



# Xe-100 Licensing White Paper Emergency Planning Approach and Regulatory Analysis

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## Abstract

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This white paper presents the emergency planning approach applicable to the Xe-100 reactor technology and provides a pathway to address the emergency planning information necessary to obtain a Construction Permit (CP) and an Operating License (OL) for prospective applicants seeking to utilize the Xe-100. A CP or an OL applicant is currently required to comply with the Emergency Planning (EP) regulatory requirements contained in 10 CFR 50.33(g), “Contents of applications; general information,” 10 CFR 50.47, “Emergency Plans,” and Appendix E to 10 CFR Part 50, “Emergency Planning and Preparedness for Production and Utilization Facilities.” Simplifying the implementation of these EP requirements commensurate with the risks posed by the Xe-100 would require prospective applicants to submit exemption requests in accordance with 10 CFR 50.12, “Specific Exemptions” to gain relief from prescriptive requirements in lieu of more performance-based approaches.

Simplified EP regulations that are performance-based which would apply to CP and OL applications for the Xe-100 reactor were recently affirmed by the U.S. Nuclear Regulatory Commission. Therefore, this white paper also includes a discussion of regulation 10 CFR 50.160 and its associated rulemaking effort: “Emergency Preparedness for Small Modular Reactors, Non-light-water Reactors, and Non-power Production or Utilization Facilities.”

The intent of this white paper is to seek NRC feedback on the approach for development and approval of an Xe-100 technology-based emergency plan for prospective applicants. This white paper describes the current and potential near-term state of emergency planning regulations. In addition, it advances an approach for:

- 1) Developing the emergency planning-related information required for an application for a CP for the Xe-100 reactor;
- 2) Developing the complete emergency plan required for an application for an OL for the Xe-100 reactor;
- 3) Determining the regulatory strategy for developing emergency plans for the Xe-100 reactor; and
- 4) Engaging with the NRC to promote regulatory review efficiency as the emergency preparedness plan is developed for the Xe-100 reactor.

The strategy includes:

- Demonstrating CP and OL applicant’s compliance with either:
  - the requirements of 10 CFR 50.47 and Appendix E to 10 CFR Part 50, considering exemptions appropriate for the Xe-100 technology, or
  - the requirements of 10 CFR 50.160 regulation.
- X-energy engagement with the NRC to address the following:
  - Development of a plume exposure pathway emergency planning zone (EPZ) -sizing methodology for use by future applicants to determine the EPZ size for their Xe-100 site;



- Development of a standard Xe-100 on-shift and augmenting Emergency Response Organization (ERO) for applicants to consider and apply to their facility; and
- Development of a generic Xe-100 Emergency Action Level (EAL) scheme for applicants to use to develop site-specific Xe-100 EALs.



## Abbreviations/Acronyms

### Abbreviations/Acronyms

Short Form	Phrase
CFR	Code of Federal Regulation
COL	Combined License
CP	Construction Permit
CPA	Construction Permit Application
EAB	Exclusion Area Boundary
EAL	Emergency Action Level
EOF	Emergency Operations Facility
EP	Emergency Planning
EPA	U.S. Environmental Protection Agency
EPZ	Plume Exposure Pathway Emergency Planning Zone
ERO	Emergency Response Organization
FSAR	Final Safety Analysis Report
GDC	General Design Criteria
HTGR	High-Temperature Gas-cooled Reactor
LTR	Licensing Topical Report
LWR	Light Water Reactor
MWe	Megawatt Electric
MWt	Megawatt Thermal
NRC	U.S. Nuclear Regulatory Commission
OL	Operating License





Short Form	Phrase
OLA	Operating License Application
OSC	Operations Support Center
PAG	Protective Action Guide
PSAR	Preliminary Safety Analysis Report
RG	Regulatory Guide
SAR	Safety Analysis Report
SMR	Small Modular Reactor
SRP	Standard Review Plan
TSC	Technical Support Center



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## 1. Introduction

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### 1.1 Purpose

This white paper presents the emergency planning approach applicable to the Xe-100 reactor technology and provides a pathway to address the emergency planning information necessary to obtain a Construction Permit (CP) and an Operating License (OL) for prospective applicants seeking to utilize the Xe-100. The intent of this white paper is to seek NRC feedback on the approach for development and approval of an Xe-100 technology-based emergency plan for prospective applicants.

The Xe-100 reactor is a graphite-moderated pebble bed, high-temperature gas-cooled reactor (HTGR). The Xe-100 is planned to be an approximately 200-megawatt thermal (MWt), 80-megawatt electric (MWe) reactor per unit, with a nominal 4-unit plant offered as a standard design, scalable to customer demand on a by-unit basis. Because the Xe-100 reactor is planned to be smaller, simpler, and safer when compared to conventional large, light-water nuclear designs that were considered in the technical basis for current emergency planning (EP) regulations, it is anticipated that the scope of EP activities for the Xe-100 can be simplified, commensurate with the reduced risk associated with the design and its enhanced safety margins. It is assumed that prospective applicants for permits and licenses will utilize a scalable, dose-based, consequence-oriented approach to establish their application-specific EPZ. Although the scope of EP is simplified for the Xe-100, the essential defense-in-depth philosophy that is integral to protecting the health and safety of the public is maintained.

