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Submission of X Energy, LLC (X-energy) Xe-100 Licensing White Paper: Use of Bounding Values

The purpose of this letter is to submit the subject licensing white paper on behalf of X Energy, LLC ("X-energy"). This submission provides a description of the approach to be taken by X-energy to develop an environmental report to meet 10 CFR 51 requirements that analyzes the potential environmental impacts associated with constructing and operating up to 12 units of the Xe-100 technology (equivalent to three Xe-100 plants) as part of a near-term licensing application. Based on the general nature of the content, X-energy has determined this report is available for unrestricted release. The specific review schedule will continue to be developed with X-energy's NRC project manager; however, we request initial feedback in the December timeframe.

If you have any questions or require additional information, please contact Milton Gorden at mgorden@x-energy.com.

Sincerely,

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Enclosures:
1) Xe-100 Licensing White Paper: Use of Bounding Values

Licensing

White Paper - Use of Bounding Values

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SYNOPSIS

This white paper addresses the use of Bounding Values in an applicant's environmental report (ER) developed as part of a Construction Permit (CP) under 10 CFR 50. X Energy, LLC (X-energy) and Advanced Reactor Demonstration Program (ARDP) partner Energy Northwest (EN) are seeking early feedback from the U.S. Nuclear Regulatory Commission (NRC) staff on this subject for advanced reactors and small modular reactors (SMRs) such as X-energy's Xe-100 design. This white paper serves three purposes:

1) To describe the need for a bounding value approach in developing the Xe-100 ARDP project ER;
2) To provide flexibility by allowing a prospective owner to add units incrementally, as needed, over about a 15-year timeframe while minimizing regulatory risk associated with the future permitting of additional units; and
3) To demonstrate how a bounding value approach is consistent with the NRC's Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations, and NUREG-1555, Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan.

X-energy is seeking NRC feedback on the bounding value and licensing approach in December 2021. This response timeframe would allow X-energy to build the approach as early as possible into the ER development activities.

CONFIGURATION CONTROL

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Action	Designation	Name	Signature	Date
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EXECUTIVE SUMMARY

This white paper reviews the licensing requirements and guidance for commercial nuclear power plants and assesses the X Energy, LLC (X-energy) Xe-100 high temperature, gas-cooled reactor (HTGR) against those requirements. These requirements and guidance principally flow from Title 10 of the Code of Federal Regulations (CFR). Specifically, this white paper addresses bounding values that will constitute bounding parameters for the Environmental Report (ER) that will be submitted to the NRC as part of a license application. X-energy also proposes a licensing scenario that supports a CP application with preliminary design information and an undefined total generation capacity need. Because the total generation capacity is not well-defined at this time (it is anticipated to be larger than the current project being developed as part of ARDP), X-energy proposes that up to 12 Xe-100 units form the basis for the scope of the license application's ER.

X-energy proposes using bounding values to implement the innovative licensing path the NRC provided in Regulatory Guide (RG) 4.2, Appendix C, Scenario 1.1. The proposed bounding values use the temporal approach provided in Scenario 1.1 by offering a phased construction approach of up to 12 units over about a 15-year period. However, based on load projections and how future needs may be met, some of the units may never be constructed within the established time frame. Therefore, some of the information provided in the ER (schedule and environmental impacts from construction/operation of all reactors) will be based on assumptions correlating with the construction of the greatest number of proposed reactors, 12 units. By analyzing up to 12 units in the ER, X-energy would bound a project that would provide sufficient power to meet the prospective owner's greatest power need, which is currently under development as part of integrated resource planning.

X-energy has followed the development of several key guidance documents by the industry, national laboratories, and the NRC staff, which aide advanced reactor developers and prospective licensees in determining appropriate scope, type, level of detail, organization, and maturity of information necessary for the NRC staff to conduct systematic reviews of licensing applications and supporting documents, such as ERs. The NRC staff has produced RGs, Environmental Standard Review Plans, and draft review guidance that provide insights to the applicability of regulations and the technical and policy bases associated with the development of licensing and supporting documents. These documents demonstrate the NRC's proposed innovative and flexible approaches to licensing SMRs such as the Xe-100. X-energy is confident that an acceptable, compliant ER can be developed using bounding values that will allow the NRC staff to efficiently and effectively analyze impacts associated with the Xe-100 deployment activities for ARDP and prospective growth at the site. X-energy is also confident that the use of bounding values in such a report will provide reasonable assurance of adequate protection of the public health and safety and provides for the common defense and security.

X-energy is submitting this white paper for review by the NRC staff to facilitate engagement on the development of an Xe-100 licensing ER that will be supported, in part, by bounding values. X-energy is also submitting this white paper to finalize the approach and scope of the ER and to improve the efficiency, timeliness, and predictability of the NRC's review and oversight of the Xe-100-based ER.

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ABBREVIATIONS

Abbreviation or Acronym	Definition
ARCAP	Advanced Reactor Content of Application Project
ARDP	Advanced Reactor Demonstration Program
COL	Combined Operating License
CP	Construction permit
EIS	Environmental impact statement
EN	Energy Northwest
ER	Environmental report
ESP	Early site permit
FOA	Funding Opportunity Announcement
IRP	Integrated Resources Plan
ISP	Interim Storage Partners, LLC
NEIMA	Nuclear Energy Innovation and Modernization Act of 2019
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NWPCC	Northwest Power and Conservation Council
OL	Operating License
PSAR	Preliminary Safety Analysis Report
RG	Regulatory Guide
S&L	Sargent & Lundy
SMR	Small modular reactor
US	United States
DOE	United States Department of Energy
WNP	Washington Nuclear Project
X-energy	X Energy, LLC
XEP	X-energy Partners

1. INTRODUCTION

X-energy is developing the Xe-100 modular high-temperature gas-cooled reactor (HTGR) for commercial deployment in the United States (US), Canada, and internationally. The US deployment of the Xe-100 is funded, in part, through the U.S. Department of Energy's (DOE's) ARDP via cooperative agreement. Successful ARDP awardees committed to work towards commercial demonstration of at least one advanced reactor within 7 years of award through a cooperative agreement with DOE (by 2027). [1] X-energy is presently completing preliminary design of the Xe-100 while simultaneously drafting an ER and a Preliminary Safety Analysis Report (PSAR) to obtain a CP and OL for the Xe-100 technology-based project. To meet the 2027 demonstration timeline, the ER must be completed in 2022. The ER will therefore rely on technical information developed in the preliminary design phase, necessitating the use of bounding values to address specific aspects of the design and to account for up to 12 units being deployed over a phased project.

The prospective owner has identified a possible need for power that could include additional generation capacity necessitating expansion of the project in the future that could be achieved by the deployment of up to 12 units. The need for power analysis is currently being completed as part of normal integrated resource planning and will take several years to be finalized in a manner that confirms the need for additional units beyond the 4-unit ARDP project. X-energy's proposed bounding values associated with the need for power would allow for the following:

1) Construction and operation of up to 12 units (each unit is comprised of a **nuclear island** (the portion of the unit that contains the reactor with the other radiological components) with an associated **conventional island** (the portion of the unit that consists of non-nuclear components such as the turbine, cooling systems, and other support infrastructure such as an administrative building and maintenance facilities), each of which can generate up to about 80 MWe for a maximum cumulative power of 960 MWe;
2) Construction and operation of the first unit by 2027; and
3) A schedule that would potentially allow for deployment of additional Xe-100 units, in options including single units, paired units, and four-pack arrangements, into the 2040s.

This white paper seeks to demonstrate that an analysis bounded by the licensing, construction, and operations of up to 12 units is consistent with NRC-licensing guidance that allows for application of the bounding values. Such an approach will reduce long-term regulatory risks by removing the need for future National Environmental Policy Act (NEPA) actions that may be required for additional units if the original NEPA action evaluated a lesser number of reactors than the number of reactors ultimately constructed. The approach is also consistent with direction the NRC staff is pursuing to demonstrate greater technological innovation, flexibility, and regulatory processes improvements for licensing advanced reactors to meet the purposes of the Nuclear Energy Innovation and Modernization Act of 2019 (NEIMA) [2]and NRC's associated NEIMA commitments. [3]

1.1. PURPOSE

The purpose of this white paper is to provide a basis for:

- X-energy's use of bounding values to bound environmental impacts associated with the deployment of up to 12 units at a single site.
- X-energy's proposed licensing scenario, which is a slightly modified approach to Scenario 1 discussed in RG 4.2, Appendix C. This approach is appropriate for this effort as it will rely on analyses associated with the greatest potential impacts.

