working on a draft licensing framework outlined in the 10 CFR Part 53 rulemaking. The draft, known as Part 53, promises to provide a risk-informed, technology-inclusive, and performance-based process, aligned with the Nuclear Energy Innovation and Modernization Act of 2019. The draft rule aims to license smaller advanced LWRs and non-LWRs [12]. In the draft rule, there are two main frameworks: Framework A and Framework B. The key distinction between these two lies in their approach to evaluating risks. Framework B offers an alternative method for risk assessment, aiming to reduce the costs and time associated with the probabilistic risk assessment required in Framework A. The alternative evaluation of risks is intended to provide risk insights for advanced reactor designs with substantial safety margins. It is important to note that the proposed licensing framework(s) in the draft Part 53 rule will use existing licensing types including ESPs.

4.2 Early Site Permits and Their Benefits

An ESP allows an applicant to receive advance approval for a site independent of applying for a construction permit plus operating license or a combined license under 10 CFR Part 52 [10] [13]. Moreover, acquiring an ESP is expected to be feasible under both Frameworks A and B outlined in the draft Part 53. In Framework A, the relevant details concerning ESPs are delineated in section 53.1140, while in Framework B, the pertinent information commences in section 53.4750 [14].

The ESP process was designed in 1989 in response to industry concerns that the 10 CFR Part 50 licensing pathway requires significant investments of time and capital before the crucial site evaluation would occur [4]. The NRC often conducts an introductory meeting close to the proposed site before an ESP application is submitted [10]. The meeting informs the public about application aspects, safety, location, and participation opportunities. Public discussions on the NRC's environmental review scope are held, and safety-related discussions between the applicant and NRC are public. The Advisory Committee on Reactor Safeguards reviews applications along with NRC staff evaluations, and public hearings precede ESP issuance, overseen by the NRC's Atomic Safety and Licensing Board Panel. Figure 2 provides an overview of activities involved in the submission and review of an ESP, highlighting specific milestones and opportunities for public engagement.

Figure 2: Summary of regulatory activities for an ESP review.



Recreated from reference [10]

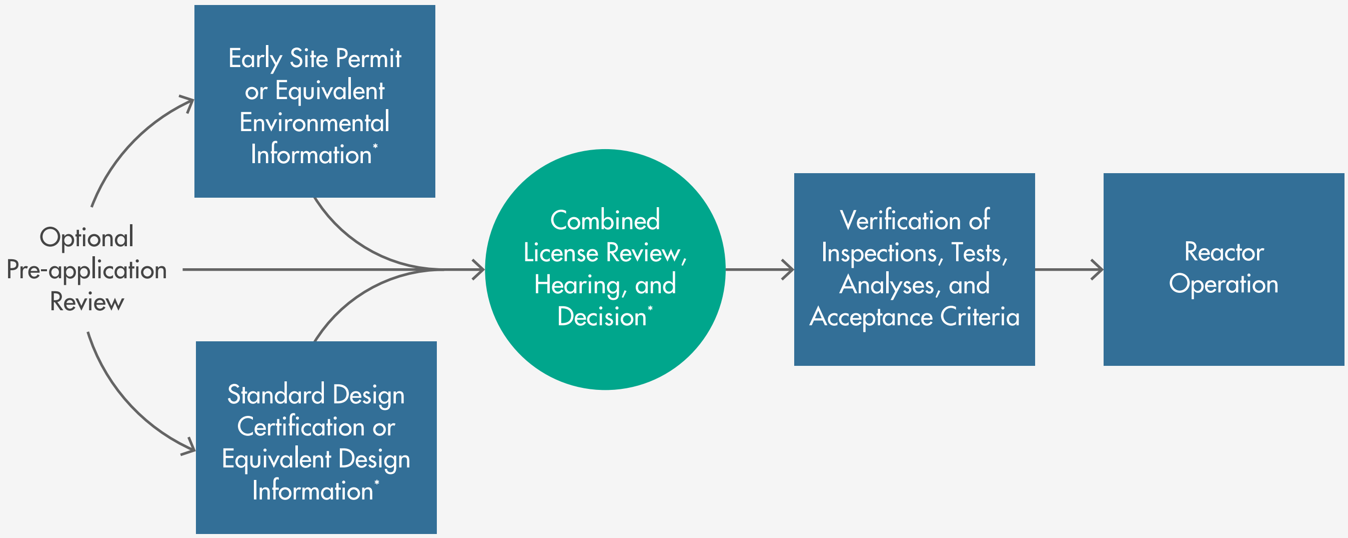
Once issued, an ESP can last for 10 to 20 years depending on the applicant's willingness to incur ongoing costs to maintain the permit and can be renewed for an additional 10 to 20 years [4]. Although existing regulations for ESPs are covered under 10 CFR Part 52, there are proposed rules that allow applicants to utilize an ESP in other licensing pathways [15]. The ESP process typically involves comprehensive reviews, including assessments of environmental factors as well as considerations of emergency preparedness and site safety issues. As of September 2023, only six ESPs have been issued; however, this area of regulation has not stagnated [5]. In a recent announcement, Duke Energy Business Services, LLC, reported it plans to submit an ESP application for the Belews Creek site in Stokes County, North Carolina; the site is currently an operating coal-fueled electric generation plant [16]. This ESP application, expected to be submitted to the NRC by August 31, 2025, involves the potential siting of small modular reactors and advanced reactors, with an anticipated online date by 2035.

The NRC recently issued regulatory guidance on the use of plant parameter envelopes (PPEs)—a set of design parameters that can be used as a surrogate for a specific reactor. The NRC and the Nuclear Energy Institute published regulatory and industry guidance for developing PPEs, respectively [17], [18]. Additionally, the Southern Ohio Diversification Initiative received funding from the DOE to develop an ESP application template, create a template PPE, and provide other supporting documents (expected to be published in early 2024) [19].

ESPs and standard design certifications (SDCs) include information that would be required for a construction permit plus operating license (CP-OL) or a combined license (COL) (Figure 3) [10]. Although neither an ESP or SDC is required, they can be incorporated into the overall CP-OL or COL application. Important advantages are that both permits can be obtained in advance and "banked" for later use, and issues resolved during the ESP or SDC process are not considered again at the CP-OL or COL stage.

[2] The relevant information can be found in subpart A of Part 52. The required contents of an application for an early site permit are found in §52.16 and §52.17, https://www.ecfr.gov/current/title-10/chapter-I/part-52/subpart-A

Figure 3: Relationships between licenses, permits, and certifications [10].



*A combined license application can reference an early site permit, a standard design certification, both, or neither. If the application does not reference an early site permit and/or a standard design certification, the applicant must provide an equivalent level of information in the combine license application

Recreated from reference [10]

The regulatory certainty of an issued ESP lowers the risk associated with a later CP-OL or COL application. This reduced risk can encourage investment and innovation and support long-term planning. ESPs decrease the risks associated with filing full CP-OL or COL applications by providing potential nuclear plant operators with regulatory certainty by addressing significant site-related issues up front. By obtaining an ESP, applicants gain a comprehensive understanding of the site's suitability, allowing them to make informed decisions regarding plant design, safety measures, and operational considerations. Furthermore, it fosters investment and innovation by instilling a higher degree of confidence in the feasibility and viability of the endeavor among investors and stakeholders. Such confidence catalyzes innovation and technological advancements in the nuclear industry while lending support to long-term planning efforts by local utility companies. On a more expansive level, by enabling identification of suitable sites for future plants, ESPs facilitate integration of nuclear energy into the broader energy transition strategy. On an individual plant level, ESPs require early communication with the local community. Early community engagement is essential to ensure fully informed consent to a reactor, allowing community members to express concerns and opinions before major decisions are made. Involving the host community from the outset also shows clear respect for its members' autonomy and acknowledges their stake in the project's outcomes.