### 1.2 Scope

This white paper presents the EP approach applicable to the Xe-100 reactor technology and provides a pathway for obtaining a CP and an OL for prospective applicants seeking to utilize the Xe-100. A CP or an OL applicant is currently required to comply with the Emergency Planning (EP) regulatory requirements contained in 10 CFR 50.33(g), "Contents of applications; general information," 10 CFR 50.47, "Emergency Plans," and Appendix E to 10 CFR Part 50, "Emergency Planning and Preparedness for Production and Utilization Facilities." Simplifying the implementation of these EP requirements commensurate with the risks posed by the Xe-100 would require prospective applicants to submit exemption requests in accordance with 10 CFR 50.12, "Specific Exemptions" to gain relief from prescriptive requirements in lieu of more performance-based approaches.

Alternatively, simplified EP regulations that would apply to CP and OL applications for the Xe-100 reactor were recently affirmed by the U.S. Nuclear Regulatory Commission (NRC) [15]. Therefore, Section 3 of this white paper also includes a discussion of 10 CFR 50.160, "Emergency Preparedness for Small Modular Reactors, Non-light-water Reactors, and Non-power Production or Utilization Facilities." Prospective applicants could elect to comply with either 10 CFR 50.160 or the existing EP regulations in 10 CFR 50.47 and Appendix E to 10 CFR Part 50.

In addition, this white paper describes the required content of a 10 CFR Part 50 Construction Permit Application (CPA) and a 10 CFR Part 50 Operating License Application (OLA) based on deployment of the Xe-100 reactor technology at the applicant's site.



This white paper also addresses the following licensing topics:

1. An optional EP regulatory pathway that an applicant considering the Xe-100 reactor technology could utilize if the NRC finalizes proposed EP regulations addressing small modular reactors and non-light-water reactors;
2. A framework of Licensing Topical Reports (LTRs) related to the Xe-100 Emergency Planning Zone methodology, generic Emergency Action Level (EAL) scheme and a generic Emergency Response Organization (ERO) for the Xe-100 reactor to be developed by X-energy;

Regulatory engagement with the NRC.

### **1.3 Document Layout**

Section 2 of this white paper presents current regulatory requirements for EP in 10 CFR 50.33(g), 10 CFR 50.47, and Appendix E to 10 CFR Part 50 and current guidance related to the content of emergency plans in CPAs and OLAs.

Section 3 presents an optional regulatory pathway for CP and OL applicants, describing the regulations under 10 CFR 50.160 and the draft guidance associated with the regulation.

Section 4 presents the Xe-100 proposed approach for an applicant to engage with the NRC.

Section 5 describes the conclusions of this white paper and presents NRC review objectives requested by X-energy.

Section 6 lists references used in the development of this white paper.



## 2. Overview of Current EP Regulations and Guidance Documents Applicable to the Xe-100 Reactor Technology

The EP requirements applicable to licensing the Xe-100 reactor technology are contained in 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." Specifically:

- 10 CFR 50.34(a) requires that each application for a CP for a nuclear reactor facility include a Preliminary Safety Analysis Report (PSAR) and specifies in general terms the information to be supplied in the PSAR. The requirements include a discussion of the applicant's preliminary plans for coping with emergencies, as detailed in Section II of Appendix E to 10 CFR Part 50. A discussion of the applicability of the requirements in Section II of Appendix E to the Xe-100 reactor technology is provided in Section 2.1 of this white paper.
- 10 CFR 50.34(a)(10) require applicants for Construction Permits to describe, within PSAR, their preliminary plans for coping with emergencies. In accordance with 10 CFR 50 Appendix E, Emergency Planning and Preparedness for Production and Utilization Facilities, Section II, the Preliminary Safety Analysis Report, the PSAR shall contain sufficient information to ensure the compatibility of proposed emergency plans for both onsite areas and the EPZs, with facility design features, site layout, and site location with respect to such considerations as access routes, surrounding population distributions, land use, and local jurisdictional boundaries for the EPZs in the case of nuclear power reactors as well as the means by which the standards of §50.47(b) will be met. Xe-100 PSAR Chapter 11.5, Emergency Planning, provides the preliminary plans required for a CPA for the Xe-100 plant to cope with emergencies.

It is important to note that, based on the regulations in 10 CFR 50.34(a)(10), an applicant's preliminary plans for coping with emergencies can be based on the requirements in either Appendix E of 10 CFR Part 50 or 10 CFR 50.160. The emergency planning standards in 10 CFR 50.160 are alternative, performance-based requirements for SMR and non-LWR designs. Based on the design and safety features of the Xe-100 plant, the Emergency Plan for the Xe-100 plant will comply with the requirements of 10 CFR 50.160.