On July 8, 2021, the NRC issued a draft white paper, "Guidance for Performing the Review of a Technology-Inclusive Advanced Reactor Application - Review Roadmap." In that draft white paper, the NRC provided a Pre-Application Engagement Guidance, which addressed Section 103 of the Nuclear Energy Innovation and Modernization Act (NEIMA). [2] The NRC noted that NEIMA Section 103 requires:

> *…the NRC to develop licensing strategies that (1) include the use of topical reports, standard design approval, and other appropriate mechanisms as tools to introduce stages into the commercial advanced nuclear reactor licensing process; (2) evaluate options for improving the efficiency, timeliness, and cost-effectiveness of licensing reviews of commercial advanced nuclear reactors, including opportunities to minimize the delays that may result from any necessary amendment or supplement to an application; and (3) options for improving the predictability of the commercial advanced nuclear reactor licensing process, including the evaluation of opportunities to improve the process by which application review milestones are established and met.*

The NRC further noted that pre-application meetings for prospective advanced reactor licensees may be particularly beneficial for advanced reactor developers as such meetings allow for early identification and resolution of technical and policy issues that could affect licensing." Additionally, the NRC offered that the applicant should use white papers to "identify any novel environmental methodology or issue to allow staff familiarization so it can develop a review strategy and review guidance, if needed." This white paper serves those purposes as it meets NEIMA objectives and goals and identifies and seeks to resolve technical and policy issues by offering novel methodologies during pre-application to reduce licensing risks for this and future projects.

This white paper achieves the above-listed purposes relying on NRC's Regulatory Guide 4.2 [4] and NUREG-1555 [5], each of which discuss the use of bounding and reasonable assumptions in ERs.

1.2. BACKGROUND

X-energy was awarded funding through DOE's ARDP program, as advertised in DOE Funding Opportunity Announcement (FOA) Number: DE-FOA-0002271. The FOA authorized the recipient to share development costs in a cost-shared cooperative agreement with DOE, valued at up to $2.4 billion USD. [1] The FOA expected a successful applicant to commercially demonstrate a reactor within 7 years. [1] The FOA's schedule is a principal driver for X-energy's schedule, including X-energy's need to submit the ER ahead of the development and finalization of some of its supporting final design information.

A single Xe-100 unit is designed to produce 200 MWt in a pebble-bed core formed from approximately 220,000 pebble fuel elements (pebbles/fuel pebbles). Circulating helium transfers heat to a single steam

generator with dual helical coils designed to produce high-grade, superheated steam at 565°C and 16.8 MPa. This steam may be used to produce 80 MWe per unit, high-temperature process heat for industrial markets, or multiple energy products in a cogeneration arrangement. The standard design Xe-100 plant deploys four identical 200 MWt units (i.e., a 4-unit plant), each consisting of a Nuclear Island (NI) containing the reactor/steam generator coupled to a Conventional Island (CI). X-energy refers to each Nuclear Island/Conventional Island pair as a unit.

Each unit can operate independently of the others with the main shared operational facilities being the control room and high-energy spent fuel storage facility. Each unit is designed for safe and secure operation during concurrent construction of additional units at the site. As discussed above, the proposed project would be bounded by the operation of up to 12 units as determined by the prospective owner's market analysis; however, the schedule of bringing each reactor unit online beyond the first unit or set of units is presently undetermined. The determination of the number of units, and the timing associated with the deployment of each unit may not be finalized until after the ER is submitted to the NRC.

Important near-term activities that need to be met to meet the ARDP goals include (under 10 CFR Part 50):

- Submittal of a PSAR (CP application)
- Submittal of an ER (CP application)
- Approval of a PSER and an environmental impact statement (EIS)

For the purposes of this white paper and scope development related to the ER, it is assumed that construction of up to 12 units would occur with the first unit being available for operation in 2027, with deployment of additional units incrementally over the next 10-15 years.

1.3. RELATIONSHIP TO OTHER DOCUMENTS

X-energy previously submitted a white paper associated with the Xe-100, titled "Xe-100 White paper Licensing Application Content and Regulatory Analysis"; however, aside from addressing the Xe-100, the two documents do not address the same subject matter. Presently, this white paper is the only document that addresses bounding values associated with the Xe-100 project and associated environmental licensing approach.

1.4. DOCUMENT LAYOUT

Section 2 of this white paper presents the bounding value concept and discusses present NRC guidance that addresses the bounding of reactor designs. Section 3 describes how the need for power plays a role in the ER, and the current and projected status of determining the need for power specific to this project. Section 4 describes how a bounding value of up to 12 units would be deployed for the ARDP, its impact on bounding values for specific design parameters, and the reasonableness of the bounding values. Section 5 summarizes X-energy's conclusions as to how the bounding value would be used within the regulatory guidance framework.

2. BOUNDING VALUE CONCEPT

A bounding value approach is not a new approach since it is currently considered in NUREG-2122, RG 4.2, and NUREG-1555. The bounding value definition proposed in this white paper is a bounding limit on a particular parameter or set of parameters (e.g., radiological emissions, footprint, etc.) that would allow the NRC to sufficiently review and analyze data and information associated with the bounded issue. Because the design of the Xe-100 is in the preliminary design stage, and the PSAR is based on the preliminary design, bounding values are associated with specific design parameters such as emissions data, land use limitations, water consumption, and waste characteristics associated with the construction, operation and decommissioning of up to 12 Xe-100 reactor units. Establishing these bounding values for the deployment of up to 12 units will allow X-energy to efficiently seek to license the greatest number of reactors anticipated to fulfill the prospective owner's need for power.

Present NRC guidance references bounding analyses for specific design parameters, such as transportation impacts and other information that drives the probabilistic risk assessment. The NRC has also adopted bounding value-like licensing approaches, including: (1) the Early Site Permit, which allows an applicant to submit several candidate sites, technologies, or a combination thereof, for NRC review prior to selecting a final site or technology; and (2) the use of a plant parameter envelope design, which allows an applicant to bound characteristics of a proposed technology to a bounded footprint. These approaches demonstrate that X-energy's bounding value approach offered in this white paper is not novel as the purpose of each of the cited approaches is to allow an applicant to analyze a maximum value (e.g., a footprint, technology, or both) when an applicant lacks complete information on such a value.

2.1. REGULATORY GUIDANCE RELATED TO BOUNDING ANALYSES

NUREG-2122 provides, and distinguishes, two-related and critical terms: (1) bounding analysis; and (2) conservative analysis. [9] Understanding these terms is helpful to understanding the application and limitations associated with X-energy's proposed bounding values.

- **Bounding Analysis:** An analysis that uses assumptions such that the assessed outcome will meet or exceed the maximum severity of all credible outcomes, both in magnitude as well as frequency.
- **Conservative Analysis:** An analysis that uses assumptions such that the assessed outcome is meant to be less favorable than the expected outcome.

Because NUREG-2122 addresses risk-informed decision making, "bounding analysis" and "conservative analysis" are defined in the context of a probabilistic risk assessment. NUREG-2122 defines "bounding analysis" as analysis that "considers both the frequency of the event and the outcome of the event" and "includes the worst credible outcome of all known possible outcomes that result from the risk assessment of that item." In other words, a bounding analysis is "bounding both in terms of the potential outcome and the likelihood of that outcome." The bounding analysis is a "special case," or a subset of conservative analysis, as the "conservative analysis" "may not be the worst result of a set of outcomes;" rather, the conservative analysis "produces a quantified estimate of a risk metric." [9]

For the ER, the application of a bounding analysis would allow for the development of an ER that would encompass all outcomes such that a result would not occur outside the bounds of the bounded inputs. The bounded analysis would assume the maximum credible event (environmental impact) that could

occur. Conversely, a conservative analysis may not provide the "maximum severity of all credible outcomes," raising the regulatory risk that a subsequent re-analysis needs to be performed if design or implementation assumptions change in a way that exceeds the bounded parameters.

RG 4.2 clarifies that bounding analyses must be bounding and reasonable and should be broad enough to overestimate impacts, yet not so broad that such assumptions could mask the true environmental impacts of the reactor and lead to invalid conclusions. [4] Thus, bounding and reasonable assumptions may be broadly applied, provided they lead to reasonable conclusions.