4.3 Opportunities to Streamline Regulation

At present, the NRC has set a generic goal of issuing the final safety evaluation for an ESP within 24 months [11]. This timeline needs to be shortened if the NRC is to be able to license many new reactors. Actions could be taken to reduce the timeline, several of which we discuss here:

a. The NRC is in the process of developing a Generic Environmental Impact Statement for Advanced Nuclear Reactors (ANR GEIS) [20]. A generic environmental impact statement (GEIS) is a document prepared by a regulatory agency to assess the potential environmental impacts of a proposed action that are common to multiple projects. Ideally, having a GEIS to reference will streamline the environmental review process for a project. For licensing nuclear reactors, if the proposed project fits within the appropriate parameters, an applicant can incorporate the ANR GEIS by reference and then provide site-specific information in a supplemental document. The ANR GEIS is currently in draft form, awaiting NRC approval since December 14, 2021 [21]. Finalizing the ANR GEIS would not only provide more regulatory certainty to advanced reactor developers but also to those seeking ESPs, as an ESP applicant can reference the ANR GEIS as well [22].

b. In the realm of environmental reviews, distinct processes are employed to evaluate proposed projects. These processes, known as a categorical exclusion (CATEX), environmental assessment (EA), and environmental impact statement (EIS), serve specific purposes in determining the potential environmental consequences of these projects.

- CATEX:
  This term designates a category of actions that federal agencies have determined to have negligible or no significant effect on the human environment. These actions, often routine or minor in nature, are exempt from the requirement for a detailed EA or EIS. While agencies must document the basis for CATEX decisions, no separate extensive environmental analysis document is mandated.

- EA:
  When there is uncertainty regarding a project's environmental impact, an EA is conducted. The EA serves as a concise public document that provides comprehensive evidence and analysis. Its purpose is to determine whether a full-fledged EIS is necessary or if a Finding of No Significant Impact can be issued. During this process, potential impacts, including alternatives, are thoroughly examined. The EA is made accessible for public review and comment, allowing for transparency and community input.

- EIS:
  For major federal actions likely to significantly affect the quality of the human environment, an EIS is imperative. This detailed written statement is a result of rigorous scrutiny, assessing the project's environmental effects and exploring various alternatives in depth. The EIS documents the analysis of environmental impacts, alternatives considered, and responses to public comments. It provides a comprehensive understanding of the project's potential ramifications, ensuring informed decision-making.

c. The NRC historically has employed the EIS excessively, well beyond the requirements of the National Environmental Policy Act (NEPA) of 1970, despite the potential suitability of using less resource-intensive EAs in many cases. Consideration of the CATEX and EAs would present opportunities when determining the appropriate level of application review on a case-by-case basis. In conjunction with other modifications to NEPA, the recently ratified Fiscal Responsibility Act of 2023 (Public Law No: 118-5. Sec. 321) mandates federal agencies to opt for EAs over the more resource-intensive EISs in scenarios where the anticipated outcome of the proposed action does not appear to entail a significant, foreseeable impact on the quality of the human environment or in cases in which the magnitude of impact is indeterminate. This mandate acknowledges the principle that, although the EIS serves a vital role in evaluating noteworthy environmental effects, it is imperative to deliberate on the suitability of commencing with an EA as a preliminary measure. Brownfield sites, such as coal power plants, have already experienced significant impact. Unless the project is anticipated to yield additional substantial impacts, the procedural sequence of NEPA evaluations should begin with an EA, with the transition to an EIS being contingent upon determination of an impact of at least moderate magnitude.

   The practice of requiring an EIS is concerning as the NRC prepares to license a new generation of advanced nuclear reactors that are much smaller and will often be manufactured entirely, or in significant part, off-site. Presently, the NRC considers the issuance of an ESP to be a "major action" that requires a full EIS under 10 CFR 51.20:

   "The following types of actions require an environmental impact statement or a supplement to an environmental impact statement.... Issuance of a limited work authorization or a permit to construct a nuclear power reactor, testing facility, or fuel reprocessing plant under part 50 of this chapter, or issuance of an early site permit under part 52 of this chapter."

   10 CFR 51.20 also requires an EIS for constructing and operating a new nuclear reactor. This decision was made with large LWRs in mind and may not be appropriate for advanced reactors, which in many cases will be far smaller and thus will have less impact on the environment. For example, if an EIS is unnecessary for the use of a microreactor, then an ESP application that uses design

parameters for a microreactor also should not require a full EIS. To address the overuse of the EIS, Congress should instruct the NRC to curtail the number of actions that categorically require an EIS. Instead, the level of environmental evaluation should be determined on a case-by-case basis, allowing a more tailored approach that considers the specific characteristics of each reactor. The recent amendments to NEPA are already in effect, and the NRC is making progress to implement those. changes. The staff intends to prepare an EA to assess the potential environmental impacts of the proposed Hermes 2 facility [23]. This EA will determine whether a FONSI is justified or if the preparation of an EIS is necessary.

Exemptions from NRC regulations including 10 CFR 51.20(b)(1) may be necessary to proceed with the EA approach. The term "exemptions" pertains to special permissions granted by the NRC. T hese exemptions enable the NRC to deviate from specific regulations, ensuring a balance between regulatory compliance and flexibility in response to unique circumstances. Specifically, 10 CFR 51.20(b)(1) mandates preparation of an EIS for issuance of a testing facility CP. To pursue an EA as a route to screen the need for a comprehensive EIS, exemptions are necessary. These exemptions serve two critical purposes:

- Regulatory Efficiency: Opting for an EA, a more streamlined process than an EIS, results in substantial time and resource savings for both the NRC and the applicant. This approach ensures a judicious allocation of resources, especially when the anticipated environmental impact is relatively minimal.
- Risk-Informed Approach: The NRC staff's decision to begin the evaluation with an EA reflects a risk-informed strategy. If the initial EA shows that the environmental impact is not significant, that finding obviates the need for an elaborate EIS. This discerning approach ensures that resources are channeled efficiently, aligning with the project's specific requirements.

The NRC has established an exacting exemption process in 10 CFR 51.6 for interested parties to seek exemptions. Each application for exemption undergoes a rigorous evaluation to ascertain its compliance with legal mandates and its alignment with public interests. The NRC carefully reviews these applications, granting exemptions where justified. These exemptions empower regulatory procedures to be tailored precisely to the distinctive demands of the project, ensuring rigorous compliance with regulatory standards while accommodating project-specific nuances. While exemptions provide a practical short-term solution, they do not address the problem with 10 CFR 51.20.

d. In parallel, the NRC's environmental standard review plan (SRP) requires consideration of the "need for power" (i.e., energy) [24][25]. Although using the SRP is not required, it is functionally mandatory in that if the SRP is not used, the staff will label the application novel, and the process will take much longer with more regulatory risk. These ESPs would be applied in many cases without an explicit need for power. Instead, it is more useful to approach cases from the outlook of repowering sites that have historically provided the community with "needed" power. The "need for power" in these cases is already a prerequisite. An ESP can help streamline the process of saving a coal community with a new nuclear reactor. Doing so isn't a need for power, but a more social need to save a community and provide power in a cleaner way.

5. DOE-LED ESP PROGRAM PROPOSAL

This proposed initiative by BTI will introduce a DOE-led program aimed at expediting decarbonization. This program will seek to streamline the conventional ESP regulatory procedures for both developers and utility companies. By doing so, it will aim to establish a heightened level of regulatory predictability for developers, achieved through the efficient allocation of resources and workforce for conducting comprehensive site assessments across the U.S. Implementing this initiative will involve close collaboration between the DOE and the NRC to facilitate acquisition of ESPs. Under this program, the DOE will categorize CPP sites appropriate for C2N repowering and then systematically rank them based on the requirements of remediation needs. Not all coal plant sites will be suited for repowering with nuclear energy [3]. The Electric Power Research Institute's (EPRI) new report *From Coal to Nuclear: A Practical Guide for Developing Nuclear Energy Facilities in Coal Plant Communities* includes a qualitative repowering tool that conducts a high-level evaluation of the acceptability of coal repowering with alternative clean energy sources [26]. This categorization and prioritization approach will serve as a mechanism to streamline the ESP acquisition process. After the NRC grants an ESP, the DOE will be able to recover the associated costs by subsequently transferring the permits to developers at an equitable expense. Additionally, this program is intended to introduce standardization into the pre-application phase, thereby enhancing the efficiency of NRC reviews and approvals.

