Feasibility Assessment and Economic Evaluation: Repurposing a Coal Power Plant Site to Deploy an Advanced Small Modular Reactor Power Plant

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Executive Summary

This report documents a Feasibility Assessment for deployment of an X-energy Xe-100 Standard Plant (four advanced small modular reactors) (SMRs) at a coal-fired power plant site in Maryland. This study has been performed by X-energy, along with its contractor, MPR Associates, under a grant from the Maryland Energy Administration (MEA Grant 2022—2-544S1), in conjunction with Frostburg State University (FSU), whose talented team performed the socioeconomic study and external communication plans for this study. Under the Grant, a proprietary, commercial confidential report, and a public report was produced. This report is the public version.

This innovative evaluation is a starting point for achieving several benefits for Maryland, including supporting plans for greenhouse gas reduction, strategic planning for decarbonization, improving energy resiliency, state-wide economic development, job sustainability, and job growth. This study provides information relating to energy management and helping MEA develop strategic plans and implement policies relating to energy supply management.

The results of this study show that the methodology of combining engineering reviews, siting, environmental, and regulatory reviews, along with the initial plant economic study, and the socioeconomic impact and benefits, is sound. The study presents a viable, comprehensive, and powerful business case for further development toward a project optimization of repurposing a coal generation facility to an advanced small modular reactor electric generation facility.

This initial review indicates that deployment of a four-unit Xe-100 SMR at a coal generation facility in Maryland may be feasible from an engineering and cost perspective, although several characteristics of the site present challenges. The site that was the focus of this study appears to be acceptable from the perspective of external hazards (seismic, flooding, etc.) and having adequate infrastructure in place (e.g., water, sewer, rail, and road connections). Environmental permitting is likely to be achievable given the coal power plant permits that are currently in place.

While the site may be large enough to accommodate the Xe-100 facility (with significant deviations from the standard Xe-100 configuration), there could be significant cost and schedule implications of modifying the standard design four-unit plant to accommodate siting constraints. Further, development adjacent to the site in combination with the constrained site may make establishing appropriate construction, security, and radiation boundaries challenging. The existing grid interconnection will require upgrades to the current electrical interconnection facilities. Consideration of a two-module unit for the site would mitigate these principal siting and interconnection risks due to the smaller footprint and lesser electrical output. Further consideration of a two-module facility is recommended.

A scoping economic feasibility evaluation was performed for the deployment of an X-energy Xe-100 advanced small modular reactor (SMR) standard plant at the coal-fired power plant site. Based on X-energy's current economic modeling, a 4-reactor 4-turbine Next-of-a-Kind (NOAK) plant has a satisfactory overnight cost and annual operating cost. This translates to a competitive LCOE. These costs are in 2020 USD and meet the requirements of an AACE Class 5 (-50%/+100%) estimate. In addition to project costs, supply chain risks; baseline and forecast electricity market prices; and available tax credits through the Inflation Reduction Act were investigated and presented.

It is recommended that the next level detailed economic evaluation be completed that expands upon the findings presented in this report. This evaluation should include a techno-economic evaluation to identify the optimal number of reactors to deploy on site, and collaboration with the plant owner to develop a tailored cost model that includes owner-specific inputs for the site. The scope would also include the project costs for decommissioning and deconstruction of the plant, and account for the overall jobs and supply-chain benefits of the transitional period toward the new plant construction. Further, alternative product and revenue sources beyond the production of electricity should be considered and assessed such as district heating. Finally, the economic modeling should be updated to account for recent supply chain price increases, which could significantly impact the resulting LCOE. It should, however, be noted that X-energy's supply chain increases are not unique, and all construction projects are experiencing increased costs.

A socioeconomic study was performed, and the results are included in this report. This study was developed by Frostburg State University with support from X-energy. In summary, the overall impacts of the shutdown of the existing coal-fired power plant and the construction and operation of the new modular nuclear power plant are significant for the local area. Without a replacement of the existing plant, the area could lose as much as $122 million of its local economic output. While there are fewer linkages between the modular nuclear power plant and the surrounding area compared to the existing plant, the impacts of the construction and operation of the new plant are notable and would represent a significant positive economic impact for an economically lagging region within the nearby county.

The FSU Strategic Communication Plan, developed to improve and strengthen communication, engagement, and understanding of X-energy’s Small Modular Reactor (SMR) technology within the Maryland community, is exceptional. The Strategic Communication Plan outlines an effective approach to improve and strengthen communication, engagement, and understanding of X-energy’s Small Modular Reactor (SMR) technology within the Maryland community. This plan will support robust communication and interaction with the local community to avoid the pitfalls of absent stakeholder engagement.

Overall, the methodologies employed in this study are effective and may be replicated for other fossil fuel generation facilities, with growth from lessons learned from this report, which include a starting point to develop the optimized Xe-100 SMR deployment strategy.

A heartfelt thank you goes out to the professional staff at the plant, who supported X-energy and Frostburg State University in this study. It is clear the transition from coal power generation to advanced nuclear power generation can be safely and effectively supported from the highly competent and professional staff at the plant. The technical interest, project support, and overall enthusiasm was well appreciated by X-energy and FSU. We believe the case will be the same for similar coal plants in Maryland. X-energy would also like to express its appreciation and gratitude to the Maryland Energy Administration for awarding this grant to X-energy and FSU to participate in developing a plan to support the State of Maryland and its goals to develop strategic plans and implement policies relating to energy supply management.

Glossary of Terms

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Term	Explanation
Contribution	Contribution (economic) represents the gross change in economic activity associated with an industry, event, or policy in an existing regional economy.
Employee compensation	Employee compensation is comprised of wages, salaries, commissions, and benefits such as health and life insurance, retirement, and other forms of cash or non-cash compensation.
Employment	Employment is a measure of the number of jobs involved, including full-time, part-time, and seasonal positions. It is not a measure of full-time equivalents (FTEs).
Exports	Exports are sales of goods to customers outside the region in which they are produced, which represents a net inflow of money to the region. This also applies to sales of services to customers visiting from other regions.
Final Demand	Final Demand represents sales to final consumers, including households, governments, and exports from the region.
Gross Regional Product (GRP)	Gross Regional Product (GRP) is a measure of total economic activity in a region, or total income generated by all goods and services. It represents the sum of total value added by all industries in that region and is equivalent to Gross Domestic Product (GDP) for the nation or Gross State Product (GSP) for states.
IMPLAN	IMPLAN is a computer-based input-output modeling system that enables users to create regional economic models and multipliers for any region consisting of one or more counties or states in the United States. The current version of the IMPLAN software, version 3, accounts for commodity production and consumption for 536 industry sectors, 10 household income levels, taxes to local/state and federal governments, capital investment, imports and exports, transfer payments, and business inventories. Regional datasets for individual counties or states are purchased separately.
Impact or **total impact**	Impact or total impact is the change in total regional economic activity (e.g., output or employment) resulting from a change in final demand, direct industry output, or direct employment, estimated based on regional economic multipliers.
Imports	Imports are purchases of goods and services originating outside of the region of analysis.
Income	Income is the money earned within the region from production and sales. Total income includes labor income such as wages, salaries, employee benefits and business proprietor income, plus other property income.

Term	Explanation
Tax on Production and Imports	Tax on Production and Imports are taxes paid to governments by individuals or businesses for property, excise, and sales taxes, but do not include income taxes.
Input-Output (I-O) model/Social Accounting Matrix (SAM)	Input-Output (I-O) model and Social Accounting Matrix (SAM) are a representation of the transactions between industry sectors within a regional economy that captures what each sector purchases from every other sector to produce its output of goods or services. Using such a model, flows of economic activity associated with any change in spending may be traced backwards through the supply chain.
Local	Local refers to goods and services that are sourced from within the region, which may be defined as a county, multi-county cluster, or state. Non-local refers to economic activity originating outside the region.
Margins	Margins represent the portion of the purchase price accruing to the retailer, wholesaler, and producer/manufacturer in the supply chain. Typically, only the retail margins of many goods purchased by consumers accrue to the local region, as the wholesaler, shipper, and manufacturer often lie outside the local area.
Multipliers	Multipliers capture the total effects, both direct and secondary, in a given region, generally as a ratio of the total change in economic activity in the region relative to the direct change**.** Multipliers are derived from an input-output model of the regional economy. Multipliers may be expressed as ratios of sales, income, or employment, or as ratios of total income or employment changes relative to direct sales. Multipliers express the degree of interdependency between sectors in a region's economy and therefore vary considerably across regions and sectors. A **sector-specific multiplier** gives the total changes to the economy associated with a unit change in output or employment in a given sector (i.e., the **direct economic effect)** being evaluated. **Indirect effects multipliers** represent the changes in sales, income, or employment within the region in backward-linked industries supplying goods and services to businesses (e.g., increased sales in input supply firms resulting from more industry sales). **Induced effects multipliers** represent the increased sales within the region from household spending of the income earned in the direct and supporting industries for housing, utilities, food, etc. An **imputed multiplier** is calculated as the ratio of the total impact divided by direct effect for any given measure (e.g., output, employment).
Other property income	Other property income represents income received from investments, such as corporate dividends, royalties, property rentals, or interest on loans.
Output/Direct Output	Output is the dollar value of a good or service produced or sold and is equivalent to sales revenues plus changes in business inventories. Direct output is the value of sales revenues within the sector(s) evaluated.
Producer prices	Producer prices are the prices paid for goods at the factory or point of production. For manufactured goods, the purchaser price equals the producer price plus a retail margin, a

Term	Explanation
	wholesale margin, and a transportation margin. For services, the producer and purchaser prices are equivalent.
Proprietor income	Proprietor income is income received by non-incorporated private business owners or self-employed individuals.
Purchaser prices	Purchaser prices are the prices paid by the final consumer of a good or service.
Region/Regional Economy	Region or Regional Economy is the geographic area and the economic activity it contains for which impacts are estimated. It may consist of an individual county, an aggregation of several counties, a state, or an aggregation of states. These aggregations are sometimes defined on the basis of worker commuting patterns.
Sector	Sector is an individual industry or group of industries that produce similar products or services or have similar production processes. Sectors are classified according to the North American Industrial Classification System (NAICS).
Value Added	Value Added is a broad measure of income, representing the sum of employee compensation, proprietor income, other property income, indirect business taxes and capital consumption (depreciation), that is comparable to Gross Domestic Product. Value added is a commonly used measure of the contribution an industry makes to a regional economy because it avoids double counting of intermediate sales.

I. Engineering and Regulatory Assessment

Introduction

This report documents a Feasibility Assessment for deployment of an X-energy Xe-100 Standard Plant (four advanced small modular reactors) (SMRs) at a coal-fired power plant site in Maryland. This study was performed by X-energy, along with its contractor, MPR Associates, under a grant from the Maryland Energy Administration (MEA Grant 2022—2-544S1) in conjunction with Frostburg State University (FSU), whose talented team performed the socioeconomic study and external communication plans for this study.

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Background

The Xe-100 SMR is a Generation IV Advanced Reactor based on High-Temperature Gas-Cooled Reactor (HTGR) technology. Power is generated with US-developed Uranium Oxycarbide (UCO) TRISO fuel embedded in spherical fuel elements, referred to as fuel pebbles. The standard Xe-100 site is sized to include up to four reactors, each capable of providing approximately 80 MWe (megawatt-electric) and planned to support construction of subsequent units during operation of the completed plants.

X Energy, LLC is one of two recipients of the Department of Energy's (DOE) Advanced Reactor Demonstration Program (ARDP), which is a policy initiative designed to demonstrate truly innovative advanced reactor (AR) designs and supporting infrastructure that will allow the US industry to reclaim its position of global leadership and influence. X-energy understands the stakes, has developed visionary market entry plans, and now is partnering with the US Department of Energy (DOE) to deliver the first-ever commercial-scale AR to the market by 2029. The ARDP award provides $1.2 billion in funding from the DOE. The award fully funds all remaining design, licensing, and commercialization milestones of the reactor.

X-energy's Xe-100 Nuclear Steam Supply System (NSSS) meets all the goals for Generation (Gen) IV Nuclear Energy Systems, and specifically the following safety and reliability goals:

- Goal 1: "Walk-away safe" achieved with a balance of four intrinsic safety functions;
- Goal 2: Zero core damage frequency; no chance of a core melt; and
- Goal 3: Passive safety-related systems allow near-infinite coping time.

