EPRI

2023 SOFTWARE MANUAL

Coal Plant Repowering: A White Paper Series

Screening Evaluation Tool for Potential Coal-Fired Power Plant Repowering Options

Coal Plant Repowering: A White Paper Series

Screening Evaluation Tool for Potential Coal-Fired Power Plant Repowering Options

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Software Manual, September 2023

EPRI Project Manager
L. Millet, P.G.

EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA
800.313.3774 ▪ 650.855.2121 ▪ askepri@epri.com ▪ www.epri.com

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EPRI prepared this report.

Principal Investigators
R. Niehaus, P.E.
L. Millet, P.G.

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Leonard Angello	Tracy Leslie
Magaly Flores Armenta	Cara Libby
Brenda Brickhouse	Caleb Tomlin
Sean Bushart	Wynter McGruder
Caleb Cooper	Erin Minear
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SOFTWARE DESCRIPTION

This software allows users to screen sites for the technological feasibility of generation development.

Description

This research evaluated the assets typically available at coal-fired power plants and developed a screening tool that correlates those assets to the needs of low- and no-carbon generation. The screening tool allows users to input information about individual sites and quickly identify feasible generation technologies for an individual site or for an entire fleet. The baseline tool provides a standardized methodology for the industry, allowing comparison across disparate sites regardless of location or individual characteristics. The screening tool also provides the option for user customization to allow utilities to make method adjustments based on their needs and priorities.

The screening tool was developed in conjunction with a series of white papers examining the considerations for repowering a coal-fired power plant for advanced nuclear reactors, battery energy storage systems, bulk energy storage, hydrogen production with electrolysis, natural gas and hydrogen generation, and solar photovoltaic generation. The series also examined the equity and environmental justice considerations for repowering, as well as the potential to repower coal-fired power plants as a hub for a net zero industrial cluster.

Benefits and Value

- Operating or recently retired coal-fired power plants have many assets that could be beneficial for the development of low- or no-carbon generation.
- Repurposing existing site assets and permits has the potential to reduce the time and cost of developing new generation.
- Development of a standardized methodology provides the capability to quickly screen large numbers of sites for technological feasibility regardless of the site location or characteristics, and provides a baseline for evaluations across the industry.
- The baseline evaluations may be useful when engaging internal or external stakeholders with regard to technological feasibility for repowering, and as a point of comparison to evaluations performed by the utility or third parties.
- Allowing utilities to customize the baseline developed for this screening tool provides the flexibility to build on the base case with consideration for the company’s needs and priorities as they begin to transition from coal-fired to low- or no-carbon generation.

Platform Requirements

Windows 10 or newer, Microsoft Office Excel 2016 or newer.

ABSTRACT

This research evaluated the assets typically available at coal-fired power plants and developed a screening tool that correlates those assets to the needs of low- and no-carbon generation. The screening tool allows users to input information about individual sites and quickly identify feasible generation technologies for an individual site or for an entire fleet. The baseline tool provides a standardized methodology for the industry, allowing comparison across disparate sites regardless of location or individual characteristics. The screening tool also provides the option for user customization to allow utilities to make method adjustments based on their needs and priorities.

The screening tool was developed in conjunction with a series of white papers examining the considerations for repowering a coal-fired power plant for advanced nuclear reactors, battery energy storage systems, bulk energy storage, hydrogen production with electrolysis, natural gas and hydrogen generation, and solar photovoltaic generation. The series also examined the equity and environmental justice considerations for repowering, as well as the potential to repower coal-fired power plants as a hub for a net zero industrial cluster.

Keywords

Coal-fired power plant
Repowering
Advanced nuclear technologies
Low-carbon technologies
No-carbon technologies
Screening evaluation

EXECUTIVE SUMMARY

Primary Audience: Utility or energy developer personnel evaluating coal-fired power plants for repowering options

Secondary Audience: Utility or energy developer personnel evaluating sites for new generation siting

KEY RESEARCH QUESTION

As economic, regulatory, and carbon reduction goals evolve, the viability and desirability of operating coal-fueled generating assets continue to decline. Utilities are evaluating former coal-fired plant sites for opportunities to add low- or no-carbon generation while managing the time and cost associated with development and construction. Evaluating the conversion of an existing coal-fired fleet can be performed by systematically creating an inventory of the existing site infrastructure, characteristics, permits, and other attributes, and correlating it with the needs of the evolving energy system with attention to maximizing useful service for both the company and the local community.

RESEARCH OVERVIEW

This research evaluated the assets typically available at coal-fired power plants and developed a screening tool that correlates those assets to the needs of low- and no-carbon generation. The screening tool allows users to input information about individual sites and quickly identify feasible generation technologies for an individual site or for an entire fleet. The baseline tool provides a standardized methodology for the industry, allowing comparison across disparate sites regardless of location or individual characteristics. The screening tool also provides the option for user customization to allow utilities to make method adjustments based on their needs and priorities.

The screening tool was developed in conjunction with a series of white papers examining the considerations for repowering a coal-fired power plant for advanced nuclear reactors, battery energy storage systems, bulk energy storage, hydrogen production with electrolysis, natural gas and hydrogen generation, and solar photovoltaic generation. The series also examined the equity and environmental justice considerations for repowering, as well as the potential to repower coal-fired power plants as a hub for a net zero industrial cluster.

KEY FINDINGS

- Operating or recently retired coal-fired power plants have many assets that could be beneficial for the development of low- or no-carbon generation.
- Repurposing existing site assets and permits has the potential to reduce the time and cost of developing new generation.

- Development of a standardized methodology provides the capability to quickly screen large numbers of sites for technological feasibility regardless of the site location or characteristics, and provides a baseline for evaluations across the industry.
- The baseline evaluations may be useful when engaging internal or external stakeholders with regard to technological feasibility for repowering, and as a point of comparison to evaluations performed by the utility or third parties.
- Allowing utilities to customize the baseline developed for this screening tool provides the flexibility to build on the base case with consideration for the company's needs and priorities as they begin to transition from coal-fired to low- or no-carbon generation.

WHY THIS MATTERS

As utilities are transforming their fleets to low- or no-carbon generation, the ability to quickly screen generation technologies may allow utilities to identify and repurpose assets from the coal-fired fleet to assist with management of cost and schedule for new generation development. The use of a standardized method for the initial evaluations provides a starting point for discussion of repowering options with internal and external stakeholders, while the flexibility to customize the method for company needs and priorities allows utilities to adapt the baseline model for internal evaluations.

HOW TO APPLY RESULTS

The output from the screening tool can be used to understand what generation technologies are more likely to be technologically feasible for a specific site. This information can be used to engage internal and external stakeholders, compare with evaluations performed internally or by third parties, and to prioritize additional studies to select an appropriate repowering technology.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- *Equity and Environmental Justice Considerations for Coal-Fired Plant Repowering* 3002026486
- *Repowering Coal-Fired Power Plants for Natural Gas and Hydrogen-Fired Generation* 3002025894
- *Repowering Coal-Fired Power Plants for Battery Energy Storage* 3002025591
- *Repowering Coal-Fired Power Plants for Bulk Energy Storage* 3002025590
- *Repowering Coal-Fired Power Plants for Hydrogen Production with Electrolysis* 3002025895
- *Repowering Coal-Fired Power Plants for Advanced Nuclear Generation* 3002025482
- *Repowering Coal-Fired Power Plants for Solar Photovoltaic Generation* 3002022919
- *Repowering Coal-Fired Power Plants to Anchor Net Zero Industrial Clusters* 3002026481

EPRI CONTACTS: Lea Millet, P.G., Senior Technical Leader, lmillet@epri.com

PROGRAM: Plant Decommissioning and Site Redevelopment, Program 255

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Installation of EPRI Software at Client Site

This software uses third party software products, operating systems, and hardware platforms. Over time, security issues may be uncovered in these third-party products. You should review your use of this software with your Information Technology (IT) department to ensure that all recommended security updates and patches are installed to all third-party products when needed.

If you experience difficulties accessing the application

If you experience difficulties accessing the application after standard installation, please consult your IT department personnel to have proper access permissions setup for your use. If the problem cannot be resolved, please call the EPRI Customer Assistance Center (CAC) at 1-800-313-3774 (or email askepri@epri.com).

1 INTRODUCTION

As economic, regulatory, and carbon reduction goals evolve, the viability and desirability of operating coal-fueled generating assets continue to decline. Since 2000, at least 90 gigawatts (GW) of older, smaller, and less-efficient coal units have been retired in response to environmental and economic changes [1]. As power generators worldwide transition to low-carbon or carbon-free energy sources, pressure rises to decommission the remaining coal fleet. Global goals for managing climate change have put intense policy pressure on the coal fleet while driving significant financial change, including an increasing difficulty in financing coal related projects [2]. Pressures to retire and decommission the remaining coal fleet continue to mount as power generators worldwide transition to low-carbon or carbon-free energy sources.

In the United States, utilities have announced thousands of megawatts of coal plant retirements, with anticipated closure dates within the next 15 years. [1] This round of plant retirements presents new challenges. The average name-plate capacity for this group of retiring coal plants is roughly 420 MW, compared to an average of 152 MW for those retired in the past 15 years. Globally, including the U.S., the expected coal retirements over the next 15 years amount to nearly 290 GW [3]. In fact, the World Economic Forum has noted that international coal plant retirements, preferable via conversion to cleaner energy, must be accelerated to meet International Panel on Climate Change (IPCC) goals by 2050 [4].