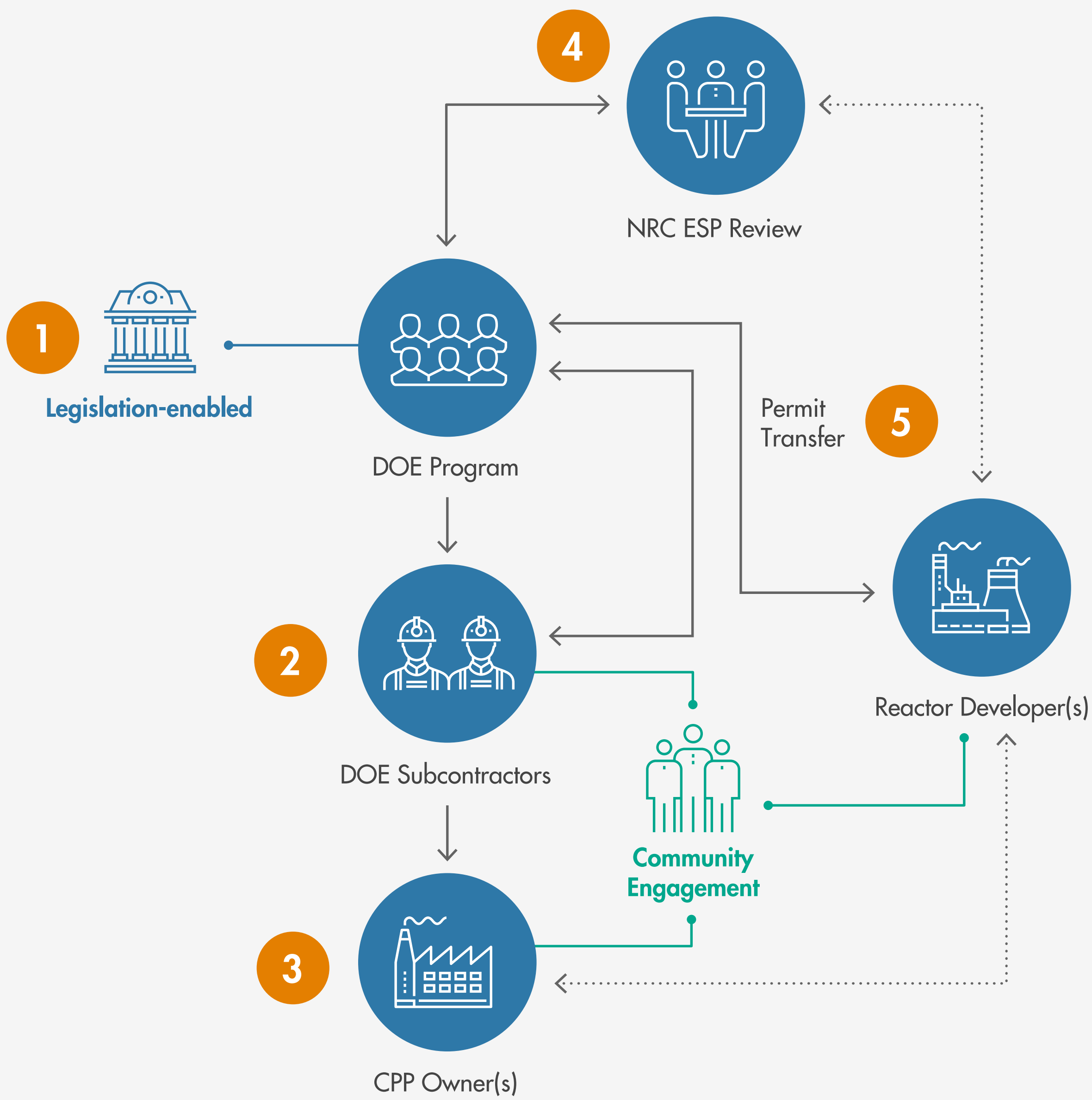
Target. This initiative aims to secure ESPs for sites that have undergone prior site screening analysis to assess their suitability for C2N. The program will primarily focus on obtaining ESPs for *retiring* CPPs with operational and economic infrastructure to enable rapid site characterization and approval. As a secondary focus, it will evaluate *retired* CPPs due to the potential for delays in site readiness depending on the strength of the dated infrastructure. Figure 4 shows a priority map of the proposed DOE program in which "effort" represents the readiness of the surrogate CPP infrastructure and "impact" represents timely completion. The program will have the most impact if it prioritizes CPPs retiring soon or very recently retired rather than prioritizing those that have been retired for several years [3].

Figure 4: Priority map in the proposed DOE program.

Program description. In this program, the DOE alongside coal plant owners will engage in community outreach initiatives at eligible CPP sites set to retire that have potential for C2N repowering, while facilitating a collaborative interface with the NRC during the pre-application phase. The program's leadership and oversight will be provided by the DOE, while subcontracted entities will undertake the task of conducting site-to-site assessments and systematically conveying the results to the DOE. Multiple specialized teams will be assigned specific geographic regions from which they will regularly execute and standardize the assessment of CPP sites. These teams will comprehensively delineate various aspects, including the site's boundaries and attributes; the presence and descriptions of neighboring industrial, military, or transportation facilities and routes; the proposed reactor placement on the site; the spectrum of envisaged reactors; anticipated maximum radiological and thermal emissions; the designated cooling system; radiological dose implications in hypothetical accident scenarios; emergency response plans; analysis of the existing and potential nearby population; and exploration of more advantageous alternative site possibilities [10]. The evaluation of alternative physical sites is a crucial aspect of NEPA review, necessitating a thorough consideration of viable alternatives. The primary objective is to ensure that communities are not prematurely dismissed from consideration solely based on the unsuitability of an existing coal plant for conversion into a nuclear facility. Instead, the focus will be on exploring nearby sites that may present favorable conditions for a nuclear plant. The Natrium site serves as a prominent illustration of such a potential alternative [27]. The program's organizational structure will embody a commitment to ongoing learning and improvement, facilitated by DOE management. The overarching aim is to continually refine the site characterization process, with the ultimate objective of cost reduction. The results derived from these site assessments will undergo rigorous scrutiny by the DOE and subsequently be incorporated into both the pre-application and application packages.

This proposal aligns with the framework depicted in Figure 5, where legislation empowers initiation of the DOE-led mass ESP acquisition program. Once this legislation is enacted, it will provide an incentive for developers of advanced reactors to collaborate with CPP owners nearing plant retirement. Their task will be to assess the site's suitability for repowering with nuclear energy technology. If the site proves viable both operationally and economically, CPP owners can present a repowering plan to the community. Subsequently, the DOE or an identified DOE subcontractor will conduct a site assessment and prepare an ESP application for submission to the NRC. The NRC will conduct a comprehensive review and subsequently issue the ESP, with the DOE as the primary holder. Reactor developers interested in the site would then engage with the DOE to obtain the ESP through a permit transfer process. Our proposed model is similar to and supported by a model previously proposed by the Nuclear Reactor Innovation Center [28].

Figure 5. Schematic demonstrating the program proposal and multi-stakeholder engagement.



