UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 12, 2024

Mr. Stephen Vaughn
Licensing Manager, Xe-100
X Energy, LLC
801 Thompson Avenue
Rockville, MD 20852

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION - FINAL SAFETY EVALUATION OF THE X ENERGY, LLC., XE-100 ATMOSPHERIC DISPERSION AND DOSE CALCULATION METHODOLOGY TOPICAL REPORT, REVISION 2 (EPID L-2023-TOP-0032)

Dear Mr. Vaughn:

By letter dated September 25, 2023 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23268A454), X Energy, LLC., (X-energy) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review, Revision 2 of its Xe-100 Atmospheric Dispersion and Dose Calculation Methodology topical report. This topical report describes a methodology for calculating the downwind dispersion for an airborne radionuclide release from the reactor buildings and the resulting doses for the Xe-100 pebble-bed, high temperature gas cooled reactor.

The NRC staff's final safety evaluation for X-energy's Xe-100 Atmospheric Dispersion and Dose Calculation Methodology topical report is enclosed. The NRC staff concluded that the subject methodology is acceptable, subject to the limitations documented in the safety evaluation. The NRC staff requests that X-energy submit an accepted version of the Xe-100 Atmospheric Dispersion and Dose Calculation Methodology topical report within 3 months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed safety evaluation.

If you have any questions, please contact Adrian Muñiz at (301) 415-4093 or via email at Adrian.Muniz@nrc.gov.

Sincerely,


Signed by Philpott, Stephen
on 09/12/24

Stephen Philpott, Acting Chief
Advanced Reactor Licensing Branch 2
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Project No. 99902071

Enclosure:
As stated

cc: Distribution via X-Energy Xe-100 GovDelivery
jmaddocks@x-energy.com

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION - FINAL SAFETY EVALUATION OF THE X ENERGY, LLC., XE-100 ATMOSPHERIC DISPERSION AND DOSE CALCULATION METHODOLOGY TOPICAL REPORT, REVISION 2 (EPID L-2023-TOP-0032) DATED: SEPTEMBER 12, 2024

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X ENERGY - SAFETY EVALUATION OF THE X-ENERGY, LLC., XE-100 ATMOSPHERIC DISPERSION AND DOSE CALCULATION METHODOLOGY TOPICAL REPORT (EPID L-2023-TOP-0032)

SPONSOR AND SUBMITTAL INFORMATION

Sponsor: X Energy, LLC (X-energy)

Sponsor Address: 801 Thompson Avenue
Rockville, MD 20852

Project No.: 99902071

Submittal Date: September 25, 2023

Submittal Agencywide Documents Access and Management System (ADAMS) Accession Package No.: ML23268A454

Request for Additional Information (RAI) Response Letter Date and ADAMS Accession No: The U.S. Nuclear Regulatory Commission (NRC) staff did not issue RAIs. However, the NRC staff issued preliminary questions on September 21, 2023; ML23264A098.

Brief Description of the Topical Report: X Energy, LLC (X-energy) submitted "Xe-100 Licensing Topical Report: Atmospheric Dispersion and Dose Calculation Methodology," Revision 2 (Reference 1) for NRC staff review and approval. The topical report (TR) describes a methodology for calculating the downwind dispersion for an airborne radionuclide release from the reactor buildings and the resulting doses. The TR states that the methodology is to be used at the exclusion area boundary (EAB) and the low population zone (LPZ) outer boundary for licensing basis events (LBEs) including design basis accidents (DBAs), and in the control room for LBEs excluding DBAs.

For additional details regarding the submittal, please refer to the documents located at the ADAMS Accession Number identified above.