The current scenario converting challenges with the existing coal-fired fleet to opportunities for new generation can be addressed by systematically creating an inventory of the existing site infrastructure, characteristics, permits, and other attributes, and correlating it with the needs of the evolving network with attention to maximizing useful service for both the company and the local community.

Following are potential benefits of repowering an existing site for clean energy generation and storage:

- Operating coal plant sites have existing transmission infrastructure and interconnection permits.
- Many such sites have access to well-developed transportation infrastructure via road, rail, and waterways, as well as existing utility connections for buildings.
- The existing environmental permits for a coal facility may be modifiable for application to the new storage facility, possibly forestalling lengthy permitting processes that require multiple periods of public input.
- Larger facilities that already have a land use permit and certificate of occupancy, as well as buffer property to provide a visual and physical barrier from nearby neighbors, provide siting advantages that may allow the new system to be constructed and commissioned more quickly than siting the plant in a new location.

- Existing buildings, warehouses, and some other on-site equipment, such as fire suppression equipment, may offer opportunities to lower the cost of construction by repurposing those for the new generation.
- Many current sites offer the advantage of access to a large daily water withdrawal and water discharge allowance. In the United States, the right to withdraw water is under more scrutiny. Modifying existing water withdrawal and discharge permits, rather than undergoing the permitting process at a new site, offer reputational and permitting advantages.

In addition to the benefits of existing equipment, infrastructure, and permits, repowering a site for new generation and storage may benefit the surrounding community. Local, state, and federal governments, municipalities, non-governmental organizations, development commissions, and environmental justice advocates increasingly call for fossil-fuel-based power generation facilities undergoing decommissioning to transition via site redevelopment to a new use for the property. The goal is to replace the taxes, jobs, and community support that are lost when plants retire, and potentially providing retraining and continued employment of a portion of the workforce. In the United States, redevelopment of decommissioning coal plants became a federal priority in 2021, with Congress and the Environmental Protection Agency (EPA) encouraging the transition of closed or closing power plants and the industries that support coal-fired electricity generation to adopt clean energy technologies. For example, in a 2021 report, the U.S. Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization identifies the need to promote job-creating investments in communities, provide funding for local infrastructure, economic development, and training, by aligning twelve separate agencies to focus on the issues [5]. Repowering a site with new generation and storage can support both owner and stakeholder goals, while allowing the owner to maintain ownership of sites that may have legacy environmental impacts.

Utilities can develop long-term plans to support their corporate objectives for transitioning to low-carbon or carbon-free generation by developing a corporate strategy to thoroughly examine the assets, liabilities, obligations, and limitations of coal-powered facilities slated for decommissioning. Currently-available options include repowering the site to a(n):

- Battery energy storage facility that stores energy from the grid, when electricity prices are low or renewable energy production exceeds demand, and discharges power to the grid when demand is high (see EPRI paper 3002025591 [6])
- Photovoltaic (PV) power generation facility that directly converts sunlight to electricity (see EPRI paper 3002022919 [7])
- Bulk energy-storage facility (most likely, thermal energy storage) that would store energy from the grid (when electricity prices are low) and discharge power to the grid when demand is high, while also leveraging existing turbomachinery (see EPRI paper 3002025590 [8])
- Concentrating solar power (CSP) facility that would create energy from solar thermal heat, potentially using the existing steam power island at the site to create power

- Natural gas-fueled (and potentially hydrogen-fueled) simple-cycle or combined-cycle power plant (see EPRI paper 3002025894 [9])
- Hydrogen production plant (most likely using electrolysis), with possible conversion to ammonia for higher-value shipment off-site for various industrial and power-production needs (see EPRI paper 3002025895 [10])
- Advanced nuclear generating station (see EPRI paper 3002025482 [11])
- A wind energy facility
- An anchor for a net-zero industrial cluster (see EPRI paper 3002026481 [12])
- Hybrid plant using two or more low-carbon or carbon-free technologies, such as wind and solar, or solar and hydrogen

EPRI is exploring low- or no-carbon repowering options for coal plants through a screening-level evaluation of the available infrastructure, permits, site characteristics, equipment, and water access typical of coal-fired generation that may be beneficial for repowering applications. A series of documents provide information on primary siting and redevelopment criteria for solar PV, bulk energy storage, and other low-carbon fuels to support decarbonization efforts, and the documents are supported by a screening-level evaluation tool to assist companies with understanding the potential for repowering coal-fired plants in their fleets

This paper provides a high-level overview of the process of determining whether a coal-fired power plant slated for decommissioning is suitable for repowering with low carbon technologies. The paper and the included screening tool cover the key issues to consider when evaluating repowering with these technologies, including the following (see Figure 1-1):

- Identify existing infrastructure, including grid interconnection and transportation access that may be available
- Assess physical site characteristics, including available land and other attributes to determine suitability for this repowering option
- Consider potential reuse of structures and equipment
- Review opportunities to renew or modify existing permits applicable to various technologies
- Consider water availability of stormwater management systems for new generation

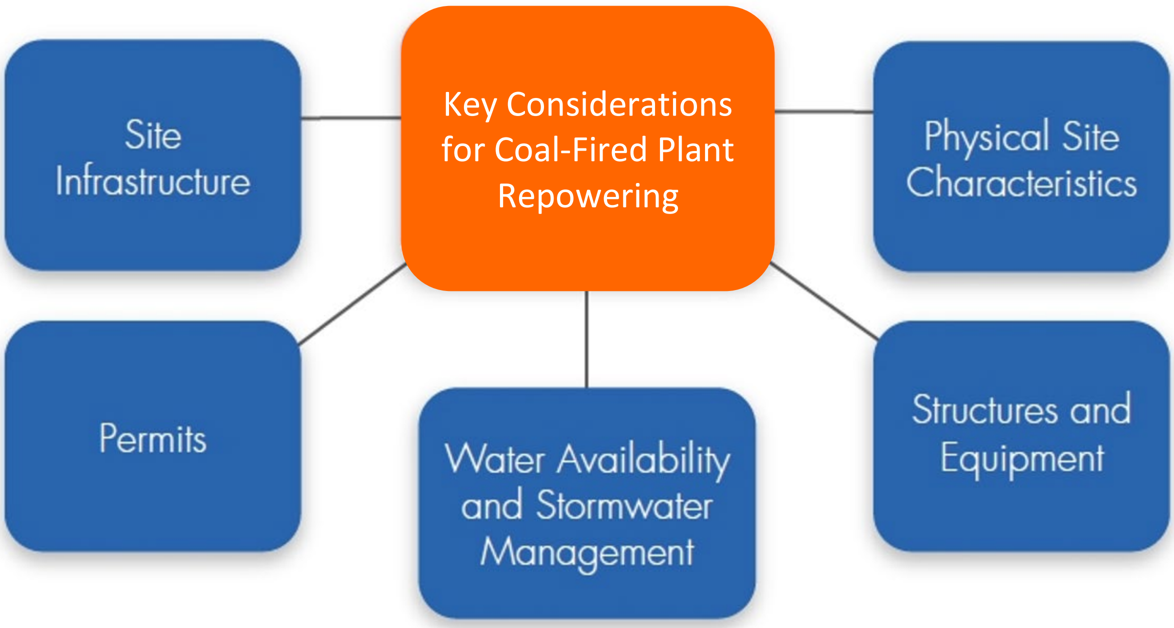

Figure 1-1. Key issues when evaluating coal plant sites for repowering

In addition to the technological considerations, equity and environmental justice (EEJ) impacts to local communities and the greater region are an important part of the repowering evaluation. EEJ is becoming a standard element of site development processes; in some locations, permitting authorities require certain actions. By understanding community impact factors and engaging with members of the community, utilities can form decisions on coal repowering that respect community needs, buffer financial impacts to the local economy, and strengthen community ties. Incorporating these topics into the repowering equation requires a local and regional understanding of workforce impacts, financial impacts, environmental impacts, and social impacts, along with a strong program for stakeholder engagement. Additional details on this important consideration are provided in Equity and Justice Considerations for Coal-Fired Plant Repowering (see EPRI paper 3002026486 [13]).

1. Screening Tool Overview

The screening tool developed to support this research (Appendix A) provides high-level screening of low- and no-carbon resource technologies that may be appropriate for repowering retired and retiring coal-powered generation sites based on site attributes. It is designed to consider the requirements for developing a generation site with a particular technology, and then to compare those needs with attributes typically present at coal-fired facilities. Some needs are specific to a certain technology (e.g., availability of natural gas or hydrogen to develop a natural gas or hydrogen-fired facility) while others may be applicable to multiple technologies (e.g., consumptive water use or withdrawal permits).This is accomplished by using spreadsheets for user input of site characteristics, technology-specific calculations, and output summary.

The input worksheet is designed to collect the information necessary to perform an initial screening of multiple technologies to provide an initial evaluation of which technologies may be appropriate for the site. The output summary is color-coded to assist users with quickly identifying the technologies that are most likely suitable for the site (green), which technologies are moderately likely to be feasible (yellow), and which technologies are least likely to be feasible at the site (red) along with a list of the most and least favorable site attributes for each technology. All non-nuclear technologies include numerical scores used to determine the color .

The color-coded output is meant to act as a guide for further evaluation rather than a final selection of a site or a specific technology. For all technologies shown in the final output regardless of color classification, additional detailed studies and evaluation will be required to determine the appropriate repowering option for a given site and users are encouraged to incorporate the output into detailed studies for every site.

