UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

October 7, 2019

The Honorable Kristine L. Svinicki
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: REVIEW OF DRAFT SECY PAPER, "POPULATION - RELATED SITING CONSIDERATIONS FOR ADVANCED REACTORS"

Dear Chairman Svinicki:

During the 666th meeting of the Advisory Committee on Reactor Safeguards, September 4-6, 2019, we reviewed the draft SECY Paper entitled, "Population-Related Siting Considerations for Advanced Reactors." Our Future Plant Designs Subcommittee also reviewed this matter during a meeting on August 23, 2019. During these meetings we had the benefit of discussions with representatives of the NRC staff. We also had the benefit of the referenced documents.

CONCLUSIONS AND RECOMMENDATIONS

1. The paper provides four options for revising siting considerations for advanced reactors. We agree that Option 3 is the most reasonable of these approaches. However, it is short on details of implementation that will determine its ultimate value.

2. While Option 3 is short on details, they should be provided for review in the revised Regulatory Guide (RG) 4.7 with appropriate illustrative examples.

BACKGROUND

The NRC staff developed a report in 2016, "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Mission Readiness," as the staff contemplated how to review and regulate a new generation of non-light water reactors (non-LWRs), including their fuel cycles and waste forms. The report lays out six strategies to accomplish its goals and provides a set of Implementation Action Plans that identify specific, actionable tasks, which can fulfill the strategies. Over the intervening years, we have provided letter reports on the vision and strategy document as well as several products of the Implementation Action Plans—non-LWR design criteria, functional containment performance criteria, and the licensing modernization project (LMP or now called the "Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors").

The draft SECY paper, "Population-Related Siting Considerations for Advanced Reactors," was prepared under Strategy 5: identify and resolve technology-inclusive policy issues that impact

regulatory reviews, siting, permitting, and/or licensing of non-LWR nuclear power plants. It is intimately related to most of the previously reviewed documents. All these issues, especially source term characterization, functional containment performance, siting, and emergency planning are interdependent.

The subject of reactor siting has a long history of technical considerations and regulatory policy that began in the 1950s, when pressure was growing to site plants closer to power producers' customers. It became important to rely more on containment than isolation and simultaneously to develop siting criteria that would protect those populations. Today we have more than 60 years of institutionalized expectations, based on large LWR experience, analyses, and bounding approximations.

DISCUSSION

THE DRAFT SECY

The staff has identified the issue of siting decisions related to nearby populations as a matter that warrants early engagement with the Commission. During development of the draft SECY the staff considered possible changes to population-related siting considerations appropriate for advanced reactors, which can have substantially different design and accident characteristics than existing LWRs.

The paper is written at a high level, leaving many details unaddressed. The viability of the implementation of any of their proposed options will depend heavily on the details. We expect these details to be included in an associated revision to RG 4.7, "General Site Suitability Criteria for Nuclear Power Stations." The paper itself becomes a bit hard to track, with a number of dense footnotes that contain essential information that provides technical justification for the approach. We suspect this came about in an attempt to retain a high-level, policy focus. Unfortunately, it also obscures much of the message.

The staff found that no changes to regulations would be required to satisfy their goal. They propose four options. One that maintains the status quo, and three more that would require changes to the guidance provided in RG 4.7: the second simply applies a source term factor based on power level, the third is based on dose calculations, and the fourth proposes developing societal risk measures.

One specific caveat not raised in the draft SECY, but implied in all the licensing activities for new non-LWR designs flowing out of the vision and strategy process, is the need for examining new designs with a clean sheet of paper. Improvements in our ability to calculate source terms and consequences in conjunction with the inherent safety aspects of advanced designs can reduce the probability and consequences of many of the events that have historically dominated the risk at LWRs. Nevertheless, one must be sure to think carefully about the failures and combinations of failures that could occur; i.e., what could go wrong. There are many tools that can help in such a search: a simple reframing—asking 'how could I make this system fail'; employing a search scheme similar to the Hazard and Operability Study (HAZOP) approach used in the chemical processing industry; and applying a modified failure modes and effects analysis at the system level rather than at the component level.

There is a tendency to believe in the perfection of new designs, especially when they are developed to eliminate the dominant failure scenarios in existing designs. However, one must remain vigilant and remember that nature provides surprises. There will be new accident

scenarios and new combinations of events to be considered that challenge our expectations and our assumptions about these advanced reactor systems. Creative thinking will be required to identify such unique situations, to thoroughly identify the scenarios that will be the basis of the safety analysis and the source of releases, and to evaluate the suitability of sites.