The Xe-100 NSSS does not require electrical power, active systems, or operator action to keep the public safe. The concept of core damage frequency is eliminated (i.e., zero): the laws of physics prevent core materials from reaching temperatures that might compromise the core. Our fuel pebbles do not melt at temperatures produced by off-normal events. This level of performance has been substantiated through many years of operational experience and confirmed for the Xe-100 design through high-fidelity modeling and simulation. The TRISO fuel has been proven for more than 50 years internationally and in the US (DOE AGR Program) and provides a test-proven basis for the safety case.

Figure 1: Artist Rendition of the Xe-100 Standard 4-Unit Plant

The site occupies a nominal area of less than 30 acres.

Overall Site Size = 1,493 ft [455 m] by 1,165 ft [335 m]

Structures, systems, and components (SSCs) required to service the reactor are contained on the nuclear island, located within a secure, Protected Area Boundary (PAB). Remaining power generation and auxiliary equipment is located on the conventional island, external to the PAB. Most of the reactor building and the on-site Interim Spent Fuel Storage Facility are located below grade, which is sized to accommodate all spent fuel from the 60-year design life of the facility. Xe-100 does not require active systems or operator actions to ensure safety. All safety functions are intrinsic to the design.

The reactor uses helium to transfer energy at high temperature (about 1,380 °F [750 °C]) from the reactor under high temperature and pressure (about 1,050 °F [565 °C] and 2,430 psig [16.8 MPa]), high efficiency, condensing steam turbine via a steam generator. The reactor and steam generator design can support flexible operation with a ramp rate of 5% per minute up or down between 40% and 100% power.

Mechanical draft wet cooling towers remove waste heat from the closed-loop circulating water system serving each condenser. A common water treatment facility provides the process water used to support the Xe-100 operations, and a common switchyard serves all four electrical generating units. Two electrical transmission lines connect the switchyard to the local electrical grid.

This footprint includes the area required for the site owner-controlled area (OCA) and the stormwater run-off system around the perimeter of that boundary. There is a single point of controlled access to the overall OCA and an additional separate single-controlled access point to the PAB that surrounds the portion of the site containing the majority of power production equipment (and all Safety-Related equipment). Other administrative, maintenance, and training buildings are located inside the OCA.

This section assesses the engineering requirements for repurposing the Station with the standard four-module Xe-100 SMR design. The assessment approach considers technical, regulatory, and schedule risks. The level of detail provided in the study (and associated level of design and analysis) is limited to a pre-conceptual level and is consistent with the objective of identifying any fatal flaws and significant advantages or challenges associated with repurposing the Station.

1.1 Station Site Characteristics

1.1.1 Site Overview

For purposes of this study, X-energy and FSU assumed that a specific coal generation facility in Maryland would be repurposed. At the request of the plant owner/operator, this site is not specified in this report.

The coal generation facility is currently operating and is not a retired facility. The Xe-100 would be able to replace all of the electrical generation currently provided by the coal generation facility. Because of the coal generation facility's design, major components such as the turbine would not be able to be repurposed for use with the Xe-100.

1.2 Site Features

1.2.1 Water, Gas, and Sanitary Waste Supply

Site water is supplied by public utilities, with sufficient water to support plant operations. A four-unit Xe-100 requires approximately 30% more water than the design water intake of this particular coal generation facility. While the piping infrastructure is sufficient to accommodate such an increase, additional water sources and permitting would be required. Natural gas is supplied to the site which is not required for Xe-100 plant operations; however, access to the gas pipeline infrastructure could be useful in future scenarios where low-cost nuclear power is used to produce hydrogen which could be sold by blending into the natural gas pipeline system.

1.2.2 Site Runoff and Wastewater Discharge

Effluent from the following onsite sources is treated prior to discharge:

- Cooling tower blowdown
- Coal pile runoff
- Demineralizer regeneration wastes
- Boiler blowdown
- Chemical metal cleaning wastes

- Wastewater
- Low volume waste sources
- Stormwater

The site has a National Pollutant Discharge Elimination System (NPDES)-permitted outfall. In addition to limitations on contaminants, a temperature limit of 90°F [32.3°C] must be maintained during the months of June, July, August, and September. The current NPDES permit expires in two years.

1.2.3 Electrical Transmission

The coal generation facility is connected to a dedicated 138 kV transmission line to connect to the transmission system. The transmission line extends for nearly 6 miles (9.5 km) to its interconnection point. The transmission line is overhead for 4.6 miles [7.4 km] and below grade for 0.9 miles [1.4 km].

1.2.4 Site and Area Topography

The site is generally at two elevations, with the area occupied by the coal stockpiles higher than the production plant area. It features a long, forested hillock along the north border of the site and a smaller hill in the northeast corner of the site. The elevation of the site is above the 100-year flood hazard elevation.

1.2.5 Wetlands

The site includes palustrine emergent and palustrine forested wetlands. The design and maintenance of these wetlands was permitted by Maryland Department of Natural Resources (DNR), Water Resources Administration which is now the Maryland Department of the Environment. Periodic inspections of the wetlands are self-performed by station personnel to verify the wetlands and the required buffer are maintained and unaffected by station operations. The wetlands are maintained by overflow from the stormwater management pond.

1.2.6 Area Features

The site is part of a low-density industrialized area. Established roadways provide access from the site to a nearby two-lane state highway. A railway is adjacent to the site, with a rail spur providing rail access to the site.

1.2.7 Rail Access

The rail access is provided by an existing switch of the spur maintained for regular use. The rail spur has not been used since initial construction of the site. Significant maintenance to the switch and a portion of the siding on the site will be required to support redevelopment.

1.3 Site Feasibility Technical Assessment

1.3.1 Arrangement of XE-100 On Site

To fit a standard four-unit Xe-100 unit into the subject site location, significant modifications to the standard plant design would likely be necessary. The driving siting features in adapting the layout were:

- Maintaining the four reactor and steam turbine design line-up from the generic configuration to maintain efficiency in the design;
- Providing sufficient space for the protected area barrier to satisfy security concerns;
- Ensuring sufficient space for the Xe-100 security boundary between the site border (existing fence) and new security corridor;
- Continuing the site drainage approach for maintaining the wetland area;
- Maintaining site access and rail access locations;
- Utilizing the locations of the site supporting utilities, including the transmission line; and
- Continuing to use wet cooling towers to support power generation on the site.

An access road to an adjacent parcel is also maintained in this area of the site plan and would be needed as a laydown area. The size and weight capacities of the access roads must be evaluated to ensure an adequate heavy haul path for equipment delivery can be established. Rail access to the site is provided but the rail spur into the site would need to be evaluated for upgrading from its current condition.

Implementation of the Xe-100 four-unit design requires use of the undeveloped property along the north boundary to accommodate plant facilities and provide clear lines of sight for facility security. This will change the perception of the site from the surrounding highways and offsite areas, although the elevation of the facility structures will be significantly less visible than the current structures.

While adaptation of the standard four-unit plant design, as described above, may be technically feasible, the potential technical challenges and cost impacts resulting from the space constraints could be significant and include required re-analysis of relocated underground facilities and structures, site boundaries, and security provisions. The potential for these issues would likely be minimized if a smaller, lower capacity, two-unit version of the Xe-100 plant were to be considered.

1.3.2 Site Geotechnical Consideration

The site is located on an alluvial plain. The overlying soils are characterized as unconsolidated reddish brown to tan sand, silt, pebbles, and cobbles that weather yellow, orange, and orange-brown. The soils are considered light loams mixed with fragments of broken shales. The underlying rock strata extend to substantial depths (> 3,500 ft [1,067 m]). Additional geotechnical studies would need to be conducted to support design and licensing of the Xe-100, but these site investigations would be conducted at every proposed site and are not unique to the subject site.

1.3.3 Use of Existing Infrastructure

As discussed earlier, the operating steam conditions of the Xe-100 are significantly greater than those used in the existing steam cycle equipment at the plant. Therefore, none of the existing equipment can be repurposed to support the new facility design. It is expected that scrapping the existing equipment would be the most cost-effective disposition, as resale opportunities are limited. The age, condition, and relative position of the cooling tower structure to the potential Xe-100 site arrangement make reuse of this equipment unlikely for repurposing the site.

The electrical output from the Xe-100 does not align with the existing switchyard components and capacities. Relocating these components would also be necessary to support the footprint requirements of the Xe-100, and further limits potential use to support the new plant. However, the existing electrical distribution yard could be used to provide construction power needs during much of the power island construction.

The addition of another 138 kV circuit is required to accommodate the power generation from the Xe-100 4-pack design as it is greater than the current site output. It is feasible for the existing pole structures to support this additional line, pending detailed verification of their design. The approximately one-mile portion of the transmission line that is underground would require installation of an additional line. This installation would involve excavation of the streets involved. Ensuring adequate separation distance between the two circuits may require shifting the location of the existing line, located under the center of the roadway.

The existing stormwater collection system could be reused to support the Xe-100 facility. Rerouting the buried piping will be required to serve the new facility arrangement. Continued use of the stormwater management pond has advantages during site construction as well as operation. Continued use of the stormwater management pond to maintain the adjacent wetlands should mitigate any permitting challenges in this area.

Although new permitting would be required, the existing wastewater discharge facilities for the site can potentially be used to support operations of the Xe-100 facility. No new piping extending from the site to the discharge point will likely be required. Modification of the discharge to the river to incorporate improved mixing of the return flow in the river to reduce thermal impacts may be required.

The existing municipal water supply and sewer connection for the site are sufficient for use during both construction and operation of the Xe-100 facility.

1.3.4 Regulatory Considerations

The feasibility of locating the Xe-100 facility at the site depends on acceptance by several regulatory organizations of the project’s compliance with local, regional, and national regulations. Table 1 provides an assessment of the main project development areas where regulatory compliance and acceptance is required. Table 1 focuses on comparing the conditions addressed in the permitting of the site to the demands imposed by the Xe-100 project implementation and are based on the current regulatory requirements. This approach is considered adequate for this initial feasibility study but will require refinement in the next step of project development.

Table 1: *Development and Regulatory Impacts on Site Re-Use*

Regulation	Assessment[1]	Potential Challenges[2]
	High Risk	
Interconnection Study and Agreement	The installed transmission capacity is not adequate to support a four-unit Xe-100 capacity (320 MWe) and will need to be upgraded. Regardless of generator capacity, a new Interconnection Feasibility Study and Subsequent System Impact and Facilities Studies will be required to determine the ultimate scope and cost of system transmission infrastructure improvements associated with and paid for by the project. The interconnection process currently takes several years and has an uncertain cost outcome.	The capacity of the current interconnection will need to be increased. Capacity at the substation where interconnection would occur is likely limiting (i.e., costly) based on system changes over the years. Additional downstream impacts are uncertain. The risk of high interconnection costs increases because the generation capacity of a four-unit Xe-100 facility is significantly greater than that of the current facility. Currently there is a moratorium on consideration of new interconnection applications due to the high backlog of applications to be processed and the need to resolve process issues.
NRC Operating License – Emergency Planning	Local highways in area of site may not be sufficient for effective area evacuation.	Emergency management processes, including evacuation plans, are required for NRC license. Implementation is not possible without an approved Emergency Plan.
	Intermediate Risk	
Water Use Permit	The Xe-100 water demand is approximately 30% higher than the design water demand for the current facility. The available size of the water pipeline is sufficient to supply the Xe-100 demand.	Expansion of permitted water use will be required.
County Building Permits	Modular construction and drilled excavation of foundations are construction techniques integral to Xe-100 design that have not been used in this locale. Much of Xe-100 construction will be like the means and methods used for the original construction of the existing coal facility.	Construction of a nuclear power plant will be a new evolution for county permitting. The impact of this evolution can be mitigated through increased engagement by X-energy and plant owner staff.