The technologies chosen for inclusion in the tool include:

- Advanced Nuclear Reactors
- Battery Energy Storage Systems (BESS)
- Bulk Energy Storage
- Gas or Gas/Hydrogen Turbines
- Geothermal Generation
- Hydrogen Production via Electrolysis
- Solar Photovoltaic (PV) Generation

There are other generating options that were not included in the screening tool. Should companies wish to evaluate these or other options alongside those included, it is possible to do so using the methods employed for the existing worksheets by creating new worksheets for the desired technology.

2 SCREENING TOOL DESIGN BASIS

The coal-fired power plant screening tool (Appendix A) was developed to provide a standardized method for utilities to screen potential repowering options on a site-specific or fleet-wide basis with emphasis on repurposing assets typically found at retiring coal-fired power plants. For each low- or no-carbon technology included, the coal-fired plant assets were evaluated for importance and applicability for repowering. This evaluation informed the development of the calculations used to perform the screening evaluation based on published technological literature, interviews with subject matter experts (SMEs) for each included technology, and generation siting SMEs.

Weighted scoring was applied to each of the no- or low-carbon technology options included in the tool. For all technologies except advanced nuclear, the output consists of a calculation that results in a weighted score for each attribute as it applies to each technology, with a sum total of all attributes used to provide insight into the likely feasibility of adapting the site to the technology. For the nuclear evaluation, rather than a numerical score, color coding was used for each attribute. The attribute weighting and calculations are described in more detail below.

2. Non-Nuclear Technologies

The tool calculates a score for each attribute (attribute calculated score) based upon technology-specific site characteristics described further in Section 3.2 Technology Worksheets. Following base scoring, a weight or importance factor (attribute weight) is assigned to each attribute to indicate the level of importance the attribute has in relation to siting the technology. The attribute calculated scores and attribute weights were developed using a 1 – 10 scale. The attribute calculated score is multiplied by the attribute weight to determine the attribute weighted score. The attribute maximum possible score is the attribute weight multiplied by 10. The sum of the individual attribute weighted scores is divided by the sum of the attribute maximum possible score to determine the achieved percentage of the maximum possible score or total evaluated score for the technology. The color-coded ratings on each technology worksheet and the summary output worksheet are determined from the total evaluated score for each technology. The scoring calculation is shown in Table 2-1.

Table 2-1. Non-Nuclear Attribute and Technology Evaluation Scoring

Individual Attribute Scoring			Technology Total Evaluated Score		
Attribute Calculated Score	A	Determined by Scoring Methodology			
Attribute Weight	B	Assigned			
Attribute Weighted Score	A * B	Attribute Weight * Score (X_1, X_2, X_3…)			
Attribute Maximum Possible Score	B * 10	Attribute Weight * 10 (Y_1, Y_2, Y_3…)			
			Technology Total Weighted Score	$X_1 + X_2 + X_3$…	Sum of Individual Attribute Weighted Scores
			Technology Maximum Possible Score	$Y_1 + Y_2 + Y_3$…	Sum of Attribute Maximum Possible Scores
			Total Evaluated Score	Σ_X / Σ_Y * 100%	Total Weighted Score divided by Maximum Possible Score multiplied by 100%

3. Advanced Nuclear Technologies

The screening evaluation of advanced nuclear technology is based on the Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities (Siting Guide) [14]. The Siting Guide outlines a five-step siting process for the full evaluation of suitability for nuclear siting, however the attributes and evaluation criteria in the screening tool are based on Step 3: Potential Sites. Step 3 identifies eleven attributes for nuclear siting that have been incorporated into the screening tool input, and provides land requirements based upon the type of nuclear technology under consideration. One additional attribute, the presence and location of coal combustion product (CCP) management units typically found at coal sites, was added to the screening tool to ensure this factor is considered when former coal-fired plant sites are evaluated for advanced nuclear technologies.

The screening tool evaluates individual site characteristics and provides a color-coded rating of green (good), yellow (fair), or red (poor) for each attribute based upon the scales detailed on the advanced nuclear worksheet. An example is provided in Table 2-2, and more detailed examples are provided in Section 3.2 Technology Worksheets.

Table 2-2. Nuclear Attribute Scoring Basis (Population)

POPULATION	
Density>500 in 20-mile radius	Red
Density>300 in 20-mile radius	Yellow
Pop Center>25K (4-mile)	Yellow
Pop Center>100K (10-mile)	Yellow
Pop Center>500 (20-mile)	Yellow
Pop Center>1M (30-mile)	Yellow
None of the above	Green

The color-coded evaluation for the complete advanced nuclear site evaluation (output) is determined as follows:

- Red: Any attribute is red.
- Yellow: If none of the attributes are red and the average of the attributes is yellow.
- Green: If none of the attributes are red and the average of the attributes is green.

3 USING THE SCREENING TOOL

The screening tool contains three components: a data input worksheet that compiles site characteristics; low- and no-carbon technology worksheets that use the input data to calculate individual attribute weighted scores and total evaluated scores; and an output summary worksheet that provides a summary of the weighted results.

Two sets of spreadsheets are provided: one set using methodology and weighting developed by EPRI and one set that allows user customization. This provides both an industry-standard base case evaluation, and allows companies the flexibility to alter attributes and weighting to better reflect company needs and priorities. The base case was developed with weighting factors and attributes that are technology-specific using knowledge from EPRI SMEs in each technology and in generation siting. The customizable sheets contain the same information and weighting as the base case but allow individual users to add or remove attributes and change the weighting factors.

Users will initially interact with the input worksheet, which contains attributes required for evaluation of each technology. Users will enter values for the attributes listed below. A detailed explanation of all available input options is included in Section 3.1 Screening Tool Inputs of this user guide.

- Land Availability
- Unit-Specific Transmission and Generation
- Water Availability/Permits
- Air Quality/Permits
- Other Existing Infrastructure
- Operations
- Fuel/Energy Resource
- Population and Land Use

The output is calculated in the individual technology worksheets and is summarized on the output summary worksheet. The output summary worksheet shows the evaluation result of each technology and the associated most and least favorable attributes as determined by the technology worksheet attribute scores. A more detailed explanation of all outputs is included in Section 3.2 Technology Worksheets.

3.1 Screening Tool Inputs

This is the main worksheet with which a user will interact. All of the user inputs are included in this worksheet. Cells are populated by either typing the information directly into the cell, or by selecting from a dropdown menu. All input cells are highlighted light blue and cells that perform calculations based on user inputs are highlighted gray. The categories and purpose of information captured for input are summarized below.

3.1.1 Basic Information

- Company Name: The name of the site owner.
- Site Name: The name of the site.
- Site Location: The county and state in which the site is located.

This information is typed directly into the cells.

3.1.2 Land Availability

Land availability is used to determine the amount of space available for construction and operations. The input provides flexibility to handle a wide variety of user mapping capabilities. For companies that have not performed buildable land evaluations, the acreage of owned and adjacent parcels can be entered individually and the tool will provide a calculation to determine the available land. If Geospatial Information System (GIS) mapping has been fully or partially completed, the user can skip the input adjustments as described in the buildable land adjustment section and directly enter only the amount of space available for construction and operations.

3.1.2.1 Determine Total Land Acreage

- Total site acres: The total acres of company-owned land at the site. This can be input as total acres or as individual parcels.
- Adjacent and contiguous land: Additional contiguous parcels not owned by the company, but that may be available for purchase or lease, can be included at the option of the user.

3.1.2.2 Buildable Land

Site mapping of land available for use typically excludes lands included in the Federal Emergency Management Administration (FEMA)100-year flood plain and Fish and Wildlife Service (FWS) jurisdictional wetlands. Calculating the excluded acreage based on these criteria can be accomplished either using county-level GIS tools or Google Earth PRO with the FEMA National Flood layer and NFWS Wetlands files available using the links below.

- These parameters can be individually mapped using the links below.
- FEMA 100-year Flood Plain: Flooding | FEMA Geospatial Resource Center [15]
- FWS jurisdictional wetlands: National Wetlands Inventory (usgs.gov) [16]

At this stage, the user may also adjust the buildable acreage to account for existing plant facilities that will be excluded from the available land. Additional adjustments can be made in the buildable land section if not excluded here. All information in the buildable land category is typed directly into the cell except for the calculated totals which are highlighted in gray.

3.1.2.3 Buildable Land Adjustments

Buildable land adjustments are designed to capture areas that may be part of the plant site but are not available for construction or operation of new generation. The space covered by each of these adjustments may be entered individually, or if GIS mapping has been completed the user can input zero for the buildable land adjustment or leave the adjustment blank while directly inputting the total acres into the following categories:

- Cell C37: Buildable Land Total – This includes all plant land that can be used for construction, plant equipment, laydown, parking, and all other uses. It is not limited by block size. The adjustments affecting the size of this area are described below.
- Cell C38: Buildable Land Solar – This includes the Buildable Land Total plus capped and closed landfills and subtractions for land slope such that slope between 5-10% is valued at 50% of the acreage, slope between 10-15% is valued at 20% of the acreage and slope over 15% has no value.

For those entering manual values rather than a GIS calculated total buildable land value, adjustments to the buildable land are captured in this section. Table 3-1 summarizes the adjustments that may be applicable for various technologies. Where applicable/available, a link has been provided to guide users to information useful for answering these questions.