REGULATORY EVALUATION

X-energy is requesting the NRC staff's approval of the methodology presented in the TR as an appropriate means to calculate radiological consequences to demonstrate compliance with applicable regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," and Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The following regulations are listed by application type and are specifically applicable, with some of them (e.g.,

10 CFR 50.34(a)(1)(ii)(D)) being related to the calculation of radiological consequences to demonstrate meeting the offsite dose criteria, while others (e.g., 10 CFR 50.34(a)(1)(ii)) being related to the safety assessment of a site and a facility:

- 10 CFR 50.34(a)(1)(ii), 10 CFR 50.34(a)(1)(ii)(D), and 10 CFR 50.34(a)(4) for Construction Permits,
- 10 CFR 50.34(b)(1) and 10 CFR 50.34(b)(2) for Operating Licenses,
- 10 CFR 52.17(a)(1)(ix) for Early Site Permits,
- 10 CFR 52.47(a)(2) and 10 CFR 52.47(a)(2)(iv) for Design Certifications,
- 10 CFR 52.79(a), 10 CFR 52.79(a)(1)(vi), and 10 CFR 52.79(a)(2) for Combined Licenses,
- 10 CFR 52.137(a)(2)(iv) and 10 CFR 52.137(a)(4) for Standard Design Approvals,
- 10 CFR 52.157(c), 10 CFR 52.157(d), and 10 CFR 52.157(f)(1) for Manufacturing Licenses, and
- 10 CFR 100.21(c) for applications for site approval for commercial power reactors.

X-energy is also requesting the NRC staff's approval of the methodology presented in the TR to calculate radiological consequences of non-DBA LBEs for the control room to meet the control room radiological habitability dose criterion in Xe-100 Principal Design Criterion 19, "Control room," in TR "Xe-100 Principal Design Criteria Licensing Topical Report" (Reference 4). The NRC staff notes that the Xe-100 Principal Design Criteria TR is intended to meet the NRC regulatory requirements for principal design criteria and is under separate NRC review.

The following regulatory guidance is applicable to the review of this TR:

- Regulatory Guide (RG) 1.233, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," (Reference 2) endorses NEI 18-04, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development," (Reference 5) with clarifications. The X-energy Xe-100 project uses the Licensing Modernization Project (LMP) methodology in RG 1.233 to show that the above regulatory requirements for safety and siting analysis/assessment are met. In the LMP methodology, LBEs include Anticipated Operational Occurrences (AOOs), Design Basis Events (DBEs), Beyond Design Basis Events (BDBEs), and DBAs.

- RG 1.247,[1] "Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities," (Reference 3), endorses, for trial use, the non-light water reactor (non-LWR) probabilistic risk assessment (PRA) standard American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) Ra-S-1.4-2021, "Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants," with exceptions. The LMP methodology uses PRA in a risk-informed and performance-based manner and includes calculation of the frequency and the radiological consequences of non-DBA LBEs (i.e., AOOs, DBEs, and BDBEs).

- RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," (Reference 6) provides an acceptable analysis methodology to calculate DBA radiological consequences to ensure that an application meets the offsite and control room dose criteria discussed above. While RG 1.183 was developed for light-water reactors, its guidance pertaining to dose calculation methodology is technology-neutral and, therefore, can be used for non-LWRs.

- RG 1.249, "Use of ARCON Methodology for Calculation of Accident-Related Offsite Atmospheric Dispersion Factors," (Reference 7) endorses the use of the ARCON computer code to calculate offsite dispersion values.

- RG 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," (Reference 8) outlines methods including the use of the ARCON computer code for calculating accident-related onsite atmospheric dispersion values.

- RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," (Reference 9) outlines a methodology for calculating EAB/LPZ dispersion.

[1] This RG has been issued for trial use. The NRC staff may use a trial RG as a reference in its regulatory processes, such as licensing. However, the NRC staff may withdraw or add positions from the trial use guide after the trial use period ends. Moreover, the trial use RG does not establish a staff position for the purposes of backfitting as that term is defined in 10 CFR 50.109, "Backfitting," and as described in NRC Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests." The trial RG also does not constitute forward fitting as that term is described in Management Directive 8.4.

TECHNICAL EVALUATION

1. Introduction

Predicting radiological consequences involves assuming or predicting an airborne radiological release from the reactor to the environment, predicting the airborne concentration at the receptor location of interest (e.g., EAB), and predicting the dose to an individual at the receptor location based on assumed breathing rates and stay times, radionuclide-specific dose conversion factors, and, for the control room, protection factors based on control room size and ventilation and leakage rates. Atmospheric dispersion factors are calculated separately and used as input to the radiological consequence prediction.