- 10 CFR 50.34(b) requires that each application for an OL include a Final Safety Analysis Report (FSAR) and specifies in general terms the information to be supplied in the FSAR. The requirements include a discussion of the applicant's plans for coping with emergencies, as detailed in Sections III and IV of Appendix E to 10 CFR Part 50. A discussion of the applicability of the requirements in Sections III and IV of Appendix E to the Xe-100 reactor technology is provided in Section 2.2 of this white paper.
- A significant consideration for prospective owners and operators of the Xe-100 reactor technology is the ability to simplify the scope of EP based on the size of the EPZ. 10 CFR 50.33(g) provides a case-by-case allowance for determining the size of the EPZ for reactors with an authorized power level less than 250 MWt. The following specific requirements related to EPZ are applicable to the Xe-100 reactor technology:

*Generally, the plume exposure pathway EPZ for nuclear power reactors shall consist of an area about 10 miles (16 km) in radius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius. The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation*



*to the local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. The size of the EPZs also may be determined on a case-by-case basis for gas-cooled reactors and for reactors with an authorized power level less than 250 MW thermal. The plans for the ingestion pathway shall focus on such actions as are appropriate to protect the food ingestion pathway.*

10 CFR 50.47(c)(2) and Paragraph 1 of Section I of Appendix E to 10 CFR Part 50 also contain provisions for determining the size of the EPZ on a case-by-case basis for reactors with an authorized power level less than 250 MWt, and are applicable to the Xe-100 reactor technology.

- 10 CFR 50.47(b) provides 16 planning standards that will be met by licensees or applicants for the NRC to make a finding of reasonable assurance. The Xe-100 reactor technology-based emergency plan will address the requirements provided in 10 CFR 50.47 and Appendix E to 10 CFR 50, except for the anticipated exemptions presented in Section 2.4 of this white paper.
- 10 CFR 50.160 is a new alternative emergency preparedness requirements for small modular reactors and other new technologies such as non-light water reactors and certain non-power production or utilization facilities.

This final rule is technology-inclusive and provides alternatives to develop a performance-based EP program rather than using the existing EP requirements. The scope of this rule is limited to small modular reactors and other new technology facilities for which the NRC expects to receive license applications under 10 CFR Part 50 or Part 52. This rule does not include within its scope emergency planning preparation or response for large light-water reactors, fuel cycle facilities, or currently operating non-power reactors.

## 2.1 Construction Permit Application and Preliminary Safety Analysis Report

Pursuant to 10 CFR 50.34(a)(10), an Xe-100 CP applicant will provide a discussion of the preliminary plans for coping with emergencies in the application's PSAR. The items requiring description are set forth in Paragraphs A through H of Section II of Appendix E to 10 CFR Part 50. X-energy is pursuing the development and review of a CP application as part of the Advanced Reactor Demonstration Program (ARDP) and has developed a PSAR based on the Xe-100 reactor technology to support this application. This content will be leveraged for other projects when applicable while accounting for site and project-specific information needs.

The Xe-100 PSAR will contain information addressing the compatibility of proposed emergency plans for both onsite areas and the EPZs, with facility design features, site layout, and site location with respect to such considerations as access routes, surrounding population distributions, land use, and local jurisdictional boundaries for the EPZs in the case of nuclear power reactors as well as the means by which the standards of 10 CFR 50.47(b) (as applicable) will be met.

The Xe-100 PSAR will describe:

- A. Onsite and offsite organizations for coping with emergencies and the means for notification, in the event of an emergency, of persons assigned to the emergency organizations.



- B. Contacts and arrangements made and documented with local, State, and Federal governmental agencies with responsibility for coping with emergencies, including identification of the principal agencies.
- C. Protective measures to be taken within the site boundary and within each EPZ to protect health and safety in the event of an accident; procedures by which these measures are to be carried out (e.g., in the case of an evacuation, who authorizes the evacuation, how the public is to be notified and instructed, how the evacuation is to be carried out); and the expected response of offsite agencies in the event of an emergency.
- D. Features of the facility to be provided for onsite emergency first aid and decontamination and for emergency transportation of onsite individuals to offsite treatment facilities.
- E. Provisions to be made for emergency treatment at offsite facilities of individuals injured as a result of licensed activities.
- F. Provisions for a training program for employees of the licensee, including those who are assigned specific authority and responsibility in the event of an emergency, and for other persons who are not employees of the licensee but whose assistance may be needed in the event of a radiological emergency.
- G. A preliminary analysis that projects the time and means to be employed in the notification of State and local governments and the public in the event of an emergency. A nuclear power plant applicant shall perform a preliminary analysis of the time required to evacuate various sectors and distances within the plume exposure pathway EPZ for transient and permanent populations, noting major impediments to the evacuation or taking of protective actions.
- H. A preliminary analysis reflecting the need to include facilities, systems, and methods for identifying the degree of seriousness and potential scope of radiological consequences of emergency situations within and outside the site boundary, including capabilities for dose projection using real-time meteorological information and for dispatch of radiological monitoring teams within the EPZs; and a preliminary analysis reflecting the role of the onsite technical support center and the emergency operations facility in assessing information, recommending protective action, and disseminating information to the public.

With respect to paragraph A, the Xe-100 PSAR discusses the onsite and offsite organizations for coping with emergencies and the means for notification, in the event of an emergency, of persons assigned to the emergency organizations.

Paragraph B requires the applicant to identify the agencies with primary responsibilities for emergency preparedness planning for situations involving real or potential radiological hazards in the state where the facility is to be located. However, because it is assumed that Xe-100 PSARs will include sufficient justification to establish their EPZ coincident with the site boundary, the extent of coordination with offsite agencies is expected to be significantly reduced.