Table 3-1. Adjustments to buildable land inputs

Adjustment	Potential Sources of Information
Presence of critical habitat (yes/no)	https://www.arcgis.com/apps/mapviewer/index.html?url=https://services.arcgis.com/QVENGdaPbd4LUkLV/ArcGIS/rest/services/USFWS_Critical_Habitat/FeatureServer&source=sd [17]
Critical Habitat area (acres)	https://www.arcgis.com/apps/mapviewer/index.html?url=https://services.arcgis.com/QVENGdaPbd4LUkLV/ArcGIS/rest/services/USFWS_Critical_Habitat/FeatureServer&source=sd [17]
USGS Public Access lands	USGS PAD-US Data Explorer [18]
National Hurricane Center Storm Surge Zone (recommend red zone exclusion)	https://experience.arcgis.com/experience/203f772571cb48b1b8b50fdcc3272e2c [19]
Known Cultural Resources	State Historic and Preservation Office (SHPO) or National Resources Conservation Services (National Register of Historic Places) information and maps. Note that this number can be adjusted based on owner's knowledge of known relocations or additional resources not currently registered through state or federal agencies.
Acres of existing or planned CCP facilities	Information available from corporate or plant environmental personnel
Stormwater or wastewater treatment ponds	Information available from corporate or plant personnel
Buildable land with slope of >15%	United States Geological Survey (USGS) topographic maps
Buildable land with slope of 11-15%	USGS topographic maps
Buildable land with slope of 5-10%	USGS topographic maps

3.1.2.4 Contiguous Block of Land for Plant Footprint

This section is used to identify the largest block of land suitable for a power block or process block plant footprint. It is used for all technologies except for solar PV. The following information is entered directly into the cells:

- Contiguous block available (L*W) larger than 15 acres consisting of a minimum 800 ft x 800 ft block. User may directly input acres instead of L*W.

3.1.2.5 Overall Site Area

This includes the single largest block where the plant will be located and all surrounding land that will be fenced as part of the site. This is only used in the advanced nuclear tab. Using the mapping information from the previous sections, the user inputs an estimate of total plant land using the largest contiguous blocks and surrounding areas that may contain additional blocks of land including isolated wetlands and streams.

3.1.3 Unit-Specific Information (Transmission and Generation)

For each operating coal unit input the following information. If coal units have been replaced by other generation, e.g., natural gas, do not input replacement generation capacity unless it is planned for retirement in the development time frame of the new no- and low-carbon technologies. This information is entered directly into the cells.

Table 3-2. Unit-Specific Information Inputs

	Transmission Capacity, MW
Unit 1	
Unit 2	
Unit X…	

The voltage and the information from the question ”Does the Regional Transmission Operator (RTO) or Independent System Operator (ISO) have a generator replacement provision” is entered via a drop-down menu, and is not used in the calculations however it is captured to identify additional information that is required for future evaluations of the transmission interconnection.

3.1.4 Water Availability and Permits

The availability of water for cooling and other operations, in addition to the status of existing permits may influence the feasibility of developing a site for a particular technology. This information, shown in Table 3-3, is entered by selecting from a dropdown menu.

Table 3-3. Water Availability and Permits Inputs

Question	Potential Sources of Information
Is there a large cooling water source within 5 miles?	Plant personnel, corporate siting personnel, USGS topographic maps
Is there an existing surface water intake?	Plant operations personnel
If there is no surface water intake, is there an accessible route to the closest water source?	Professional judgment based on obstacles and terrain.
Is the proposed water source designated as critical habitat?	https://www.arcgis.com/apps/mapviewer/index.html?url=https://services.arcgis.com/QVENGdaPbd4LUkLV/ArcGIS/rest/services/USFWS_Critical_Habitat/FeatureServer&source=sd [17]
Does the plant have once-through cooling?	Plant operations personnel
Does the plant have cooling tower(s) or cooling water pond(s)?	Plant operations personnel
Make-up water source	Plant operations personnel
Is a water withdrawal permit required in this area?	Plant or corporate environmental personnel, state and local regulations
If a withdrawal permit is required, is the plant grandfathered into the regulation?	Plant or corporate environmental personnel, state and local regulations, state and local permit search
Does the plant have a permitted MSGP NPDES discharge?	Plant or corporate environmental personnel, state and local permit search
If the plant has a Zero Liquid Discharge (ZLD) System in lieu of a discharge permit, what are the major components?	Plant operations personnel
Is there a municipal, county, or drinking water well source of potable water on-site?	Plant operations personnel, county or city GIS maps, state and local permit search
Is there an existing Publicly Owned Treatment Works (POTW) discharge on site?	Plant operations personnel, county or city GIS maps
Are there existing stormwater ponds?	Plant operations personnel

3.1.5 Air Quality/Permits

The status of attainment with regional, state, and federal air regulations, in addition to the status of existing permits may influence the feasibility of developing a site for a particular technology. The information shown in Table 3-4 is entered by selecting from a dropdown menu.

Table 3-4. Air Quality and Permits Inputs

Question	Potential Sources of Information
Has the coal plant operated over the past 3 years with at least a 10% capacity factor?	Plant operational or environmental personnel.
Is the location in attainment for ozone?	https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors [20]
Is the location in attainment for particulate matter?	https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors [20]
Is the location in attainment for carbon monoxide?	https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors [20]
Is the location in attainment for sulfur dioxide?	https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors [20]
Is the location in attainment for nitrogen dioxide?	https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors [20]
Does the plant sit in a valley or surrounded by hills or mountains that may inhibit dispersion?	USGS topographic maps, GIS terrain maps
Does current plant operating experience or data indicate potential dispersion issues, such as inverted plume or plume touchdown from stack or cooling tower?	Plant or corporate environmental personnel

3.1.6 Other Existing Infrastructure

Existing infrastructure at a site may influence the cost and feasible timelines of constructing and operating a new technology. The information shown in Table 3-5 is entered by selecting from a dropdown menu.

Table 3-5. Other Existing Infrastructure Inputs

Question	Potential Sources of Information
Are rail or barge unloading facilities available on-site?	Plant operations personnel
Are there existing warehouse(s) available for reuse?	Plant operations personnel
Are the existing warehouse(s) detached from the existing powerhouse?	Plant operations personnel
Are there existing office building(s) available?	Plant operations personnel
Are available office building(s) detached from the existing powerhouse?	Plant operations personnel
Is there an existing full flow raw water treatment (clarification) system?	Plant operations personnel
Is there an existing demineralized water system designed for high pressure boiler water?	Plant operations personnel
Are there existing raw water, service water, or demineralized water tanks with total capacity in excess of 300,000 gallons?	Plant operations personnel
Are there existing wastewater treatment settling ponds?	Plant operations personnel
What is the condition of the steam turbine?	Plant operations and maintenance personnel

3.1.7 Operations

The presence or absence of a trained workforce that can be retrained to work on a new technology, as well as the presence of craft labor, can influence the feasibility and cost of constructing a new generating site. This information is not used for the technological evaluations in the screening tool, but is captured to assist with detailed evaluations of technological feasibility. This information shown below is entered by selecting from a dropdown menu.

- Is the coal plant currently in operation?
- Current coal plant staff (persons)

3.1.8 Fuel/Energy Source

Access to a fuel source may significantly influence the feasibility of repowering a coal site with a particular technology. Distances from the site to each fuel source are directly typed into each cell. All other information shown in Table 3-6 is entered by selecting from a dropdown menu.

Table 3-6. Fuel Availability Inputs

Question	Potential Sources of Information
Is there a high-pressure (500 psig) gas supply to the existing plant?	Plant operations personnel. Interstate natural gas pipeline maps, https://atlas.eia.gov/datasets/natural-gas-interstate-and-intrastate-pipelines/explore?location=31.149683%2C-95.221420%2C4.00 [21]
What is the distance to the closest interstate gas pipeline?	https://atlas.eia.gov/datasets/natural-gas-interstate-and-intrastate-pipelines/explore?location=31.149683%2C-95.221420%2C4.00 [21]
What is the distance to closest high-pressure intrastate pipeline greater than 12 inches in diameter?	https://atlas.eia.gov/datasets/natural-gas-interstate-and-intrastate-pipelines/explore?location=31.149683%2C-95.221420%2C4.00 [21]
What is the average global horizontal solar irradiance (GHI) factor for the location (kwh/m^2/day)	NSRDB (nrel.gov) [22]
What is the Geothermal Resource Favorability based on the NREL Map?	geothermal-identified-hydrothermal-and-egs.jpg (5101×3301) (nrel.gov) [23]
What is the value of the geothermal gradient?	Geothermal Gradient Map of the Conterminous United States - Side 1 - UNT Digital Library [24]
Estimated temperature at 4.5 Km	SMU_2011_4point5kmTemperature_small.png (1381×1000) [25]
What is the Heat Flow at the location of the coal plant?	SMUHeatFlowMap2011_CopyrightVA0001377160_jpg.jpg (3600×2239) [26]

3.1.9 Population and Land Use

Population density can have a significant influence on the feasibility of certain technologies, such as advanced nuclear generation. Other factors that may determine whether a technology is more or less feasible are also captured in this section. The information shown in Table 3-7 is entered by either dropdown menu (for yes/no questions) or direct entry (for numerical values). For the population information, it is important to enter the information using the units shown, e.g., persons per square mile or total population.