Regulation	Assessment[1]	Potential Challenges[2]
	Limiting reuse of existing buildings will facilitate the permitting by keeping focus on new construction.	
NRC Operating License – Public Opposition	Long-term (beyond the 60-year plant design life) storage of spent fuel on-site may create negative public perception of Xe-100 facility. Neighboring industrial facilities concerns regarding the security and workplace safety of locating next to Xe-100 facility.	Intervenor and local opposition to permitting of Xe-100.
NRC Operating License – 10CFR100 Exclusion Area Boundary (EAB) Definition	An EAB must be established to ensure the public is not exposed to unacceptable radiological dose. Current X-energy design goals indicate an EAB of about 1,300 ft [400 m] will be required. Based on the site geometry including likely locations of the Nuclear Island and proximity of neighbors, there is a substantial risk that an appropriate EAB cannot be established, thus challenging the feasibility of siting a four-unit Xe-100 plant on this site.	Ongoing evaluations may also identify a shorter EAB distance than 1,300 ft [400 m]. However, a smaller number of reactor units may allow better use of site. The resulting lower power generation capacity of a smaller facility could present challenges to project economics.
	Low Risk	
Title V Permit	Air emissions permit will be required for the site consistent with Xe-100 equipment, although the impact on site area will be substantially reduced relative to the coal facility. Emissions reductions will substantially improve air quality and address global warming concerns,	
NPDES Permit	The contaminant loading requirements in the current permit will not be challenged by the Xe-100 wastewater discharge. Xe-100 discharge flowrate requirements are roughly 33% lower than the design discharge for the Station. Temperature limit in the existing NPDES permit has not proven a challenge for the Station. Through continued use of wet cooling towers, Xe-100 design should not challenge this permit constraint.	Future reduction in the water emissions limits could impact the Xe-100 NPDES permit.
Fire Protection and Emergency Services Permit	Emergency services are provided by a Volunteer Fire Department. Existing services have been modernized, but focus on the needs of essentially a rural community (50 sq. mile [129 km^2] service district)	Training of volunteer fire department to comply with the needs of a nuclear power plant will be significant. EMS capabilities will need to be expanded to address concerns unique to Xe-100 operations.

Regulation	Assessment[1]	Potential Challenges[2]
Sewer Connection Permit	The sanitary wastewater disposal requirements of the Xe-100 design are substantially bounded by the design of the current facility. This is expected to be sufficient to accommodate the increased occupancy during Xe-100 operations (about twice the current facility).	Design capacity planned for the site may not be representative of capacity available at time of Xe-100 construction due to growth of the area or change in area demand.
Maryland DOT Permit	Truck traffic associated with operation of the Xe-100 plant will be significantly less than associated with the coal facility. Current intersection already facilitates highway access to the site.	Bridge capacity could limit highway deliveries to site during construction.
EPA Environmental Impact Statement	Repowering the coal facility reduces the overall environmental impact compared to the currently permitted technology. The current industrialization of the area significantly reduces the potential for new impacts from the construction of the Xe-100.	Development of more stringent standards in an evolving environment could adversely impact permitting.
County Conservation District Erosion and Sedimentation Control Plan	A grading and sediment control plan will be required for the construction of the Xe-100 facility. No unique challenges are expected from the construction as the water table will be maintained during excavations. The operational plant will preserve wetland and enhance areas of the site currently used for coal and ash storage.	Staging of site demolition with construction adds a complexity to the plan development and permit approval.
Maryland Department of the Environment	The use of the site by Xe-100 will not change the existing wetland area or the approach to collecting stormwater. Covered surface area in Xe-100 will be approximately the same as the Station footprint. Additional stormwater runoff collection will be performed due to elimination of the separate coal stockpile runoff collection and treatment system.	Potential risk could result from future changes in the wetlands regulations in Maryland.

Notes: 1. Assessments are based on the current development of the Xe-100 facility design and detail of the information provided on subject site.
2. Potential challenges described are expected to bound the potential project risks, but do not imply any probability of occurrence.

1.3.5 Implementation Approach

It is preferrable to minimize the period between suspension of coal plant operations and commercial operation of a replacement Xe-100 facility. The potential Xe-100 site arrangement to repower the facility provides opportunities for beginning significant construction on the site prior to the coal facility shutdown. Implementing this approach will require creative contracting and detailed planning for the use of the site and for the execution of the Xe-100 project.

Step 1: Initial construction activities would focus on the currently unused areas of the site. The activities include clearing, grubbing, and grading of the unused buffer area and possible installation of a temporary pond to handle construction-related stormwater runoff. The inactive coal pile area would be prepared for construction of the first unit of the Xe-100 facility. Removal of the coal pile liner will likely involve off-site disposal of contaminated soil. Construction runoff control should use the existing coal pile runoff pond. Enhanced station management of the active coal stockpile will be required.

Step 2: The active coal pile would be retired, and the area prepared for construction of the second unit of the Xe-100. Removal of the coal pile liner will likely involve off-site disposal of contaminated soil. Construction runoff control should use the existing coal pile runoff pond.

Step 3: After coal facility operations cease, buildings and foundations from the remainder of the area required for the construction of the Xe-100 units (including the third and fourth units) would be decommissioned and cleared. Rubble from concrete can be stored for use as fill material elsewhere on site. Removed paved area materials can be stored for reuse in paved areas of the new site. Construction runoff control could use the existing coal pile runoff pond.

Step 4: The coal pile runoff pond would be retired using material from grading of previous area to fill the pond. Construction runoff control should use the existing stormwater management pond. Any temporary construction runoff control pond supporting clearing should also be retired.

Step 5: In parallel with Steps 3 and 4, remaining buildings and foundations would be decommissioned and removed, including the current cooling towers. Significant material can be sold as scrap from the demolition of the boiler, turbine-generator, condensers, and coal-handling conveyor. Rubble from concrete will require off-site disposal. Store removed pavement materials for reuse in paved areas of new site. The switchyard area would be maintained as source of construction power.

Step 6: A significant amount of material can be sold as scrap. Foundations can be left in place unless new use for this small area is identified beyond laydown to support plant construction.

Unused adjacent property to the site is accessible by an existing road (unpaved) and adjacent to onsite rail access. The offsite property could be temporarily leased, and the onsite rail spur area could be used to provide additional lay-down space during the construction of the Xe-100 facility. These areas would need to be cleared and graded to provide suitable surface for lay-down, with potential re-use of the crushed concrete rubble resulting from the clearing and grading.

The steps identified in the phased development plan identify opportunities that should reduce both the cost and schedule for the construction of Xe-100 facility. The contractual and coal facility operational challenges of implementing this approach need to be fully considered prior to pursuing the strategy involved in this staged approach. Further evaluation also needs to address the complication of managing construction personnel on an operating plant site, including necessary parking and construction support facilities.

1.3.6 Implementation Schedule

X-energy has developed a schedule for the initial implementation of the Xe-100 design at another site under the US DOE ARDP. The durations and major activities from this schedule were adapted to support implementation of an Xe-100 project on the site. This conceptual schedule is integrated with the overall Xe-100 project development schedule and accounts for the scheduled end of current plant commercial operations.

The Xe-100 ARDP schedule is based on a 10CFR50 application process. Licensing could be implemented under the 10CFR50 or 10CFR52 approach. In a 10CFR50 approach, a two-step process is used: 1) obtain a construction permit, and 2) obtain an operating license for each unit. This approach requires an applicant to submit a construction permit application and an operating license application sequentially. This approach is beneficial as it allows a project to start construction earlier while updating final design information as part of the operating license. Under a 10CFR52 approach, X-energy would submit a design certification application for the Xe-100 based on the results of the NRC review of the ARDP Operating License application, and a combined license application. A regulatory analysis would be performed in the feasibility stage of the project to determine the appropriate regulatory path. The Feasibility Schedule shown below assumes that the NRC approval of the Xe-100 Certified Design would occur prior to COL issue, or as a contingency, the approved ARDP Operating License would be available to incorporate by reference in this project's COLA. The schedule also uses the NRC's generic review schedules. Table *2* summarizes the initial feasibility schedule.

Table 2: ***Initial Feasibility Schedule for Xe-100 Project at a Maryland Coal Facility Site***

Schedule Activity	Key Project Dates	
	Start	End
Site-Specific Engineering	30 Jun 2025	30 Jun 2027
COLA Preparation	30 Jun 2025	30 Sep 2027
COLA Submittal	30 Sep 2027	
Interconnection Studies	30 Sep 2026	30 Sep 2029
Site Preparation	1 Oct 2029	30 Sep 2030
Long Lead-Time Material Procurement	30 Mar 2028	1 Jun 2031
COL Issued	1 Oct 2030	
Site Demolition and Remediation	1 Oct 2030	1 Oct 2033
Interconnection Upgrades	1 Jun 2030	1 Jun 2032
Unit 1 Build	1 Jun 2030	30 Nov 2032
Unit 1 Start-Up	1 Dec 2032	31 May 2033
Unit 2 Build	1 Feb 2031	31 Jul 2033
Unit 2 Start-Up	1 Aug 2033	31 Jan 2034

Schedule Activity	Key Project Dates	
	Start	End
Unit 3 Build	1 Aug 2031	31 Jan 2034
Unit 3 Start-Up	1 Feb 2034	31 Jul 2034
Unit 4 Build	1 Feb 2032	31 Jul 2034
Unit 4 Start-Up	1 Aug 2034	31 Jun 2035

The overall project schedule for repowering the coal site using the Xe-100 technology is about 9 to 10 years using generic NRC review schedules and the planned Xe-100 construction schedule.

The period without any generation on site is about 32 months, based on using the existing transmission line to support the operation of the first two reactors. The construction portion of the schedule reflects the site development approach discussed previously. The objectives of the construction portion of the schedule were to begin selected construction activities during coal facility operation to advance the schedule, and to provide for phased initiation of facility operation to minimize the period without power generation at the site.

The activities associated with construction of Xe-100 buildings and components on a prepared site were based on the generic X-energy schedule. The durations of the other construction activities were based on first-order estimate of the work required based on site walk-down observations of the existing site arrangement. As the generic schedule did not assume constraints associated with the site footprint, coincident operations, decommissioning activities, and other site-specific elements, this work plan and schedule should be revisited when completing the feasibility study for the project.

1.3.7 Implementation Challenges

Several issues related to implementation of the Xe-100 have been identified and require further consideration. These issues are discussed in Table *3*.

Table 3: *Implementation Challenges for "Home" County Site Feasibility Assessment*

Potential Site Use Challenges	Potential Project Impacts	Mitigating Actions
Design change implications of constrained site footprint.	Reconfiguration of the standard four-unit Xe-100 plant layout to fit the existing site would lead to an extended design period.	Use of a two-unit configuration will likely reduce or eliminate layout constraints. The detailed arrangement of the two-unit configuration requires additional evaluation.
Security visibility demands (timber buffer removal) present unacceptable sight lines to adjacent historic/cultural resources.	Permitting and public relations challenges to sites viability.	Argument based on limited length of exposure and similar concerns to nearby facilities. Political support based on favorable impact on climate change in long view.
Removal of forest barriers (to support site security) may impose additional requirements for offsets at high rate (e.g., 3 to 1).	Challenge locating sufficient area to accommodate reforestation mitigation.	Determine specific requirements for offsets. Identify options for tree planting in local area.
Non-nuclear hazardous waste generated by the site cannot be handled by area facilities.	Unlikely to be a significant impact because non-nuclear hazardous waste generation should be bounded by current coal plant operations.	Identify strategy for hazardous waste disposal consistent with area capabilities and alternative remote disposal locations using coal facility operator experience.
Existing site does not provide sufficient lay-down area to support construction schedule approach.	Inefficiencies and delays in the site construction due to need for off-site areas and lack of on-site construction space.	Lease adjacent parcel to provide sufficient lay-down area to support construction activities.
Challenges coordinating site characterization and development activities in parallel with coal facility operations and decommissioning.	Delays in licensing and construction schedule.	Early identification of critical issues (e.g., need for geotechnical boring samples beneath operating facilities). Effective coordination with current owner/operator and State of Maryland to develop an integrated schedule and communication plan.
Station owner may not be open to site development activities in advance of the coal facility shutdown and decommissioning.	Extends the construction schedule by 17 months.	Pay to advance the retirement date to an earlier year consistent with Xe-100 technology development schedule.

1.4 Engineering Conclusion

The deployment of the Xe-100 design at the plant site considered in this study is likely feasible, with no critical characteristics identified that would preclude the use of the technology on-site. There are several advantages to siting at a re-purposed coal facility, although the considered site does present some specific challenges that may not exist at other locations. These site-specific issues include (1) a small site footprint and proximity of local population which could challenge the establishment of an EAB and implementation of acceptable emergency management plans, (2) the schedule and cost implications of design changes required to accommodate a four-unit facility on the site, and (3) a limited grid interconnection that will require local and likely broader system upgrades. These challenges would be minimized by consideration of a two-unit facility for the site, although the corresponding negative impact of downsizing on plant LCOE needs to be considered. Table *4* summarizes of the areas evaluated notes expected challenges.