RG 4.2 addresses "bounding," and "conservative" estimates, as follows: [4]

> *[RG 4.2, page 83] If assumptions are used to fill in missing or highly uncertain data (e.g., commute distances, persons per vehicle, and shipping distances for materials**), the assumptions should be bounding and reasonable** (i.e., the assumptions used in the analysis would be broad enough to overestimate the transportation impacts yet not so broad that they could mask the true environmental impacts of the reactor and lead to invalid conclusions).*
>
> *[RG 4.2, page 106] Where assumptions are used to fill in missing or highly uncertain data (e.g., commute distances, persons per vehicle, and number of deliveries), **the assumptions should be bounding and reasonable** (i.e., the assumptions tend to overstate transportation impacts yet are not so conservative that they could mask the true environmental impacts of the reactor and lead to invalid conclusions).*
>
> [RG 4.2, page 60] *Impacts to terrestrial resources should be **based on a conservatively estimated footprint** of ground disturbance encompassing the plant and associated facilities. The estimated footprint should also account RG 4.2, Rev. 3, Page 71 for temporary features, such as laydown areas. Estimates of the footprint used in the ER **should be conservative enough to characterize terrestrial impacts in a way not overwhelmed by future minor adjustments** to the proposed site layout.*
>
> *[RG 4.2, page 71] Wetland permit applications are sometimes prepared subsequent to the ER; in such cases, wetland impact data presented in the ER **should be conservative enough to account for likely impact levels ultimately reported in permit applications.***
>
> *[RG 4.2, page 119] DBA analyses have a direct impact on the design of safety-related systems, structures, and components that are designed to ensure adequate protection of the public health and safety. These safety analyses are intentionally **performed in a very conservative manner to compensate for uncertainties in accident progression**.*

NUREG-1555 [5] also provides review guidance that addresses "bounding" and "conservative" analyses, including the following examples:

> *[NUREG-1555, page 7.3-6, referring to the dose from the groundwater pathway] Evaluate the applicant's basis for estimating the degree to which various alternatives would reduce risk (expressed as a reduction in core damage frequency or in terms of person-rem averted). In performing its independent assessment, **the staff may make bounding assumptions** to determine the magnitude of the potential risk reduction for each* severe accident mitigation alternative*.*

[NUREG-1555, page 5.3.1.1-6] The reviewer should ensure that analyses involving mathematical or physical modeling of intake flow fields are appropriate for the specific situation being modeled, have been verified or ***shown to be conservative****, and are documented and referenc*ed… For analyses involving less detailed procedures than mathematical or physical models, **the reviewer should ensure that the procedures used were appropriate for the specific situation and were adequately conservative.**

[NUREG-1555, page 5.3.2.1-7] If the thermally affected discharge area will be relatively small and have low ecological impacts, then **use simple methods of analysis and conservative assumptions**.

[NUREG-1555, page 5.4.1-8] For gaseous pathways… consult with the ESRP 2.7 reviewer to **determine a conservative effluent release point** for the hypothetical plant.

[NUREG-1555, page 5.4.2-6] Ask the reviewer for ESRP 5.4.1 to re-evaluate the exposure pathway data. ***The objective of this re-evaluation is to determine if conservative estimates have been used, and if so, to see if more realistic pathway data can be identified that would result in decreased dose predictions.*** *When more realistic input data can be identified, repeat the preceding review procedures of this ESRP and provide the reviewer for ESRP 3.5 with the revised dose calculations.*

RG 4.2 and NUREG-1555 demonstrate that the NRC allows and encourages the use of bounding analyses where such analyses are reasonable, reflect realistic assumptions and data, and result in true estimates of potential environmental impacts. The proposed bounding values analyze the construction and operation of up 12 Xe-100 units, a defensible number of units based on projected power needs for the region. However, until the prospective owner completes its need for power analysis that will also include an analysis of how power needs would be met, the ER must be bounded by "reasonable" and "conservative" estimates, which X-energy proposes through the analysis of the construction and operation of up to 12 units over a period of time.

2.2. LICENSING SCENARIOS RELATED TO THE SCOPE OF AN ENVIRONMENTAL REPORT

It is important to consider licensing scenarios when considering the analysis of up to 12 units for the ARDP project because the licensing process is currently ongoing and evaluating up to 12 units in the NEPA context influences the licensing approach. Because the current need for power analysis is predicting the need for additional units (see Section 3.1), it is reasonable to develop the ER with up to 12 units as a conservative assumption. Appendix C of RG 4.2 directly addresses four potential licensing scenarios for SMRs that depend on future actions (e.g., when future small modular reactors are built and operated in a modular fashion). The following descriptions from Appendix C summarize four licensing scenarios that the NRC staff have noted may be possible SMR licensing scenarios.

- Scenario 1: An applicant requests licenses for all Units installed over time. The outcome of Scenario 1 is that the NRC staff would have completed its environmental analysis for all Units, the licensing action would have been taken, and no further environmental analysis would be required. The information submitted by the applicant to support the need-for-power analysis, alternative energy analysis and benefit-cost analysis should be based on an accounting of the full capacity of all the modules for which

licenses are being requested. This approach requires a proposed schedule for Unit construction and operation.

- Scenario 2: An applicant requests licenses for one or more Units and informs the NRC that it intends to request licenses for additional Units in the future. The future Units would be treated as "reasonably foreseeable," and the first siting study would consider all proposed Units. The information requested for the need-for-power analysis, alternative energy analysis, and benefit-cost analysis would be based on only the modules for which licenses were being requested. The outcome of Scenario 2 is that, if the applicant applies for licenses for future units, the NRC would prepare a supplemental EIS that would tier off the EIS prepared for the initial units in which the cumulative impacts for the future units were assessed. The supplemental EIS would evaluate any new and significant information, need for power, and the cost-benefit for the additional Units being licensed. The supplemental EIS would not evaluate alternative sites.

- Scenario 3: An applicant may identify the need for additional Units that were not identified as reasonably foreseeable in a previous application, and therefore not addressed in the previous application (e.g., siting, alternative energy). In such a case, the ER (and the NRC's EIS) for the subsequent application must address all of the issues in the Regulatory Guide, including alternative sites and alternative energy. The NRC would evaluate only the requested number of Units and any subsequent application for additional Units at that site would need to address all environmental review areas including alternative sites and alternative energy.

- Scenario 4: An applicant may request an early site permit (ESP) for all planned Units and then request COLs for only those Units it plans to build in the short term. In this scenario, the information that should be supplied in the ER for the ESP review should include consideration of all the Units that are planned. The NRC would prepare a supplemental EIS for each COL application referencing the ESP.

Scenario 1 requires the use of a well-defined project definition and associated bounding and reasonable analyses and assumptions to ensure that the environmental impacts presented in the ER do not lead to invalid conclusions. Scenario 1 requires a well-defined need for power analysis that addresses the full capacity of all modules, including a proposed schedule for implementation of all modules.

Under Scenario 2, X-energy would apply for "reasonably foreseeable" licenses (presumably no more than 4 units) and a future applicant would apply to license the 8 remaining reactors. The future applicant would need to revise the original (X-energy) ER and would also need to identify any new and significant information, including analysis of the need for power and the cost-benefit for the additional modules. The NRC would use the updated information to develop a supplemental EIS. This approach would not benefit X-energy as the licensee of the initial 4 units; however, it would provide a future application with foundational information from X-energy's ER. Nonetheless, the future applicant would need to analyze all new impacts associated with the construction and operation of the additional 8 units. This approach would require that those units that do not have a well-defined schedule or identified applicant would have to be considered as part of cumulative impacts. If additional units are proposed to be deployed, then

the revised ER and related supplemental EIS would need to move those units from the cumulative impact analysis into the Proposed Action.

X-energy does not believe Scenario 3 would apply to this project as the project takes into account a maximum number of reactors that could be needed, based on preliminary projections for need for power. Scenario 3 would require a new environmental licensing process for each new set of units and would cause significant project risks to a prospective owner with little-to-no measurable benefit to the applicant.

Scenario 4 would apply to this project if the X-energy Partnership (XEP), team, which consists of X-energy and EN, was pursuing an ESP that addresses up to 12 units. Under this scenario, the XEP team would prepare a revised ER and the NRC would prepare a supplemental EIS for each COL or CP application.