Streamlining through standardization. Utilizing specialized experts dedicated to the collective assembly of ESP applications offers distinct advantages. The proposed program holds promise for enhancing the efficiency of the ESP approval process, aiming to generate a substantial number of standardized ESPs. The adoption of a standardized format, with guidance on the minimum information necessary to meet NRC requirements, for these ESPs is expected to expedite both NRC reviews and the application compilation process for applicants. Furthermore, establishing a generic ESP application has the potential to significantly decrease the volume of requests for additional information

(RAIs) from NRC staff, leading to substantial reductions in licensing durations. We encourage the NRC to embrace these prospective enhancements for regulatory efficiency and effectiveness.

5.1 Legislative and Regulatory Milestones

Incorporating the proposed DOE program, Figure 6 shows a high-level overview of the distinct phases and milestones in the C2N transition. The proposal assumes a need for legislative approval to create and activate the program to perform site characterizations from which ESPs will be issued by the NRC. Additional regulatory review and approval of a COL are expected to follow, as well as final regulatory administrative efforts before initiating the C2N construction process. We evaluated the high-level process shown in Figure 6 on expedited, estimated, and delayed timelines to assess the potential implications of urgent action or lack thereof for the C2N transition. The estimated timeline was largely approximated based on the generic schedules published by the NRC. The expedited timeline generally accelerates the estimated timeline by subtracting a year for each phase, except at the site characterization phase. On the other hand, the delayed timeline sets back the estimated timeline by adding at least an additional year per phase. Table 1 provides an overview of three scenarios based on possible timelines for the milestones in Figure 6. Readers are advised to consider that the timeline estimates presented in Table 6 are intended to illustrate the duration of each phase and do not necessarily reflect the current feasibility from a precise chronological standpoint.

Figure 6: High-level overview of milestones identified in C2N transition.

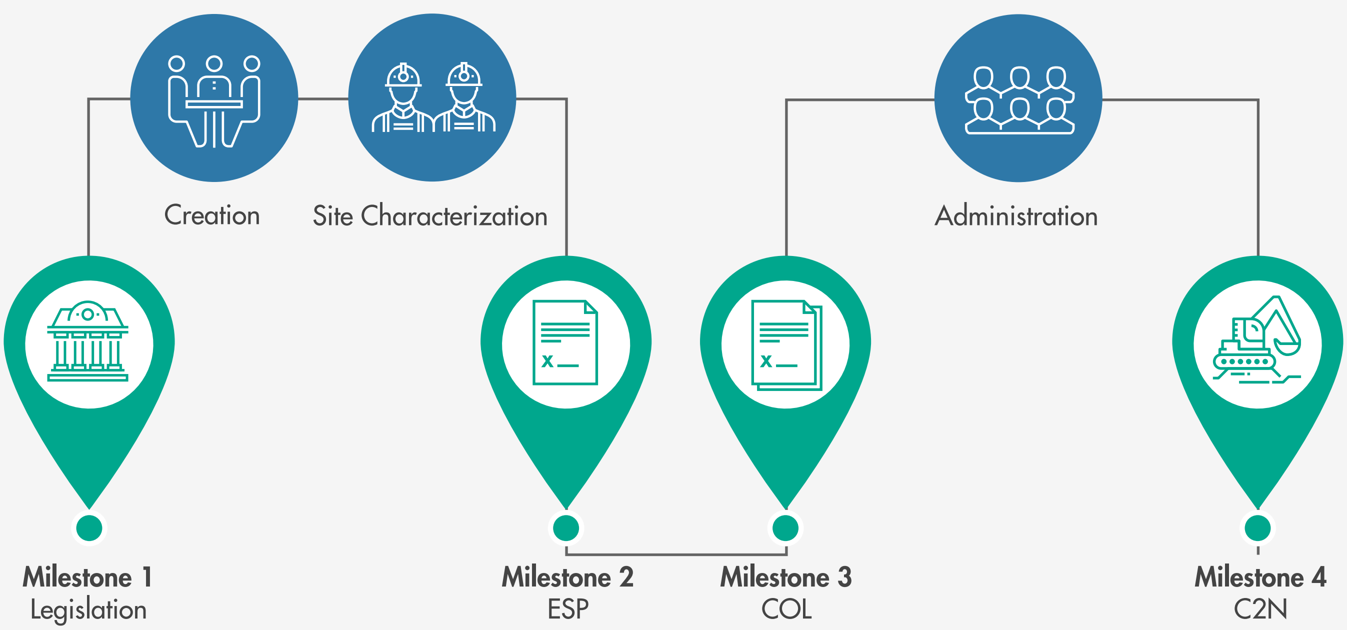
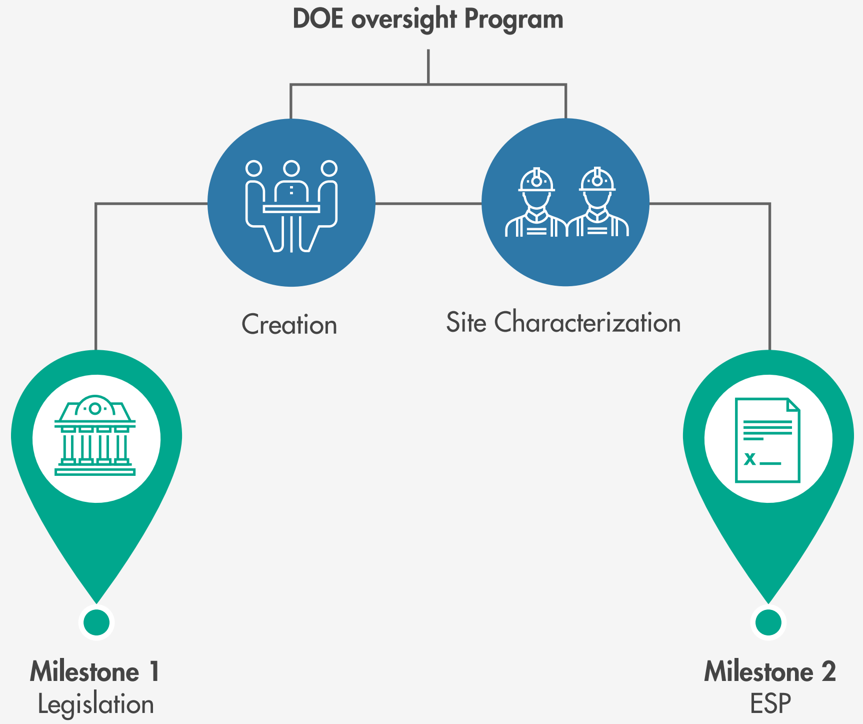


Table 1: Three primary scenarios predicated on potential milestone timelines.

	Milestone 1	Milestone 2			Milestone 3	Milestone 4	
Scenario	Legislation	Creation of Program	Site Characterization	ESP Issued	COL Issued	Admin	C2N Begins
Expedited	2024	2024	2025	2028	2030	2031	2031
Estimated	2025	2026	2028	2030	2033	2035	2035
Delayed	2026	2029	2032	2035	2039	2042	2042

The proposed program aims to streamline the process up to ESP issuance (Milestone 2) as shown in Figure 6 (streamlining other milestones shown in that figure is outside the scope of this study). Consequently, for the expedited, estimated, and delayed timelines up to ESP issuance, the program will focus on CPPs retiring before 2028, 2030, and 2035, respectively. For those CPPs retiring before the program is created, the program's focus will be on community engagement in those locations as well as pre-engagement with the NRC.

Figure 7: ESP-specific milestones associated with DOE-led ESP program.



5.2 Eligibility and Possible Outcomes of Retiring CPP Sites

The U.S. Energy Information Administration (EIA) database was used to investigate the status of CPPs with announced retirements, and we determined eligibility of the CPP sites for the proposed DOE-led ESP program on the start-up timelines discussed in the previous section. This study assumes that the announced retirement date of each CPP coincides with the dates of generators with the earliest announced retirement. For example, the Kingston CPP has nine generators, with three retiring in 2026 and the remaining six in 2027; therefore, the plant retirement year is assumed to be 2026. The retiring CPPs considered in this study are those that have planned retirement according to the EIA [29]. It is noteworthy that not all brownfield sites can support a C2N transition; rather, each site will need to be screened for repowering with the appropriate alternative energy source [3]. To make a case for the value of the proposed program, the following sections will address the CPP profile of the U.S. in mid-2023.