Paragraph C requires protective measures to be taken within the site boundary and within each EPZ to protect health and safety in the event of an accident; procedures by which these measures are to be carried out (e.g., in the case of an evacuation, who authorizes the evacuation, how the public is to be notified and instructed, how the evacuation is to be carried out); and the expected response of offsite agencies in the event of an emergency. The boundary of the EPZ for the Xe-100 is expected to coincide



with the site area boundary for the facility. Therefore, protective measures to evacuate the public, shelter in place, and administer potassium iodide are not required. The protective measures of the EPZ are the same as the protective measures within the site area boundary. Site procedures will describe the process for implementing protective measures. Protective measures to be taken within the site area boundary may include the following:

- Administering first aid
- Transportation of plant staff offsite for medical care
- Establishing physical boundaries to prevent access to hazardous areas
- Evacuation of plant personnel from hazardous areas in the plant
- Site evacuation of plant personnel for severe weather, hazardous chemical releases, high radiological conditions, or security events
- Communication of protective measures are made using the public address system (or other alerting systems)

With respect to paragraph D, Xe-100 PSARs discuss the features of the facility to be provided for onsite emergency first aid and decontamination and for emergency transportation of onsite individuals to offsite treatment facilities.

With respect to paragraph E, Xe-100 PSARs discuss offsite hospital facilities that are expected to be able to provide: (a) emergency care and (b) definitive patient care for acute radiation injury. These facilities have medical staff that are trained and prepared for treating individuals with radiological emergencies and contamination and have standard operating procedures for dealing with radiological emergencies and contamination. The location and description of the facility is based on the location of the project. Evidence will be given that preliminary contact with a relatively nearby hospital has established a willingness and potential capability to receive and treat individuals from the plant site who may have been affected by radiological emergencies.

With respect to paragraph F, Xe-100 PSARs discuss the provisions for a training program for employees of the licensee, including those who are assigned specific authority and responsibility in the event of an emergency, and for other persons who are not employees of the licensee but whose assistance may be needed in the event of a radiological emergency. Initial training for Xe-100 plant staff is described in the Xe-100 PSAR, and emergency response personnel will contain training in accordance with the radiological emergency response training program. Xe-100 emergency response personnel will receive periodic continuing and requalification training as required by the radiological emergency response training program. Individuals at offsite facilities and agencies required to respond to an emergency at the Xe-100 plant will be offered the necessary training to perform their emergency response actions. Training may include drills and emergency preparedness exercises with Xe-100 ERO and supporting offsite agencies to ensure effectiveness of emergency response training.

With respect to paragraph G, Xe-100 PSARs state that the Xe-100 plant will have the capability for 24-hour notification to onsite and applicable offsite organizations. A primary and a backup means of notification will be provided. Offsite support during emergencies will not be required because the boundaries of the Xe-100 EPZ are expected to coincide with site area boundary. Therefore, no offsite protective actions, such as public evacuations, sheltering, and administration of potassium iodide, are required.





With respect to paragraph H, Xe-100 PSARs provide descriptions of the physical characteristics of the site to determine whether there are any characteristics that could pose a significant impediment to the development of emergency plans (10 CFR 100.20, Factors to be considered when evaluating sites). Xe-100 PSARs will also evaluate and describe the results of nearby credible hazards analyses that are external to the Xe-100 EPZ, including gas and chemical releases from contiguous or nearby industries, and radiological hazards inside the EPZ of an existing adjacent LWR power plant if so located.

## 2.2 Operating License Application (FSAR)

Based on current regulation contained in 10 CFR 50.34(b)(6)(v), an applicant for a OL should provide plans for coping with emergencies, including the items specified in Appendix E to 10 CFR Part 50.

10 CFR 50.47(a)(1)(i) provides, in part, that the NRC find that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency prior to issuing an initial OL. For an OLA, the applicant is required by 10 CFR 50.34(b)(6)(v) to include in the FSAR the plans for coping with emergencies, which shall include the applicable items in Appendix E to 10 CFR Part 50. This plan should be a physically separate document identified as Section 13.3 of the FSAR.

The plan should show how the objectives and requirements of Sections I and III and paragraphs A to I of Section IV of Appendix E to 10 CFR Part 50 are to be implemented.

- Paragraph 1 of Section I of Appendix E to 10 CFR Part 50 requires an applicant for an operating license to include in the FSAR, plans for coping with emergencies, as required by 10 CFR 50.34(b).
- Section III of Appendix E to 10 CFR Part 50 requires that an application for an OL include plans for coping with emergencies. The plans are required to describe the overall concept of operation; the essential elements of advance planning and the provisions that have been made to cope with emergency situations. The plans are required to incorporate information about the emergency response roles of supporting organizations and offsite agencies, with sufficient information to provide assurance of coordination among the supporting groups and with the licensee.

Section III also states that the plans must include a description of the elements set out in Section IV of Appendix E to 10 CFR Part 50 for the EPZs to an extent sufficient to demonstrate that the plans provide reasonable assurance that adequate protective measures can and will be taken in the event of an emergency.

