POLICY ISSUE
(Notation Vote)

May 8, 2020 SECY-20-0045

MEMORANDUM TO: The Commissioners

FROM: Margaret M. Doane
Executive Director for Operations

SUBJECT: POPULATION-RELATED SITING CONSIDERATIONS FOR ADVANCED REACTORS

PURPOSE:

The purpose of this paper is to provide options and a recommendation to the Commission on possible changes to guidance documents to address population-related siting considerations for advanced reactors. The staff's recommendation is to pursue a revision to the population-related siting guidance used to implement Commission policy to provide technology-inclusive, risk-informed, and performance-based criteria to assess certain population-related issues in siting advanced reactors. The activities associated with this paper are included within the budget for developing regulatory infrastructure for advanced nuclear reactor technologies, which is funded by specific appropriations pursuant to the Nuclear Energy Innovation and Modernization Act (NEIMA). Therefore, this paper does not address any resource implications.

SUMMARY:

The U.S. Nuclear Regulatory Commission (NRC) has a longstanding policy of siting nuclear reactors away from densely populated centers and preferring areas of low population density. The NRC's guidance and experience relate to large light-water reactors (LWRs) and possible releases from a hypothetical major accident related to water coolant, zirconium alloy fuel cladding, and other characteristics of LWRs. Advanced reactor designs may use different fuel forms, coolants, and barriers for limiting the release of radioactive materials to offsite

CONTACT: William Reckley, NRR/DANU
301-415-7490

environments. For the purpose of this paper, the term “advanced reactors” refers to light-water small modular reactors (SMRs) as defined in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 170, “Fees for Facilities, Materials, Import and Export Licenses, and Other Regulatory Services Under the Atomic Energy Act of 1954, as Amended,” microreactors, and non-light-water reactors (non-LWRs). This usage is included in, but not coextensive with, the definition of “advanced nuclear reactor” in NEIMA. Attributes of advanced reactors are expected to provide a reduced likelihood of accidents and to result in a smaller and slower release of radioactive material in the unlikely event of an accident. These attributes of advanced reactors, if demonstrated, may support siting them closer to population centers than large LWRs typically have been. The staff has interacted with stakeholders to develop several options for the Commission’s consideration to address population-related siting questions for advanced reactors. The staff recommends revising NRC guidance to provide an alternative population-density criterion that is directly related to the potential radiological consequences estimated from analyzing a range of possible design-specific events.

BACKGROUND:

The NRC has established regulations and guidance for a broad range of factors to be considered in the siting of nuclear reactors. One of those factors relates to nearby populations and the NRC has implemented a policy of siting nuclear reactors away from very densely populated centers. The NRC’s guidance and experience for siting nuclear power plants relate to large LWRs. The population-related siting considerations for large LWRs are based on a fission product release from a hypothetical major accident, which has generally been assumed to result in substantial meltdown of the core with subsequent release into the containment of appreciable quantities of fission products. Compared to previous generations of reactor designs, advanced reactor designs are expected to have a reduced likelihood of accidents and result in a smaller and slower release of radioactive material in the unlikely event of an accident. This is discussed in detail in the enclosure.

Histories of the Commission’s consideration of population-related issues in siting nuclear power plants can be found in the Statements of Consideration for the last revision to 10 CFR Part 100, which the NRC published on December 11, 1996 (Volume 61 of the *Federal Register*, page 65157 (61 FR 65157)), and the related report NUREG-0625, “Report of the Siting Policy Task Force,” issued August 1979 (ADAMS Accession No. ML12187A284). Additional background information on this topic is provided in Oak Ridge National Laboratory (ORNL)/TM-2019/1197, “Advanced Reactor Siting Policy Considerations” (ADAMS Accession No. ML19192A102), prepared by ORNL for the NRC.

DISCUSSION:

The staff has interacted with stakeholders to develop several options for the Commission’s consideration to address population-related siting questions for advanced reactors. As discussed in the enclosure and summarized below, the staff has focused on developing options to revise the guidance in Regulatory Guide (RG) 4.7, “General Site Suitability Criteria for Nuclear Power Stations,” Revision 3, issued March 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12188A053) related to 10 CFR 100.21(h), which states that reactor sites should be located away from very densely populated centers and that areas of low population density are generally preferred. RG 4.7 currently provides guidance for assessing the population around possible reactor sites using the criterion of the population density not exceeding 500 persons per square mile (ppsm) out to 20 miles.

