NRC STAFF'S PRELIMINARY QUESTIONS
ON THE NRC ASSESSMENT OF
THE X ENERGY, LLC XE-100 PRINCIPAL DESIGN CRITERIA LICENSING TOPICAL REPORT

This topical report (TR) describes the development of the principal design criteria (PDCs) for the X Energy LLC (X-energy) Xe-100 pebble-bed, high-temperature gas-cooled reactor (HTGR). X-energy states that the PDCs described in the TR were developed using the guidance in Regulatory Guide (RG) 1.232, "Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors," Nuclear Energy Institute (NEI) 21-07, "Technology Inclusive Guidance for Non-Light Water Reactor Safety Analysis Report: Content for Applicants Using the NEI 18-04 Methodology," Revision 1, and Xe-100-specific probabilistic risk assessment (PRA) safety functions and design features. X-energy requested review and approval of these PDCs by the U.S. Nuclear Regulatory Commission (NRC) for use by future applicants for permits, licenses, certifications, and/or approvals under applicable regulations under Title 10 of the *Code of Federal Regulations* (10 CFR) governing the development of PDCs.

The NRC staff has prepared the following questions for discussion at an upcoming public meeting:

<u>Questions</u>

1. The NRC staff recognizes that the Xe-100 design has not been finalized at the time of this TR review. Thus, X-energy's implementation of the risk-informed and performance-based process in NEI 18-04 (called the Licensing Modernization Project (LMP)) is in progress including the development of the PRA for the Xe-100 design. The TR uses the terminologies (e.g., PRA safety function (PSF), Required Function Design Criterion (RFDC), and Complementary Design Criterion (CDC)) associated with NEI 18-04 and NEI 21-07. However, as the Xe-100 design progresses and the LMP process continues to be implemented, it is possible that the LMP yields results that are different from those assumed in this TR. For example, the PRA may identify new or different PSFs that form the basis for new or different CDC(s). **How are LMP terminologies in the TR used in relationship to the preliminary design and the future implementation of the LMP?**

2. The TR maintains the use of the terminology "anticipated operational occurrence [AOO]" for various PDCs (e.g., PDCs 25, 26, 29, and so on) the same as RG 1.232. The NRC staff notes that the definition of AOO used in the LMP (see NEI 18-04) is different from the definition in 10 CFR Part 50 Appendix A. **What definition of AOO is intended in the TR?**

3. The TR uses 'postulated accident' for PDCs 31, 34, 61, 64, 70, and 71. It is not consistent with NEI 18-04 terminology for licensing basis events (LBEs). **Why don't these PDCs use NEI 18-04 terminology?**

4. Tables 1 - 4: It is not clear to the NRC staff whether X-energy is requesting NRC staff review and approval of the information in these tables. For example, for Tables 1 and 2,

is X-energy requesting the NRC staff review and approval of the acceptability of RSFs and PSFs and their relationship to PDC in the tables? Since the Xe-100 design is conceptual or preliminary at the time of this TR review and thus the implementation of the LMP process (including the probabilistic risk assessment) in NEI 18-04 may not have been sufficiently completed, it is not clear how the RSFs and PSFs in Tables 1 and 2 are final. **What are expectations for NRC staff review of Tables 1-4?**

5. Table 6, PDC 1: The phrase "throughout the life" was changed to "for an appropriate period of time" to account for the application of quality assurance special treatments to NSRST [Non-Safety-Related with Special Treatment] SSCs [structures, systems, and components]." The NRC staff understand that this is consistent with NEI 21-07, and while NEI 21-07 is under NRC review, it has not been endorsed. **As such, what other justification can be provided for this change?**

6. Table 6, PDC 5: The proposed PDC states that "…shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their required safety functions [RSFs]…" X-energy proposed to replace 'safety functions' used in RG 1.232, Appendix C, Criterion 5 (MHTGR-DC 5) with RSFs. According to RG 1.233, safety-significant SSCs (i.e., Safety-related (SR) and NSRST SSCs) perform both RSFs and risk-significant functions or functions that are necessary for defense-in-depth (DID) adequacy. Accordingly, the use of RSFs in PDC 5 appears to cover only a portion of safety-significant functions. **Why does this PDC use RSFs instead of safety-significant functions?**