- Section IV of Appendix E to 10 CFR Part 50 details the required content of an applicant's emergency plans, including the need to demonstrate compliance with the following elements: organization for coping with radiological emergencies, assessment actions, activation of an emergency organization, notification procedures, emergency facilities and equipment, training, maintaining emergency preparedness, recovery, and onsite protective actions during hostile action.

In addition, the emergency response plans submitted by an applicant for an OL must contain information needed to demonstrate compliance with the standards described in 10 CFR 50.47(b), and they will be evaluated against those standards. According to 10 CFR 50.57, all of the standards of 10 CFR 50.47(b), as supported by the guidance in the corresponding planning standards and evaluation criteria of NUREG-0654/FEMA-REP-1 must be met before an OL is issued.





## 2.3 Current EP Guidance Documents Applicable to the Xe-100 Reactor Technology

Although the following documents provide guidance applicable to LWRs, the documents provide significant insight and adequate guidance to inform the content of CPAs and OLAs for the Xe-100 design.

- Regulatory Guide (RG) 1.70, “Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants – LWR Edition,” Revision 3 issued November 1978, provides guidance for the development of CPAs and OLAs. Section 13.3 of RG 1.70 details the necessary EP-related content of the PSAR (13.3.1) and FSAR (13.3.2). Section 13.3 of RG 1.70 details the necessary EP-related content of the PSAR (13.3.1) and FSAR (13.3.2). Information from RG 1.70 that is applicable to the Xe-100 reactor technology is presented in Section 2.1 of this white paper.
- RG 1.101, “Emergency Response Planning and Preparedness for Nuclear Power Reactors,” Revision 6, dated June 2021, describes an approach that is acceptable to NRC staff to meet the regulatory requirements for emergency response planning and preparedness.
- RG 1.242, “Performance-based Emergency Preparedness for Small Modular Reactors, Non-light Water Reactors, and Non-power Production or Utilization Facilities,” provides methods and procedures the staff of the NRC considers acceptable for an applicant to comply with the requirements of 10 CFR 50.160. X-energy is utilizing and adhering to the guidance in draft RG 1.242 in developing the EP for the Xe-100 plant for the Operating License Application. However, as mentioned above, the information required by 10 CFR 50 Appendix E.II is sufficient for the EP for the CPA for early applicants of permits and licenses for Xe-100 technology-based projects.
- NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants – LWR Edition,” Revision 3 issued March 2007 (SRP), provides guidance to NRC staff in performing safety reviews of CPAs and OLAs under 10 CFR Part 50. Section 13.3 of the SRP addresses the evaluation of EP including evidence of preliminary planning in the PSAR and substantive planning in the FSAR. In addition, Section 2.1.3 of the SRP addresses the requirements of 10 CFR 100.20(a), thereby providing assurance that members of the public living in the proximity of an operating reactor will not be subjected to excessive radiological doses in the unlikely event of a radiological emergency.
- NUREG-0654/FEMA-REP-1, Revision 2, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,” issued December 2019, provides a basis for applicants to develop radiological emergency plans that comply with the standards set forth in 10 CFR 50.47. It is used by reviewers to determine the adequacy of those plans and preparedness. Note that the applicability of evaluation criteria for each planning standard of 10 CFR 50.47(b) would be dependent upon the anticipated exemptions from 10 CFR 50.47 presented in Section 2.4 of this white paper.
- NUREG-0396/EPA 520/1-78-016, “Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants,” issued December 1978, introduced the concept of generic EPZs as the basis for pre-planned response actions that would result in dose savings in the environs of a nuclear facilities in the event of a serious power reactor accident. The document provides guidance related to the rationale for the planning basis and size of EPZs.



- EPA-400/R-17/001, “PAG Manual Protective Action Guides and Planning Guidance for Radiological Incidents” (EPA PAG Manual) presents the principal protective actions associated with the Early Phase PAG and the related guidelines, dose-related criteria, and planning guidance. The EPA PAG Manual provides levels of exposure to radiation at which public protective action should be taken. With regard to establishing EPZ size and boundary, the EPA PAG Manual states, “Although the size of the EPZ is based on the maximum distance at which a PAG might be exceeded, the actual boundary of an EPZ should be demarcated by features readily identifiable by people within that area.”
- NUREG-0696, “Functional Criteria for Emergency Response Facilities,” describes the facilities and systems to be used by licensees to respond to emergency situations. The facilities typically include the technical support center (TSC), onsite operational support center (OSC), and near-site emergency operations facility (EOF), as well as the emergency response function of the control room. This document establishes criteria that the NRC staff uses in evaluating whether an applicant/licensee meets the requirements of 10 CFR 50, Appendix E, Article IV.E.8 and Appendix A of General Design Criteria (GDC) 19. These facilities could differ for the Xe-100, based on the exemptions to 10 CFR 50.47 and Appendix E to 10 CFR Part 50.