Option 1

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. The guidance calls for the population to be less than about 1,600 people within a mile from the plant site. The guidance also calls for the total population within the first 10 miles to be less than about 157,000 people and to be less than about 628,000 people within 20 miles from the site. Applicants for either a remote site with a population greater than 1,600 people within a mile or a site with higher population densities within 20 miles from the plant could propose an alternative to the population-density guidance in RG 4.7. A possible proposed justification for an alternative to the guidance in RG 4.7 would cite the attributes of a particular advanced reactor design, which if demonstrated, could support a finding that the frequency of and consequences from accidents with radiological releases were both acceptably low. Additional details of Option 1 are discussed in the enclosure.

Advantages: The agency would not spend its resources on developing the related guidance documents within the current planning horizon. The staff could take up the issue in the future on a case-by-case basis when there is increased certainty that advanced reactor applications will include proposed alternatives to the population-related siting criteria in RG 4.7.

Disadvantages: Addressing population density for advanced reactors on a case-by-case basis does not reduce the regulatory uncertainties that the staff and some stakeholders have identified. Addressing such issues on a case-by-case basis does not support the agency's goals as described in "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness" issued December 2016 (ADAMS Accession No. ML16356A670), to minimize complexity and add stability and predictability in the licensing and regulation of advanced reactors. These uncertainties may also complicate the ability of reactor developers and potential applicants to make design and business decisions as they assess potential design features and possible sites for advanced reactors.

The options described in this paper were discussed in a public meeting on June 27, 2019. While there was not a specific discussion from individuals or organizations favoring Option 1 at that meeting, a broader survey would likely identify some stakeholders that would advocate taking no action at this time and assessing proposed siting decisions for advanced reactors on a case-by-case basis.

Option 2

Under Option 2, the staff would revise the guidance in RG 4.7 that relates to 10 CFR 100.21(h) to include provisions for advanced reactor designs and more specifically for SMRs and microreactors. As described in NUREG-0625, the NRC's practice of restricting possible reactor sites based on population density was in large part intended to limit overall societal risks from severe reactor accidents. One way to characterize societal risk is in terms of the potential radiation dose to the larger population around nuclear power plants beyond the regulatory limits for calculated doses to individuals. The simplicity of this option in providing alternative population densities and areas of interest is supported by its use of a source term factor such as power level as a surrogate for a more detailed mechanistic source term model that would consider all the attributes of an advanced reactor design. Details and an example of the proposed approach for Option 2 are provided in the enclosure.

Advantages: This option uses a combination of the regulatory requirements related to population and revisions to the population density criterion in RG 4.7 to support the policy on siting plants away from population centers and introduces a variable criterion based on source term or a determining parameter such as power level. The variable criterion is based on a general relationship between possible radiological releases and the inventory of radionuclides (e.g., power level) while otherwise maintaining the independence between siting and design. A revision to RG 4.7 would (1) promote regulatory stability, predictability, and clarity, (2) eliminate the need for future applicants to propose alternatives to the existing criteria in RG 4.7, (3) recognize technology advancements and design features associated with the NRC-recommended attributes of advanced reactors, and (4) replace a single prescriptive criterion on population density with a scalable criteria based on the general relationships between accident consequences and the inventory of radionuclides available for release. The population values shown in Figure 3 of the enclosure maintain the general approach to societal risk provided in the current guidance for large LWRs. The approach also provides a relatively simple and flexible way to address the expected lower source terms for advanced reactors in comparison to the traditional LWR severe or "Class 9" accident on which the current policy is based.[1] This option would increase the number of allowable sites, including retiring fossil stations and isolated communities with populations below 25,000 residents.

Disadvantages: This option would require resource expenditures, which could largely be addressed by current and expected future dedicated budget appropriations for the NRC to develop infrastructure for licensing and regulating advanced reactors. A disadvantage of this option is that the population-related siting decisions consider only the inventory of radionuclides (e.g., power level) and do not consider other potential attributes of advanced reactor designs. The required resources for the generic activities associated with implementing this option would be more than Option 1, comparable to Option 3, and less than Option 4.

Both positive and negative views about Option 2 were received from stakeholders during a public meeting on June 27, 2019. Some stakeholders at the meeting observed that this option would recognize attributes of some advanced reactor designs (e.g., lower radionuclide inventories) and provide flexibility for siting decisions for reactors with lower power levels. This group of stakeholders generally favored Option 3, which as described in the next section considers how multiple aspects of an advanced reactor design influence potential offsite releases of radionuclides. Other stakeholders, namely the Union of Concerned Scientists (UCS), expressed the view that Option 2 was overly simplistic in that it considers only a source term factor (e.g., power level).