2.3. GUIDANCE FOR PERFORMING THE REVIEW OF A TECHNOLOGY-INCLUSIVE ADVANCED REACTOR APPLICATION - REVIEW ROADMAP, INTERIM STAFF GUIDANCE

On July 8, 2021, the NRC issued a draft white paper, “Guidance for Performing the Review of a Technology-Inclusive Advanced Reactor Application - Review Roadmap.” [10] This draft white paper is associated with the Advanced Reactor Content of Application Project (ARCAP); once finalized, it will support the implementation of 10 CFR Part 53, “Licensing and Regulation of Advanced Nuclear Reactors.” The draft guidance “provides a general overview of the information expected to be included in an advanced reactor application, and a review roadmap for NRC staff with the principal purpose of ensuring consistency, quality and uniformity of staff reviews, and to present a well-defined base from which to evaluate proposed changes in the scope and requirements of reviews” (page 8 of the draft white paper). The guidance cites NEIMA Section 103 and the NRC’s need for a “flexible regulatory framework” in reviewing and regulating advanced reactors as background to the development of the guidance.

The guidance identifies the SAR as the “principal document in which the applicant provides the information needed to understand” that the reactor can be operated safely. 10 CFR Part 50 requires the submission of a PSAR to support a CP application and is one acceptable way for the applicant to address project scope and level of detail. The guidance in Appendix E of the draft NRC white paper addresses Chapters 9 and 10 of the SAR, which relate to environmental impacts evaluated in the ER. The guidance references 10 CFR 50.35(a), which states that the NRC may issue a CP that “approves all proposed design features,” even in cases where a CP applicant has not furnished all required technical information. 10 CFR 50.35(a) further notes that such additional information “will be supplied in the final safety analysis report” to support the issuance of the CP. Finally, the updated guidance notes that: [10]

> *[Appendix E, page 4] In cases where a novel design has not sufficiently progressed and certain information is not available at the submission of the CP application, the PSAR should provide the criteria and bases used to develop the required information, the concepts and alternatives under consideration, and the schedule for completion of the design and submission of the missing information. In general, the PSAR should describe the preliminary design of the facility in sufficient detail to enable the staff to evaluate whether the facility can be constructed and operated without undue risk to the health and safety of the public.*

10 CFR 50.35(a) allows for the submittal of a PSAR with “preliminary” facility design so long as it is sufficiently detailed to “enable the staff to evaluate whether the facility can be constructed and operated without undue risk to the health and safety of the public.” In effect, 10 CFR 50.35(a) necessitates the use

of bounding values as the regulation allows a preliminary design to be proposed that may not have complete information, yet information in the CP application must be sufficient to allow NRC staff to evaluate health and safety risks. To reduce and eliminate regulatory risks associated with subsequent revisions that update criteria and bases, X-energy's proposed bounding values present conservative or bounding assumptions in the ER that will address aspects of the preliminary design until such design parameters are otherwise available. With this approach X-energy's proposed bounding values are aligned with regulatory guidance and 10 CFR requirements.

2.4. SIMILAR APPROACHES FROM PRIOR NRC LICENSEES

The NRC has used similar approaches to licensing facilities, such as the issuance of the SHINE Medical Technologies, Inc. (SHINE) CP application, Docket No. 50-608, the Interim Storage Partners' EIS, Docket No. 72-1050, and the Design Certification for the NuScale SMR, Docket No. 52-048. Such approaches are discussed below.

2.4.1. SHINE Environmental Impact Statement (NUREG-2183) and Safety Evaluation Report (NUREG-2189)

The SHINE EIS related to a CP application evaluates bounding conditions. Table 1 shows examples of bounding parameters identified in the EIS [11] that the NRC used to evaluate environmental impacts and demonstrates that the NRC may adopt EISs, that are based, in part, on bounding values.

Table 1: Examples of Use of Bounding Values in SHINE's Construction Permit License Application EIS

EIS Page	Reference to Bounding Analysis
2-17	Table 2-3 provides bounding values for the quantity of the chemical inventory associated with operations.
4-7 and 4-8	Table 4-3 provides bounding conditions for construction-related air emissions.
4-12	Table 4-6 provides bounding air dispersion modeling results for pollutants emitted during operations.
4-14 to 4-16	Table 4-8 and Table 4-9 show diesel equipment used during decommissioning and the total activity of equipment use, and their air emissions, which are "bounding and conservative."
4-23	Table 4-10 shows water requirements during construction. The NRC staff "considers these values to be conservative (i.e., bounding)."
4-47 to 4-48	NRC staff shows the maximum hypothetical accident for which a bounding calculation is performed. The analysis assumes a bounding source term.
4-49	NRC evaluated "bounding" facility hazardous chemical source terms and concentrations as part of their accident analysis, as shown in Table 4-13.

These references demonstrate the NRC's support for the use bounding analyses, even in the adoption of an EIS (that occurs after the NRC's acceptance of an ER).

The SHINE Safety Evaluation Report (SER) for a CP application "documents the U.S Nuclear Regulatory Commission (NRC) staff's technical review of the construction permit application submitted by SHINE."

[12] As part of the NRC's development of the SER, the NRC sent Requests for Additional Information (RAI) to SHINE, seeking supplemental information. As summarized in Table 2, several of these RAIs address SHINE's use of bounding estimates and analyses and were closed with NRC confirming acceptance of SHINE's use of such bounding parameters.

Table 2: Examples of Use of Bounding Values in SHINE's Construction Permit License Application SER

RAI Ref #	SER Page	Reference to Bounding Analysis
2.4-4	2-18	NRC staff requested that the applicant provide additional information on the bounding estimates for travel time through the unsaturated zone. NRC staff found applicants response to the RAI acceptable.
4a2.8-4	4-29	NRC noted that the applicant's use of TSV off-gas condenser specifications based on the bounding inputs and conservative assumptions was acceptable.
6a.2.2-3	6-7, 6-8	NRC noted that the applicant's use of bounding analyses associated with Section 6a2.2.1.2, "Confinement Systems and Components," was sufficient.
19.2-4	A-33	NRC noted the applicant's use of bounding dimension of the footprint of the SHINE facility associated with hazard analysis and visual impact analysis. The NRC approved SHINE's use of such bounding conditions.

RAI 19.2-4 is similar to X-energy's proposed bounding value as each assessed the greatest potential impacts associated with the facility, as X-energy is proposing with the analyzation of up to 12 Xe-100 units. SHINE, through the RAI process, noted that the "bounding elements" in the PSAR were greater than the proposed facility dimensions and were used to "conservatively estimate the effective SHINE impact area in the aircraft hazard evaluation." Likewise, "the facility bounding dimensions provided in Subsection 19.4.1.2 of the PSAR and used in the visual impact assessment were based on an earlier facility design." The dimensions were subsequently modified along with a reduction in acreage that would be temporarily impacted from construction. The SHINE experience is valuable as it demonstrates that the NRC can review a bounding analysis, including proposed footprint, site dimension, and site layout, as long as the applicant can justify the bounding elements, and as design and licensing progress, provide an accurate layout with associated impacts. This is precisely the process EN/X-energy propose through the bounding values discussed in this white paper.

2.4.2. Environmental Impact Statement for Interim Storage Partners LLC's License Application for a Consolidated Interim Storage Facility for Spent Nuclear Fuel in Andrews County, Texas, NUREG-2239

The Interim Storage Partners, LLC (ISP) EIS [13] addresses a license application to construct and operate a consolidated interim storage facility (CISF) for spent nuclear fuel (SNF) and Greater-Than-Class C waste, along with a small quantity of spent mixed oxide fuel in Andrews County, Texas. Per pages xviii, 1-3, and 2-1, ISP sought a license to store 5,000 metric tons of uranium (MTU) and requested subsequent amendments to the license that would allow for the storage of up to 40,000 MTUs over the course of 20 years (EIS Page iii). In recommending the license for 5,000 MTUs, the NRC reviewed the "potential future expansion" (UP TO 40,000 MTUs) as a bounding analysis for the project. The NRC noted that "future expansion phases would require license amendment requests for which NEPA environmental reviews would be conducted," but noted that "NRC staff would use the bounding analysis documented in this EIS to facilitate the NEPA reviews for the subsequent expansion license amendments if the NRC staff

determines that the bounding analysis is applicable." In the ISP EIS, the NRC concluded that phased licensing efforts bounded by the first analysis is appropriate. The ISP approach is like the proposed X-energy bounding value, although it differs as the ISP approach would require subsequent NEPA reviews. While the NRC was not clear as to whether such reviews would require an EIS or an EA, the purpose of the proposed bounding value is to allow X-energy to plan for licensing up to 12 units simultaneously while constructing the units in a phased approach. This work would occur under a single NEPA process, barring new and significant information.