## 2.4 Anticipated Exemption Requests to Relax EP Requirements

Previous new plant applicants for SMR technologies have identified anticipated exemptions from portions of 10 CFR 50.33(g), 50.47(b) and (c)(2), and 10 CFR Part 50, Appendix E, to the extent that these regulations apply to specific provisions of onsite and offsite emergency planning. The requested exemptions will allow for the development and implementation of emergency plans that are commensurate with the significantly reduced risk associated with SMR technology. The current 10 CFR Part 50 regulatory requirements for EP provide an appropriate planning basis for the current fleet of domestic operating plants. However, some of these requirements are not necessary to protect the health and safety of the public in the vicinity of an SMR facility due to the decreased potential consequences of event sequences resulting in radiological releases associated with such a facility. The requested exemptions would require the reactor design to meet the established criteria at the selected EPZ boundary. The criteria utilized in previous exemption requests are consistent with, and based upon, the U.S. Environmental Protection Agency (EPA) Protective Action Guides (PAG) of 1 rem dose criteria for early phase protective actions in the unlikely event of a severe accident. The intermediate and late phase EPA PAGs are not relevant to sizing of the EPZ.

Because the Xe-100 is a gas-cooled reactor less than 250 MWt, exemptions associated with the size of the EPZ may not be required as identified in §50.33(g). However, it is expected that exemptions from specific provisions of 10 CFR 50.47(b) and Appendix E to 10 CFR Part 50 would be necessary to simplify EP commensurate with the risks associated with the Xe-100. If it is determined that the EPZ would be within or coincident with an applicant’s site boundary, then the exemptions presented in Table 1 would be appropriate. The establishment of the EPZ at the site boundary ensures public protection from doses in excess of EPA PAGs established in the EPA PAG Manual, and offsite planning (including the establishment of EPZs) is not needed.

As stated in Section 3 of this paper, utilizing 10 CFR 50.160 as an alternative approach eliminates the need for Xe-100 reactor technology applicants to request exemptions from 10 CFR 50.47(b) and Appendix E to 10 CFR Part 50.

**Table 1: Anticipated Exemptions from 10 CFR 50.47 and Appendix E to 10 CFR Part 50**

Regulation	Exemption From
10 CFR 50.47(b)	Offsite Emergency Plans
10 CFR 50.47(b)(3)	Offsite Emergency Operations Facility
10 CFR 50.47(b)(4)	Offsite Response Measures
10 CFR 50.47(b)(5)	Prompt Notification and Instruction to Population in EPZ
10 CFR 50.47(b)(6)	Prompt Communications to the Public
10 CFR 50.47(b)(7)	Periodic Dissemination of Information Brick-and-mortar Joint Information Center
10 CFR 50.47(b)(9)	Assessment of Offsite Dose Consequences
10 CFR 50.47(b)(10)	Offsite Protective Actions
Appendix E, IV.2	Evacuation Time Estimate
Appendix E, IV.3	
Appendix E, IV.4	
Appendix E, IV.5	
Appendix E, IV.6	
Appendix E, IV.7	
Appendix E, IV.A.3	Licensee’s Headquarters Support Personnel
Appendix E, IV.A.8	Offsite Protective Actions
Appendix E, IV.B.1	Assessment of Dose Offsite Consequences
Appendix E, IV.C.1	Emergency Classification Levels (Site Area Emergency and General Emergency)



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Regulation	Exemption From
Appendix E, IV.C.2	Notification Times
Appendix E, IV.D.2	Periodic Dissemination of Information
Appendix E, IV.D.3	Public Alert and Notification
Appendix E, IV.D.4	
Appendix E, IV.E.8.a	Emergency Response Facilities (TSC, OSC, and EOF)
Appendix E, IV.E.8.b	
Appendix E, IV.E.8.e	
Appendix E, IV.F.1.viii	Licensee's Headquarters Support Personnel
Appendix E, IV.F.2	Public Alert & Notification System
Appendix E, IV.F.2.a	Full Participation Exercise
Appendix E, IV.F.2.a(i)	
Appendix E, IV.F.2.a(ii)	
Appendix E, IV.F.2.a(iii)	
Appendix E, IV.F.2.b	
Appendix E, IV.F.2.c	
Appendix E, IV.F.2.d	
Appendix E, IV.F.2.f	FEMA Evaluation of Offsite Emergency Plans
Appendix E, IV.F.2.i	Emergency Classification Levels (Site Area Emergency and General Emergency)



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### 3. Potential Impact of Ongoing Regulatory Initiatives

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As detailed in the September 2017 Regulatory Basis for Rulemaking for Emergency Preparedness for Small Modular Reactors and Other New Technologies (RIN Number 3150-AJ68, NRC Docket ID NRC-2015-0225), the NRC recognized that regulatory issues exist regarding licensing of new technologies, because potential hazards from small modular reactors (SMRs) or non-light water reactors (non-LWR) could differ substantially from those posed by the current fleet of large LWRs. These differences could result in different EPZ sizes, source terms, and offsite dose consequences and their associated technical bases.

Therefore, the NRC initiated rulemaking intending to create alternative EP requirements that would:

- establish performance-based EP requirements for SMRs and non-LWR applicants and licensees;
- continue to provide reasonable assurance that adequate protective measures can and will be implemented by an SMR or ONT licensee;
- promote regulatory stability, predictability, and clarity;
- reduce requests for exemptions from EP requirements;
- recognize advances in design and technology advancements embedded in design features;
- credit safety enhancements in evolutionary and passive systems; and
- credit smaller sized reactors' and non-LWRs' potential benefits associated with postulated accidents, including slower transient response times, and relatively small and slow release of fission products.