Table 3-7. Population and Other Factors Inputs

Question	Potential Sources of Information
What is the population density within a 20-mile radius of the site (persons/sq. mile)?	https://ejscreen.epa.gov/mapper/ [27] https://mtgis-portal.geo.census.gov/arcgis/apps/MapSeries/index.html?appid=2566121a73de463995ed2b2fd7ff6eb7 [28]
What is the population density within a 4-mile radius of the site (persons/sq. mile)?	https://ejscreen.epa.gov/mapper/ [27] https://mtgis-portal.geo.census.gov/arcgis/apps/MapSeries/index.html?appid=2566121a73de463995ed2b2fd7ff6eb7 [28]
Is there a population center of greater than 25,000 within 4 miles of the site?	Identify cities and incorporated town populations within the radius
Is there a population center of greater than 100,000 within 10 miles of the site?	Identify cities and incorporated town populations within the radius
Is there a population center of greater than 500,000 within 20 miles of the site?	Identify cities and incorporated town populations within the radius
Is there a population center of greater than 1,000,000 within 30 miles of the site?	Identify cities and incorporated town populations within the radius
Is there a Commercial Service or Cargo Service airport within a 10-mile radius of the site?	FAA Airport Data (Form 5010) with FAR139 certification https://adip.faa.gov/agis/public/#/airportSearch/advanced [29]
Are military installations within 10 miles of the site?	https://www.google.com/maps/d/viewer?mid=1XFBnIuaJ-71hcaDJvdmBmeXNhYM&ll=47.32324810439339%2C-114.050835&z=3 [30]
Are there major industrial areas or other hazards within 10 miles of the site?	Plant operations personnel, local firefighting organizations, ASTM Phase I data, USGS topographic maps
Are there any public amenity areas near the site?	https://maps.usgs.gov/padus/ [18]
Is the site located in the region of a U.S. EPA Class I groundwater resource and/or a Sole Source Aquifer?	https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=9ebb047ba3ec41ada1877155fe31356b [31]
Is the site on an EPA defined Class I source? Class I sources are of unusually high value but highly vulnerable to contamination and are irreplaceable sources of drinking water and/or ecologically vital.	Plant or corporate environmental personnel, USGS topographic maps

Table 3-7 (continued). Population and Other Factors Inputs

Question	Potential Sources of Information
What is the seismic hazard rating for the site?	https://www.usgs.gov/media/images/2018-long-term-national-seismic-hazard-map [32]
	Input peak ground acceleration value (PGA), determined from the intersection of the black curve (PGA) with the blue line (time horizon 2475 years) Unified Hazard Tool (usgs.gov) [33]
In the 25-mile radius region around the plant what type of zoning best characterizes the land?	Plant operations personnel, real estate personnel, county zoning maps
Is the Total Plant Area within CCP Inundation Zone?	See Coal Combustion Product (CCP) Management Unit section below.
Is the Total Plant Area within 1000 yards of Existing or Planned Ash Landfills?	See Coal Combustion Product (CCP) Management Unit section below.
How far away Is the closest existing geothermal plant? (miles)	
In a 10-mile radius from the site, is there a hydrocarbon development site or significant hydrothermal resource?	Map of United States Oil and Gas Wells, 2017 | U.S. Geological Survey (usgs.gov) [34]
What is the measured temperature at the well depth?	If data is available from CRC Well Catalog (usgs.gov) [35]

3.1.9.1 Coal Combustion Product (CCP) Management Units

As part of the advanced nuclear evaluation, a category for CCP management units was included to address the potential for unstable areas near the operational areas of a new facility. This was broken into two separate questions to evaluate the location of the CCP units compared to the potential location of any advanced nuclear generation. In both cases, these questions are designed to provide insight into the need for further evaluation of advanced nuclear feasibility rather than to exclude this repowering option. The information for these two questions is entered by using a dropdown menu.

Inundation maps are planning tools that illustrate the areas that could be impacted in the unlikely event of a complete dam failure for an impounded CCP management unit, assuming the unit was filled to capacity with coal ash and water. Inundation maps are publicly available for any US coal-fired power plant that used impounded ponds to handle or store coal ash. Since the 2015 Coal Combustion Residuals rule [36] was promulgated by the Environmental Protection Agency, most of the CCP units in the US have undergone partial or full dewatering and either have been closed or are undergoing closure. Based on the current state of these facilities, the inundation maps published for each site present a worst-case scenario that provides a very conservative estimate of the potential inundation area for the CCP unit once it has been dewatered and closed, however, there is no requirement in the CCR rule to update the inundation maps following unit dewatering and closure.

The location of current and planned CCP landfills at coal sites is available from corporate or plant environmental personnel and/or corporate CCP websites required under the 2015 regulation. As coal plants cease operations, the CCP landfills will be closed and managed in compliance with state and federal regulations. The units are typically required to undergo at least 30 years of post-closure monitoring to ensure compliance with state and federal regulations, including slope stability.

3.2 Technology Worksheets

The technologies included in the screening tool are each evaluated on separate tabs within the workbook. This section describes the design and function of the technology worksheets.

The generation technologies selected for the baseline evaluation include advanced nuclear, battery energy storage systems, bulk energy storage, geothermal, hydrogen production via electrolysis, natural gas and hydrogen blended generation, and solar PV. If users wish to evaluate other types of generation technologies, the tabs designed for customization can be copied and modified as needed to accommodate user needs.

3.2.1 Non-Nuclear Technologies

The eight site attributes used in the baseline screening are in the row across the top of each worksheet starting with available land and ending with fuel/energy source, though not all of the eight attributes are applicable to every technology. The second section of horizontal cells contains the scoring as described Section 2, Table 2-1, and shown in more detail in Table 3-8. For this example, the attribute calculated score for available land attribute is 2 based upon the criteria developed for this technology. The attribute calculated score is multiplied by the attribute weight of 7 to achieve an attribute weighted score of 14. The attribute maximum possible weighted score is calculated by multiplying the attribute weight by 10 (7 x 10 = 70). The sum of all attribute scores is shown in the total evaluated score columns. The attribute weighted scores are summed to determine the total score (271 in example). This value is divided by the sum of the attribute maximum possible weighted scores (400) and multiplied by 100 to determine the value of the total evaluated score as a percentage. The color-coded output of green, yellow, or red is determined by the total evaluated score percentage. Green means the technology achieved a total score of >80%, yellow 50%-80%, and red <50% of the maximum possible weighted score.

Table 3-8. Site Attribute and Scoring Example

Attribute	Available Land	Population and Land Use	Transmission	Water Availability/ Permits	Air Quality/ Permits	Other Existing Infrastructure	Existing Labor Force	Fuel/ Energy Source	Total Evaluated Score	
Attribute Calculated Score	2	10	8	9	10	10	5	0		
Attribute Weight	8	3	6	5	6	4	3	10		
Attribute Weighted Score	16	30	48	45	60	40	15	0	Total Weighted Score	254
Attribute Maximum Possible Weighted Score	80	30	60	50	60	40	30	100	Maximum Possible Technology Score	450
									Total Evaluated Score	56%

3.2.1.1 Evaluation Methodology

The third section of horizontal cells contains the technology-specific scoring methodology for each attribute. The maximum possible attribute calculated score is ten for each attribute. The attribute scoring is either a graded scale or a point scale, depending on the attribute characteristics. An example of each type of scoring (graded scale and points) is shown in Table 3-9. The scoring methodology for available land in the example is based on a graded scale. The attribute calculated scores for graded scale attributes are calculated using if/then logic and data from the input tab. In the example, the scoring methodology for water availability/permits is calculated on points assigned based on sub-attributes. The attribute calculated score for point-based attributes is calculated in the scoring methodology section of each technology worksheet based on the user input data and the summation of the points. The scoring methodology for individual technologies is tailored to the technology and therefore total points and scoring methods vary between technologies. The basis for scoring and weighting is provided in the last section of rows in each technology worksheet to provide insight into the development of attribute scoring,

Favorable and unfavorable attributes are determined by selecting attributes with weights greater than 5 along with high (favorable >5) or low (unfavorable ≤5) attributes scores. These are shown at the bottom of each technology worksheet and in the output summary page.

Table 3-9. Non-Nuclear Evaluation Method Example

Attribute	Available Land	Water Availability/Permits
Attribute Calculated Score	*Calculation based on Scoring Methodology and user Input = 10*	*Sum of individual point categories based on user Input = 6*
Attribute Weight	9	10
Attribute Weighted Score	90	60
Attribute Maximum Possible Score	90	100
Scoring Methodology	10 > 30 acres contiguous	4 Existing Intake
	8 > 20 acres contiguous	1 Existing Potable Water
	6 > 10 acres contiguous	4 Existing MSGP NPDES
	4 51-100 acres total non-contiguous	4 ZLD (Evap Ponds)
	2 20-50 acres total non-contiguous	3 ZLD (Evap Ponds and BC)
	0 < 20 acres total	0 ZLD (BC Only)
		-2 Critical Habitat

Table 3-9 (continued). Non-Nuclear Evaluation Method Example

Attribute	Available Land	Water Availability/Permits
		Attribute Score *(Sum of Points)*
		4 Existing Intake
		4 Existing Potable Water
		0 Existing MSGP NPDES
		0 ZLD (Evap Ponds)
		0 ZLD (Evap Ponds and BC)
		0 ZLD (BC Only)
		-2 Critical Habitat
		6 Total
Basis	Corresponds to commercial 100 MW Electrolyzer approximately 10 acres with 3x land preferred for construction laydown and storage.	River water source and NPDES are preferred for process and cooling and potable and sewer are preferred. Critical habitat could complicate permitting depending on species. High priority need for feedstock.

3.2.2 Advanced Nuclear Generation

The screening tool evaluates advanced nuclear site characteristics and provides a color-coded rating of green (good), yellow (fair), or red (poor) for each attribute as outlined below. The example in Table 3-10 shows three of the ten advanced nuclear site attributes for demonstration purposes.

The site attributes are shown in the first row. The scoring methodology is in the second section of rows. The scoring for each attribute is categorized as green, yellow, and red and is based on the Siting Guide [14]. The geology/seismology site attribute is based on a single value of peak ground acceleration, and is the only site attribute based on a single value. The population site attribute is based on multiple sub-attributes and is more typical of the scoring method for the advanced nuclear site attributes.