Option 3

Under Option 3, the staff would revise the guidance in RG 4.7 that relates to 10 CFR 100.21(h) to include provisions for advanced reactor designs. This option is similar to Option 2 except that the criteria are directly related to estimates of radiological consequences from design-specific events rather than a general correlation of offsite doses to radionuclide inventories or power level. Also, this option is more comprehensive than Option 2 in that it considers the integrated

[1] Additional information on the traditional approaches for LWR severe or "Class 9" accident evaluations can be found in NUREG-1070, "NRC Policy on Future Reactor Designs; Decisions on Severe Accident Issues in Nuclear Power Plant Regulation" dated August 1984 (ADAMS Accession No. ML15307A423), and NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants," dated February 1995 (ADAMS Accession No. ML041040063).

safety performance of the entire reactor design. The assessment under Option 3 would include features beyond lower power levels or radionuclide inventories and consider attributes related to fuel designs, inherent safety features, and other contributors to the retention of radionuclides within an advanced reactor facility. This option would, therefore, have the potential to result in different siting decisions for various reactor designs with comparable power levels. Additional details and examples for the proposed approach for Option 3 are provided in the enclosure.

Advantages: This option allows consideration of the design and site-specific accident consequences and specific features of an advanced reactor design, including but not limited to possible lesser power levels considered in Option 2, that may limit the release of radionuclides. The approach uses a combination of the regulatory requirements in 10 CFR 50.34, 10 CFR 52.17, 10 CFR 52.79, 10 CFR 100.21(b), and revisions to population density criteria in RG 4.7 associated with 10 CFR 100.21(h) to support a more performance-based approach to the policy on siting away from population centers as a means to help control societal risks. This option would increase the number of allowable sites for advanced reactors in comparison to current guidance, including sites at retiring fossil stations and isolated communities with populations below 25,000 residents. The staff would pursue a revision to RG 4.7 that would provide the benefits of Option 2, but with potentially additional flexibility based on a more design-specific assessment of risks.

Disadvantages: This option would require resource expenditures, which could largely be addressed by current and expected future dedicated budget appropriations for the NRC to develop infrastructure for licensing and regulating advanced reactors. The required resources for the generic activities associated with implementing this option would be more than Option 1, comparable to Option 2, and less than Option 4.

During interactions with the NRC staff, the Nuclear Energy Institute (NEI), the Nuclear Industry Council (NIC), and individual developers identified Option 3 as their preferred option. The stakeholders favoring this option cite the goal of reducing regulatory uncertainties and providing a process by which advanced reactor attributes—characterized in this case by estimations of offsite radiological consequences from licensing basis events—are credited to provide operational flexibility, including revisions to population-related siting guidance. NEI and some developers favoring Option 3 have proposed for the NRC to proceed with revisions to RG 4.7 but to also consider changing the limitations for locating reactors within population centers of approximately 25,000 residents as part of a future rulemaking activity (e.g., the rulemaking mandated by NEIMA to provide a technology-inclusive regulatory framework for advanced reactors).

Option 4

Option 4 calls for the NRC staff to develop societal risk measures beyond what is proposed in Options 2 and 3 for assessing specific advanced reactor designs at specific sites. This option could be pursued without changes to NRC regulations by including the assessment of societal risks in RG 4.7 as an alternative to the current criterion on population density. The assessment of the potential impact of a reactor design at a site would consider factors beyond the potential dose to individuals and populations, including matters such as adverse effects on economies, land availability, population displacement, and decontamination costs. The unit of measure for Option 4 would likely be in monetary units (e.g., dollars) with consideration of the event frequencies leading to offsite releases. Additional discussion of Option 4 is provided in the enclosure.

Advantages: This option would provide an assessment of the societal risks associated with a specific reactor design located on a specific site for comparison to other societal risks or performance measures. Such an approach could supplement the current NRC practice of basing most consequence-based assessments on the estimated doses to individuals.

Disadvantages: This option would require significant resources and would be unlikely to be timely to support some current reactor developers with their design and siting decisions. Option 4 is a significant change from considering siting as an independent element of defense in depth; instead, it would include the specific combinations of reactor designs and sites to assess societal risks. Some approaches to assessing societal risks and using them in decisionmaking would require the NRC to characterize nonnuclear risks (e.g., natural disasters and other energy supplies) for use as part of comparisons and findings that the societal risks associated with a reactor and site were acceptably low.

Both positive and negative views about Option 4 were received from stakeholders during a public meeting on June 27, 2019. For example, NIC expressed the opinion that the NRC should not consider developing broader societal measures. However, Option 4 was the stated preference of UCS if the NRC were to pursue any option other than the status quo.