Table 4: ***Initial Feasibility Site Specific Impact Summary***

Impact Factor	Impact on Xe-100 at the Coal Facility Site	
	Favorable	Challenge
Site Access		
• Highway	✓	
• Rail	✓	
Water Supply – Municipal	✓	
Domestic Wastewater – Municipal	✓	
Industrial Wastewater	✓	
Site Boundaries		
• Security		✓
• Exclusion Area		✓
• Property	✓	
Electrical Interconnection		
• Construction Power Supply	✓	
• Transmission		✓
Site Stormwater Management	✓	
• Existing wetlands	✓	
Environmental Impact		
• Wetlands		✓
• Adjacent land users	✓	
• Air emissions	✓	
• Water emissions	✓	
• Solid waste	✓	
• Radioactive waste/fuel storage		✓

Impact Factor	Impact on Xe-100 at the Coal Facility Site	
	Favorable	Challenge
Site Emergency Support		
• Emergency services and fire protection		✓
• Area evacuation		✓
Geotechnical Design		
• Foundation capability	✓	
• Seismic design	✓	
Brownfield Site Development		
• Building demolition/disposal	✓	
• Foundation demolition	✓	
• Soil remediation/disposal	✓	
Clearing and Grading		
• Elevation modifications	✓	
• Deforestation		✓
• Construction site runoff control	✓	
Construction Laydown Area		
• On-site area		✓
• Adjacent parcel	✓	
Schedule		
• Site availability compatible with Xe-100 development		✓
• Site transition (operations to construction)		✓
• Interconnection schedule		✓
• Construction schedule		✓

While implementing a 4-unit Xe-100 project may be feasible, the overall construction cost benefits associated with repurposing the existing coal project site are very limited in this case. The only facilities that are expected to be able to be repurposed for the Xe-100 plant are associated with offsite transportation infrastructure and water intake/discharge. These savings are expected to be on the order of $10M or less and thus are not significant in the overall context of the repowering investment at this particular site. Further, these savings would likely be more than offset by the increased design, project management, construction, and interconnection costs of implementing a four-unit project with the constrained site and interconnection facilities.

A potential alternative is to repower the site is with a one or two-unit Xe-100 plant in which the smaller capacity and footprint would reduce the impacts of both the limited grid connection and site footprint restrictions. However, due to economy of scale this downsizing would likely result in a higher LCOE.

1.4.1 Key Risks

The following are risks that should be further evaluated and addressed in follow-on studies:

- The limited site size relative to the footprint of the standard Xe-100 design presents numerous challenges and risks to implementing a four-unit Xe-100 facility at this site. At the most general level, these challenges and risks are associated with the cost and schedule impact of redesign and reanalysis activities associated with deviating from a standard plant configuration.
- Feasibility of implementing an EAB consistent with the bounds of this site requires further investigation. The required supporting analysis is expected to be completed by March, 2023. The findings will need to be verified for this site to support completing a feasibility study. The proximity of the Xe-100 facilities to the site perimeter and the need to create an appropriate security boundary for the Xe-100 facility will require removal of wooded areas along the existing site boundary.
- The constrained site limits complicates the ability to coordinate operations and/or demolition of site facilities with new project construction activities, thus likely extending the overall project delivery timeline and introducing potential for construction schedule delay risks.

Implementation of the Xe-100 standard 4-unit design at the site will require a significant upgrade to the transmission facilities to support power delivery. The plant switchyard and the installed transmission line to the point of interconnection will required evaluation to support the 320 MWe of capacity of a four-unit Xe-100 facility. The capability of the point of interconnection to support the additional generation is also likely insufficient. Finally, system upgrades beyond the substation will likely be required. While the specific costs (and schedule) of expected local interconnection facility upgrades may be simple to define in a feasibility study, the determination of scope and cost of broader system impacts is dependent on entering the interconnection analysis process and on what, if any, other projects are developed in the region. This is because interconnection rights are assigned based on the order of entry into the process.

The interconnection cost uncertainty will persist for some time, so additional analysis and early action on the interconnection application process will be required to inform and mitigate this risk. The current range of system upgrade costs for projects of this size in the power administration queue for that particular interconnection region is from $10-20M. However, the queue is dynamic and other areas of the power administration system with higher levels of installed generation, interconnection activity, and/or system constraints see interconnection costs for projects an order of magnitude higher or more than the $10-20M. There is additional uncertainty based on how upgrade costs might be reallocated in the future as other projects go online and leverage capacity created by investments by prior applicants. Note that the power administration applicable to this site has currently suspended review of applications because of excessive backlog and delays and the identified need to reform its processes. Because of these issues, future investigations relating to this site repowering project should start with a study to optimize the facility size and layout based on site and transmission constraints and the economy of scale associated with a larger multi-unit facility.

1.4.2 Key Opportunities

While the above risks should be further evaluated for this site, the following are opportunities that should be further evaluated and addressed in follow-on studies:

- Potential hydrogen production
  - Distribution by blending with pipeline natural gas
  - Distribution by truck (tube trailer)

- Potential for operation of the first and/or second Xe-100 units prior to completion of units 3 and 4. If desired, sequenced installation is achievable. Feasibility of implementation depends on prompt construction of interconnection upgrades and access to site for phased construction prior to the closure of the coal facilities
- Use of steam production to support adjacent industrial activity
- Development of industrial users located in the industrial park due to proximity and availability of water supply
- An analysis of a bigger-picture development approach to ensure synergy develops in a timely manner to support the implementation of the project
- Potential economic benefit to the community due to the Xe-100 project
- Investment Tax Credit
    - The ITC provides a significant tax credit for energy infrastructure investments in new zero-carbon electricity facility, including nuclear plants. The specifics of how this tax credit will be implemented are still being evaluated, but this tax credit should add a large benefit to nuclear investment;
    - There are multiple adders to the ITC, such as for building at the site of a previous coal plant. These additional tax benefits may increase the value of this site, lowering the LCOE.

II. Economic Evaluation

Introduction

The purpose of this study is to assess the economic feasibility of an X-energy Xe-100 advanced small modular reactor (SMR) standard plant at the coal-fired power plant site in Maryland. Deployment of an SMR at the site is being considered because the current plant owner/operator has announced plans to retire the plant, and the existing site infrastructure at the site could be transitioned to support the deployment of an Xe-100 advanced reactor plant. This report presents preliminary investment and operating costs for an Nth of a kind Xe-100 4-unit standard plant. Additionally, supply chain risks, baseline and forecast electricity market prices, and available tax credits through the Inflation Reduction Act are presented.

This study was undertaken with the support of Maryland Energy Administration (MEA) and, the owner of the Station.

1 Baseline Markets

1.1 Electricity Market

The Station currently operates under a Power Purchase Agreement. A 4-reactor, 4-turbine Xe-100 site produces 320 MWe of net generation, which would allow for the current and future electricity needs to be met using a carbon free generation technology.

To identify the baseline market price and future predictions for electricity within the region, IHS Markit was used. The on-peak and off-peak wholesale spot power price from 2017 to 2027 can be seen in Figure 2. Note that electricity prices from 2017 to Q1 2022 are based on market prices, while prices from Q2 2022 to 2027 are based on forecasts.

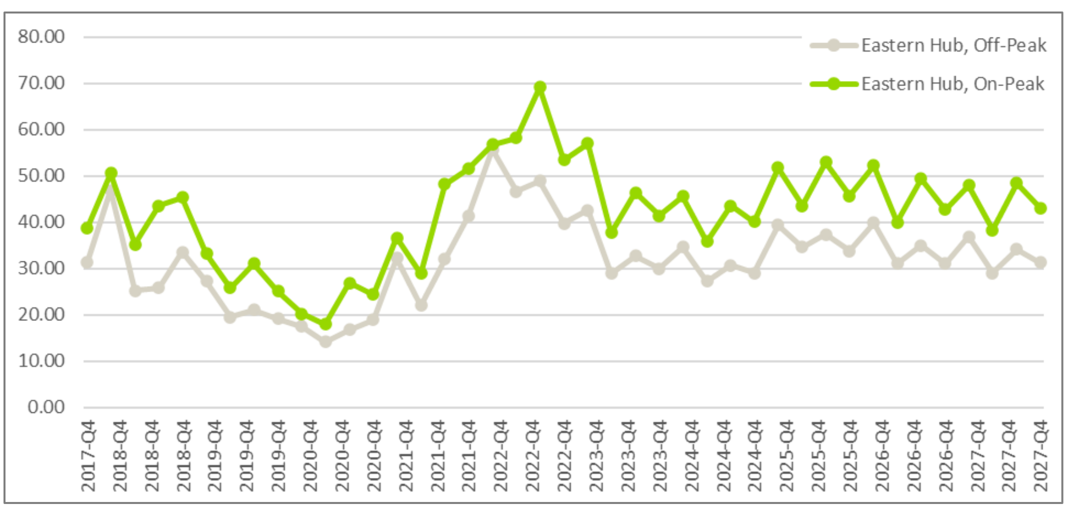

Figure 2 IHS Markit Eastern Hub Electricity Price Forecasts

As seen in Figure 2, the baseline market price as of Q1 2022 ranged from $55.72/MWh to $56.80/MWh. Looking outwards toward 2027, electricity prices are expected to become more stable, apart from sessional variances. In 2027, wholesale spot prices are forecast to vary from $31.34/MWh to $48.44/MWh.

2 Xe-100 Levelized Cost of Electricity (LCOE)

The Xe-100 plant investment and operating cost are developed based on the Generation IV International Forum *Cost Estimating Guidelines for Generation IV Nuclear Energy Systems* using a Code of Accounts (CoA) approach. In total there are ten CoAs. CoAs 10 to 60 are one-time construction costs, while CoAs 70 to 100 are annualized costs.

- CoA 10: Pre-Construction Costs (CPC)
- CoA 20: Direct Plant Costs (CDC)
- CoA 30: Indirect Plant Costs (CIC)
- CoA 40: Owner's Costs (COC)
- CoA 50: Supplementary Costs (CSC)
- CoA 60: Financial Costs (CFC)
- CoA 70: O&M Costs (AOC)
- CoA 80: Fuel & Spent Fuel Costs (ASC)
- CoA 90: Financial Costs (AFC)
- CoA 100: Decommissioning & Decontamination Costs (ADD)

A high-level overview of the Nth-of-a-Kind (NOAK) Xe-100 Plant costs are in alignment within an AACE Class 4 estimate (-30%/+50%). A more detailed description of the costs considered within each CoA is available within the *Cost Estimating Guidelines for Generation IV Nuclear Energy Systems*.

2.1 CoA 10: Pre-Construction Costs (CPC)

Pre-construction costs are defined as all costs incurred prior to plant construction including land rights, site permits, plant licensing, plant permits, plant studies, and plant reports.

2.2 CoA 20: Direct Plant Costs (CDC)

Direct plant costs are defined as all costs to construct a permanent plant, excluding support services such as field indirect costs, construction supervision, and other indirect costs. Direct costs include equipment, direct installation labor-hours, and commodities for installation such as wire and concrete.

Within this CoA, cost certainty was achieved by using the Pareto Principle, which states that approximately 20% of the plant contributes 80% of the direct cost. As such, high-fidelity quotes were received for these systems to increase cost certainty.

2.3 CoA 30: Indirect Plant Costs (CIC)

Indirect plant costs are defined as all the costs not directly associated with a specific permanent plant, such as field indirect, construction supervision, design services, and EPCM services.

2.4 CoA 40: Owner's Costs (COC)

Owner's costs are defined as cost components that are typically the owner's responsibility such as staff recruitment and training, staff housing, and staff salary-related costs.

2.5 CoA 50: Supplementary Costs (CSC)

Supplementary costs are defined as general costs of the undertaking including shipping costs, spare parts, taxes, and initial fuel load. The initial fuel load cost was provided by TRIstructural-ISOtropic (TRISO)-X.

2.6 CoA 60: Financial Costs (CFC)

Financial costs are defined as costs associated with project financing including escalation, fees to be capitalized with the plant, and interest during construction.

Note that per the Generation IV Cost Estimating Guidelines, the capitalized financial cost is not included in the Overnight Cost and LCOE.

2.7 CoA 70: O&M Costs (AOC)

O&M costs are defined as all non-fuel costs, such as costs of plant staffing, consumable operating materials (worn parts) and equipment, repair, and interim replacements, purchased services, and nuclear insurance. They also include taxes and fees, and miscellaneous costs. In addition, the costs of general and administrative support functions and the cost of providing working capital for plant O&M are included.