2.4.3. NuScale Design Certification Application

NuScale submitted a Design Certification Application (DCA) and the NRC issued a Final SER based on its review of the DCA. [17] NRC found that the NuScale Power Plant is designed for use at a site with site characteristics bounded by the site parameters described in Chapter 2, "Site Characteristics," of the DCA, in which the design accommodates "up to 12" modules (page 1-1). Table 3 summarizes some examples of specific bounding values noted in the Final SER. Not shown are instances from Chapter 3, "Design of Structures, Systems, Components, and Equipment," where the term "bounding" is used 54 times. A bounding approach for a SMR where the range of number of units could be up to 12 is therefore proven and can be acceptable to the NRC.

Table 3: Examples of Use and Acceptance of Bounding Values in NRC's Evaluation of NuScale's Design Certification Application

EIS Page	Reference to Bounding Analysis
8-59	Regarding the design-basis accident conditions, the NRC staff found that the design conforms to RG 1.155, Regulatory Position C.3.2.4, "because the environmental conditions for installed SBO equipment are bounded by the design-basis accident conditions" (page 8-59).
11-2 to 11-3	NuScale used a bounding fuel isotopic inventory.
11-15	NuScale determined bounding results for liquid releases at any chosen site that meets bounding site characteristics.
12-35	The NRC staff verified that the values used in the applicant's shielding calculations were sufficient to bound the total neutron radiation fluence expected during the design life of the plant.

The NuScale experience demonstrates that the NRC will accept an application that addresses a maximum number of proposed modules (reactor units), even though it may be that not all reactors would be constructed.

3. ESTABLISHMENT OF THE NEED FOR POWER RELATED TO THE ADVANCED REACTOR DEMONSTRATION PROGRAM

3.1. ROLE OF NEED FOR POWER IN DEVELOPMENT OF THE ENVIRONMENTAL REPORT

In general, the NRC assumes that the need for power is well established and that the selection of the above licensing scenario is based on this assumption:

> *[RG 4.2, page 143] The goal of the need for power analysis is to provide confidence that the power generated by the proposed project will be produced and consumed in a manner consistent with the stated purpose and need of the project*.

RG 4.2 notes that an Applicant's establishment of the need for power is an integral part of the ER. As stated in RG 4.2, Section 8.0: [4]

> *The goal of the need for power analysis is to provide confidence that the power generated by the proposed project will be produced and consumed in a manner consistent with the stated purpose and need of the project. The analysis also provides the basis for the consideration of baseload alternative generating technologies for the proposed project. The need for power analysis should be limited to the discussion of the supply and demand for electricity. Discussion of ancillary benefits (e.g., reduced greenhouse gas emissions, fuel diversity, or grid stability) should be addressed in the benefit-cost section of the environmental report (ER).*
>
> *The need for power analysis should fully describe and characterize the physical, geographic, regulatory, and administrative provisions and constraints which affect the current and forecast supply of and demand for power. The analysis should be in sufficient detail to fully demonstrate how the proposed project would supply some or all of the service area's future need for power.*

Chapter 8, Need for Power, of an ER addresses the applicant's power market, power demand, and power supply. For this project, X-energy will assess the applicable service area (power market). The prospective owner's 2020 Integrated Resources Plan (IRP) document, an example of what could be used, addresses power consumption and cost by consumer type (industrial, residential, commercial, or agricultural) and contains a discussion of possible power generation sources (renewable/non-renewable, etc.). [15] The IRP notes that while the prospective owner presently meets its customers' power needs. With power demand increasing throughout the Pacific Northwest, and power production simultaneously decreasing, the prospective owner will need to bolster its present operations either through a power purchase or through the construction of a new generation facility, as demonstrated in the IRP. Over the past five years, the prospective owner has determined an annual growth rate (power need) of over 3% and forecasts an annual growth of 4.9% over the next 10 years (i.e., by 2030).

Simultaneously with the prospective owner's growth in need for power, the enactment of the Washington Clean Energy Transformation Act (CETA) [20] will result in the retirement of several energy generation assets by 2030. Specifically, CETA requires Washington utilities to: (1) retire coal generation assets by 2025, (2) become greenhouse gas neutral portfolios by 2030, and (3) retire of natural gas generation assets by 2045. Retirement of the assets necessary to achieve these goals will result in a deficit of energy production in the amount of 3,610 MW in the State of Washington by 2032, with the retirement of an additional 199 MW of proposed (planned, but not certain) coal generation plants by 2027. In total, 3,809 MW of power generating facilities are presently scheduled to be retired by 2032, with a total of 1,633 MW

proposed to replace these generating facilities by 2030, leaving a deficit of 2,176 MW (page 13 of the IRP). As the prospective owner concludes in its IRP, "[t]he challenge will be choosing additional resources in the next few years that comply with CETA while allowing the prospective owner to serve customers at the lowest possible cost." [15]

The prospective owner is presently considering how to meet its growing need for power in a CETA compliant manner. In its IRP, the prospective owner notes that its "need for physical capacity and energy beyond its current generation assets will need to be addressed" within the next 10 years and that it intends to "acquire these resources through market purchases of firm generation as well as Purchaser Power Agreements (PPAs) which may include solar and natural gas resources and call options on firm capacity to cover peak demand." [15] The prospective owner is also considering the deployment of nuclear technology, although this technology was not addressed in the IRP as the IRP did not assess technologies that would require "future technological breakthroughs." Likewise, the prospective owner is considering a gas-fired production plant, although it's operational life would be limited to ±20 years as CETA would require retirement by 2045. These factors leave nuclear a viable technology for the prospective owner. The path forward for technology selection to meet all power needs will not be available for completion of the CP application.

3.2. CURRENT AND PROJECTED STATUS OF THE ADVANCED REACTOR DEMONSTRATION PROGRAM FUNDED XE-100

3.2.1. Development of the Preliminary Safety Analysis Report

The PSAR is currently being developed. X-energy and EN are drafting the PSAR. It is expected that sufficient preliminary design and safety-related information will be available to develop bounding values for the ER.

3.2.2. Site Selection Process

X-energy has contracted with Sargent & Lundy (S&L) to conduct a site selection analysis, which will consist of the review of 12 sites throughout central and southeastern Washington. S&L will screen each candidate site to determine which, if any site, is "environmentally preferable" (RG 4.2, pages 152, 158) [4] or "obviously superior" (NUREG-1555, page 9.3-1). [5] RG 4.2 notes that the term "environmentally preferable" only analyzes environmental impacts, whereas an "obviously superior" site considers environmental impacts, costs, and institutional constraints. S&L is reviewing each of the potential and candidate sites to determine whether an "environmentally preferable" or "obviously superior" site exists as compared to Washington Nuclear Project (WNP)-1/4. The draft report will be made available to the NRC staff for feedback.

3.2.3. Water Rights

X-energy and S&L are working with EN to determine whether one of EN's several water rights may be transferred for use if the former WNP-1/4 site(s) is used. If the WNP-1/4 is not used, EN will not seek a transfer of such rights, and X-energy/the prospective owner will obtain a new water right certificate from Washington Department of Ecology or from another water right owner. If the former WNP-1/4 site(s) is

used and Ecology will not allow EN to transfer a water right, a new water right will be required. Ecology presently has 25,000-acre feet of fee-based water rights available at Lake Roosevelt that can be considered if a new water right is required. The maximum rights Ecology will transfer to a single user is presently unknown. EN and S&L are coordinating these rights with Ecology.

3.2.4. Energy Northwest Site Control and Lease Negotiations

EN leases the former WNP-1/4 sites from DOE. The lease expires in 2032 and has two options totaling 20 years; therefore, the lease will terminate no later than January 1, 2052. X-energy presumes that the NRC will issue an Xe-100 license for at least 40 (if not 60) years. If the first Xe-100 operating license is issued in 2027, the lease will cease on year 25 of the operating license. EN is working with DOE to extend the lease until at least 2067. The EN/DOE lease negotiations will also include revising the lease to expressly allow for the construction and operation of a new SMR and to ensure that the lease language sufficiently demonstrates EN's control of the site, as defined in RG 4.2.

3.2.5. Development of the ER

X-energy has contracted with S&L for the development of the ER and supporting documentation and the work has commenced. EN has significant historical information associated with the former WNP-1/4 sites, and if either or both of those sites is selected as the preferred site, the X-energy team intends to use historical information and data in EN's possession to determine what additional characterization activities need to be performed and to the support development of the ER.