Staff Assessment

The NRC staff recommends Option 3 because it best meets the goals for the timely resolution of policy issues as described in "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness" (ADAMS Accession No. ML16356A670) while also taking into consideration likely attributes of advanced reactor designs beyond potentially lower radionuclide inventories or power levels. Option 3 also promotes (1) consideration of safety in the early stages of design and siting as recommended in the agency's policies related to advanced reactors, (2) risk-informed and performance-based regulations commensurate with the risks posed by advanced reactor designs, and (3) efficiency and clarity as described in the NRC's Principles of Good Regulation. A revision to the guidance in RG 4.7 would allow for a technology-inclusive, risk-informed, and performance-based approach to address the specific population-related siting issue related to the guidance for 10 CFR 100.21(h).

Stakeholder Interactions

The NRC staff discussed population-related siting considerations during several public meetings. The staff prepared and made publicly available white papers on the topic (ADAMS Accession Nos. ML17354B219 and ML19163A168) to support the public interactions. Feedback from stakeholders received during public meetings is summarized in the enclosure. A draft of this paper was made publicly available (ADAMS Accession No. ML19203A219) to support interactions with the Advisory Committee on Reactor Safeguards (ACRS).

The ACRS issued a letter dated October 7, 2019 (ADAMS Accession No. ML19277H031), providing its conclusions and recommendations. The ACRS stated that Option 3 is the most reasonable of the approaches presented in the draft paper. The staff revised this paper following the ACRS observation that the draft paper could benefit from additional detail and their suggestion that more information and examples should be provided for review during the development of the draft guidance document.

Relationship to other Advanced Reactor Priorities

Clarity on the regulatory approach for siting advanced reactors would improve the ability of designers to complete their assessments of plant designs and sites. The staff is currently interacting with light-water SMR and non-LWR stakeholders (e.g., Department of Energy, designers) on a variety of policy and regulatory issues. An example is ongoing interactions between the staff and stakeholders on regulatory approaches for microreactor designs, as described in the Nuclear Energy Institute white paper "Micro-Reactor Regulatory Issues" (ADAMS Accession No. ML19319C497). The staff is pursuing an integrated approach to resolving issues and developing a regulatory framework for advanced reactors, which is reflected in papers such as SECY-18-0096, "Functional Containment Performance Criteria for Non-Light-Water Reactors," dated September 28, 2018 (ADAMS Accession No. ML18115A157), SECY-18-0103, "Proposed Rule, 'Emergency Preparedness for Small Modular Reactors and Other New Technologies'," dated October 12, 2018 (ADAMS Accession No. ML18134A076), and DG-1353. The staff's efforts to address population-related siting considerations are an important part of the integrated approach to help inform the design and siting processes and the related content of applications for licenses, certifications, and approvals for advanced reactors. In addition, NEIMA requires the NRC to develop and implement, where appropriate, strategies for the increased use of risk-informed, performance-based techniques to resolve policy issues such as siting considerations that may unnecessarily restrict the development of commercial advanced nuclear reactors.

COMMITMENT:

If the Commission approves an option involving changing regulatory guidance related to population-related siting considerations, the staff will undertake the process of developing guidance as an alternative to the existing RG 4.7 using the established agency processes such as those described in Management Directive 6.6, "Regulatory Guides" (ADAMS Accession No. ML16083A122).

RECOMMENDATION:

The staff recommends that the Commission approve Option 3, which consists of revising guidance to provide technology-inclusive, risk-informed, and performance-based criteria to assess population-related issues in siting advanced reactors.

COORDINATION:

The Office of the General Counsel has reviewed this paper and has no legal objection. The staff also considered its interactions with the ACRS in finalizing this paper.

Margaret M. Doane

Digitally signed by Margaret M. Doane
Date: 2020.05.08 09:40:24 -04'00'

Margaret M. Doane
Executive Director
for Operations

Enclosure:
Options and Recommendation for
Population-Related Siting Considerations
for Advanced Reactors

SECY PAPER "SITING CONSIDERATIONS RELATED TO POPULATION FOR ADVANCED REACTORS" – DATED MAY 8, 2020

ADAMS Accession No: ML19262H055 (Pkg) *via e-mail SECY-012

OFFICE	NRR/DANU	QTE	NRR/DANU	NRR/DANU
NAME	WReckley	JDougherty*	JSegala	JMonninger
DATE	05/16/2019	05/22/2019	07/16/2019	07/19/2019
OFFICE	OGC	NRR	EDO	
NAME	MCarpentier*	HNieh*	MDoane	
DATE	02/26/2020	04/13/2020	5/8/2020	

OFFICIAL RECORD COPY