This rule would establish a performance-based, technology-inclusive, risk-informed, and consequence-oriented approach that would provide an alternative to the EP requirements under 10 CFR 50.47. The purpose of the 10 CFR 50.160 rulemaking is to enhance the effectiveness and efficiency of the regulatory framework for applicants and licensees of SMRs and non-LWRs, and the NRC, by enacting a performance-based EP framework that enables applicants to have options for EPZ size, and other facets of EP, while continuing to provide adequate protection of public health and safety.

The guidance in draft RG 1.242, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities," would address methods that NRC considers acceptable for SMRs and non-LWR applicants and licensees to demonstrate compliance with the performance-based EP requirements in 10 CFR 50.160. Appendix A to draft RG 1.242 provides a sample format acceptable to the NRC for the analysis for establishing the EPZ size, as required by 10 CFR 50.33(g)(2). Appendix B to draft RG 1.242 provides guidance for establishing source terms to support radiological dose assessment for EPZ sizing.

While applicants and licensees utilizing the Xe-100 reactor technology would continue to have the option to develop an EP program using the existing, deterministic EP requirements in 10 CFR Part 50, the new rule would allow for Xe-100 reactor technology applicants and licensees to demonstrate how they meet the EP performance-based framework based on their design and site-specific considerations through the implementation of a performance objective scheme and the conduct of drills and exercises.



Utilizing 10 CFR 50.160 eliminates the need for Xe-100 reactor technology applicants to request exemptions from 10 CFR 50.33(g), 10 CFR 50.47(b) and (c)(2), and Appendix E to 10 CFR Part 50. The 10 Future CP/OL or COL applicants could elect to comply with 10 CFR 50.160 and the associated RG 1.242.



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## 4. U.S. NRC Engagement Plan for EP

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Pre-application regulatory engagement with the NRC would provide future CP and OL applicants with some regulatory stability in content expectations prior to developing a Part 50 application. There are several areas where early NRC engagement would provide opportunities for early alignment on EP matters with future applicants. These topics are addressed in this section starting with the most critical.

### 4.1 EPZ Sizing Methodology

To determine a site-specific EPZ size, regardless of the regulatory pathway (exemptions from 10 CFR 50.47 and Appendix E or 10 CFR 50.160) that a CP or OL applicant elects, an applicant must be able to demonstrate to the NRC that certain criteria are met considering accident likelihood, source term, timing of the accident sequence, and meteorology. Based on guidance provided in Appendix A of RG 1.242 (associated with the 10 CFR 50.160 Rule), the EPZ size may be developed based on the area within which public dose is projected to exceed 1 rem total effective dose equivalent (TEDE) over 96 hours from the time of the release of radioactive materials from all internal event LBEs and external design basis hazards. In addition, the EPZ is the area in which predetermined, prompt protective measures are necessary. This approach has been generalized from the dose assessment methodologies that informed EPZ size determinations in NUREG-0396.

X-energy will develop an LTR that provides a technical basis for the Xe-100 EPZ sizing methodology and submit to the NRC for review and approval and is tentatively scheduled for submission in June 2024. This LTR would provide future applicants utilizing Xe-100 reactor technology with a sufficient basis to determine a site-specific EPZ size using site-specific information. The LTR would provide a basis for a future applicant to demonstrate that the size of the EPZ encompasses an area where it may be expected that predetermined, prompt protective measures, such as evacuation and sheltering, may be needed to minimize the exposure to individuals. X-energy is calculating dose at the Xe-100 EAB/EPZ using dispersion and dose methodology that adheres to the guidance in RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," Revision 1 and RG 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," Revision 0. Further information on the Xe-100 dispersion and dose methodology is found in the Xe-100 LTR, "Atmospheric Dispersion and Dose Calculation Methodology" [13].

Sufficient time may be available for offsite emergency response agencies to initiate an appropriate protective response to adequately protect public health and safety after the accident occurs but before the release is expected to occur, or after the release is expected to occur but before protective measures are necessary. In these cases, predetermined prompt protective measures are not required, and such accidents may be excluded from consideration in determining the size of the EPZ based on the dose criterion. X-energy anticipates that the boundary of the EPZ for the Xe-100 coincides with the site area boundary. Therefore, protective measures to evacuate the public, shelter in place, and administer potassium iodide will not be required. The protective measures of the EPZ are the same as the protective measures within the site area boundary.

Successful determination of an EPZ size would be necessary to simplify EP requirements regardless of the regulatory pathway (exemptions from 10 CFR 50.47 and Appendix E or 10 CFR 50.160) that a CP or OL applicant elects. Utilizing the Xe-100 reactor EPZ topical report, a CP applicant will include sufficient justification to establish their EPZ at the site boundary, the extent of coordination with offsite agencies is



expected to be significantly reduced. At the OL stage (FSAR), the applicant would provide the analysis, incorporating the Xe-100 reactor EPZ topical report, necessary to demonstrate the EPZ size and include in the application emergency plans that comply with applicable standards, and allow the NRC to find that adequate protective measures can and will be taken in the event of an emergency.