Section 1 of the TR describes the purpose, scope, interfacing documents, and layout of the TR. Section 2 discusses regulations and regulatory guidance related to atmospheric dispersion and radiological consequence analysis. Section 3 provides an overview of the Xe-100 design. Because the information presented in sections 1 through 3 of the TR provides background information to support the NRC staff's review of the methodology provided in the TR, the NRC staff is not making any regulatory findings on sections 1 through 3 of the TR.

Sections 4 through 6 of the TR describe the dose calculation methodology which is the focus of the NRC staff's regulatory review.

Section 7 of the TR provides a sample calculation demonstrating and verifying the dose calculation methodology. The case used for the sample calculation is RADTRAD Acceptance Test Case 1 from NUREG/CR-6604, "RADTRAD: A Simplified Model for RADionuclide Transport and Removal and Dose Estimation," Supplement 2 (Reference 10). In section 7 of the TR, the sample calculation is done two ways: using the XDIS code and using a hand calculation. The sample calculation is based on an assumed constant release rate to the environment for the first 2 hours of the accident. The sample calculation demonstrates that the XDIS code and the hand calculation calculate the same dose at the EAB for this first 2-hour period that was calculated by the RADTRAD code in RADTRAD Acceptance Case 1. The verification calculations in section 7 of the TR aided in the NRC staff's understanding and evaluation of the TR dose calculation methodology. While the TR requests the NRC staff's approval of sections 4 through 7 of the TR, section 7 is a sample calculation and does not need NRC approval. Therefore, the NRC staff is not making any regulatory findings on section 7 of the TR.

Under the LMP process, an LBE may involve one or more reactor modules or radionuclide sources. Because this TR focuses on a specific release point from the radionuclide sources within a single Nuclear Island Auxiliary Building (NIAB), the methodology in this TR is only applicable to an LBE associated with a single reactor module and the radionuclide sources within the corresponding NIAB.

For non-DBA LBE analyses, RG 1.247 provides guidance as an acceptable approach regarding the acceptability of a non-LWR PRA, which includes technical elements applicable to radiological consequence calculations including atmospheric dispersion analysis. The use of the methodology in this TR may support the development of the PRA and the conformance with

RG 1.247; however, the NRC staff is not making any conclusions regarding the acceptability of the PRA in this safety evaluation.

2. Dose Calculation Methodology

Section 5 of the TR provides an overview of the methodology, with detail on the dose calculation methodology in section 5.3. Section 6 of the TR discusses generic site atmospheric dispersion factor calculations.

2.1. EAB and LPZ Outer Boundary

The TR methodology uses the following parameter values and assumptions:

- a distance between the release point (the outside edge of the Nuclear Island Auxiliary Buildings for a 4-unit site) and the EAB and the LPZ outer boundary of 400 meters (TR section 5.1.1.1.2),
- generic-site or site-specific atmospheric dispersion factors as discussed below,
- no credit for plume depletion due to deposition on the ground (TR section 5.3),
- dose conversion factors from U.S. Environmental Protection Agency (EPA) Federal Guidance Reports 11 and 12 (Reference 11, Reference 12) (TR section 5.3.1), and
- a series of three breathing rates as follows (TR section 5.3.1):
    - 3.5×10^{-4} cubic meters per second for the first 8 hours of the accident,
    - 1.8×10^{-4} cubic meters per second for the next 16 hours of the accident, and
    - 2.3×10^{-4} cubic meters per second for the next 29 days of the accident.

The NRC staff finds the above parameter values and assumptions for non-DBA LBEs and DBAs to be consistent with the dose calculation methodology in RG 1.183 and, therefore, acceptable.