As of May 2023, there were 60 CPP sites (totaling 59,955 MW nameplate capacity) with announced retirement dates (2023-2040) and another 185 (totaling 147,162 MW nameplate capacity) without announced retirements. That is, only 29% of the total CPP capacity in the U.S. has announced retirement timelines, though retirement announcements are expected to increase as time progresses. With a large number of CPPs still far away from retirement, there is an opportunity to alleviate the regulatory burden for ESPs by creating a program to investigate the eligibility of retiring CPPs consistently and efficiently for advanced nuclear transition. Without such a program, there will inevitably be a lack of predictability, which will not only increase the regulatory burden but will discourage CPP owners and utility companies from the C2N transition, devastate local economic activity and employment, and result in a failure to rapidly decarbonize. Table 2 summarizes the number of CPPs that will retire in various timelines. The longer the activation of such a program, the more rapid the deterioration of critical infrastructure necessary for the advanced nuclear reactor transition. There are 39 CPP sites with 73 associated generators retiring before 2028. As the timeline progresses, that number increases to 55 CPP sites with 116 retiring generators by 2035. The regulatory burden to issue ESPs for these sites will only increase without a guarantee of regulatory certainty. On the delayed timeline, by 2035 a total of 53,858 MW of retired energy production will need to be replaced.

Table 2: Existing landscape of retiring CPP sites as a function of projected timelines.

Timeline	Retiring Before	No. of CPP sites	Total No. of Generators	Approx. Total Nameplate Capacity, MW
Expedited	2028	39	73	32,636
Estimated	2030	50	96	46,684
Delayed	2035	55	116	53,858

The sooner the proposed DOE-led ESP program is activated, the higher the likelihood of obtaining ESPs for many CPPs before their announced retirement (Table 3). For example, if the program is active within five years on the expedited schedule, then between 2028 and 2040 a total of 26 CPPs will have acquired ESPs. If the program is active within seven years on the estimated schedule, then between 2030 and 2040, a total of 12 CPPs will have ESPs. If the program becomes active in 12 years on the delayed schedule, then between 2035 and 2040, only five CPPs will have ESPs. The expedited timeline offers the most advantage for a program active within the next five years. Of course, this review only considers CPPs with announced retirement dates as of May 2023. As other CPPs announce retirements, the number of eligible CPPs for the program will increase.

Table 3: Existing landscape of CPP sites eligible for the program as a function of timelines.

Timeline	If Active by	No. of Eligible CPPs	No. of Generators	Total Installed Capacity, MW
Expedited	2028	26	55	27,319
Estimated	2030	12	32	13,271
Delayed	2035	5	12	6,097

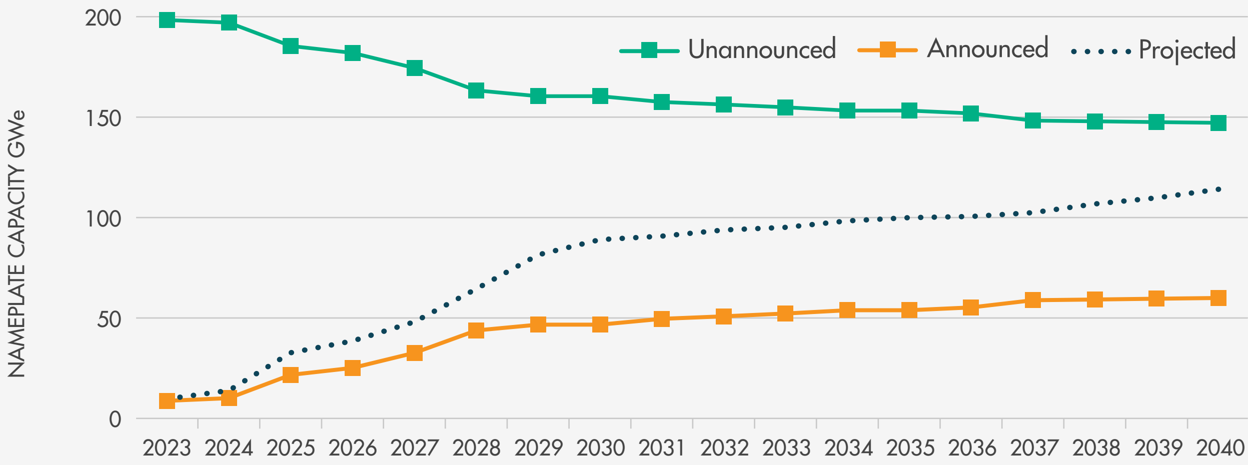
6. RETIRING COAL-FIRED AND NATURAL GAS PLANTS

It is possible to expand the scope of brownfield sites with the potential for placement of advanced nuclear reactors to include natural gas plants (NGPs). The coal and natural gas technologies we considered are coal-integrated gasification combined cycle, conventional steam coal, natural gas-fired combined cycle, natural gas internal combustion engine, and natural gas steam turbine. The EIA publishes data on the energy landscape of all energy sources being utilized in the U.S. Using the EIA database, we investigated and compared the nameplate capacity of announced, unannounced, and projected retirements of both coal and gas plants for the U.S. as a whole and by region [29][30].

6.2 Coal

Figure 8 shows the cumulative nameplate capacity of operating CPPs as of May 2023 as a function of the retirement year for announced, unannounced, and projected retirements. The cumulative retiring capacity of CPPs is projected to dramatically increase by 2030: an estimated nine times the cumulative retiring capacity in 2023. The loss in generating capacity from retiring CPPs will require replacement by reliable clean energy sources, and nuclear energy will inevitably play a major role in the required transition. The comparison of the announced, unannounced, and projected retirements of CPPs by cumulative nameplate capacity shows a discrepancy between the announced and projected retirements. Figure 8 shows the stark difference between announced and unannounced retirements, where the capacity of CPPs with unannounced retirements is almost three times that of the capacity of CPPs with announced retirements. The difference in unannounced and announced retirements demonstrates the immense challenge ahead to arbitrarily evaluate those brownfield sites for clean energy replacement.

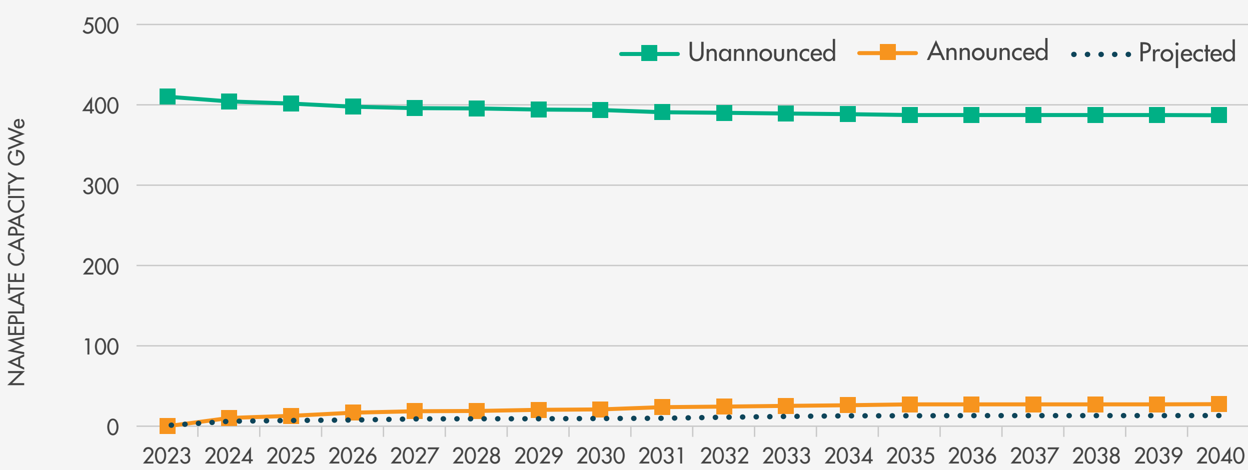
Figure 8: U.S. CPP cumulative nameplate capacity as a function of time.