The land area site attribute incorporates Siting Guide criteria for flooding, wetlands, land use, and critical habitat by exclusion. The land area is evaluated by the land required for the power block, the additional construction area, and the total fenced land area from Table 1 of the Siting Guide [14].

The third section of rows provides the scoring based on the user input. In the geology/seismology site attribute the single value of peak ground acceleration is copied directly from the input tab. At the bottom of this section, the value is compared to the scoring methodology and categorized into 1 – red, 2 – yellow, or 3 – green using if/then logic. These numbers are used to color-code the site attribute title in the first row using conditional formatting. The population site attribute follows the same process but includes multiple yes/no questions for which results are included in a nested IF function to calculate the score.

The land area site attribute is more complex than the other site attributes but generally follows the same process. The power block and the overall site land area calculations are performed on the input worksheet based on contiguous blocks of land with the exclusions for non-buildable land. The construction land area includes additional calculations in this section of the advanced nuclear worksheet by subtracting out the minimum and maximum power block land from the total buildable land calculated on the input worksheet to determine if there is sufficient additional land for construction. Note that in the example, the maximum construction acres sub-attribute is negative. This does not mean that that construction land is not adequate, only that it cannot be scored as a 3 (green). If both the minimum and maximum do not meet their respective criterion, then it would result in a 1 or red score. The scores for each of the three land sub-attributes are scored using if/then logic. Based on the sub-attribute scores and the scoring methodology the available land attribute is then scored using if/then logic.

The last section of rows in the table provides the basis and Siting Guide reference for each attribute. Favorable and unfavorable attributes are determined by selecting attributes with relatively high weights along with high (favorable) or low (unfavorable) attributes scores. These are shown at the bottom of each technology worksheet and in the summary output page.

A site composite score is calculated and shown in the last column of the advanced nuclear worksheet. It is determined by the following criteria:

- Red: Any of the site attributes have a numerical score of 1 (red)
- Yellow: If none of the site attributes have a numerical score of 1 and the average of the numerical scores is less than 2.5.
- Green: If none of the site attributes have a numerical score of 1 and the average of the numerical scores is 2.5 or greater.

Table 3-10. Advanced Nuclear Technology Evaluation Example

Site Attribute	Geology/Seismology	Population	Available Land
Scoring Methodology			Exclude
	Peak Ground Acceleration	Density>500 in 20-mile radius Red	3 Flooding
	<0.03g Green	Density>300 in 20-mile radius Yellow	9 Wetlands
	0.03g - 0.05g Yellow	Pop. Center>25K (4-miles) Yellow	10 Land Use
	>0.05g Red	Pop. Center>100K (10-miles) Yellow	8 Critical Habitat
		Pop. Center>500K (20-miles) Yellow	
		Pop. Center>1M (30-miles) Yellow	**Power Block**
		None of the Above Green	Green > 200 acres
			Yellow >24 and <200 acres
			Red <25 acres
			Overall Site
			Green > 500 acres
			Yellow >49 and <500 acres
			Red <49 acres
			Construction
			Green > 100 acres
			Yellow >49 and <100 acres
			Red <50 acres
		From Input tab	**Composite**
			Green All Green
			Yellow Not Green or Red
			Red All Red
Scoring	PGA Value 0.049	Density>500 in 20-mile radius No	Power Block (acres) 103
		Density>300 in 20-mile radius No	Overall Site (acres) 120
		Pop. Center>25K (4-miles) No	
		Pop. Center>100K (10-miles) No	Max Construction (acres) - 91
		Pop. Center>500K (20-miles) No	Min Construction (acres) 84
	1 = Red 2 = Yellow 3 = Green	Pop. Center>1M (30-miles) No	
			Power Block 2
			Overall Site 2
			Construction 2
	Geology/Seismology	Population	Available Land
	2	3	2
Basis	Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide) 2022, Section 3.1.1.1	Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide) 2022, Section 3.1.2.1.	Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide) 2022, Table 1, Sections 3.1.1.3, 3.1.1.4, 3.2.2.3, and 3.3.4.

3.3 Screening Tool Customization

The unprotected version of the screening tool can be adapted to the user's preferences and to better align with the utility's integrated resource plan. There are numerous levels of adaptation, and some examples are presented below. Any of these modifications can be used individually or in combination to meet company needs. A cross-referenced table of input values and their occurrence on the technology worksheets is included in Appendix B to assist users with identifying the location of changes needed to complete customizations.

Change Attribute Weight: The user may simply change the attribute weights in the non-nuclear technologies by typing the desired number in the scoring methodology cell and the spreadsheet will recalculate the evaluation based on the new attribute weights. The change will affect the calculation, as shown in Figure 3-1, and will update both the attribute weighted score and the attribute maximum possible weighted score. This will also change the total evaluated score for the technology worksheet and on the output summary.

	EPRI Base Case	**Modified Case**
	TRANSMISSION	TRANSMISSION
Attribute Calculated Score	8	8
Attribute Weight	6	5
Attribute Weighted Score	48	40
Attribute Maximum Possible Weighted Score	60	50
Scoring Methodology	10 >1000MW	10 >1000MW
	8 601-1000MW	8 601-1000MW
	6 401-600MW	6 401-600MW
	4 201-400MW	4 201-400MW
	2 81-200 MW	2 81-200 MW
	0 <80 MW	0 <80 MW

Figure 3-1. Example of modification process for attribute weight.

Modify Scoring Methodology: The user may change the scoring methodology for non-nuclear technologies using the tool template. To change the scoring, the user should change the description of the methodology and must change the cells where the score is calculated.

In point score calculations, the calculated score must be changed in the calculated score totals by changing the points awarded based on sub-attributes. These sub-attribute points tie back to yes/no answers the input worksheet. An example where the user may want to change the scoring methodology is knowledge of the utility's integrated resource plan that affects the site-specific land and transmission requirements, as available land and transmission are graded scores for all technologies. To change the point scores, users update the points that will be assigned (yellow box in Figure 3-2), then click into the calculation cell and update the number in the nested IF function (green box in Figure 3-2). The change is carried through the calculations, affecting the attribute calculated score as well as the total evaluated score for the technology worksheet and on the output summary.

WATER AVAILABILITY/ PERMITS		WATER AVAILABILITY/ PERMITS	
Points		Points	
4	Existing Intake	5	Existing Intake
2	Existing Potable	0	Existing Potable
4	NPDES	5	NPDES
	Score		Score
4	Existing Intake	5	Existing Intake
2	Existing Potable	0	Existing Potable
4	NPDES	5	NPDES

=IF(INPUT!C71="yes",4,0)

EPRI Base Case Formula

=IF(INPUT!C71="yes",5,0)

Modified Formula

Figure 3-2. Example of modification process for attributes scored on a points scale.

In graded score calculations, the attribute calculated score must be changed in the attribute calculated score cell as shown in Figure 3-3. The technology worksheet was updated in the scoring methodology so the changes are visible, and the changes were then made in the formula used within the worksheet so that the grading scale will calculate the attribute calculated score as shown in the scoring methodology. After the change is made in the formula, the attribute calculated score in this example is 10 based on the updated scale. In addition, the attribute weight was adjusted in the modified case and resulted in a change to the attribute maximum possible weighted score. These two changes resulted in a change in the attribute weighted score of 48 in the EPRI base case to 50 in the modified case. The change is carried through the calculations, affecting the total evaluated score for the technology worksheet and on the output summary.

Unit Specific (Transmission and Generation)		
		Transmission Capacity, MW
Unit 1		500
Unit 2		500
Unit 3		
Unit 4		
Unit 5		
Unit 6		
Unit 7		
Unit 8		
Unit 9		
Unit 10		
Total Plant		1000

INPUT!C64

=IF('EPRI INPUT'!C64>1000,10,IF('EPRI INPUT'!C64>600,8,IF('EPRI INPUT'!C64>400,6,IF('EPRI INPUT'!C64>200,4,IF('EPRI INPUT'!C64>80,2,1)))))

EPRI Base Case Formula

INPUT!C64

=IF('EPRI INPUT'!C64>600,10,IF('EPRI INPUT'!C64>500,8,IF('EPRI INPUT'!C64>400,6,IF('EPRI INPUT'!C64>200,4,IF('EPRI INPUT'!C64>80,2,1)))))

Modified Formula

	EPRI Base Case Score	**Modified Case Score**
	TRANSMISSION	**TRANSMISSION**
Attribute Calculated Score	8	10
Attribute Weight	6	5
Attribute Weighted Score	48	50
Attribute Maximum Possible Weighted Score	60	50
Scoring Methodology	10 >1000MW	10 >600MW
	8 601-1000MW	8 501-600MW
	6 401-600MW	6 401-500MW
	4 201-400MW	4 201-400MW
	2 81-200 MW	2 81-200 MW
	0 <80 MW	0 <80 MW

Figure 3-3. Example of modification process for attributes scored on a graded scale.