THE SITING REGULATIONS

The siting regulations are brief and clear. They are provided in 10 CFR Parts 50, 52, and 100. The regulations define an exclusion area (EA), a low population zone (LPZ), and a population center distance. The boundaries of the EA and LPZ are set by dose limits of 25 Rem Total Effective Dose Equivalent (TEDE) over the most limiting 2 hours for the EA and over the entire passage of the radioactive cloud for the LPZ. The plant must be sited a distance at least 1.33 times the radius of the LPZ from the boundary of any densely populated center of more than 25,000 people.

EXISTING POPULATION GUIDANCE

Siting guidance is provided in RG 4.7. It adds a population density criterion to the requirements of the regulations. “A reactor should be located so that, at the time of initial plant approval and within about 5 years thereafter, the population density, including weighted transient population, averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the circular area at that distance), does not exceed 500 persons per square mile (ppsm). A reactor should not be located at a site where the population density is well in excess of this value.”

STAFF OPTIONS IN THE DRAFT SECY

While deciding to maintain siting and population considerations as an element of defense in depth for future reactors, the NRC has recognized for many years that the specific source term and siting practices used for large LWRs may not be appropriate for the licensing and regulation of advanced reactor designs. For large LWRs dose calculations are based on an assumed set of severe accidents with substantial degradation of the core and the subsequent large release of radioactive material from the plant. Factors such as smaller source terms (fission product release to the environment), passive safety systems, and advances in barrier technology may allow for siting such reactors closer to densely populated centers than has historically been accepted for large LWRs.

The staff has identified two primary issues for the possible deployment of advanced reactors and the NRC’s current siting requirements and guidance. The first issue involves the current limitations in RG 4.7 on population density to not exceed 500 ppsm out to a distance of 20 miles from a reactor site. This provision might unnecessarily preclude many sites associated with retiring fossil plants or industrial sites with relatively large population centers closer than 20 miles. The second issue involves the potential use of small modular reactors (SMRs) and microreactors for remote communities or smaller grids with relatively small but concentrated populations that would be near a reactor site.

The draft SECY paper describes four options the NRC staff has developed following a series of public meetings at which attendees discussed modifying the NRC rules and guidance to accommodate expected advances in reactor designs.

Option 1 is to maintain the status quo with no changes to the current population-related siting regulations or the existing guidance in RG 4.7.

This option gives no consideration to the expected improvements in new designs that eliminate vulnerability to some initiating events and limit source terms thereby reducing the likelihood and severity of most accidents. Option 1 does not reduce regulatory uncertainty and goes against the Commission goal to minimize complexity and add stability.

Option 2 would revise the population-related guidance in RG 4.7 to include provisions for advanced reactor designs and more specifically for SMRs using a scaling of the source term with power level.

We find that Option 2, while providing some benefit, is arbitrary and does not account for other important specific design attributes of new reactors.

Option 3 would revise the population-related guidance in RG 4.7 to include additional provisions for advanced reactor designs. The criteria are directly related to estimates of radiological consequences from design-specific events.

We find that Option 3 is attractive on several counts: it appears reasonable; it directly accounts for specific characteristics of each new design; and the criteria are directly related to calculated estimates of radiological consequences. It retains established principles, while allowing consideration of new reactor characteristics. Application of Option 3 will require substantial effort in identifying licensing basis events for evaluation and in developing mechanistic source terms to support dose calculations. Perhaps bounding simplifications for each source term may be possible.

Although calculable, the essence of the change is summarized in the paper as “The proposed criterion is that the population density (500 ppsm) would be assessed out to a distance equal to twice the distance at which a hypothetical individual could receive a calculated dose of 1 rem over a period of 1 month from the release of radionuclides resulting from the subject event categories.” At first glance, this criterion seems to be deterministic rather than risk informed. In discussions with the staff that helped explain the footnotes in the draft SECY, it became clear that this criterion, based on dose, time and distance, does have risk-informed elements. First, the dose (1 rem) and time (1 month) are consistent with the required approach outlined in the LMP and DG-1353, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," for characterization of the dose from proposed advanced reactor designs. Further, the prescribed distance of twice the 1-rem dose boundary is approximately consistent with the distance required for relocation of local populations to satisfy the US Environmental Protection Agency Protective Action Guides. This approach seems reasonable, however, the use of footnotes to explain it to the reader made it quite inscrutable to the committee. This should be rectified in revisions to the final SECY.

The draft SECY permits an alternative to using the approach of the LMP and DG-1353. Applicants could take the traditional LWR approach using a stylized set of design basis accidents (DBAs) (still developed carefully for the new design), conservative single failure assumptions, and conservative source term in a manner similar to guidance provided in NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear

Power Plants: LWR Edition," and RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," but adapted to their new designs.

Option 4 calls for the NRC staff to develop societal risk measures for assessing specific advanced reactor designs at specific sites. This option could be pursued by including the assessment of societal risks in RG 4.7 as an alternative to the current criteria on population density.