6.3 Natural Gas

While the announced retirement of CPPs shows a clear increase over time, the announced retirement of NGPs is largely uniform. Figure 9 depicts the cumulative nameplate capacity of currently operating NGPs as a function of retirement year for announced, unannounced, and projected retirements. Even more surprising is the projected retirement of NGPs, which underestimates those retirements. The data shows that, unlike CPPs, NGPs will continue to operate, largely maintaining existing operating capacity in the long term. The total capacity of NGPs is two times that of CPPs in 2023, suggesting that natural gas is playing a dominant role in energy generation and will continue to do so. Between 2023 and 2040, unannounced NGP capacity will decrease by only 5.6%.

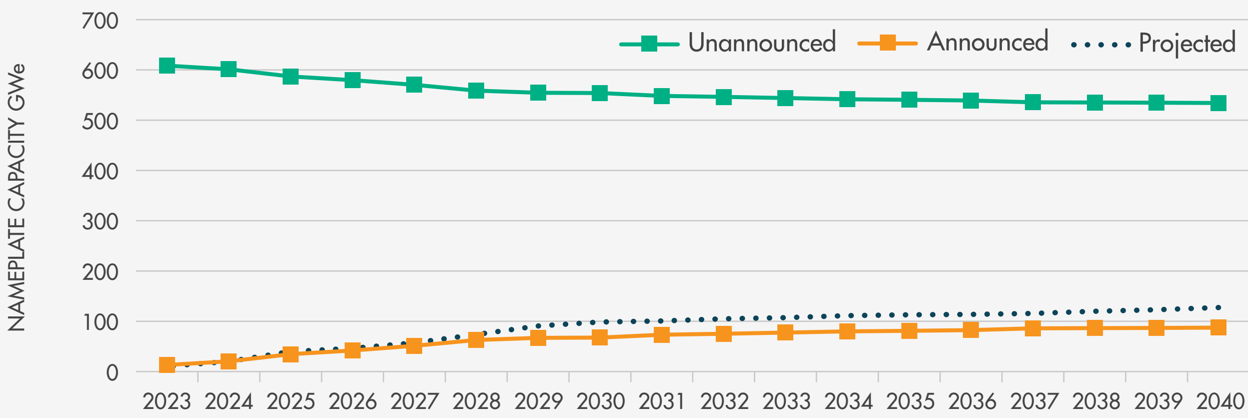
Figure 9: U.S. NGP cumulative nameplate capacity as a function of time.



6.4 Coal and Natural Gas

A joint assessment of the evolving capacity of announced, unannounced, and projected retirement for CPPs and NGPs is shown in Figure 10. There is a distinct gap between those operating plants with announced retirements and those without announced retirements. The trend shown does not reflect a rapid decarbonization effort to address the climate emergency; instead, it reveals a steady, slow-paced effort to remove carbon-intensive energy sources. Of the unannounced retirement capacity, only 1% will be retired by 2040. The projected retirement capacity aligns with the announced retirement capacity up to 2027, at which point projected and announced capacity retirements deviate. Nevertheless, neither the projected nor announced capacity retirements are increasing at a rapid enough rate to displace carbon emissions from coal and natural gas plants.

Figure 10: U.S. coal and natural gas cumulative nameplate capacity as a function of time.



7. CPP AND NGP ELIGIBILITY FOR C2N TRANSITION

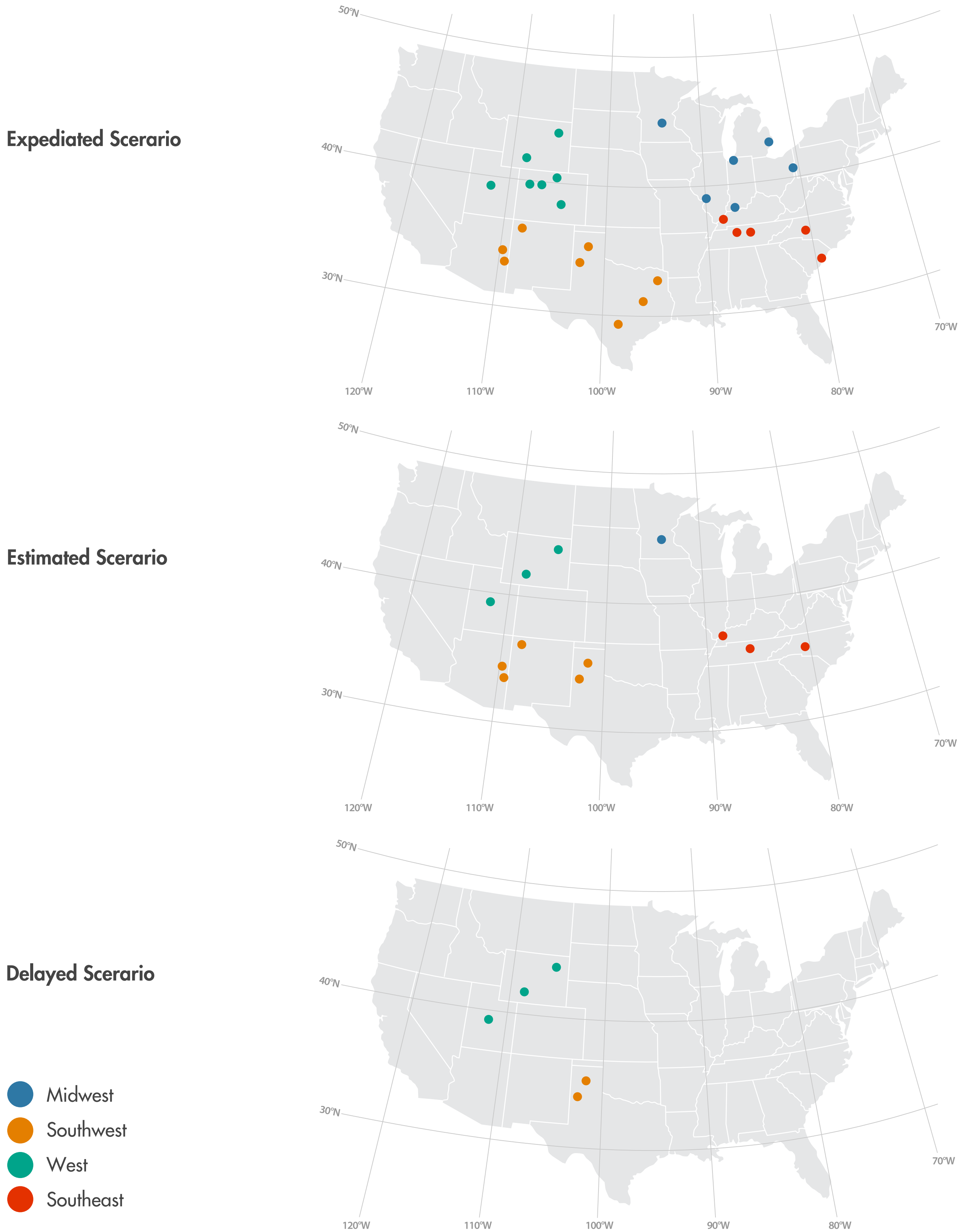
In alignment with a 2022 DOE report [3], our analysis divides the U.S. into five main regions: Midwest, Northeast, Southeast, Southwest, and West. Table 4 lists the states included in each region. With a focus on the CPP sites with announced retirement, we mapped their locations based on the DOE-led ESP program initiation according to the expedited, estimated, and delayed timelines.