The presented methodology also includes a method to calculate the dose of DBAs, identified using NEI 18-04, for the EAB. The applicable regulatory requirements specify that the applicant's evaluation must demonstrate that an individual located at any point on the EAB for any 2-hour period following the onset of the postulated fission product release would not receive a radiation dose in excess of 25 rem total effective dose equivalent (TEDE). Section 4.1.5 of RG 1.183 provides guidance to meet the DBA regulatory requirements by calculating the EAB dose for the 2-hour period with the highest integrated release and a single breathing rate of 3.5×10^{-4} cubic meters per second. In the responses to the NRC staff's preliminary questions pertaining to this TR (Reference 13), X-energy stated that the EAB dose will be calculated based on the assumption that an individual remains at the EAB for 30 days for both non-DBA LBEs and DBAs. The NRC staff understands, from this statement, that applicants referencing this TR, and not necessarily X-energy, will perform this action.

Because the breathing rates in the series of three breathing rates above are lower than $3.5x10^{-4}$ cubic meters per second after the first 8 hours, using those may result in a lower predicted DBA dose for the EAB if the 2-hour period with the highest integrated release does not fall within the first 8 hours of the accident. Therefore, the DBA dose for the EAB calculated through implementation of the TR methodology may not be bounding for any 2-hour period for some events. Consequently, the NRC staff added item 1 to the Limitations and Conditions section below, which requires the applicant applying the TR methodology for DBA analysis for the EAB dose to show that the dose calculated by the methodology is bounding for any 2-hour period.

2.2. Control Room

The TR methodology uses the following parameter values and assumptions:

- A distance of 16.6 meters between the release point (the nearest outside edge of the nearest NIAB to the control room) and the control room for estimating radionuclide concentration at the control room. The TR states that this distance may be updated when the plant design is finalized. (TR section 5.1.1.1.1)

- The assumptions in section 4.2, “Control Room Dose Consequences,” of RG 1.183. (TR section 5.3.2)

- No dose reduction from control room building shielding, control room isolation, control room heating, ventilation, and air conditioning (HVAC) filtration, and personal protective equipment or prophylactic drugs. (TR section 5.3.2)

The NRC staff finds the above parameter values and assumptions for non-DBA LBEs and DBAs to be consistent with the dose calculation methodology in RG 1.183 and, therefore, acceptable.

3. Atmospheric Dispersion Methodology

The TR describes a methodology to estimate atmospheric dispersion factors for the EAB, the LPZ outer boundary, and the control room. In section 4.1 of the TR, X-energy outlines its two-phased approach to the atmospheric dispersion analysis. In the first phase, this TR provides a generic set of dispersion factors that X-energy describes as conservative values to be used as part of the standard Xe-100 technology development process. These dispersion factors are calculated for a generic site using applicable NRC regulatory guidance. This methodology is described in section 5.1 of the TR. X-energy describes the development of the generic site dispersion factors that are calculated for a generic site, prior to site selection, and in the absence of site-specific data. X-energy then outlines the inputs, methodology, and assumptions used in the calculations. X-energy states that the distance between the release point and either the EAB or LPZ outer boundary is 400 meters. The closest distance between the release point and the control room for estimating the dispersion factors is 16.6 meters, and the cross-sectional area of a NIAB is 746 square meters.

In the second phase, once a site is selected for a project and site-specific meteorology is obtained, X-energy states that the generic dispersion factors will be either validated as conservative for that site or replaced using site-specific atmospheric dispersion factors.

Therefore, consistent with the approach proposed by X-energy, the NRC staff has imposed a condition, as listed below, on the use of generic dispersion factors calculated by the TR methodology. In section 4.2 of the TR, X-energy states that, in the second phase, following a project site selection, it plans to use the ARCON computer code to calculate the Xe-100 plant site characteristic dispersion factors based on site-specific meteorology data sources in accordance with RG 1.249. The NRC staff understands from this statement that applicants referencing this TR, and not necessarily X-energy, will perform this action. RG 1.249 provides guidance to industry for complying with and implementing the NRC requirements by endorsing the use of the ARCON computer code to calculate offsite dispersion values at the EAB and LPZ out to distances of 1,200 meters. As stated in RG 1.249, the use of the ARCON computer code for calculating accident-related onsite (control room) atmospheric dispersion values is outlined in RG 1.194.