2.8 CoA 80: Fuel and Spent Fuel Costs (ASC)

Fuel and spent fuel costs are defined as all costs involving the fueling and refueling of the plant including refueling operations, nuclear fuel, and fuel reprocessing charges. The special nuclear materials (helium) are considered in CoA 70: O&M Costs and the spent fuel costs are considered in CoA 20: Direct Plant Costs.

2.9 CoA 90: Financial Costs (AFC)

Financial costs are defined as all costs associated with annual financing including cost of fees incurred for the licensed reactor process, nuclear operating license fees, escalation, and the cost of money.

2.10 CoA 100: Decommissioning and Decontamination Costs (ADD)

Decommissioning and decontamination costs are treated as a sinking fund, where a specified amount is saved annually (growing with interest) that will be used at the end of the Xe-100 plant's lifetime.

2.11 Summary of Costs and LCOE

A summary of the Xe-100 plant costs were calculated and determined to be competitive, with recommendations for further evaluation.

To calculate the levelized cost of electricity (LCOE), a US Department of Energy (DOE) model was used as shown in Figure 3.

Parameter	Function, interpretation
$LCOE = \frac{Capital\ Cost * CRF * (1 - T * D_{PV})}{8760 * Capacity\ Factor * (1 - T)} + \frac{Fixed\ O\&M}{8760 * Capacity\ Factor} + variable O\&M + Fuel\ Price * Heat\ Rate$	
$CRF = \frac{D * (1 + D)^N}{(1 + D)^N - 1}$	
CRF – capital recovery factor, turning capital costs into annual values (if capital is financed at discount rate D)	

Variables		
Notation	**Definition**	**Assumed value**
D	Discount rate	0.07 (real)
N	Lifetime of investment	30 years for the new plants
D_{PV}	Present value of depreciation	In line with the US Modified Accelerated Cost Recovery System (MACRS) schedule[1]
Capital cost	Cost of the plant construction	Specific for technology types
Fixed O&M	O&M cost of the plant per capacity	Specific for technology types
Variable O&M	O&M of the plant per unit generated	Specific for technology types
Fuel Price	Fuel cost of the plant	Fuel prices assumptions: Bio Gas - 4.67; Biomass – 2; Coal - 2.11; Natural Gas - 4.67; Oil-Gas-Steam - 4.67; Uranium - 0.5 ($/mmBTU)
Heat Rate	energy content of fuel used per kWh generated	Specific for technology types
T	Tax rate	39.2%

Source: (Short et al., 1995; US DOE, 2013; US DOE & NREL, 2013)

Figure 3: LCOE Model by US DOE

3 State and Federal Tax Credits

As part of the Inflation Reduction Act (IRA), the United States Congress has passed two technology-neutral clean electricity tax credits that advanced nuclear energy is eligible for as a zero-emitting energy source:

- 45Y, Clean Electricity Production Credit (PTC)
- 48D, Clean Electricity Investment Credit (ITC)

These new technology-neutral credits are available for projects where the greenhouse gas emission rate is not greater than zero and placed in service after 31 December 2024. A project developer can elect either tax credit, but not both. If a developer elects to take either tax credit, then they may not also elect to take any other relevant tax credit, including the existing 45J Advanced Nuclear Tax Credit, the new 45U Existing Nuclear Zero-Emissions Power Production Credit, or the new 45V Hydrogen Production Tax Credit.

3.1 Production Tax Credit

The clean electricity production credit for any taxable year is an amount equal to the number of kilowatt hours of electricity produced or sold by the taxpayer at a qualified facility.

The base PTC value is 0.3 cents/kWh in 1992 dollars (0.52 cents/kWh in 2022 dollars). However, the value is increased to 1.5 cents/kWh in 1992 dollars (2.6 cents/kWh in 2022 dollars) if:

- The power produced in the facility is less than 1 MW, or
- The project meets prevailing wage requirements for construction of the facility and meets apprenticeship requirements.

Additionally, the PTC value can be increased by 10% if the project meets specific domestic content requirements based on construction requiring any steel, iron, or manufactured components made in the US, including the raw materials. For manufactured components there is a percentage requirement ranging from 40-55%, as opposed to a 100% requirement, depending on when the construction of the project is commenced. Similarly, there are exemptions if materials/components of sufficient quality or quantity cannot be sourced from the US.

Furthermore, the PTC value can also be increased by 10% if it is located in an "energy community", which is a term newly defined in this Bill as a brownfield site (as defined by CERCLA) [or] an area which has had significant employment related to the extraction, processing, transport, or storage of coal, oil, or natural gas (includes census tracts adjacent to closed mines and closed coal-fired electric generating units).

Each year the credit value is adjusted for inflation. The PTC can be claimed by an eligible project for up to ten years after the project is placed in service. Critically, this is equivalent to the value of the Wind PTC, originally established in the Energy Policy Act of 1992 and extended at the same level (with the same inflation adjustment) in the Inflation Reduction Act.

3.2 Investment Tax Credit

The clean electricity investment credit for any taxable year is an amount equal to the applicable percentage of the qualified investment at a qualified facility or energy storage technology.

The base ITC value is 6% of the qualified investment. However, the value is increased to 30% if:

- The power produced in the facility is less than 1 MW, or
- The project meets prevailing wage requirements for construction of the facility and meets apprenticeship requirements.

Similarly, the ITC value can be increased by meeting the domestic content requirements or locating the facility in an "energy community", as discussed for the PTC. In both cases the base value and higher ITC value can be increased by 2 percentage points and 10 percentage points, respectively.

4 Project Direct Cost Cash Flow

The anticipated long lead procurement – direct plant payment schedule was calculated.

Note that this cash flow only considers the NOAK CoA 20: Direct Plant Costs and begins prior to the start of construction in 2030. This is because there are numerous pieces of equipment, such as pressure vessels and graphite, which require deposits to ensure that manufacturing space and materials can be reserved/procured to meet the desired construction schedule.

5 Supply Chain Risks

Over the last several years the economy and supply chain have experienced significant levels of disruption. At a high level, the key identified supply chain risks is inflation.

Based on inflation rates determined from US Labor Department Consumer Price Index (CPI) data, the inflation rate from 2012 to 2020 was generally stable and typically remained below 2.5% per year. In 2021 an inflation rate of 7% was recorded, with current data indicating that the 2022 inflation rate will be closer to 8.2%. As such, the United States Dollar has experienced approximately 16% inflation since 2020, however, many industries have seen price increases well above this rate. For example, global steel prices have, as shown in Figure 4, increased by approximately 100% since September 2020 and are forecast to slowly decrease as we advance toward 2026. Additionally, lead times for equipment and commodities are increasing, requiring earlier deposits to ensure that equipment is available as needed during construction. X-energy is working to mitigate supply chain risks using several approaches.

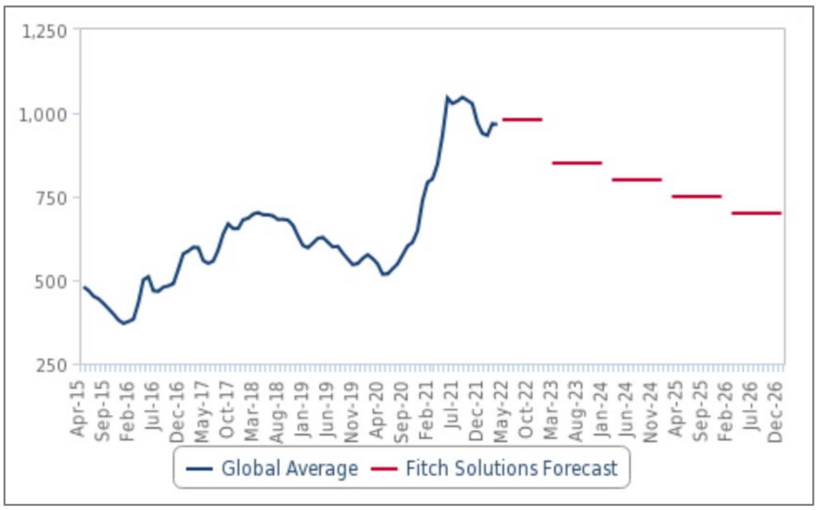

Figure 4: Global Steel Price Averages and Forecasts (USD/tonne)

6 Conclusion and Recommendations

This report presents a scoping economic feasibility evaluation for the deployment of an X-energy Xe-100 advanced small modular reactor (SMR) standard plant at a coal-fired power plant site located in Maryland. Based on current economic modeling, a 4-reactor 4-turbine NOAK plant has a competitive overnight cost and annual operating cost. These costs are in 2020 USD and meet the requirements of an AACE Class 5 (-50%/+100% estimate). In addition to project costs, supply chain risks, baseline and forecast electricity market prices, and available tax credits through the Inflation Reduction Act were investigated and presented.

It is recommended that an additional economic evaluation be completed that expands upon the findings presented in this report. This evaluation should include a techno-economic evaluation to identify the optimal number of reactors to deploy on site, and collaboration with the plant owner to develop a tailored cost model that includes owner-specific inputs for the site. Additionally, alternative product and revenue sources beyond the production of electricity should be considered and assessed. Finally, the economic modeling should be updated to account for recent supply chain price increases, which could significantly impact the resulting LCOE. It should, however, be noted that X-energy's supply chain increases are not unique, and all construction projects are experiencing increased costs.

III. The Economic Impact of a Change in Power Generation

Acknowledgements:

- Dr. Anthony G. Stair, Chair, Dept. of Economics at Frostburg State University
- Dr. Caleb A. Stair, Lecturer and Faculty Affiliate Economic Impact Analysis Program, Florida University
- Ivy G Mackereth, PhD Candidate, Natural Resource Economics, West Virginia University
- Dr. Evan H Offstein, Professor, Business Management, Frostburg State University

Introduction

This report discusses the potential economic impact of two separate events on both regional (around the evaluated plant in Maryland) and the State of Maryland as a whole. The first potential economic impact results from the proposed shutdown of a Maryland coal plant. The second potential economic impact results from the proposed construction and operation of a new advanced modular nuclear-powered electricity generation plant at the same location. The construction of this plant is scheduled to last six years. Operation of the plant will begin in year four. In year seven, construction will be completed and the only remaining economic impact will be from plant operation.

1 The Region

The Maryland region around the coal plant is largely rural and the counties in this area are similar both geographically and economically. It is reasonable to assume that any significant event in one county will also affect the surrounding counties. In order to determine the economic impact of these events on the entire region, Frostburg State University purchased IMPLAN data for the impacted counties. The six regional counties relatively rural. They also possess economies that frequently struggle even though the more urban parts of their states are economically prosperous. The following data provides an overview of these county economies.

	Population	Per Capita Personal Income	Total Employment
Six County Region (County Avg)	66484	43559	29402

Figure 5: 2019 Average Population Income and Employment Totals

Figure 5 depicts 2019 Population, Per Capita Income, and Total Employment for the individual counties in the region. As shown, population, per capita income, and employment in these counties are relatively low.

	Total Change	Percent Change
Six County Region (County Avg)	-1601	-3.405

Figure 6: Population Change for the Six-County Region

Figure 6 above depicts the change in population between 2010 and 2019 for each of the counties. As shown, all but one of the counties in the six-county region saw a decline in population over this 9-year period.

These data, collected from the Bureau of Economic Analysis (BEA), indicate that the region could benefit significantly from events that would have a positive economic impact on output, income, and employment in the region.

1.1 The Method of Analysis

In order to determine the economic impact of these two events on the "Home" County, the surrounding region, and the State of Maryland, we will use a nationally recognized input/output model: IMPLAN.

The theory behind input/output analysis is simple. Since Industry A utilizes outputs from Industry B as inputs in its production process, increased output in Industry A will also cause increased output in Industry B. Hence, overall output in the region increases by more than the increase in output in industry A. Another way of saying this is that there is a multiplied increase in output in the region from an increase in the output of any industry. It also works in reverse. There will be a multiplied decrease in output in the region from the closure of any plant or industry. The most difficult part of input/output analysis is building input/ output tables that accurately reflect the linkages between industries in a region. Researchers can spend thousands of hours and dollars trying to build their own input/output tables for a region.

IMPLAN is a nationally recognized, established input/output modeling system that can be used to develop input/output tables and to determine economic impacts for any region of the United States. This study uses IMPLAN input/output modeling to estimate the economic impact of the closure of the current fossil fuel powered electricity generating plant at the Station in "Home" County, Maryland, the surrounding region, and the State of Maryland. It also uses IMPLAN to estimate the economic impact of the construction and operation of a new nuclear powered electricity generating plant at the same location. IMPLAN analysis provides resultant economic impact data for the region for a wide variety of economic variables.