4. PROPOSED BOUNDING APPROACH

Pursuit of a 10 CFR Part 50 license presents uncertainty and regulatory risks, examples of which include:

- NRC staff not accepting the ER;
- NRC determining that some of the bounding values do not meet regulatory criterion; and
- Revisions to the ER identifying new and significant information.

While these regulatory risks are common to all applications for power production facilities, they may pose increased risk to permitting SMR technologies as these technologies provide flexibility in the number of units that can be constructed and operated on a single footprint while not having a final fixed/completed design. With such flexibility, an applicant proposing to deploy an SMR technology must be able to provide adequately accurate and complete information as required by 10 CFR 50.9 despite:

- uncertainties associated with the design and a rapidly changing power market;
- a lack of certainty on the number of reactor units required under the license;
- an applicant who may not have nuclear power experience; and
- the length of time over which reactor units may be deployed.

From the technology provider's standpoint (i.e., X-energy), the licensing process must be completed with a design that has yet to reach the final design stage. The preliminary status of the Xe-100 design requires reliance on bounding values for components and processes critical to licensing the Xe-100 in a timely manner. X-energy's timing is critical as the intent is to ensure that X-energy will meet the timeframe required in the ARDP award. The preliminary nature of the Xe-100 design, combined with the desire to maximize flexibility for the prospective owner by proposing a maximum number of units, allows for greater variability associated with environmental impacts. For example, the proposed number of units will affect the disturbed land area, impacting environmental aspects such as cultural and ecological resources. Variability in environmental impacts is addressed in more detail in Section 4.2.2.

To provide the most flexibility in planning the deployment of the Xe-100, a bounding approach should allow a corresponding flexibility in defining long-term deployment plans while minimizing regulatory risks as much as possible. X-energy's proposed bounding values achieve this flexibility by allowing X-energy to permit a not-to-exceed number of units on an indefinite timeline.

4.1. LICENSING SCENARIOS

This Section addresses X-energy's proposed project and compares it to the four licensing Scenarios discussed in RG 4.2, Appendix C. Figure 1 summarizes the four licensing scenarios in RG 4.2 and states the problems associated with each scenario as related to the ARDP project.

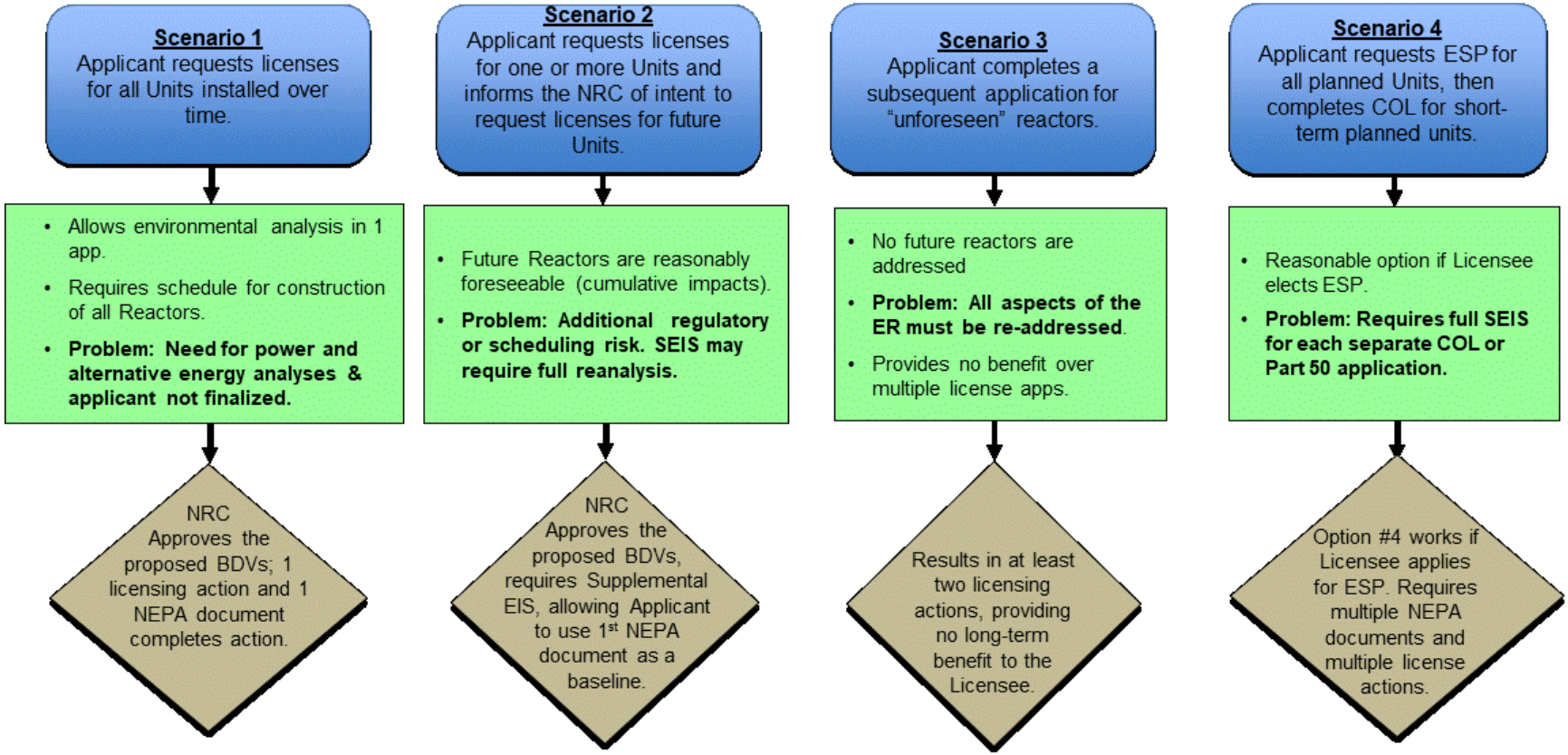

Figure 1: Possible Licensing Scenarios for ARDP Xe-100 Deployment

4.1.1. Scenario 1 Applicability to the ARDP Xe-100 Project

X-energy believes that the NRC's Scenario 1 (see Section 2.3, referring to RG 4.2, Appendix C) is the optimum approach for permitting the Xe-100 project to achieve minimization of regulatory risk. This scenario would allow X-energy to license up to 12 units and construct the reactors in sequence, which is the fundamental purpose of Scenario 1. The reactor technology would not change over time. However, there are potential limitations associated with this project that limit the ability to be considered under Scenario 1.

> Limitation 1: While X-energy would analyze up to 12 units, there is no certainty that by the time the license application is submitted, that X-energy will have a defined construction schedule for all 12 units. A well-defined construction schedule is expected for the first set of units, but the schedule for future units is contingent on Limitations 2 and 3.
>
> Limitation 2: X-energy anticipates that the Need for Power will show market demand that could be met by up to 12 units (equivalent to about 960 MWe); however, the market demand beyond the initial set of units may not be decided by the time the Part 50 CP application is submitted. The need for additional electrical power could be met by a combination of natural gas plants, solar and wind power plants, and commercial nuclear plants.

X-energy proposes a slightly modified Scenario 1 approach, which allows for an applicant to request several modules (units) that will be installed over time. The distinction between X-energy's proposed scenario and Scenario 1 is that X-energy proposes bounding values that will allow X-energy to analyze an estimated need for power analysis, rather than using a well-defined need for power. X-energy's bounded/modified Scenario 1 approach would allow X-energy to license up to 12 Xe-100 units in a phased manner over the course of about a 15-year period, consistent with the Scenario 1 approach. Additionally, X-energy proposes bounding the schedule submitted with the license application. X-energy will provide a detailed schedule for the deployment of the first 4 units, as required by RG 4.2, while providing a less detailed schedule associated with future additional units. If it is subsequently determined that less than 12 units will be deployed, the schedule for any remaining non-constructed units would be revised. As such changes occur, the licensee would modify the application, as required under 10 CFR 50.90.

4.1.2. Scenario 2 Applicability to the ARDP Xe-100 Project

Under Scenario 2, the potential environmental impacts associated with the units beyond the original units would be presented as cumulative impacts. If X-energy desires to construct and operate additional units, X-energy would need to revise the original ER to consider, in more detail, the previously identified cumulative impacts as part of the proposed action. The number of units intended in the Proposed Action is presently unclear. Because the number of units in the Proposed Action is unclear, an approach under Scenario 2 would require complete revision of the ER for future units not addressed in the original Proposed Action, thus adding uncertainty and unnecessary regulatory burden for expanding to more units Under a Scenario 2 licensing option, X-energy would only license the first 4-unit reactor module through the initial ER and would be required to revise the ER and adopt a new NEPA document (supplemental EIS), increasing regulatory risk associated with a long lead-time to obtain approval for construction of

additional reactors. The supplemental EIS will require reanalysis of environmental issues raised in the initial ER and EIS and could require extensive effort to resolve.