<u>Change Attribute Calculated or Weighted Score</u>: The user may change any attribute calculated score by replacing the calculated score with a score based on the user's subjective opinion or other methodology. For example, the user may know that transmission for net energy user technologies such energy storage may be problematic due to the site location. The user may then simply change the score based on subjective opinion or other methodology. Directly changing attribute scores may also be used to determine sensitivities of individual attributes. An example of this type of change is shown in Figure 3-4. The change is carried through the calculations, affecting the attribute calculated score as well as the total evaluated score for the technology worksheet and on the output summary

	EPRI Base Case	**Modified Case**
	TRANSMISSION	TRANSMISSION
Attribute Calculated Score	8	10
Attribute Weight	6	6
Attribute Weighted Score	48	50
Attribute Maximum Possible Weighted Score	60	50
Scoring Methodology	10 >1000MW	10 >1000MW
	8 601-1000MW	8 601-1000MW
	6 401-600MW	6 401-600MW
	4 201-400MW	4 201-400MW
	2 81-200 MW	2 81-200 MW
	0 <80 MW	0 <80 MW

Figure 3-4. Example of modification process for attribute calculated or weighted score.

<u>Add Technology</u>: The user may add worksheets for additional technologies. The most similar technology from the screening tool can then be pasted into the new worksheet. The new technology worksheet can then be modified by changing attribute weights and modifying scoring methodology. The technology description in the tab and in Cell 1A of the new technology worksheet must be changed. The new technology can be added to the Output worksheet by copying the last technology (Geothermal) cells down and replacing the references in the copied cells with the new technology worksheet references. Depending on the number of technologies added, the print format may need to be scaled to print the output on a single page.

4 CASE STUDIES

4.1 Introduction

In order to assess functionality, ease of use, and technological feasibility for the screening tool, EPRI member companies were invited to submit the required plant-specific input data for analysis. The use of real input data provided EPRI an opportunity to test the tool for bugs or errors, and comparing the case study output to information and knowledge previously developed by the participating companies provided an opportunity for both EPRI and the companies to assess whether the tool was functioning in a way that provided a realistic evaluation of each technology's feasibility for the sites included. It also provided a method for companies to compare their existing feasibility assessments with an evaluation that used the same data as previous studies to determine whether the same conclusions were reached by both methods.

Two case studies were performed, the first using a single plant at a western U.S. site and the second using two plants at eastern U.S. sites. The inputs for the case studies were provided by the utilities, and the screening was performed by EPRI personnel. Following the screening, a workshop was held with each company to evaluate the inputs and outputs of the screening tool while collecting feedback on potential points of confusion or areas where the output resulted in a different assessment than those previously perform. The results of these efforts are summarized below.

4.2 Case Study 1

This case study was conducted using a single plant owned by an integrated utility based in the western United States mountain region. The site selected for the case study has an announced decommissioning date and is under consideration for repowering by the owner, which made it a good candidate for technology screening.

EPRI provided the utility a copy of the input data sheet to provide the information necessary for the screening. The utility reported minimal issues collecting the data and entering the information into the Input spreadsheet. Participating employees reported that most of the information provided was collected by the plant site personnel and the utility's land management organization. During EPRI's review of the input data provided, it was noted that the peak ground acceleration value for the site was entered incorrectly. The error was attributed to inadequate instructions on how to apply the Unified Hazard tool provided, and as a result, additional instructions were added to the Input spreadsheet and the User's Guide.

Once the input data were reviewed and the peak ground acceleration value updated, the input was entered into the screening tool. This revealed that the original design for the land input category 'blocks of land' was unnecessarily cumbersome, and identified a calculation error in one of the technologies. To address these findings, the calculation error was corrected, some land inputs were eliminated, and nuclear land calculations were simplified.

The output summary for the Case Study 1 is shown in Table 4-1 with numerical scores included for the non-nuclear technologies. The original version of the tool did not include the numerical scores and was developed to use a stoplight approach (green >80%, yellow 50%-80%, red <50%) for the Output Summary, however in the version used for this case study the scores were shown to indicate how small changes in the inputs can affect the outputs, e.g., whether the electrolysis result is green (80%) or yellow (79%). This highlights the importance of viewing not only the Output Summary during tool use, but also reviewing the results for each individual technology to determine whether a technology is on the cusp of a different feasibility category. Based on this discussion, the company indicated they found it useful to include the numerical scores in the Output Summary.

During the review workshop, the discussion included the fact that Electrolysis and Geothermal did not have any Unfavorable Attributes in the summary output. In the case of Electrolysis, the scores for each individual attribute were high enough that no single attribute was considered unfavorable. For the Geothermal evaluation, the scores for the attributes considered were not unfavorable but were also not high enough be considered favorable.

When compared to the results of technological feasibility and expectations previously developed by the utility for this site, the ranking of geothermal resulted in questions. While the utility has not yet performed geothermal studies, it was assumed the plant location would be more favorable for that technology than the result developed by the screening tool. The results for all other technologies were similar to the feasibility evaluations and expectations developed by the utility for this particular site.

The utility participating in this case study also identified value in the EPRI repowering screening tool to use during community engagement efforts. The technology feasibility screening provided by the tool presents an opportunity to provide a neutral, third-party evaluation for use in discussions with community leaders to assist with gaining agreement for the future site plans.

Table 4-1. Output summary from Case Study 1

TECHNOLOGY	EVALUATION (GREEN-GOOD, YELLOW - FAIR, RED - POOR)	FAVORABLE ATTRIBUTES	UNFAVORABLE ATTRIBUTES
SOLAR PHOTOVOLTAIC	**68%**	**Available Land** **Transmission**	**Fuel/Energy Source**
GAS TURBINE	**74%**	**Available Land** **Transmission** **Air Quality/Permits**	**Fuel/Energy Source**
ADVANCED NUCLEAR		**Geology/ Seismology** **Cooling Water** **Population** **Atmospheric Dispersion** **Groundwater Radionuclide Pathway**	
MOLTEN SALT ENERGY STORAGE	**94%**	**Available Land** **Transmission** **Other Infrastructure**	
Li-I BESS	**94%**	**Available Land** **Transmission** **Other Infrastructure**	
ELECTROLYSIS	**79%**	**Available Land** **Transmission** **Water Avail/Permits** **Other Infrastructure**	
GEOTHERMAL	**68%**	**Fuel/Energy Source**	

4.3 Case Study 2

This case study was conducted using two retired and demolished coal plant sites owned by an integrated utility based in the southeast United States. The sites selected for the case study have completed CCP closures activities and are currently repurposed as natural gas combined cycle sites on a portion of the sites.

EPRI provided the utility a copy of the input data sheet to provide the information necessary for the screening. The utility reported minimal issues collecting the data and entering the information into the Input spreadsheet. Participating employees reported that most of the information provided was readily available from previous work completed by the utility's CCP and GIS groups. There was some confusion of whether to incorporate the existing generation and employees from the combined cycle plants. Since the tool is used to evaluate retired asset value to new technologies, neither the existing generation nor the employees from the gas plants were included for the screening inputs. EPRI and the utility concluded that the tool and User's Guide should provide explicit direction for these cases.

The output summary for Case Study 2 Site A and Site B is shown in Table 4-2 and Table 4-3, respectively, with numerical scores included for the non-nuclear technologies. Both sites have very similar characteristics and this was reflected in the closely aligned output for the two sites.

Advanced nuclear is the only technology that rated as green for these sites. Geothermal and molten salt energy storage were rated as red, and the rest of the technologies were rated as yellow. All of the non-nuclear technologies were penalized in this analysis because their favorability is influenced by utilization of existing assets including retired transmission capacity, whereas advanced nuclear is only evaluated by the site characteristics. The existing assets for both sites are in various stages of demolition so they are not available for any new generation.

As expected, geothermal is a poor application due to the geology in the southeastern United States. Molten salt energy storage rated as red or poor because the existing steam turbine cycles (a key resource in employing thermal energy storage at retiring coal sites) had been demolished at both sites.

When compared to the previous technological feasibility and expectations developed by the utility for these sites, the ranking of gas turbines raised questions. Given that there are existing gas combined cycles at these sites, they can be considered for any additional gas generation, however, screening tool assesses the repowering options based upon available assets and in this case the transmission and air quality/permits drove the score to the Fair range because the existing combined cycles have repurposed these asset classes.

The utility participating in this case study also identified value in the EPRI repowering screening tool to use as part of their justification for repowering site selection for various technologies, including advanced nuclear. The utility has performed their own evaluation using the Nuclear Siting Guide and indicated the results of this screening validate previous internal studies conducted for these sites.

Table 4-2. Output summary from Case Study 2, Site A

TECHNOLOGY	EVALUATION (GREEN-GOOD, YELLOW - FAIR, RED - POOR)	FAVORABLE ATTRIBUTES	UNFAVORABLE ATTRIBUTES
SOLAR PHOTOVOLTAIC	54%	Available Land	Transmission Fuel/Energy Source
GAS TURBINE	66%	Available Land Fuel/Energy Source	Transmission Air Quality/Permits
ADVANCED NUCLEAR		Geology/ Seismology Cooling Water Population Atmospheric Dispersion Groundwater Radionuclide Pathway	
MOLTEN SALT ENERGY STORAGE	45%	Available Land	Transmission Other Infrastructure
Li-I BESS	56%	Available Land	Transmission Other Infrastructure
ELECTROLYSIS	56%	Available Land Water Avail/Permits	Transmission Other Infrastructure
GEOTHERMAL	33%		Fuel/Energy Source

Table 4-3. Output from Case Study 2, Site B

TECHNOLOGY	EVALUATION (GREEN-GOOD, YELLOW - FAIR, RED - POOR)	FAVORABLE ATTRIBUTES	UNFAVORABLE ATTRIBUTES
SOLAR PHOTOVOLTAIC	54%	Available Land	Transmission Fuel/Energy Source
GAS TURBINE	68%	Available Land Fuel/Energy Source	Transmission Air Quality/Permits
ADVANCED NUCLEAR		Geology/ Seismology Cooling Water Population Atmospheric Dispersion Groundwater Radionuclide Pathway	
MOLTEN SALT ENERGY STORAGE	45%	Available Land	Transmission Other Infrastructure
Li-I BESS	58%	Available Land	Transmission Other Infrastructure
ELECTROLYSIS	57%	Available Land Water Avail/Permits	Transmission Other Infrastructure
GEOTHERMAL	33%		Fuel/Energy Source

5 SUMMARY

As economic, regulatory, and carbon reduction goals evolve, the viability and desirability of operating coal-fueled generating assets continue to decline. Utilities are evaluating former coal-fired plant sites for opportunities to add low- or no-carbon generation while managing the time and cost associated with development and construction. Evaluating the conversion of an existing coal-fired fleet can be performed by systematically creating an inventory of the existing site infrastructure, characteristics, permits, and other attributes, and correlating it with the needs of the evolving energy system with attention to maximizing useful service for both the company and the local community. The ability to quickly screen generation technologies may allow utilities to identify and repurpose assets from the coal-fired fleet to assist with management of cost and schedule for new generation development.