3.1. EAB and LPZ Dispersion Factors Methodology

For the first phase, in TR section 5.1.1.2.1, X-energy references RG 1.145, which outlines a methodology for calculating EAB/LPZ dispersion. The PAVAN computer code implements the methodology of RG 1.145 for the calculation of offsite atmospheric dispersion factors. RG 1.145 also contains procedures to estimate dispersion factors by using equations listed in the RG. X-energy identifies the applicable equations from RG 1.145 to calculate its generic EAB/LPZ dispersion factors and lists the values for the variables used in the equations. The NRC staff finds these parameter values and assumptions to be consistent with the guidance of RG 1.145 and, therefore, acceptable for use for the first phase of the atmospheric dispersion analysis.

X-energy proposes the use of reduction factors for its generic site EAB/LPZ dispersion factors calculated with the equations of RG 1.145 to account for conservatism in the equations. X-energy bases its justification and its calculations of the reduction factors on data and assumptions taken from the document PNL-10286, “Atmospheric Dispersion Estimates in the Vicinity of Buildings,” (Reference 14) and several related documents that X-energy references in the TR. X-energy proposes to use a larger reduction factor for non-DBA LBEs and a smaller reduction faction for DBAs. The NRC staff is not approving the reduction factors, or the methodology used to calculate them as described in PNL-10286, but is allowing them in this specific instance because of the condition for comparison to actual site measurements as outlined below. While the NRC staff has conducted studies in the past on the conservatism of its atmospheric dispersion modeling guidance, the NRC staff has not specified a numerical value to represent said conservatism.

Therefore, consistent with the approach proposed by X-energy, the NRC staff has imposed a condition on the use of generic dispersion factors calculated by the TR methodology. The condition is that that an applicant for a specific site referencing this TR will perform a dispersion analysis with site-specific data to either: 1) affirm that the Xe-100 analysis results using these generic dispersion factors are conservatively bounding, or 2) provide site-specific analysis results using dispersion factors developed during site characterization. The reduction factors for the first phase do not apply to site-specific dispersion analysis performed in the second phase using the NRC-approved dispersion codes, as the codes were developed to account for the conservatism in the equations. X-energy stated that it plans to use the NRC dispersion code, ARCON, to calculate the Xe-100 plant dispersion factors based on site-specific meteorology in

accordance with RG 1.249. The NRC staff understands from this statement, that applicants referencing this TR, and not necessarily X-energy, will perform this action.

3.2. Control Room Dispersion Factors Methodology

For the first phase, in TR section 5.1.1.2.2, X-energy references RG 1.194 pertaining to its generic control room dispersion calculation methodology. While RG 1.194 discusses the calculation of the site-specific atmospheric dispersion factors using the ARCON computer code, it also contains alternative procedures to estimate dispersion factors by using equations listed in the RG. X-energy identifies the applicable equation from RG 1.194 to calculate its generic control room dispersion factors and lists the values for the variables used in the equations. The NRC staff finds these parameter values and assumptions to be consistent with the guidance of RG 1.194 and, therefore, acceptable for use in control room dose calculations for a generic site.

The two-phase approach for control room dispersion factors does not involve the use of reduction factors. Also, control room dispersion factors are used for non-DBA LBEs (and not for DBAs) as discussed above.

As stated by X-energy in TR section 6.3, applicants for specific licensing actions referencing this TR methodology for dose calculation will perform a dispersion analysis with site-specific data to either: 1) affirm that the Xe-100 analysis results using these generic dispersion factors are conservatively bounding, or 2) provide site-specific analysis results using dispersion factors developed during site characterization. As such, the NRC staff has imposed a condition for this TR that the values are affirmed to be conservatively bounding for the site characteristic dispersion or replaced using site-specific data.

3.3. Generic Site Atmospheric Dispersion Factors Calculations

In section 6 of the TR, X-energy presents its calculations for the generic site atmospheric dispersion factors for the EAB, the LPZ, and the control room. The dispersion factors are listed in TR table 3, “Calculated Generic Site Dispersion Factors,” and the summary of the usage of the dispersion factors is presented in TR table 4, “Generic Site Atmospheric Dispersion Factors Summary.” The NRC staff finds the calculation of these generic dispersion values to be consistent with the guidance of RG 1.145 and RG 1.194 and, therefore, acceptable to be used for LBEs in the first phase of X-energy’s proposed two-phased approach.