4.1.3. Scenarios 3 and 4 Applicability to the ARDP Xe-100 Project

Scenario 3 does not apply to this project because up to 12 units are considered possible, so there are no "unforeseen" reactors. Under Scenario 4, X-energy would develop an ER to support an ESP. However, X-energy is seeking to construct four units in the immediate future and the ARDP funding requires demonstration of a unit in 2027, so an ESP is not ideal as the process would be too lengthy to achieve the 2027 demonstration date. This scenario would require a three-step NEPA process under 10 CFR Part 50, with an ER for an ESP and a related EIS, a revised ER for the CP application, and another revised ER for the OL application, with NRC publishing associated supplemental EISs if any new and significant information is identified. The above-described factors leave the conclusion that neither Scenario 3 nor 4 provides a beneficial approach to the Xe-100 licensing process.

4.2. X-ENERGY PROPOSED LICENSING SCENARIO FOR THE ARDP XE-100 PROJECT

X-energy proposes a scenario that analyzes impacts associated with the construction and operation of up to 12 Xe-100 units, which may be constructed over about a 15-year period. X-energy would analyze all impacts, including the bounding values, associated with the 12 units in a single ER. The text box below addresses X-energy's proposed scenario in greater detail.

4.2.1. Major Design Parameters Associated with Bounding Values

When considering design parameters that could be impacted by the number of reactor units and how these parameters could affect discussion of environmental impacts, it is important to understand that environmental impacts could change depending on the actual number of units deployed in order to determine the "reasonableness" of the impacts. Sections 4.2.2 and 4.2.3 discuss the general design elements that could have significant environmental impacts.

4.2.2. Major Design Parameters

A number of components required for a four-unit Xe-100 Plant constitute major design parameters. The following components and facilities would be repeated for each additional Xe-100 Plant built at the same site to accommodate additional units. Within the Nuclear Island, the fuel handling corridor would be a common facility used by all of the units and would extend the full length of the units and would tie-in to the reactor auxiliary building. If fewer than 4 units are constructed in a Xe-100 plant, the fuel handling corridor would only extend the length needed. An example of a facility constructed in the Nuclear Island regardless of the number of constructed units that could be expanded as necessary instead of having multiple facilities performing the same function, would be the radwaste building. Facilities common to more than one unit in the Conventional Island and surrounding area include the electrical switchyard, electrical building, administrative building, security facilities, maintenance building, and other smaller support facilities and structures. Below is a discussion of potential environmental impacts associated with these facilities.

4.2.3. Sensitivity of Major Design Parameter Bounding Values

The following section briefly describes how variation in the number of units would generally impact environmental resource areas.

Land Use: Land use impacts address land uses on the proposed site and in the surrounding area. For the ARDP, the former WNP-1 site, which contains a decommissioned unfinished nuclear plant, is the proposed site. XEP intends to conduct cultural and ecological surveys over most of the area of the WNP-1, which is mostly graded/disturbed area that has had several historical/cultural and ecological surveys for an area that would contain up to 12 reactors. If significant cultural/historic or ecological resources are identified through these surveys, a stop work would be called to ensure sufficient protection of these resources. Because the WNP-1 site is mostly disturbed, it is not anticipated that such resource would be found on the WNP-1 site, regardless of the number of units (i.e., 4 compared to 12). Likewise, it is not anticipated that the number of units would significantly change the result in onsite historic and cultural impacts or land use, in general. X-energy anticipates that there would be no change in offsite land use impacts regardless of the number of units deployed as either approach would likely require improvements associated with transportation (i.e., roadway improvements, rail improvements, etc.). WNP-1 is located within the Hanford Reservation and surrounding land uses not within the Hanford Reservation are primarily related to agriculture with no nearby large populations.

Water-Related Impacts: X-energy anticipates the use of surface water for cooling purposes. EN presently has rights to 80 acre-feet of groundwater at WNP-1 through its lease with the DOE, which is intended for domestic (sanitary sewer, drinking water, etc.) use. It is proposed that the surface water will be delivered through an existing intake system in the Columbia River and piping that runs from the intake structure to the WNP-1 site. [18] While pumps and some piping may require replacement, no in-water work is anticipated for the intake infrastructure as the structure was assessed in 2019 and deemed compliant with applicable regulations. [19] Water use would generally be proportional to the number of units deployed. The method of water cooling has yet to be decided, but it is anticipated that water quality technical and regulatory requirements would cause these impacts to be the same regardless of the number of units being constructed. The number of units to be constructed could impact the management of cooling water, with alternative methods possibly being needed depending on the amount of cooling water.

Ecological Impacts: At WNP-1, impacts to terrestrial impacts generally would be the same regardless of the number of units constructed as the majority of the WNP-1 site terrestrial environment has been previously disturbed. Ecological surveys will be conducted across the majority of WNP-1 to cover an area that would encompass up to 12 units and all supporting areas (i.e., the laydown area and other improvements), regardless of the actual number of units deployed. Impacts to aquatic systems depend on the cooling technology used. If there are discharges to the Columbia River, then those discharges generally may be proportional to the number of units deployed, keeping in mind the impact to aquatic systems depends on the aquatic environment at and near the discharge point. Ecological impacts would also be dependent on how management of cooling water is performed; cooling water may be managed differently depending on the number of units built.

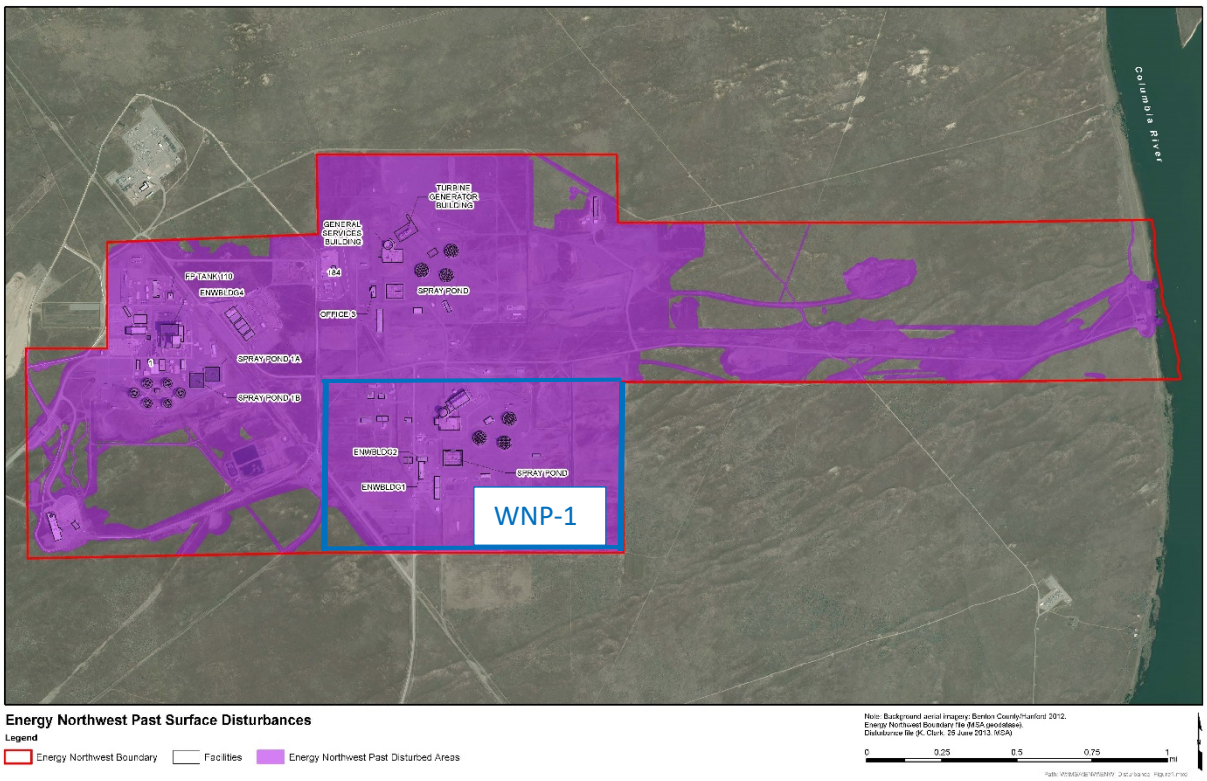

Figure 2: **Figure Energy Northwest Previously Disturbed Leased Lands (in purple)**

Socioeconomic Impacts: Socioeconomic information related to Xe-100 deployment at the WNP-1 site has yet to be established, and workforce parameters have yet to be set, so it is unclear how socioeconomic impacts would vary based on the number of units or Xe-100 plants. The construction workforce would generally remain steady over a longer period of time as the number of units deployed increases. While it is logical to assume the operational workforce would increase as additional units are deployed, the increase may not be proportional to the number of units or Xe-100 plants as the advanced SMR technology includes features such as a common control room and other common operational facilities. Workforce size influences the impacts to other socioeconomic aspects such as housing, schools, recreation and tax base. Impacts to the tax base related to corporate taxes and impacts to consumers related to electricity prices are also currently unknown and cannot be generally addressed at this time.