1.2 Event #1- Shut Down of Existing Plant

The first event this study analyzes is the closure of the existing electricity generating plant.

The closure of this plant will result in the loss of over $8M in direct employee compensation. For IMPLAN, this was entered as a loss in sector 40 "Electric power generation - fossil fuel."

	Total Employment	Total Labor Income (Millions)	Total Output (Millions)	Total Tax Revenue (Millions)
Home County	-171.4	-15.12	($122.40)	-14.28
State of Maryland	-231.98	-29.28	-133.87	-21.03

Figure 7: Total Impact of Existing Plant Shutdown

1.3 Summary Event #1

Shown above in Figure 7 are the impacts of the plant shutdown for the three regions and the State of Maryland by type. Employment impacts represent a total loss of 0.5%, and 0.006% of the total employment in "Home" County, and the State of Maryland, respectively. Output losses account for 2%, 0.003% of the total output in "Home" County, and the State of Maryland, respectively.

The impacts are relatively high, most likely due to the linkages between the existing coal-fired power plant and coal suppliers. A shutdown of part of the economic base of the region would be detrimental to the region's economy. The magnitude of these impacts reduces as we move farther from the core coal region of Maryland and are much lower in relative significance compared to the entire State of Maryland.

1.4 Event #2- Construction and Operation of Nuclear-Powered Electricity Generation Plant

The second event this paper analyzes is the construction and operation of a new modular nuclear-powered electricity generating plant at the same site. The construction of this plant is scheduled to last six years. Operation of the plant will begin in year four. In year seven, construction will be completed and the only remaining economic impact will be from plant operation. The following is a brief description of the proposed new plant:

X-energy based out of Rockville, Maryland, was founded in 2009 by Kam Ghaffarian, a visionary entrepreneur and engineer whose aim is to reinvent nuclear energy and fulfill the growing energy needs of future generations while protecting our planet. X-energy's vision is to be the world's leading provider of highly innovative, 100% safe, and environmentally friendly small-scale nuclear energy solutions for government, industry, and private consumers. At the center of this vision is the Xe-100 a Generation (Gen) IV high-temperature gas reactor (HTGR).

The Xe-100 reactor is a true Gen IV reactor, with each module being an 80MWe/200MWt pebble bed HTGR with significant advantages in safety, sustainability, economics, and reliability. An Xe-100 standard plant consists of 4 units with a combined output of 320MWe/800MWt and can be sited on less than 40 acres of land. Each reactor is paired to its own turbine-generator system, ensuring generation redundancy. The design is strongly influenced by a series of market studies and significant customer engagement over the last 10 years. The design is "walk away safe" with intrinsic safety that does not require electrical power, active systems, or operator action to protect the public.

X-energy is driving the Xe-100 development and deployment forward as one of two awardees of the Department of Energy's Advanced Reactor Demonstration Program (ARDP). This program is a remarkably bold policy initiative designed to restore US leadership in nuclear power by demonstrating truly innovative advanced reactor (AR) designs. X-energy has partnered with Energy Northwest and Grant County PUD in Washington State to construct and perform commercial-scale operations of the Xe-100 standard plant by 2028. This first-of-kind deployment in Washington State will pave the way for nth-of-kind deployments at coal plants such as the one assessed in this study.

Only local construction expenditures were counted as affecting the region and entered into IMPLAN. Construction expenditures made elsewhere, Tennessee for example, will not affect the Maryland region and were not included. The determination of local versus nonlocal spending came from numerous discussions with X-energy employees.

1.5 Background for Analysis

This analysis uses the 2019 structure of the economy and 2022 prices. The latest data available is 2020, but the advent of COVID-19 has made that structure anomalous. Sometimes a new firm is coming to an area where the industry does not currently exist. This is the first nuclear power plant in our study area. First, we determined this would be Industry 41 - Electric power generation - Nuclear. Given this determination, we can borrow the information about the Industry from another Region. Here we follow national averages as a "proxy Region."

The potential economic impact of the new plant is discussed below. In the body of the text, we provide a summary of some of the most interesting statistics. For the complete results, see appendices B through G.

At its peak in year 4, the combined construction and operation of the new plant results in 1,346 new jobs in "Home" County. This is approximately 3.6% of total employment in 2019 in "Home" County. Also, in year 4 it adds $72.88 million to total labor income, or approximately 3.9% of total labor income. By year 7, construction is complete. In year 7 and beyond, the only economic impact on the county will be from the operation of the plant with 101 direct employees. The operation of the new plant results in 195 new jobs in: "Home" county with $17.7 million in new labor income in the county. While that is more impactful than the shutdown of the existing plant, the multiplier is not as large as for the existing plant because the backwards linkage with coal and other local inputs is absent. The tables and graphs that follow are a brief summary of the IMPLAN results for the six-county region, and the entire state of Maryland from new plant construction and operation.

Total Impact by Indicators: Maryland Region

	total employment	total labor income (millions)	total output (millions)	total tax revenue (millions)
Year 1	187.9	$9.00	$89.34	$6.51
Year 2	318.73	$15.16	$79.57	$7.05
Year 3	602.46	$28.63	$107.71	$10.98
Year 4	1357.68	$72.88	$191.48	$29.02
Year 5	641.12	$38.88	$160.91	$21.34
Year 6	322.2	$23.73	$133.58	$17.17
Year 7	195.61	$17.70	$79.20	$13.11

Figure 8: Economic Impact MRIO on Maryland Region

Total Impact by Indicators: State of Maryland				
	total employment	**total labor income (millions)**	**total output (millions)**	**total tax revenue (millions)**
Year 1	233.61	$17.16	$103.52	$8.27
Year 2	363.62	$25.07	$92.62	$9.16
Year 3	665.67	$44.85	$125.32	$14.38
Year 4	1,592.55	$127.45	$290.51	$48.42
Year 5	850.25	$79.93	$255.15	$38.04
Year 6	512.91	$57.96	$223.41	$32.48
Year 7	356.96	$46.64	$160.08	$27.27

Figure 9: Economic Impact MRIO on State of Maryland

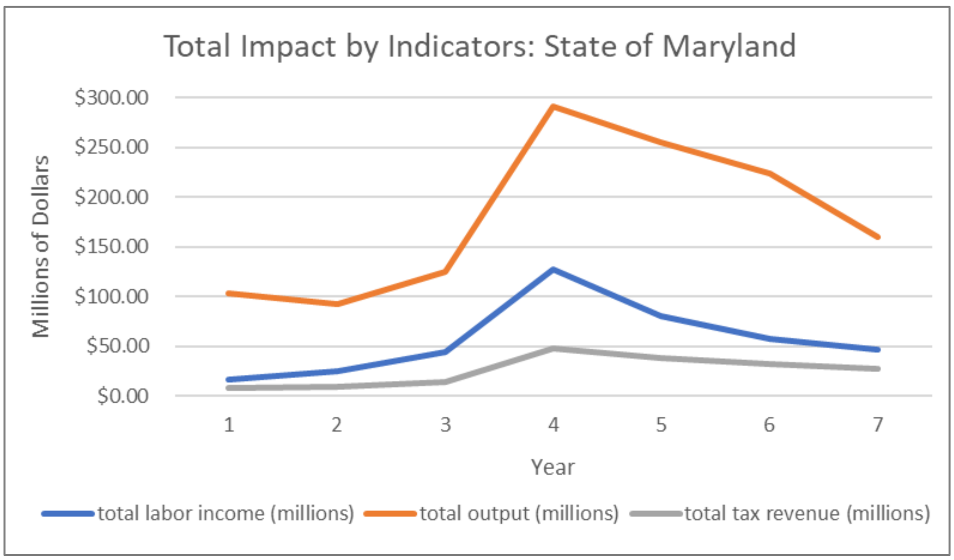

Figure 10: Graph of Economic Impact on State of Maryland

1.6 Summary Event #2

Results for surrounding regions are very similar to the "Home" County. The largest impact is in year 4 when construction and the initial operation of the plant happen simultaneously. There were 1,357 new employees in the area and 1,417 new employees in the region representing 0.97% and 0.68% of total employment in those regions, respectively, with 1,593 new employees in the State of Maryland, representing 0.04% of total employment statewide. Output impacts were $191.48 million, $202.26 million, and $290.51 million in year 4 as well. These represent 0.84%, 0.60%, and 0.04% of total output in "Home" county area, the six-county region, and the State of Maryland, respectively. The operation of the new plant and its 101 employees results in 195.61 new employees in the area, 224 new employees in the region, and 357 new employees in the State of Maryland. Again, this more than replaces the shutdown of the existing plant. Appendices B through G provide more detailed results from IMPLAN of the construction and operation of the new plant in each region.

IV. Strategic Communication Plan for X-energy

Introduction

The purpose of this Strategic Communication Plan is to improve and strengthen communication, engagement, and understanding of X-energy's Small Modular Reactor (SMR) technology within the site community. Effective implementation of this plan will result in broad-based acceptance and perhaps even enthusiasm among the community and key stakeholders of Maryland.

We will be successful if we can effectively embed the simple, but potent, elements of **SEE** into the public consciousness.

S (Safety). Nuclear power is often misunderstood and mischaracterized as being an unsafe source of energy. Cultural forces, such as Hollywood storytelling, lead to outsized and unwarranted fears related to nuclear power. The facts are overwhelmingly clear—commercial nuclear power is exceedingly safe. SMR technology, in general, and that developed by X-energy, in particular, has even greater defense-in-depth protections. The safeguards are rock-solid. Our communication plan will cement the primacy of safety in SMR technology. X-energy will prioritize the health and safety of the public in all communications. This is the most important variable in all communication across all mediums.

E (Economic Benefits). Nuclear power is special and unique. SMR technology extends that premise; it is cutting edge. Maryland, historically economically depressed and disadvantaged, has an opportunity to be on the leading edge of a fast-growing energy sector. X-energy will need to repeatedly communicate the profound economic impact that will result by welcoming SMR technology within the community. This means contributions to the tax base, spending that will occur within the community, but, most importantly, X-energy must speak to the number that almost all can understand—jobs and job growth.

E (Environmental Impact). To date, commercial nuclear power provides a baseload of safe, reliable, and carbon-free energy. Nuclear power, generally, contributes close to 20% of all power generated in the United States. No other source of energy can produce this amount of reliable and safe energy that is also carbon-free. There is growing sentiment that the US will not be able to meet ambitious climate change goals without heavy participation from the nuclear industry. For that reason, many environmental groups have warmed to the thought of nuclear power as part of our national energy portfolio. It is also important to note that nuclear power, unlike solar or wind, take a much smaller acreage footprint—the impact to the physical environment is negligible in comparison. For the environment and to combat climate change, SMR technology is a game changer. X-energy and its partners will need to speak to the topic of nuclear waste—the lone, environmental variable yet to be completely addressed by the traditional commercial nuclear industry.

Maryland embraces a deep-rooted mentality of self-reliance. For that reason, arguments and communication aimed at energy security and self-reliance may particularly resonate with the surrounding area.

1 How to Use this Plan

This plan will serve as a resource and as a signal of commitment to effective communication, education, and understanding/knowledge sharing between X-energy and the surrounding community of Maryland. This plan will help X-energy organize presentations, develop specific communication initiatives, and plan events and communication activities.

X-energy and its partners will:

- Embrace their responsibility to communicate effectively with the public;
- Provide timely, accurate, and complete information to the public and key stakeholders regarding updates and changes, to include regulatory concerns, to its core business;
- Standardize the form and appearance of communications to ensure the community readily recognizes information originating from X-energy;
- Deliver consistent **SEE** messaging related to their technology;
- Ensure frequent opportunities for meaningful trust building with the community; that means talking and engaging with the public—not talking to the community; and
- Begin to align and sufficiently resource this plan to ensure information reaches the appropriate audiences.

2 Action Plans

The following indicate specific communication initiatives that should be considered moving forward and are consistent with the values, aims, scope, and purpose mentioned above. While there is a sequential “flavor” to the below listing, many of these action plans can be done independently and/or concurrently.

2.1 Convene a Listening Tour

In short, this involves select leaders from X-energy to attend listening events where communication is purposefully unidirectional. More specifically, concerned, and curious community members would do the majority of the speaking. The primary purpose of this initiative to build trust; identify critical community values and concerns; foster community relations; and create community environments where exploring ideas, feelings, and concerns can be safely shared. Interestingly, Frostburg State does have a record of accomplishment in this area.