## 4.2 Standard Xe-100 On-Shift and Augmenting ERO

To determine the appropriate number of on-shift and augmenting ERO positions necessary to respond to an emergency declaration, an applicant must perform an analysis. This analysis would be required regardless of the regulatory pathway (exemptions from 10 CFR 50.47 and Appendix E or 10 CFR 50.160) that a CP or OL applicant elects.

An LTR that provides a standard methodology to be used by OL applicants for the Xe-100 will be developed and submitted to the NRC for review and approval and is tentatively scheduled for submission in December 2024. This LTR would provide future applicants with a sufficient basis to determine a site-specific on-shift and augmenting ERO staffing. The LTR would provide future applicants with a standard methodology to determine on-shift staffing.

## 4.3 Xe-100 Generic EAL Scheme

Regulations require that the emergency classification scheme and the associated EALs, as applicable for the design of the facility, and the technical basis and methodology for determining the thresholds corresponding to each of the EALs, include consideration of the following:

- (a) those standard classes (i.e., notification of unusual event, alert, site area emergency, general emergency) appropriate for dealing with accident consequences for the specific facility;
- (b) the use of guidance provided or endorsed by the NRC that is applicable to the facility design;
- (c) any hazards or initiating conditions associated with a nearby, adjacent, or contiguous facility where a hazard would adversely impact the implementation of emergency plans; and
- (d) the EALs associated with each class of emergency and the particular immediate actions to provide an appropriate graded response.

Typically, COL applicants will include a proposed License Condition in their application that proposes future submittal of an EAL scheme developed in accordance with an NRC-endorsed document. Due to the uniqueness of the Xe-100 design, existing industry guidance would be of little use to OL applicants developing a site-specific EAL scheme. Accordingly, it is recommended that a generic EAL scheme be developed and submitted to the NRC for approval and thereby satisfying the regulatory requirement that an EAL scheme be “endorsed” by the NRC. An NRC-approved document would provide future applicants with a sufficient basis to develop a site-specific EAL scheme. This LTR is tentatively scheduled for submission in June 2025.

As development of these LTRs progress, X-energy will assess opportunities to combine and organize such methodologies to enhance regulatory review efficiency.





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## 5. Conclusions

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The intent of this white paper is to seek NRC feedback on the approach for licensing the Xe-100 reactor technology and developing emergency plans for regulatory approval. This white paper describes the current and potential near-term state of emergency planning regulations. In addition, it advances a strategy for:

- 1) Developing the emergency planning-related information required for an application for a CP,
- 2) Developing the complete emergency plan required for an application for an OL,
- 3) Determining the regulatory strategy for developing emergency plans for the Xe-100, and
- 4) Engaging with the NRC on generic information that future customers would further refine as site-specific emergency plans are developed.

The regulatory strategy includes:

- CP and OL applicant's compliance with either:
  - the requirements of 10 CFR 50.47 and Appendix E to 10 CFR Part 50, considering exemptions appropriate for the Xe-100 technology, or
  - the requirements of 10 CFR 50.160 regulation.
- X-energy engagement through LTR reviews with the NRC to address the following:
  - Development of an EPZ-sizing methodology for use by future applicants to determine the EPZ size for their site;
  - Development of a standard Xe-100 on-shift and augmenting ERO for applicants to consider and apply to their facility; and
  - Development of a generic EAL scheme for applicants to use to develop site-specific EALs.



## 6. References

	<b>Document Title</b> Cross References: X-energy documents that <u>may</u> impact the content of this document. References: X-energy or other documents that <u>will not</u> impact the content of this document	<b>Document No.</b>	<b>Rev.</b>	<b>Cross Reference/ Reference</b>
[1]	Determining the Appropriate Emergency Planning Zone Size and Emergency Planning Attributes for an HTGR	INL/MIS-10-10799	0	Reference
[2]	Next Generation Nuclear Plant – Emergency Planning Zone Definition at 400 Meters	NGNP-LIC-GEN-RPT-L-00020	0	Reference
[3]	RG 1.70, Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, LWR Edition	n/a	3	Reference
[4]	NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants – LWR Edition	n/a	3	Reference
[5]	RG 1.101, Emergency Response Planning and Preparedness for Nuclear Power Reactors	n/a	6	Reference
[6]	NUREG-0654/FEMA-REP-1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants	n/a	2	Reference
[7]	NUREG-0396/EPA 520/1-78-016, Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants	n/a	0	Reference
[8]	NUREG-0696, Functional Criteria for Emergency Response Facilities	n/a	0	Cross Reference
[9]	RG 1.242, Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities	n/a	0	Reference
[10]	RG 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants	n/a	1	Reference
[11]	RG 1.194, Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants	n/a	0	Reference
[12]	Xe-100 Final PSAR Safety Analysis Dose Summary Report	008078	0	Cross Reference
[13]	Xe-100 Licensing Topical Report, Atmospheric Dispersion and Dose Calculation Methodology	007116	1	Cross Reference
[14]	ARDP PSAR Chapter 11, Regulatory Analysis	006992	1	Reference
[15]	SECY-22-0001 – Rulemaking – Final Rule: Emergency Preparedness for Small Modular Reactors and Other New Technologies	ML23226A184	n/a	Cross Reference