From: Edwin Lyman <ELyman@ucsusa.org>
Sent: Monday, August 12, 2024 6:31 PM
To: TerraPowerEnvironmental Resource
Subject: [External_Sender] Union of Concerned Scientists scoping comments for the Kemmerer-1 EIS
Attachments: UCS scoping comments on the Kemmerer1 CP EIS 8 12 24.pdf

Please find attached the scoping comments of the Union of Concerned Scientists for the Kemmerer-1 EIS. Thank you for your consideration.

Sincerely,

Edwin Lyman
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Comments of the Union of Concerned Scientists (UCS) on the Scope of the Environmental Impact Assessment for the Kemmerer, Unit 1 Construction Permit Application NRC-2024-0078

Edwin S. Lyman
Director of Nuclear Power Safety
August 12, 2024

The Kemmerer, Unit 1 project, a $9 billion+ sodium-cooled fast nuclear reactor, is something that the world simply does not need. If it ever operates, which is highly unlikely, it will pose an unacceptable menace to domestic and international safety and security. Unfortunately, due to the incredibly poor judgment and lack of understanding of the project's backers, including TerraPower, which is being played for a patsy by a cadre of fast reactor enthusiasts within the Department of Energy and its national lab system, it continues to move forward.

Fast reactors have numerous, fundamental design flaws which render them significantly more dangerous than light-water reactors. However, TerraPower and other promoters of fast reactors continue to disseminate dangerous misinformation about them, misleading policymakers and the public about these risks. Consequently, it is incumbent on the NRC to fully discharge its statutory responsibilities under NEPA and comprehensively assess the dire human health, environmental, and security implications of the proposed action.

1. **Severe accident consequences on public health, safety, and the environment must be fully evaluated.**

The Kemmerer-1 construction permit application fails to evaluate the most severe accident scenarios that are known to be credible for fast reactors. These include unprotected loss-of-flow (ULOF) and unprotected transient overpower (UTOP) accidents, as well as so-called "hypothetical" core disassembly (Bethe-Tait) accidents resulting from core compaction to a highly supercritical state.

In the case of ULOF accidents with failure of the electromagnetic sodium coolant pumps, metal-fueled fast reactors such as the Natrium depend on artificial "coast-down" mechanisms that delay total cessation of coolant flow until negative reactivity feedback mechanisms associated with fuel expansion have sufficient time to take effect and mitigate the transient. However, if coast-down fails, then the power and coolant temperature can rapidly rise due to the positive sodium void coefficient, leading to bulk sodium boiling, fuel melt, and further rapid power increases on the order of tens of seconds. These events can lead to ten-fold increases in power that can cause a Chernobyl-like destruction of the reactor core and its confinement. In such events, a significant fraction of the core radionuclide inventory can be expected to be expelled to the environment, especially for a plant without a physical containment that can (to a limited extent) withstand the force of the core and coolant explosion.[1]

It is not straightforward to back out from the public information in the Kemmerer-1 CP environmental report (ER) what the radionuclide releases for the severe accidents it evaluates actually are and assess whether any of them correspond to accidents of the severity we describe here. However, there are some clues. The ER states that the two severe accidents it evaluates are a reactivity transient and an accident leading to "local boiling" of the sodium coolant. TerraPower concedes in the PSAR (page 4.1-1) that a source term that only involves local boiling may underestimate the calculated average population cancer and early fatality risks that it compares with the quantitative health objectives (QHOs).

For instance, the population-averaged 10-mile latent cancer fatality risk per event (obtained by dividing the LCF risks per reactor-year listed in Table 5.11-21 with the corresponding event frequencies listed in Table 5.11-20) is either 2.6×10^{-4} or 1.2×10^{-3}, depending on the release category. Comparing with the NUREG-1150 factor of 4×10^{-3} for an accident at the Surry PWR with early containment failure and a "very large" release (corresponding to radioactive iodine, cesium, and strontium releases of over 10 percent, and lanthanide releases of a few percent), and scaling for the lower power level (0.35 percent of Surry-1) we see that corresponding LCF risks per reactor-year for Kemmerer-1 are 1.2-5.4 times lower than those for the Surry PWR severe accident. But this is not an apples-to-apples comparison, since the NUREG-1150 results assumed evacuation of the 10-mile EPZ, whereas the Kemmerer-1 analysis did not. Since NUREG-1150 finds that assuming degraded evacuation would triple the mean LCF risk within 10 miles, a comparison of the risk metrics assuming no evacuation in each case finds risks about 4-16 times lower for Kemmerer-1 than for Surry. Based on this, the iodine and cesium release fractions assumed for the Kemmerer-1 severe accident would be, on average, around an order of magnitude lower than those of the Surry severe accident—releases of cesium, iodine, and strontium on the order of a few percent, and lanthanide releases of a fraction of a percent.

However, the actual release fractions for fast reactor severe accidents with core melt are considerably higher than these values. The analysis in the Department of Energy (DOE) Versatile Test Reactor (VTR) Final Environmental Impact Statement (Table D-32), a metal-fueled fast reactor of very similar design, found that for fuel melting at 1,100°C, release fractions of alkali metals (including cesium), as well as europium, would approach 1, and release fractions of halogens (including iodine) and lanthanides other than europium would approach 0.3. At 1,300°C and above, even the halogen release would be nearly total.