Table 4: Categorization of U.S. by region.

Midwest	Northeast	Southeast	Southwest	West
Illinois	Connecticut	Alabama	Arizona	Alaska
Indiana	Delaware	Arkansas	New Mexico	California
Iowa	Maine	Florida	Oklahoma	Colorado
Kansas	Maryland	Georgia	Texas	Hawaii
Michigan	Massachusetts	Kentucky		Idaho
Minnesota	New Hampshire	Louisiana		Montana
Missouri	New Jersey	Mississippi		Nevada
Nebraska	New York	North Carolina		Oregon
North Dakota	Pennsylvania	South Carolina		Utah
Ohio	Rhode Island	Tennessee		Washington
South Dakota	Vermont	Virginia		Wyoming
Wisconsin		West Virginia		

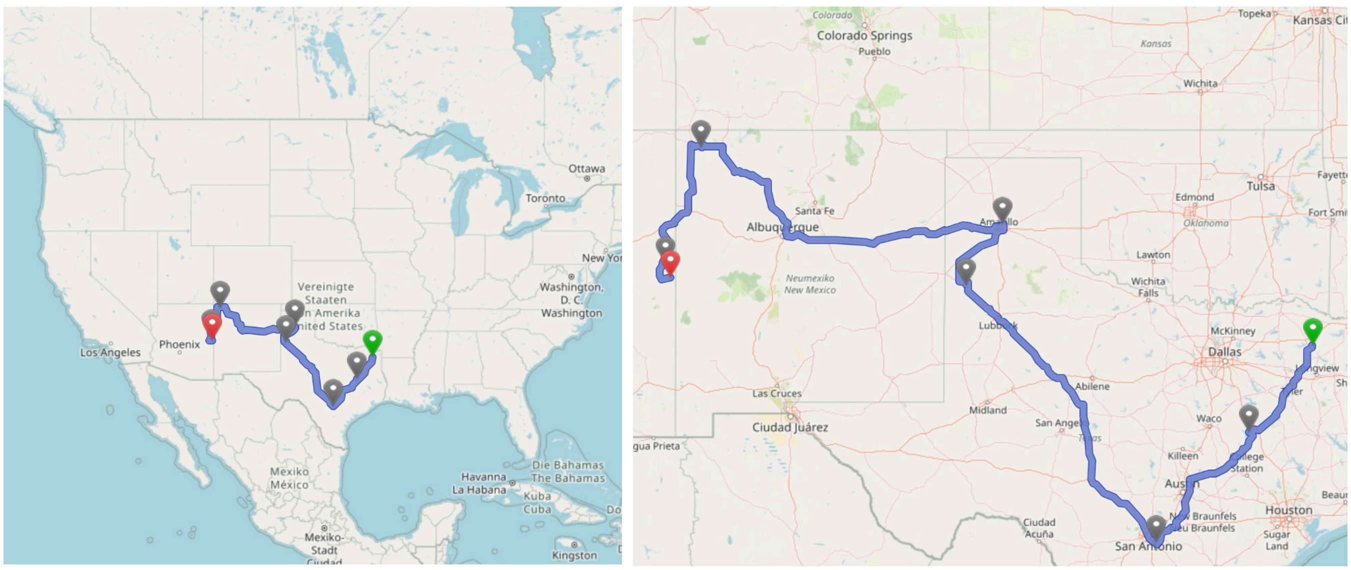
In the expedited timeline scenario, the majority of CPPs eligible to benefit from the new program are in the West and Southwest (Figure 11). In the estimated timeline scenario, the number of eligible coal plants with announced retirement reduces by more than half of that shown for the expedited timeline. In other words, although the estimated timeline shows an opportunity for eligible CPPs to acquire ESPs, the real value proposition lies in the expedited timeline—the as quickly as reasonably achievable option. Certainly, as delays occur, the timeframe for achieving rapid decarbonization will diminish, as demonstrated in the delayed timeline scenario. Though further retirement announcements are expected as time progresses, this scenario can be accompanied by the maximum value of the expedited scenario.

Figure 11: Eligibility of CPP sites in three timeline scenarios by U.S. region.



We assessed the CPP locations, as defined by the five main regions, to determine route mapping by the subcontracted teams assigned to specific regions for site-to-site characterization. Because there are five regions, five main teams will perform the activities required for site characterization as described in Section 4.2. The five main teams will perform site-to-site characterization based on an efficiently planned route from one CPP to another in their regions. For example, Figure 12 shows a defined site-to-site mapping by motor vehicle for the West region to optimize efficiency while standardizing CPP site assessment. Of course, alternative modes of transportation can be considered. The takeaway is that site-to-site characterization will occur in multiple regions in parallel.

Figure 12: Route mapping for retiring CPPs in western U.S.



8. EXPECTED INCREASE IN CPP RETIREMENT ANNOUNCEMENT

Announcements of CPP site retirements are expected to increase as CPPs are forced out of the market to accommodate global demand for cleaner, safer, and more reliable energy technologies, not limited to nuclear energy. However, it follows that CPP site eligibility for the C2N transition is expected to increase, creating more opportunities for an already standardized and efficient DOE-led ESP acquisition process to facilitate rapid decarbonization. Furthermore, expediting CPP retirements would enhance the overall value of the ESP program. Of the total 263,699 MW nameplate capacity of retired CPPs from January 2002 to April 2023, 81,221 MW have been retired for five or more years. CPPs eligible for C2N will require similar site characterization as their currently operating counterparts with announced retirement; however, the level of remediation and infrastructure development is likely to be greater.

9. COST- AND TIME-SAVING RECOMMENDATIONS

Efficiency gains can be achieved by implementing several key measures, including:

1. Establishing standardized and consistent site characterization expectations.
2. Developing standardized data collection processes and streamlined scopes.
3. Implementing a uniform application format and content structure.
4. Reducing the frequency of RAIs and audits through the above-described standardization efforts.
5. Promoting a predictable exchange of information between the DOE and the NRC.

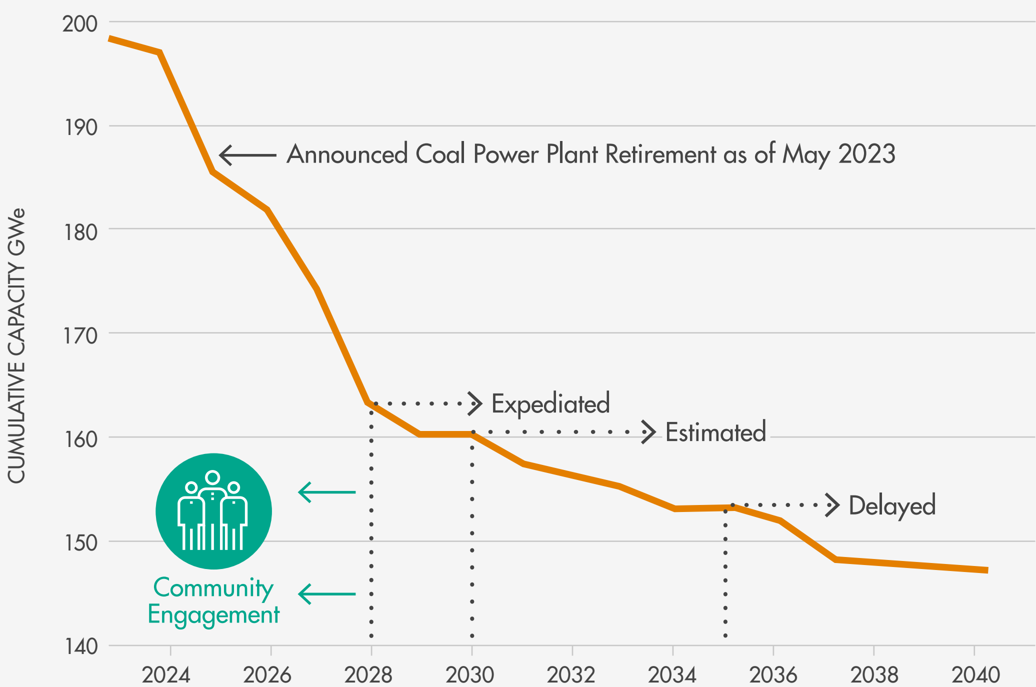
The primary objective of these measures is to streamline the application process by reducing the need for extensive document reconsideration and instead focusing on the technical distinctions between different sites. It is essential to emphasize that the anticipated improvements will only materialize if all involved parties effectively implement these measures. Collaboration and adherence to these standardized processes are critical for realizing the full potential of increased efficiency.