We find the idea of Option 4 laudable. It has been considered in the past and societal risk can yield different results than individual risk as witnessed by the events at Fukushima. Unfortunately, this could be difficult to develop into a widely accepted form and could devolve into interminable argument. Perhaps land contamination can be a suitable surrogate for societal risk, and it is calculated in full scope risk assessments. It could be added to the considerations in Option 3, provided that criteria could be developed that meet wide acceptance—perhaps a daunting task.

The staff recommends in the conclusions of the draft SECY Paper that the Commission approve Option 3, which consists of revising guidance to provide performance-based criteria to assess population-related issues in siting advanced reactors.

SUMMARY

The draft SECY paper provides four options for revising siting considerations for advanced reactors. We agree that Option 3 is the most reasonable of these approaches. Implementing it will require substantial work in identifying licensing basis events for evaluation and in developing mechanistic source terms for dose calculations. The preferred approach is technology-inclusive and risk-informed. There appears to be nothing that is focused on non-LWR aspects of design, and we see nothing that should preclude its use for LWR-based designs. It provides design-specific results and should be preferred technically to the present one-size fits all approach.

Sincerely,

/RA/

Peter C. Riccardella
Chairman

REFERENCES

1. U.S. Nuclear Regulatory Commission, SECY Paper, "Population-Related Siting Considerations for Advanced Reactors," Draft, July 18, 2019 (ML19203A219).

2. Oak Ridge National Laboratory, "Advanced Reactor Siting Policy Considerations," ORNL/TM-2019/1197, June 2019 (ML19192A102).

3. U.S. Nuclear Regulatory Commission, "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness," December 21, 2016 (ML16356A670).

4. U.S. Nuclear Regulatory Commission, “NRC Non-Light Water Reactor (Non-LWR) Vision and Strategy Staff Report: Near-Term Implementation Action Plans: Volume 2 – Detailed Information,” Draft, November 2016 (ML163324A495).

5. Advisory Committee on Reactor Safeguards, “NRC Non-Light Water Reactor Vision & Strategy – Near-Term Implementation Action Plans and Advanced Reactor Design Criteria,” March 21, 2017 (ML17079A100).

6. Advisory Committee on Reactor Safeguards, “Draft Final Regulatory Guide 1.232, ‘Guidance for Developing Principal Design Criteria for Non-Light Water Reactors,’” March 26, 2018 (ML18081A306).

7. Advisory Committee on Reactor Safeguards, “Draft SECY Paper, ‘Functional Containment Performance Criteria for Non-Light Water Reactor Designs,’” May 10, 2018 (ML18108A404).

8. Advisory Committee on Reactor Safeguards “Draft SECY Paper and Guidance Documents to Implement a Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors,” March 19, 2019 (ML19078A240).

9. Advisory Committee on Reactor Safeguards, “Draft Proposed Rule, ‘Emergency Preparedness for Small Modular Reactors and other New Technologies,’” October 19, 2018 (ML18291B248).

10. U.S. Nuclear Regulatory Commission, SECY-93-092, “Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, AND PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements,” April 8, 1993 (ML040210725).

11. U.S. Nuclear Regulatory Commission, SECY-03-0047, “Policy Issues Related to Licensing Non-Light-Water Reactor Designs,” March 28, 2003 (ML030160002).

12. U.S. Nuclear Regulatory Commission, SRM-SECY-03-0047, “Policy Issues Related to Licensing Non-Light-Water Reactor Designs,” June 26, 2003 (ML031770124).

13. Advisory Committee on Reactor Safeguards, “ACRS Comments Regarding NRC Review of Advanced Reactor Designs,” April 16, 1986 (ML16316A033).

14. Advisory Committee on Reactor Safeguards, “Next Generation Nuclear Plant (NGNP) Key Licensing Issues,” May 15, 2013 (ML13135A290).

15. U.S. Nuclear Regulatory Commission, “General Site Suitability Criteria for Nuclear Power Stations,” Regulatory Guide 4.7, Revision 3, March 2014 (ML12188A053)

16. Title 10, Code of Federal Regulations, Part 50, “Domestic Licensing of Production and Utilization Facilities.”

17. Title 10, Code of Federal Regulations, Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants.”

18. 10 Code of Federal Regulations, Part 100, “Reactor Site Criteria.”

19. U.S. Nuclear Regulatory Commission, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," Draft Regulatory Guide 1353, August 16, 2018 (ML18264A093).

20. U.S. Nuclear Regulatory Commission, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” NUREG-0800, March 2007.

21. U.S. Nuclear Regulatory Commission, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors,” Regulatory Guide 1.183, July 2000 (ML003716792).

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