Environmental Justice: Impacts related to Environmental Justice are anticipated at this time to be relatively fixed, regardless of the number of units constructed. It is anticipated that environmental justice issues would be related more to the presence of any units deployed and would not necessarily vary according to the number of units.

Air Resources: Impacts to air resources from construction activities would be prolonged further as additional units are deployed. During operations, air emissions would be generally proportional to the number of units deployed, with each unit generating about the same quantity of emissions with the same characteristics.

Radiological Impacts of Normal Operation: Radiological impacts to the construction workforce would increase as the number of units increase, but it is unclear if it can be assumed that this increase would be proportional to the number of units because of factors such as construction worker location in relation to deployed units. During operations, while it can be assumed that radiological impacts to workers would increase as the number of deployed units increases, worker location, their responsibilities in relation to their support among the units, and number of workers needed makes it unclear at this time how total worker dose, and dose to individual workers would be impacted. Dose to the public due to air emissions would increase as the number of units increases, but modeling would need to be conducted to determine how these increases would impact members of the public.

Environmental Impacts of Waste: Storage space for spent fuel generated by the deployed units would be proportional to the number of units deployed. The volume of hazardous, low-level radioactive, and mixed waste can be expected to be proportional to the number of units. X-energy's design of fuel storage will be commensurate with the number of deployed units.

Transmission System Impacts: Changes to the transmission system are unknown at this time. Potential environmental impacts to the transmission system would be related to the addition of additional power lines to existing transmission corridors. While it can be expected that transmission impacts would increase in some manner, it is unclear at this time whether these impacts would be in a step-wise fashion that is related to a certain number of units deployed. Likewise, transmission impacts are site-based; while the WNP-1 site would likely connect with BPA's Ashe substation, any alternative site would require an entirely new transmission corridor. Once a final site is selected, prior to the issuance of the ER, X-energy will address these impacts.

4.2.4. Reasonableness of Bounding Values

As described in RG 4.2 and summarized in Section 2.2 of this white paper, the bounding values need to reasonably reflect the environmental impacts. In other words, the potential environmental impacts posed by the deployment of up to 12 units should not be so conservative that the potential impacts mask the true environmental impacts leading to wrong conclusions or otherwise fail to reflect what would actually occur if a much lesser number of units are actually deployed. To the extent possible, X-energy has projected these impacts in this document in a conservative and reasonable manner. As more information become available, and throughout the ER process, X-energy will refine these analyses to avoid masking true environmental impacts and to ensure that the analysis leads to correct conclusions.

To address the reasonableness of bounding values, each resource area in Chapters 4 (construction impacts) and 5 (operations impacts) of the ER would need to describe the reasonableness of impacts, taking into consideration the number of units deployed. For example, in some cases, addressing the reasonableness of the bounding values could be demonstrated by showing that the potential environmental impacts would be the same regardless of the number of units. As another example, tables could be used to demonstrate that potential impacts for varying numbers of units. If a technology or process change occurs based on the number of units deployed, multiple technologies or processes would be assessed as part of the analysis to ensure that the analysis is sufficiently bounded and reasonable.

5. CONCLUSIONS

XEP concludes the following:

- X-energy's proposed bounding value approach to licensing the Xe-100 project is an approach based on established regulatory guidance.
- Up to 12 units, constructed over time, would be analyzed as part of the Proposed Action. The ER supporting the CP application would include a preliminary schedule, and a less-defined schedule will be provided for potential subsequent units.
- A slightly modified version of Licensing Scenario 1 from RG 4.2, Appendix C (incorporating X-energy's proposed bounding values) is the ideal licensing scenario for this project, with the assessment of up to 12 units as part of the Proposed Action.
- If some, but not all, of the units are deployed initially, then the bounding value approach could reduce the regulatory burden associated with developing future NEPA documentation for newly proposed units at WNP-1.
- X-energy will demonstrate the reasonableness of environmental impacts in the ER such that the impacts are not masked regardless of the actual number of units deployed, for up to 12 units.

6. REFERENCES

The following documents are referenced within this document.

	Document Title	Preparer/Author	Document Number	Revision or Date of Issue
[1]	"Advanced Reactor Demonstration Program Application" for DOE FOA announcement number: DE-FOA-0002271.	X-energy	n/a	Aug-2020
[2]	Nuclear Energy Innovation and Modernization Act of 2019 (NEIMA), https://www.govinfo.gov/content/pkg/PLAW-115publ439/pdf/PLAW-115publ439.pdf	US Law	Public Law 115-439	14-Jan-2019
[3]	Policy Issue: Advanced Reactor Program Status	NRC	SECY-21-0010	01-Feb-2021
[4]	Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations"	NRC	ML18071A400	Rev 3, September 2018
[5]	NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants"	NRC	n/a	Oct-1999
[6]	Title 10 of the Code of Federal Regulations, Part 51	NRC	n/a	n/a
[7]	Title 10 of the Code of Federal Regulations, Part 50	NRC	n/a	n/a
[8]	Title 10 of the Code of Federal Regulations, Part 52	NRC	n/a	n/a
[9]	NUREG-2122, "Glossary of Risk-Related Terms in Support of Risk-Informed Decisionmaking"	NRC	n/a	Nov-2013
[10]	Draft White Paper Associated with Advanced Reactor Content of Application Project titled, "Guidance for Performing the Review of a Technology-Inclusive Advanced Reactor Application Review Roadmap"	NRC	ML21190A012	08-Jul-2021
[11]	NUREG-2183, "Environmental Impact Statement for the Construction Permit for the SHINE Medical Radioisotope Production Facility.	NRC	ML15288A046	October 2015

	Document Title	Preparer/Author	Document Number	Revision or Date of Issue
[12]	NUREG-2189, "Safety Evaluation Report Related to SHINE Medical Technologies, Inc. Construction Permit Application for a Medical Radioisotope Production Facility." Docket Number 50-608.	NRC	ML16229A140	August 2016
[13]	NUREG-2239, "Environmental Impact Statement for Interim Storage Partners LLC's License Application for a Consolidated Interim Storage Facility for Spent Nuclear Fuel in Andrews County, Texas: Final Report." Docket No. 72-1050.	NRC	ML21209A955	July 2021
[14]	Northwest Power and Conservation Council, Pacific Northwest Power Supply Adequacy Assessment for 2024	NWPCC	2019-11	31-Oct-2019
[15]	2020 Integrated Resources Plan	Grant County PUD	Resolution 8948	25-Aug-2020
[16]	Energy Northwest, Grant County PUD and X-energy announce TRi Energy Partnership, https://x-energy.com/media/news-releases/energy-northwest-grant-county-pud-and-x-energy-announce-tri-energy-partnership	X-energy	n/a	April 1, 2021
[17]	NuScale DC Final Safety Evaluation Report	NRC	ML20023A318	28-Aug-2020
[18]	Contract No AT (4501)-2416, Amended and Re-stated Lease (WNP 1&4 Parcels), Exhibit B.	DOE/Energy Northwest	n/a	22-5-2017
[19]	Columbia Generation Station § 316(B) Addendum to EPA Form 2-C Supplemental Cooling Water Intake Structure in adherence with §122.21(R)(2), (3), (4), (5), (6), (7) and (8)	Energy Northwest	n/a	04-2019
[20]	Washington Senate Bill 5116, Supporting Washington's clean energy economy and transitioning to a clean, affordable, and reliable energy future.	State of Washington	n/a	May 7, 2019