The cost of NRC ESP regulator reviews has significantly increased over time, according to the report *Recommendations for Enhancing the Safety Focus of New Reactor Regulatory Reviews*, published in April 2018 by the Nuclear Energy Institute (NEI). For example, the regulatory review cost of ESPs has tripled between 2009 and 2016. Moreover, the NEI study found that safety enhancements to reactor designs have not resulted in a significant reduction in regulator review costs. With correction to 2018 inflation, the cost for ESP regulatory reviews from 2007 to 2018 ranged from $6 million to $19 million.

One of the notable contributors to the lengthy time and expense of the ESP regulatory review process is the generation of RAIs when the applicant has not provided sufficient information. These numerous RAIs result in unnecessary delays, emphasizing the need for improved management discipline in addressing them promptly. For example, the most recent NRC-issued ESP had 13 RAIs that had to be addressed, adding 17 months to the review timeline. Consequently, more clarity from the NRC based on lessons learned is needed to minimize this impediment. The need to streamline the ESP regulatory review process while reducing associated costs is widely recognized. For this effort, the advanced reactor development community is focusing on streamlining the regulatory review process by guiding PPE. Our proposal takes a similar approach with the goals of increasing efficiency and regulatory certainty for ESP reviews by creating a DOE-led program that standardizes the site characterization process.

There would be obvious time savings for implementing the proposed DOE-led program because it will streamline the ESP review process by standardizing CPP site evaluation and reduce the regulatory burden on the NRC. The program would significantly decrease lengthy reviews via generation of RAIs and create a predictable consistent exchange between the DOE licensing team and the NRC. Figure 13 shows the nameplate capacity loss of the retiring CPP generators over time and compares the impact of initiating the program on the expedited, estimated, and delayed timelines. The graph demonstrates that the earlier the ESPs are issued, the more likely the C2N transition will begin in the 2030s. With the first ESPs being issued by 2028 on the expedited timeline, the window for C2N transition is already narrow, leaving the estimated and delayed timelines unfavorable to meet the transition demand.

Figure 13: U.S. cumulative CPP capacity retirement with time.



10. OTHER RECOMMENDATIONS FOR INCREASING PROGRAM EFFICIENCY

EPRI's new report *From Coal to Nuclear: A Practical Guide for Developing Nuclear Energy Facilities in Coal Plant Communities* references a coal plant technology screening tool to evaluate the best energy source transition for CPP sites [26]. The tool requires multiple inputs to qualitatively grade site attributes including geology, cooling water supply, nearby hazardous land uses, population atmospheric dispersion, groundwater radionuclide pathway, disruption of habitat, pumping distance, and available land, among others. EPRI's siting tool provides a good preliminary survey to determine the eligibility of a CPP site for replacement with other energy sources including nuclear energy. Terra Praxis is working on digital tooling to accelerate pre-development activities for delivering nuclear power plants.

11. ESP TRANSFER FROM DOE TO DEVELOPER

10 CFR 52.28 states that the process for an application to transfer an ESP is found in 50.80. First, no license can be transferred without the written consent of the NRC. An application to transfer an ESP under Part 52 should include "as much of the information described in §§ 52.16 and 52.17 of this chapter concerning the identity and technical qualifications of the proposed transferee as would be required by those sections if the application were for an initial license." Additionally, the application must include "a statement of the purposes for which the transfer of the license is requested, the nature of the transaction necessitating or making desirable the transfer of the license, and an agreement to limit access to Restricted Data according to § 50.37."

Upon providing notice to interested parties and completing other necessary procedures, the NRC will approve a transfer application if it finds that the proposed transferee is qualified and that the "transfer of the license is otherwise consistent with applicable provisions of law, regulations, and orders issued by the Commission pursuant thereto." At present, the draft Part 53 does not introduce any alterations to the process of transferring an ESP (though the financial qualification provisions are reserved, so that could change the information needed in an application depending on how it is written). In fact, the draft Part 53 merely reformats the regulation: instead of a subsection listing what is required to transfer each type of license (OL, manufacturing license, ESP, etc.), it addresses all the license types in one subsection. For Framework A, 53.1170 addresses transfers of ESPs and is functionally the same as 52.28 in that it sends applicants to a different section that governs transfers of licenses broadly. In this case, that section is 53.1570 (the functional equivalent of 50.80). 53.1570 directs the applicant to 53.1109, which contains generic information required in applications. Framework B works the same way.

12. ESSENTIAL STEPS

12.1 Community Engagement

The community engagement process required for the C2N transition is not unlike the typical process for siting a new reactor at a greenfield site. Community engagement with residents, stakeholders, and other groups plays a pivotal role in fostering transparency when siting a nuclear reactor. This engagement would be led by the coal plant owners/operators, the DOE, and the NRC to gather input, address concerns, and build public trust throughout the decision-making process. Before issuance of the first ESP in 2028 under the proposed program, efforts will need to focus on five main areas:

1. Passing legislation to mandate the DOE to create the new DOE-led ESP program.
2. Funding the program.
3. Creating and organizing the program, including staffing at the DOE and NRC.
4. Having the DOE engage with the NRC and with communities near existing CPP sites.
5. Performing site characterizations for the first CPPs to obtain ESPs by 2028.

12.2 Enabling Rapid Decarbonization through Legislation

The imperative for legislation to support a program for rapid decarbonization via nuclear energy is driven by the urgent global need to combat climate change and ensure a reliable and sustainable energy future. Legislation offers a framework to accelerate nuclear energy deployment while ensuring safety, regulatory clarity, and a cohesive approach. Clear rules can expedite approvals, attract investments, and facilitate collaboration among diverse stakeholders. Legislative backing can also foster research, innovation, and public-private partnerships essential for technological advancements. Legislation provides stability amidst political shifts and promotes consistent progress. It necessitates public engagement, ensuring transparency, trust-building, and shared ownership of decarbonization efforts. Ultimately, the legislation serves as the linchpin for a comprehensive approach to swiftly achieving decarbonization goals.

13. SUMMARY

This report proposes a DOE-led ESP program that aims to expedite the transition from coal to nuclear power in the U.S. The program focuses on streamlining the process of obtaining ESPs for retiring CPPs with existing operational infrastructure. The goal is to achieve rapid decarbonization while minimizing the negative community impacts and delays caused by regulatory hurdles. The proposed program involves site-to-site evaluations conducted by a contractor and overseen by the DOE. Community engagement and collaboration with the NRC are central to the process. The proposed program will categorize CPP sites based on their need for remediation and rank them for priority acquisition of ESPs. The program aims to establish regulatory certainty for developers by efficiently obtaining ESPs, which will be transferred to developers at an equivalent cost. Standardization of the ESP application process is a key aspect of the program, potentially reducing review time and minimizing RAIs from the NRC. The program's structure includes continuous learning to streamline site characterization and reduce costs. This report provides a high-level overview of the proposed program and timelines for the C2N transition process. The program assumes the need for legislative approval to initiate site characterizations, followed by NRC approval for ESPs and subsequent regulatory phases for COLs and construction. The BTI-proposed program takes an innovative approach to overcoming regulatory challenges for nuclear energy and accelerating the transition to cleaner energy, aiming to achieve both environmental benefits and economic growth in local communities.

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