The use of a standardized method for the initial evaluations provides a starting point for discussion of repowering options with internal and external stakeholders, while the flexibility to customize the method for company needs and priorities allows utilities to adapt the baseline model for internal evaluations based on their needs and priorities.

The output from the screening tool can be used to understand what generation technologies are more likely to be technologically feasible for a specific site. This information can be used to engage internal and external stakeholders, compare with evaluations performed internally or by third parties, and to prioritize additional studies to select an appropriate repowering technology.

The screening tool was developed in conjunction with a series of white papers examining the considerations for repowering a coal-fired power plant for advanced nuclear reactors, battery energy storage systems, bulk energy storage, hydrogen production with electrolysis, natural gas and hydrogen generation, and solar photovoltaic generation. The series also examined the equity and environmental justice considerations for repowering, as well as the potential to repower coal-fired power plants as a hub for a net zero industrial cluster. Together, the white paper series and the coal-fired power plant repowering screening tool provide utilities a method for quickly assessing the feasibility of multiple repowering technologies during a screening-level evaluation that can be used as an industry baseline or a customized assessment to facilitate directed evaluations.

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A COAL-FIRED PLANT REPOWERING SCREENING TOOL

B COAL-FIRED PLANT REPOWERING SCREENING TOOL INPUT SPREADSHEET CROSS-REFERENCE LIST

In order to facilitate customization of the coal-fired power plant screening tool, EPRI has developed a cross-referenced list of the locations in each technology worksheet where input values are used. The following table provides a cross-reference of each input value with the location of the information as used by the technology worksheets. This allows users to ensure the appropriate formulas are modified during customization.

INPUT		Advanced Nuclear	Geothermal	Electrolysis	LI-I BESS	Molten Salt Energy Storage	Solar Photovoltaic	Gas/Hydrogen Turbine
Basic Information	Cell							
Owner	C2	A2	A2	A2	A2	A2	A2	A2
Plant Name	C3	A3	A3	A3	A3	A3	A3	A3
Plant Location (County and State)	C4	A4	A4	A4	A4	A4	A4	A4
Land Availability								
Is a significant portion of the site Critical Habitat?	C26	O30						
Buildable Land Total	C37	S31, S32	C8	C8	C8	C8		C8
Buildable Land Solar	C38						C8	
Plant Footprint	C44	S28	C8	C8	C8	C8		C8
Contiguous Land Containing Power Block Land (acres)	C48	S29						
Unit Specific (Transmission and Generation)								
Total Plant	C64		G8	G8	G8	G8	G8	G8
Water Availability/Permits								
Is there a large cooling water source within 5 miles?	C70	E28,Q30						
Is there an existing surface water intake?	C71	Q29	H27	H27	H27	H27		H27
If no intake and a cooling water source within 5 miles, is it accessible?	C72	Q31						
Is the plant cooling water source designated as "Critical Habitat"	C73	O29	H34	H34		H34		H34
Does plant have cooling tower(s) or cooling pond?	C75					L28		

INPUT		Advanced Nuclear	Geothermal	Electrolysis	LI-I BESS	Molten Salt Energy Storage	Solar Photovoltaic	Gas/Hydrogen Turbine
Does plant have a MSGP NPDES permitted discharge?	C79		H29,H30, H31,H32	H29,H30, H31,H32	H29,H30, H31,H32	H29,H30, H31,H32		H29,H30, H31,H32
If the plant has a Zero Liquid Discharge (ZLD) System in lieu of a discharge permit, What are the major components?	C80		H30,H31, H32	H30,H31, H32	H30,H31, H32	H30,H31, H32		H30,H31, H32
Is there municipal, county or water well source of potable water source on site?	C81		H28	H28	H28	H28	H25	H28
Is there an existing Publicly Owned Permit Works (POTW) discharge on site?	C82		H33	H33	H33	H33		H33
Are there existing stormwater ponds?	C83							
Air Quality/Permits								
Has the coal plant been operating over the past 3 years with at least a 10% capacity factor?	C87							J32
Is location in attainment for ozone?	C88							J34
Is location in attainment for particulate?	C89							J35
Is location in attainment for carbon monoxide?	C90							J36
Is location in attainment for sulfur dioxide?	C91							J38
Is location in attainment for nitrogen dioxide?	C92							J37
Does the plant sit in a valley or surrounded by hills or mountains that may inhibit dispersion?	C93	K29						
Does current plant OE and data indicate potential dispersion issues, such as experienced Inverted plume or plume touchdown from stack or cooling tower?”	C94	K30						

INPUT		Advanced Nuclear	Geothermal	Electrolysis	LI-I BESS	Molten Salt Energy Storage	Solar Photovoltaic	Gas/Hydrogen Turbine
Other Existing Infrastructure								
Are Rail or Barge Unloading Facilities on site?	C98		L32	L27	L28	L29	L24	L32
Are there existing warehouse(s) available for reuse?	C99		L33	L29	L29	L31	L25	L34
Are there existing office building(s) available?	C101		L34	L30	L30	L32	L26	L35
Is there an existing full flow raw water treatment (clarification) system?	C103			L32				
Is there an existing demineralized water system designed for high pressure boiler water?	C104			L28		L30		
Are there existing raw water, service water, or demineralized water tanks with total capacity in excess of 300,000 gallons?	C105				L27			
Are there existing wastewater treatment settling ponds?	C106		L35	L31	L31	L33	L27	L36
What is the condition of the steam turbine-generator?	C107					L27		L33
Operations								
Is the coal plant currently in operation?	C111		O8	O8	O8	O8	O8	O8
Fuel/Energy Source								
Is there high pressure (500 psig) gas supply to the existing plant?	C116							
What is the distance to the closest interstate pipeline? (miles)	C117							P35
What is the distance to closest high pressure intrastate (LDC) pipeline greater than 12-inch diameter? (miles)	C118							P36

INPUT		Advanced Nuclear	Geothermal	Electrolysis	LI-I BESS	Molten Salt Energy Storage	Solar Photovoltaic	Gas/Hydrogen Turbine
What is the average global horizontal solar irradiance (GHI) factor for the location (kwh/m2/day)	C119						Q8	
What is the Geothermal Resource Favorability based on the NREL Map?	C120		P35					
What is the value of the geothermal gradient?	C121		P36					
Estimated temperature at 4.5 Km	C122		P37					
What is the Heat Flow at the location of the coal plant?	C123		P38					
Population and Land Use								
What is the population density of the location within a 20-mile radius (persons/sq. mile)?	C128	I28, I29						
What is the population density of the location within a 4-mile radius (persons/sq. mile)?	C129							E8
Is there a population center of greater than 25,000 within 4 miles?	C130	I30			D22			
Is there a population center of greater than 100,000 within 10 miles?	C131	I31						
Is there a population center of greater than 500,000 within 20 miles?	C132	I32						
Is there a population center of greater than 1,000,000 within 30 miles?	C133	I33						
Is a "Commercial Service" or "Cargo Service" airport within 10 miles?	C134	G29						
Are military installations within 10 miles	C135	G28						

INPUT		Advanced Nuclear	Geothermal	Electrolysis	LI-I BESS	Molten Salt Energy Storage	Solar Photovoltaic	Gas/Hydrogen Turbine
Are there major industrial areas or other hazards within 5 miles?	C136	G30						
Are there public amenities with 10 miles?	C137	G30						
Is the site located in the region of a U.S. EPA Class I groundwater resource and/or a "Sole Source Aquifer"?	C138	M29						
Is the site on an EPA defined Class I source aquifer. Class I sources are of unusually high value but highly vulnerable to contamination and are irreplaceable sources of drinking water and/or ecologically vital.	C139	M30						
Seismic Hazard (Peak Ground Acceleration 2% in 50 Years) Input PGA value for intersection of the black curve (PGA) with the blue line(Time Horizon 2475 years).	C140	C28						
In the 25-mile radius region around the plant what type of zoning best characterizes the land?	C141			D30				
Is the Total Plant Area within CCP Inundation Zone?	C142	U28						
Is the Total Plant Area within 1000 yards of Existing or Planned Ash Landfills?	C143	U29						
How far away Is the closest to an existing developed geothermal plant? (miles)	C144		D28					
In a 10-mile radius from a coal site, is there a hydrocarbon development site or significant hydrothermal resource?	C145		D29					
What is the measured temperature at the well depth?	C146		D29					

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Program

Plant Decommissioning and Site Redevelopment Supplemental Program

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EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA
800.313.3774 ▪ 650.855.2121 ▪ askepri@epri.com ▪ www.epri.com