These high release fractions would likely result in much higher estimates for latent cancer fatality and early fatality risks for severe accidents at Kemmerer-1 than are presented in the ER. The thermal power rating for Kemmerer-1 is nearly three times that for the VTR. Scaling the

[1] U.S. Department of Energy, "Final Versatile Test Reactor Environmental Impact Statement," Volume 2, Appendix D, p. 79-93.

results of the severe accident analyzed for the VTR at Oak Ridge National Laboratory for the difference in power rating and 10-mile population (16.75 times smaller for Kemmerer-1), the estimated number of latent cancer fatalities within 10 miles would be about 535, or an average risk of about 0.06—that is, 50 times greater than the largest value in the Kemmerer-1 ER. (One caveat: the difference in source term between the Natrium, which is HALEU-fueled, and the VTR, which is plutonium-fueled, also needs to be taken into account, which may reduce the relative Natrium dose for some release categories and scenarios where actinide releases are significant contributors to dose. However, fission products with similar inventories in both cores, such as lanthanides, make significant contributions to dose. All these considerations should be analyzed in detail in the EIS.)

Moreover, while the Kemmerer-1 ER claimed that the early fatality risk within 1 mile of the exclusion area boundary would be zero for all release categories, the VTR FEIS found that even for an individual located at 3.1 miles from a VTR located at the Idaho National Laboratory site, lethal early doses would be expected. Thus the Kemmerer-1 ER is quite nonconservative, and simply not credible, when compared to the DOE VTR FEIS.

The EIS should correct the omissions in the Kemmerer-1 ER and include accidents at least as severe as those evaluated in the VTR FEIS. It should also clearly discuss the accident progression and present the source terms and other input parameters for the consequence analysis in detail—information that is largely absent from the Kemmerer-1 ER.

In addition, the hypothetical core disassembly accident also needs to be fully evaluated and potential Bethe-Tait explosive loadings estimated, especially in the context of a decision regarding the need for a physical versus functional containment (see below).

2. **Severe Accident Mitigation Design Alternatives (SAMDAs) should be fully analyzed in the EIS at the construction permit stage, not at the operating license stage.**

The Kemmerer-1 ER does not include an analysis of severe accident mitigation design alternatives (SAMDAs), deferring this step to the operating license application stage. While there is apparently no legal requirement that SAMDAs be evaluated in the construction permit stage, it defies logic to defer consideration of *design* alternatives until after the preliminary design has been approved and, moreover, construction is underway or nearly complete. This is particularly important for major design alternatives that cannot be simply tacked on to a plant in the late stages of construction, such as a physical, pressure-resisting, low-leakage containment.

Given the large differences discussed above in the severe accident consequence analyses for the Natrium and the very similar VTR, inclusion of more realistic source terms in the Kemmerer-1 EIS could lead to much more severe radiological consequences and, for example, cause the inclusion of a physical containment to be a cost-beneficial and substantially safety-significant SAMDA. This is a design choice that must be made at the construction permit stage before other major design decisions are locked in and contracts with suppliers are signed.

3. **The impact of the Natrium's poor uranium utilization compared to alternatives on the environment must be evaluated.**

The EIS should fully evaluate the implications of the Kemmerer-1 design's wasteful use of the natural uranium resource. Based on the publicly reported enrichment and burnup of the Natrium Type 1 fuel, one can calculate that the reactor will require about 550 metric tons of natural uranium per GWe-yr, or about three times as much as a light-water reactor uses for typical burnups. Although TerraPower hopes to develop and qualify a higher burnup fuel type, called Type 1B, it is remote and speculative to assume that it will be successful over the timeframe considered by the EIS. Thus the EIS should include an analysis of all the direct and indirect environmental impacts of the Natrium's excessive need for natural uranium compared to other reactor types. We note that the broad assertion that the NRC draws in the draft Generic Environmental Impact Statement for Advanced Nuclear Reactors (NUREG-2249) that advanced nuclear reactor (ANR) fuel cycle environmental impacts will be SMALL because they are bounded by those for current LWRs simply does not hold true in this case.

4. **The environmental impacts of indefinite on-site storage of spent fuel at the Kemmerer-1 site needs to be specifically evaluated, as the Continued Storage GEIS is not applicable for non-LWR spent fuel.**

It should be self-evident that the spent fuel from the Kemmerer-1 reactor will have significant differences from spent LWR fuel and there is very little operating experience with similar spent fuels to inform predictions of its storage behavior in the long-term. Thus the EIS must contain a site-specific and material-specific analysis of the safety and security of indefinite storage, fully accounting for uncertainties, in order to satisfy the legal requirements. The implication in the draft ANR GEIS that the NRC could conclude the environmental impacts of this exotic and reactive material would be bounded by those of LWR spent fuel without a detailed analysis is not technically justifiable.

5. **The EIS should fully evaluate the impacts of radiological sabotage and theft scenarios.**

From its use of multi-ton quantities of HALEU fuel, which is likely directly usable in nuclear weapons,[2] to the many ways in which the reactor and its spent fuel can be sabotaged to cause massive radiological releases, Kemmerer-1 will pose major threats to domestic and international security. The EIS must fully evaluate the security impacts of all credible sabotage and theft scenarios associated with this project. Although such an analysis would be voluntary for a reactor in Wyoming, it would be required if it were 20 miles away in Idaho, a state in the 9th Circuit. It would be ludicrous for the NRC to hide behind its minimum legal obligations here.

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[2] R. Scott Kemp et al., "The Weapons Potential of High-Assay Low-Enriched Uranium," *Science* **384** (2024), 1071-1073.