2.2 Conduct Tailored Focus Groups

Focus groups provide insight into complicated topics where opinions or attitudes may be complex and span emotional, affective, cognitive, and political arenas. Focus groups are different from the Listening Tour mentioned above as focus groups are narrower in their focus and scope. These, too, can be more researcher led, where the principal investigator determines the agenda, places boundaries on discussions, and retains more command and control. We propose the following guidance to X-energy and its partners as it relates to Focus Groups. First, this communication effort should be viewed as a campaign. More specifically, Focus Groups should be convened at the start, mid-point, and toward the end of the communication effort. Second, Focus Groups should be pulled from geographically diverse parts of

Maryland. This means pulling respondents from neighboring counties and selecting citizens from the rural areas of these counties, special care should be taken to include key cities in the areas.

2.3 Engage in a Scientifically Designed/Quantitative Community Analysis

Similar to the Focus Group initiative mentioned above, we recommend that X-energy support a continual quantitative survey program. The most important rationale behind this program is to verify community engagement, support, and understanding of X-energy's technology and product implementation. Much like political polling, this will require constant surveying and analysis. Even more, sophisticated marketing and social scientists may use Regression Analysis to locate pockets of demographic resistance or misunderstanding.

2.4 Build a Robust Social Media Presence

We recommend at least Facebook and Twitter. This infrastructure should be built prior to any formal launch and, in truth, could be started now. We recommend that X-energy assign a singular individual or singular vendor to manage any ongoing efforts. Also, this singular individual/vendor should provide monthly metric reports where likes, impressions, shares, and other metrics can be communicated. Some marketing and public relations firms use a dashboard tool with red, yellow, and green visuals. We recommend that X-energy pursue this approach.

2.5 Develop and Launch an Online Website/Engagement Tool

This professionally developed website will allow members of the public to engage directly with representatives of X-energy on any issues or concerns that they may have. As conceptualized, this website, then, is more than instructional. Rather, it allows and encourages members of the community to actively engage with representatives of the X-energy. Borrowing from the websites of major corporations such as Mercedes-Benz or Dodge/Jeep, X-energy may wish to use a chat-box function to engage in real time with interested members of the community.

2.6 Embrace Local and Traditional Media

The regional area surrounding the "Home" county skews older and more traditional in demographic and mentality. The local newspaper still enjoys consistent and significant readership and advertisement. The same can be said for the area radio stations. Consequently, we recommend that X-energy actively engage local media for interviews and also set aside an advertising budget for these local agenda setters.

2.7 Design and Deploy X-energy E-newsletter

Emphasizing the **SEE** principles above, X-energy should deliver a newsletter to interested local and non-local stakeholders with some regular periodicity, perhaps monthly.

2.8 Execute Speaker Series

Further reinforcing the **SEE** precepts, we recommend that X-energy fully fund a Speaker Series. Local partners in this effort should be sought out. Speakers should be selected intentionally and purposefully. Leaders in safety and environmentalists favorable to nuclear power could be potential speaking candidates. Also, government representatives from the State and Federal level, such as senior leaders from the Dept of Energy (DoE) could also prove beneficial. We recommend that X-energy execute this action plan quarterly.

2.9 "Frankly Speaking" Town Halls

We imagine X-energy partnering with each affected county's library system or the well-respected Community College campuses in the area for the venue. These "Frankly Speaking" Town Halls provide a setting in which community members and interested stakeholders can meet one-on-one with senior leaders of X-energy. This initiative is meant to build trust and demonstrate approachability and accessibility between the community and X-energy leadership. This action plan should rotate through specific geographic locales in neighboring counties. We recommend a monthly cadence for this initiative.

2.10 Partner with FSU's College of Liberal Arts and Sciences

X-energy should leverage a partnership with FSU. This can be operationalized in several ways. First, X-energy should consider an internship program and partnership with select departments such as Marketing, Business Management, Political Science, Physics, and Computer Science. Second, representatives of X-energy may wish to speak about their technology as guest lecturers in courses related to Physics, Business Ethics, and Sustainability. Third, select X-energy leaders may wish to sit on the Advisory Boards on key university or college committees such as the College of Business Advisory Board.

2.11 Secure Active Presence on Rotary and Chamber of Commerce

X-energy should not only join local rotary, the Chambers of Commerce in both neighboring counties, and the Greater Regional Committee as paid members. X-energy should also present during membership meetings and events across all of these important business groups. This 20- to 30-minute presentation, of course, will embed **SEE** precepts.

2.12 Walking Tours/Open Orientation of Facility

Once X-energy's facility reaches a point of strong industrial safety safeguards, which could be during construction, X-energy should convene regular "Walking Tours" of this facility. The periodicity of this could be monthly such as the first Monday of every month. This practice facilitates openness and transparency with the surrounding community. In our view, the tour guides should be trained and professional—ambassadors, if you will, of X-energy. Also, many existing commercial nuclear power stations manage a community engagement center at the front of their properties before security protocols are required. In these facilities, utilities build and operate models and "table-tops" that simplify nuclear power and increase comfort levels with the technology, itself.

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Appendix A Explanation of Construction Costs

Pre-Construction Costs:

- Land and Land Rights
- Site Permits
- NRC Plant Licensing
- Plant Permits
- Plant Studies
- Plant Reports
- Other Pre-Construction Costs

Direct Plant Costs:

- Equipment Costs
- Instrumentation
- Balance of Plant
- Buildings
- Construction Labor
- Commodities (cabling, piping, etc.)

Indirect Plant Costs:

- Field Indirect Costs
- Construction Supervision
- Commissioning and Startup Costs
- Demonstration Test Run
- Design Services Offsite
- Project Management/Construction Management Services Offsite
- Design Services Onsite
- Project Management/Construction Management Services Onsite

Owner's Costs:

- Staff Recruitment and Training
- Staff Housing
- Staff Salaries
- Other Owner's Capitalized Costs (transmission lines and switchyard)
- Safety, Risk, and Quality Assurance

Supplementary Costs:

- Shipping and Transportation Costs (pressure boundary only)
- Taxes (State and Local)
- Insurance (pressure boundary only)
- Initial Fuel Core Load

Financial Costs

- Escalation
- EPC Fees

O&M Costs:

- Plant Staff Salaries
- Training
- Maintenance Support
- Staff Programs
- Management Staff Salaries
- Salary-Related Costs (Fringe, G&A, etc.)
- Operations Chemicals, Lubricants, etc.
- Spare Parts
- Utilities, Supplies, Consumables
- Capital Plant Upgrades
- Taxes and Insurance
- Annual NRC Licensing Fees

Fuel and Spent Fuel Costs

- Annual Fresh Fuel

Financial Costs (Owner Specific, no costing provided here)

Decommissioning and Decontamination

- Annual decommissioning and decontamination sinking fund payment that is accumulated throughout operation. At the end of plant operation, this sinking fund will be spent to decommission and decontaminate the plant.

Appendix B Economic Impact by Indicators – Site Region

Economic Impact by Indicators: MD Site Region

		employment	labor income	value added	output
Year 1	direct	49.68	$2,395,418.85	$19,046,361.40	$65,337,147.
	indirect	106.61	$5,221,975.34	$10,492,526.82	$19,373,870.
	induced	31.61	$1,385,733.14	$2,647,011.04	$4,632,727.
	total	187.9	$9,003,127.33	$32,185,899.27	$89,343,745.
Year 2	direct	187.33	$9,032,377.12	$21,872,178.65	$57,567,726.
	indirect	80.98	$3,936,517.63	$7,947,562.78	$14,626,105.
	induced	50.43	$2,188,747.21	$4,208,998.47	$7,372,682.
	total	318.73	$15,157,641.97	$34,028,739.90	$79,566,513.
Year 3	direct	413.98	$19,961,054.69	$35,020,599.29	$76,887,187.
	indirect	95.04	$4,620,550.07	$9,327,269.02	$17,166,073.
	induced	93.44	$4,049,217.94	$7,790,771.14	$13,658,540.
	total	602.46	$28,630,822.69	$52,138,639.45	$107,711,802
Year 4	direct	1034.25	$57,477,424.72	$81,056,875.36	$130,250,499
	indirect	94.77	$5,515,116.66	$12,761,509.33	$27,819,934.
	induced	228.67	$9,891,018.66	$19,038,119.09	$33,410,687.
	total	1357.68	$72,883,560.04	$112,856,503.79	$191,481,121
Year 5	direct	404.99	$27,136,620.92	$53,850,147.22	$111,756,721
	indirect	114.33	$6,463,912.38	$14,681,589.30	$31,350,531.
	induced	121.81	$5,275,950.75	$10,149,171.42	$17,799,187.
	total	641.12	$38,876,484.04	$78,680,907.94	$160,906,439
Year 6	direct	144.18	$14,561,156.06	$39,709,019.97	$93,262,942.
	indirect	104.38	$5,979,610.46	$13,705,421.59	$29,552,999.
	induced	73.64	$3,193,617.05	$6,139,840.07	$10,761,729.
	total	322.2	$23,734,383.56	$59,554,281.64	$133,577,671
Year 7	direct	101.75	$12,515,148.20	$27,649,011.55	$53,363,311.
	indirect	41.25	$2,911,331.98	$7,510,071.94	$18,152,009.
	induced	52.62	$2,277,454.31	$4,380,207.39	$7,685,799.
	total	195.61	$17,703,934.49	$39,539,290.89	$79,201,120.

Figure 11: Economic Impact by Indicators: MD Site Region

Appendix C Tax Impact – Site Region

Tax Impact: MD Site Region

		subcounty general	sub county special districts	County	State	Federal	Total
Year 1	direct	$92,348.30	$558.78	$290,896.08	$849,458.53	$1,000,571.23	$2,233,832.92
	indirect	$195,050.54	$1,173.00	$617,223.32	$1,530,202.50	$1,256,070.06	$3,599,719.41
	induced	$26,596.37	$140.22	$94,648.21	$234,868.60	$315,195.71	$671,449.11
	total	$313,995.20	$1,872.00	$1,002,767.60	$2,614,529.64	$2,571,836.99	$6,505,001.43
Year 2	direct	$75,165.19	$430.89	$281,902.61	$816,254.30	$2,062,698.63	$3,236,451.60
	indirect	$149,738.73	$904.53	$471,903.30	$1,170,925.33	$950,504.26	$2,743,976.13
	induced	$43,906.91	$246.36	$150,134.38	$377,097.95	$501,000.66	$1,072,386.26
	total	$268,810.82	$1,581.77	$903,940.28	$2,364,277.57	$3,514,203.54	$7,052,813.99
Year 3	direct	$93,314.41	$505.38	$405,713.68	$1,167,550.33	$4,102,519.63	$5,769,603.43
	indirect	$175,666.68	$1,060.91	$553,721.50	$1,373,867.56	$1,115,552.41	$3,219,869.05
	induced	$82,130.45	$469.21	$277,450.31	$699,525.87	$928,180.32	$1,987,756.16
	total	$351,111.54	$2,035.49	$1,236,885.50	$3,240,943.76	$6,146,252.35	$10,977,228.64
Year 4	direct	$592,360.38	$3,449.11	$2,120,880.91	$5,442,432.91	$11,518,109.93	$19,677,233.24
	indirect	$259,071.15	$1,569.65	$808,507.57	$2,004,906.12	$1,400,803.38	$4,474,857.86
	induced	$202,916.77	$1,179.97	$677,110.94	$1,713,742.44	$2,270,520.01	$4,865,470.12
	total	$1,054,348.30	$6,198.72	$3,606,499.41	$9,161,081.48	$15,189,433.30	$29,017,561.22
Year 5	direct	$592,797.96	$3,554.29	$1,928,845.31	$4,911,410.48	$6,173,362.89	$13,609,970.92
	indirect	$295,478.43	$1,790.44	$922,878.53	$2,288,941.71	$1,630,302.69	$5,139,391.80
	induced	$107,202.86	$613.80	$361,591.18	$912,052.47	$1,209,548.20	$2,591,008.50
	total	$995,479.24	$5,958.52	$3,213,315.03	$8,112,404.66	$9,013,213.78	$21,340,371.22
Year 6	direct	$577,318.36	$3,501.74	$1,802,508.37	$4,554,420.52	$3,860,019.97	$10,797,768.97
	indirect	$277,168.81	$1,680.14	$865,045.17	$2,145,529.24	$1,513,507.74	$4,802,931.09
	induced	$64,325.76	$362.96	$219,124.51	$550,975.03	$731,287.29	$1,566,075.54
	total	$918,812.93	$5,544.84	$2,886,678.04	$7,250,924.78	$6,104,815.00	$17,166,775.60
Year 7	direct	$521,446.27	$3,165.69	$1,622,709.27	$4,029,966.10	$3,149,484.97	$9,326,772.30
	indirect	$160,407.15	$974.68	$497,126.76	$1,232,580.92	$772,583.89	$2,663,673.41
	induced	$46,428.54	$267.01	$156,120.99	$394,137.61	$522,283.99	$1,119,238.14
	total	$728,281.96	$4,407.37	$2,275,957.03	$5,656,684.63	$4,444,352.85	$13,109,683.85