As stated by X-energy in the TR, applicants for specific licensing actions referencing this TR methodology for dose calculation will perform a dispersion analysis with site-specific data to either: 1) affirm that the Xe-100 analysis results using these generic dispersion factors are conservatively bounding, or 2) provide site-specific analysis results using dispersion factors developed during site characterization. As such, the NRC staff has imposed a condition for this TR that the values are affirmed to be conservatively bounding for the site characteristic dispersion or replaced using site-specific data as re-stated by X-energy in TR section 6.3.

LIMITATIONS AND CONDITIONS

An applicant may reference the TR for use as applied to the applicant’s facility only if the applicant demonstrates compliance with the following limitations and conditions:

1. The applicant applying the TR methodology for DBA analysis for the EAB dose must show that the dose calculated by the methodology is bounding for any 2-hour period in order to show compliance with the offsite-dose-related safety analysis report requirements.

2. A condition of the use of generic dispersion factors calculated by the TR methodology in an analysis is that an applicant for a specific site referencing this TR will perform a dispersion analysis with site-specific data to either: 1) affirm that the Xe-100 analysis results using these generic dispersion factors are conservatively bounding, or 2) provide site-specific analysis results using dispersion factors developed during site characterization.

CONCLUSION

The NRC staff has determined that X-energy Xe-100 Licensing Topical Report: Atmospheric Dispersion and Dose Calculation Methodology, Revision 2, provides an acceptable methodology to calculate the downwind dispersion and resulting doses at the EAB, the LPZ outer boundary, and in the control room for the LBEs for the Xe-100 reactor subject to the limitations and conditions discussed above. Accordingly, the NRC staff concludes that this TR can be used for evaluation of atmospheric dispersion and dose for LBEs to demonstrate compliance with the safety analysis requirements discussed above in the "Regulatory Evaluation" section. The NRC staff is not making any regulatory findings on sections 1, 2, 3, and 7 of the TR.

REFERENCES

1. "Submittal of X Energy, LLC (X-energy) Xe-100 Licensing Topical Report: Atmospheric Dispersion and Dose Calculation Methodology, Revision 2," dated September 25, 2023 (ML23268A454).

2. Regulatory Guide 1.233, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," Revision 0, dated June 2020 (ML20091L698).

3. RG 1.247 (for trial use), "Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities," dated March 2022 (ML21235A008).

4. Xe-100 Licensing Topical Report Principal Design Criteria," Revision 3, dated August 12, 2023 (ML24047A310).

5. NEI 18-04, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development," Revision 1, dated August 2019.

6. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," dated July 2000 (ML003716792).

7. RG 1.249, “Use of ARCON Methodology for Calculation of Accident-Related Offsite Atmospheric Dispersion Factors,” Revision 0, dated August 2023 (ML22024A241).

8. RG 1.194, “Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants,” dated June 2023 (ML031530505).

9. RG 1.145, “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants,” Revision 1, dated February 1983 (ML003740205).

10. NUREG/CR-6604, RADTRAD: A Simplified Model for RADionuclide Transport and Removal and Dose Estimation, Supplement 2, dated October 2002.

11. “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,” Federal Guidance Report 11, EPA-520/1-88-020, Environmental Protection Agency, dated 1988.

12. “External Exposure to Radionuclides in Air, Water, and Soil,” Federal Guidance Report 12, EPA-402-R-93-081, Environmental Protection Agency, dated 1993.

13. “Submission of X Energy, LLC (X-energy) Responses to Preliminary Questions for Topical Report, ‘Xe-100 Licensing Topical Report Atmospheric Dispersion and Dose Consequence Methodology’,” dated December 8, 2023 (ML23342A233).

14. PNL-10286, “Atmospheric Dispersion Estimates in the Vicinity of Buildings,” dated January 1995.

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Date: September 12, 2024