7. Table 6, PDC 6: X-energy proposes a single, generic PDC (i.e., PDC 6) for RG 1.232, Appendix C, Criteria (MHTGR-DCs) 18, 32, 36, 37, 45, and 46 associated with monitoring, testing, and inspection. The following expressions used in MHTGR-DCs 18, 32, 36, 37, 45, and 46 are not used in proposed PDC 6:

    - "structural and leaktight integrity" (MHTGR-DCs 32, 37, and 46)
    - "appropriate material surveillance program" (MHTGR-DC 32)
    - "integrity and capability of the system" (MHTGR-DCs 36 and 45)
    - "for reactor shutdown" (MHTGR-DC 46)

    What is the justification for omitting these expressions?

8. Table 6, PDC 6: As describe above PDC 6 is a single PDC for monitoring, testing, and inspection of selected MHTGR-DCs. However, several other proposed PDC also contain testing and inspection requirements similar to those associated with PDC 6. For example:

    - Table 6, PDC 21: "The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred."
    - Table 6, PDC 61: "These systems shall be designed (1) with a capability to permit appropriate periodic inspection and testing of components that are required to

perform safety-significant functions… (4) with a residual heat removal capability having reliability and testability that reflects the safety-significance of decay heat and other residual heat removal…"

- Table 6, PDC 72: "The reactor building shall be designed to permit (1) appropriate periodic inspection of all important structural areas and the depressurization pathway, and (2) an appropriate surveillance program."

Why is PDC 6 only used to capture monitoring, testing, and inspections from some of the relevant MHTGR-DCs?

9. Table 6, PDC 12 omits the language "or can be readily detected and suppressed." This change appears to be more restrictive, especially considering the stage of the design. **Why was this language omitted?**

10. Table 6, PDC 14 adds the phrase "that may cause changes in core geometry." Based on the level of design information available, it is not clear to the NRC staff that core geometry is the only function of the pressure boundary. Provided RSFs 1.14 and 1.24 are consistent with this, but RSFs 1.31 and 1.32 may not only require geometry to be maintained. **Why was this terminology added to constrain the PDC?**

11. Table 6, PDC 19 restricts the scope of the design criteria to AOOs and design basis events (DBEs); while this is consistent with the described function of the operators and control room for safety functions of the facility, exposure to the operators is also included in the scope of the PDC. **What events will operators be protected against radiation exposures in excess of 5 rem total effective dose equivalent (TEDE)?**

12. Table 6, PDC 20 states that "The protection system shall be designed… and (2) to sense conditions to initiate the operation of systems and components that are to perform required safety-significant functions." The NRC staff interprets "required safety-significant functions" to be RSFs in RG 1.233.

    RG 1.232, Appendix C, Criterion 20 (MHTGR-DC 20) states that "The protection system shall be designed … and (2) to sense accident conditions and to initiate the operation of systems and components important to safety." The expression 'systems and components important to safety' in MHTGR-DC 20 is not limited to those performing RSFs, i.e., SR SSCs according to RG 1.233. **Why is this PDC limited to SSCs performing RSFs?**

13. Table 6, PDC 20: The first instance of Xe-100 PDC 6 uses the expression 'required safety-significant functions' but the red-line strikeout replaces this with 'required safety functions.' **Why is this inconsistent?**

14. Table 6, PDC 26 omits of fuel loading from the scope of the PDC. **Why is this, given fuel loading is a continuous reactivity manipulation for the design?**

15. Table 6, PDC 34 (and specifically, the RFDC portion) removes constraints on the role of the system. It is not clear what constitutes "effective cooling" with respect to the safety

function (e.g., what SSCs are needed to be cooled and what functions does this cooling support). Further, it is not clear what role the RFDC/CDC split for this PDC is. **Why is the "safety-significant function" language in the CDC versus having this make-up part of the RFDC?**

16. Section 4, "REFERENCES," contains several that are not used in the TR although they are described as being referenced**.**

17. Section "ABREVIATIONS," (Page 6 of 80) contain abbreviations that are not used in the TR (e.g., SRDC, PSAR), although they are described as being used.

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