Figure 12 Tax Impact: MD Site Region

Appendix D Economic Impact by Indicators – Six-County Region

Economic Impact by Indicators: Six-County Region

		employment	labor income	value added	output
Year 1	direct	49.68	$2,395,418.85	$19,046,361.40	$65,337,147.76
	indirect	109.8	$5,386,453.76	$10,778,699.76	$19,959,236.53
	induced	52.21	$2,274,039.79	$4,323,948.03	$7,578,993.31
	total	211.69	$10,055,912.38	$34,149,009.20	$92,875,377.60
Year 2	direct	187.33	$9,032,377.12	$21,872,178.65	$57,567,726.09
	indirect	85.13	$4,181,273.05	$8,358,035.66	$15,486,733.26
	induced	69.19	$3,003,873.51	$5,736,121.78	$10,062,883.31
	total	341.65	$16,217,523.68	$35,966,336.09	$83,117,342.66
Year 3	direct	413.98	$19,961,054.69	$35,020,599.29	$76,887,187.92
	indirect	100.45	$4,940,317.85	$9,863,600.16	$18,289,295.64
	induced	118.86	$5,153,328.51	$9,859,264.09	$17,302,661.14
	total	633.29	$30,054,701.05	$54,743,463.52	$112,479,144.70
Year 4	direct	1034.25	$57,477,424.72	$81,056,875.36	$130,250,499.45
	indirect	108.95	$6,527,247.63	$14,627,040.50	$31,990,802.72
	induced	274.73	$11,895,085.51	$22,794,819.03	$40,020,901.27
	total	1417.93	$75,899,757.87	$118,478,734.88	$202,262,203.45
Year 5	direct	404.99	$27,136,620.92	$53,850,147.22	$111,756,721.12
	indirect	127.63	$7,422,299.67	$16,456,770.23	$35,336,452.68
	induced	160.59	$6,964,737.45	$13,315,332.60	$23,368,285.72
	total	693.22	$41,523,658.04	$83,622,250.05	$170,461,459.52
Year 6	direct	144.18	$14,561,156.06	$39,709,019.97	$93,262,942.79
	indirect	116.51	$6,868,108.31	$15,363,326.62	$33,294,620.68
	induced	105.96	$4,601,696.93	$8,780,149.77	$15,404,192.46
	total	366.66	$26,030,961.30	$63,852,496.36	$141,961,755.93
Year 7	direct	101.75	$12,515,148.20	$27,649,011.55	$53,363,311.53
	indirect	50.45	$3,626,399.80	$8,877,147.61	$21,283,162.09
	induced	72.13	$3,128,799.58	$5,977,464.75	$10,490,932.48
	total	224.32	$19,270,347.58	$42,503,623.91	$85,137,406.11

Figure 13: Economic Impact by Indicators: Six-County Region

Appendix E Tax Impact – Six-County Region

Total Impact by Indicators: Six-County Region

		subcounty general	sub county special districts	County	State	Federal	Total
Year 1	direct	$92,348.30	$558.78	$290,896.08	$849,458.53	$1,000,571.23	$2,233,832.92
	indirect	$196,942.86	$6,040.93	$623,760.15	$1,554,899.23	$1,292,256.86	$3,673,900.03
	induced	$36,953.13	$21,193.34	$136,339.36	$371,000.17	$514,818.96	$1,080,304.96
	total	$326,244.28	$27,793.05	$1,050,995.59	$2,775,357.93	$2,807,647.05	$6,988,037.91
Year 2	direct	$75,165.19	$430.89	$281,902.61	$816,254.30	$2,062,698.63	$3,236,451.60
	indirect	$152,137.75	$5,079.04	$482,203.32	$1,202,583.07	$1,002,341.10	$2,844,344.28
	induced	$53,298.07	$19,147.93	$188,136.29	$500,582.25	$683,658.66	$1,444,823.20
	total	$280,601.01	$24,657.87	$952,242.22	$2,519,419.62	$3,748,698.37	$7,525,619.08
Year 3	direct	$93,314.41	$505.38	$405,713.68	$1,167,550.33	$4,102,519.63	$5,769,603.43
	indirect	$178,794.69	$6,506.36	$567,149.76	$1,415,155.92	$1,183,284.21	$3,350,890.93
	induced	$94,848.97	$26,117.34	$328,877.15	$866,778.88	$1,175,607.36	$2,492,229.70
	total	$366,958.07	$33,129.08	$1,301,740.59	$3,449,485.12	$6,461,411.20	$11,612,724.06
Year 4	direct	$592,360.38	$3,449.11	$2,120,880.91	$5,442,432.91	$11,518,109.93	$19,677,233.24
	indirect	$273,733.43	$25,207.77	$872,654.23	$2,191,792.94	$1,619,532.95	$4,982,921.33
	induced	$226,073.75	$46,286.37	$771,976.20	$2,017,659.37	$2,719,280.90	$5,781,276.58
	total	$1,092,167.55	$74,943.24	$3,765,511.34	$9,651,885.22	$15,856,923.78	$30,441,431.14
Year 5	direct	$592,797.96	$3,554.29	$1,928,845.31	$4,911,410.48	$6,173,362.89	$13,609,970.92
	indirect	$309,635.66	$24,540.62	$984,861.25	$2,469,123.36	$1,837,621.18	$5,625,782.08
	induced	$126,735.47	$38,250.00	$441,925.07	$1,168,243.40	$1,587,618.92	$3,362,772.87
	total	$1,029,169.09	$66,344.91	$3,355,631.63	$8,548,777.25	$9,598,602.99	$22,598,525.87
Year 6	direct	$577,318.36	$3,501.74	$1,802,508.37	$4,554,420.52	$3,860,019.97	$10,797,768.97
	indirect	$290,648.80	$23,248.07	$924,122.20	$2,316,759.34	$1,706,014.41	$5,260,792.81
	induced	$80,627.24	$31,433.38	$286,430.98	$764,654.37	$1,046,441.40	$2,209,587.37
	total	$948,594.39	$58,183.19	$3,013,061.55	$7,635,834.23	$6,612,475.79	$18,268,149.15
Year 7	direct	$521,446.27	$3,165.69	$1,622,709.27	$4,029,966.10	$3,149,484.97	$9,326,772.30
	indirect	$172,183.77	$19,580.55	$548,889.45	$1,381,339.77	$928,364.05	$3,050,357.60
	induced	$56,314.51	$18,452.36	$197,446.01	$523,470.91	$712,688.15	$1,508,371.94
	total	$749,944.55	$41,198.60	$2,369,044.72	$5,934,776.80	$4,790,537.17	$13,885,501.83

Figure 14: Tax Impact: Six-County Region

Appendix F Economic Impact by Indicators – State of Maryland

Economic Impact by Indicators: State of Maryland					
		employment	**labor income**	**value added**	**output**
Year 1	direct	49.68	$3,352,619.15	$24,004,904.87	$65,337,147.76
	indirect	125.83	$10,526,697.00	$17,054,812.75	$28,200,763.44
	induced	58.11	$3,279,633.97	$6,206,297.54	$9,981,999.43
	total	233.61	$17,158,950.12	$47,266,015.16	$103,519,910.64
Year 2	direct	187.33	$12,641,830.62	$27,610,443.76	$57,567,726.09
	indirect	91.2	$7,629,666.62	$12,361,193.22	$20,439,690.02
	induced	85.09	$4,802,788.83	$9,088,128.59	$14,617,208.90
	total	363.62	$25,074,286.07	$49,059,765.57	$92,624,625.00
Year 3	direct	413.98	$27,937,143.23	$44,246,540.61	$76,887,187.92
	indirect	99.37	$8,313,079.09	$13,468,422.93	$22,270,535.28
	induced	152.32	$8,597,264.17	$16,267,888.18	$26,165,142.39
	total	665.67	$44,847,486.48	$73,982,851.73	$125,322,865.59
Year 4	direct	1,034.25	$90,125,886.81	$118,698,775.84	$166,771,037.18
	indirect	122.63	$12,733,766.93	$26,304,370.73	$48,938,257.73
	induced	435.67	$24,591,787.67	$46,499,445.75	$74,799,706.82
	total	1,592.55	$127,451,441.41	$191,502,592.32	$290,509,001.72
Year 5	direct	404.99	$47,660,727.27	$84,220,509.56	$148,277,258.85
	indirect	171.29	$16,804,774.19	$32,900,007.21	$59,844,386.50
	induced	273.96	$15,464,938.77	$29,230,378.11	$47,023,994.22
	total	850.25	$79,930,440.24	$146,350,894.87	$255,145,639.57
Year 6	direct	144.18	$30,060,151.58	$66,322,332.57	$129,783,480.52
	indirect	169.48	$16,653,083.54	$32,654,245.82	$59,438,010.96
	induced	199.25	$11,248,303.12	$21,251,865.95	$34,191,332.95
	total	512.91	$57,961,538.24	$120,228,444.34	$223,412,824.42
Year 7	direct	101.75	$27,196,793.48	$51,119,061.39	$89,883,849.26
	indirect	94.3	$10,363,294.23	$22,463,852.87	$42,587,819.44
	induced	160.91	$9,084,376.21	$17,156,950.89	$27,605,195.53
	total	356.96	$46,644,463.93	$90,739,865.15	$160,076,864.22

Figure 15: Economic Impact by Indicators: State of Maryland

Appendix G Tax Impact – State of Maryland

Economic Impact by Indicators: MD Site Region

		employment	labor income	value added	output
Year 1	direct	49.68	$2,395,418.85	$19,046,361.40	$65,337,147.
	indirect	106.61	$5,221,975.34	$10,492,526.82	$19,373,870.
	induced	31.61	$1,385,733.14	$2,647,011.04	$4,632,727.
	total	187.9	$9,003,127.33	$32,185,899.27	$89,343,745.
Year 2	direct	187.33	$9,032,377.12	$21,872,178.65	$57,567,726.
	indirect	80.98	$3,936,517.63	$7,947,562.78	$14,626,105.
	induced	50.43	$2,188,747.21	$4,208,998.47	$7,372,682.
	total	318.73	$15,157,641.97	$34,028,739.90	$79,566,513.
Year 3	direct	413.98	$19,961,054.69	$35,020,599.29	$76,887,187.
	indirect	95.04	$4,620,550.07	$9,327,269.02	$17,166,073.
	induced	93.44	$4,049,217.94	$7,790,771.14	$13,658,540.
	total	602.46	$28,630,822.69	$52,138,639.45	$107,711,802
Year 4	direct	1034.25	$57,477,424.72	$81,056,875.36	$130,250,499
	indirect	94.77	$5,515,116.66	$12,761,509.33	$27,819,934.
	induced	228.67	$9,891,018.66	$19,038,119.09	$33,410,687.
	total	1357.68	$72,883,560.04	$112,856,503.79	$191,481,121
Year 5	direct	404.99	$27,136,620.92	$53,850,147.22	$111,756,721
	indirect	114.33	$6,463,912.38	$14,681,589.30	$31,350,531.
	induced	121.81	$5,275,950.75	$10,149,171.42	$17,799,187.
	total	641.12	$38,876,484.04	$78,680,907.94	$160,906,439
Year 6	direct	144.18	$14,561,156.06	$39,709,019.97	$93,262,942.
	indirect	104.38	$5,979,610.46	$13,705,421.59	$29,552,999.
	induced	73.64	$3,193,617.05	$6,139,840.07	$10,761,729.
	total	322.2	$23,734,383.56	$59,554,281.64	$133,577,671
Year 7	direct	101.75	$12,515,148.20	$27,649,011.55	$53,363,311.
	indirect	41.25	$2,911,331.98	$7,510,071.94	$18,152,009.
	induced	52.62	$2,277,454.31	$4,380,207.39	$7,685,799.
	total	195.61	$17,703,934.49	$39,539,290.89	$79,201,120.

Figure 16: Tax Impact: State of Maryland