Insights from Siting New Nuclear Power Plants in the Central and Eastern United States[1]

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The staff of the U.S. Nuclear Regulatory Commission (NRC) has completed its review for four early site permits and for four standard reactor designs. It is currently reviewing applications for fourteen combined license applications and three additional reactor designs. The staff is applying lessons it has learned from the reviews to date to the review work going forward.

The licensing process being used by current applicants[2]differs significantly from that used by the current operating fleet. The previous process required two steps. First an applicant had to obtain a construction permit to build the plant. Then, near the end of construction, the applicant had to obtain an operating license. Under the process in Part 52, an applicant can apply for a combined license (COL) that allows construction and (once certain conditions are met) operation of a new plant – a one-step process. An applicant for a COL may reference an early site permit (ESP[3]), a standard design certification[4], both, or neither.

In addition to developing Part 52, the NRC also revised 10 CFR Part 100 by adding Subpart B, which includes sections 100.21, "Non-seismic siting criteria," and 100.23, "Geologic and seismic siting criteria." The NRC staff also revised the Standard Review Plan (NUREG-0800) and developed Regulatory Guide (RG) 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)." The NRC staff incorporated into the revision of NUREG-0800 and development of RG 1.206 some early lessons learned from its review of the first three ESPs.

Staff work begins before the application is received, as the staff interacts with the applicant to identify issues that will require special treatment or specific staff resources. After the application is submitted, if the NRC finds the application acceptable, the safety and environmental reviews begin, proceeding in parallel. The safety review culminates in the issuance of a safety evaluation report (SER) after it has been reviewed by the Advisory Committee on Reactor Safeguards. The environmental review[5] results in an environmental impact statement (EIS). Both of these documents are then reviewed in an

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[1] Note: This paper was prepared, in part, by an employee of the United States Nuclear Regulatory Commission on his or her own time apart from his or her regular duties. NRC has neither approved nor disapproved its technical content.
[2] See Title 10 of the Code of Federal Regulations (10 CFR) Part 52, "Licenses, certifications, and approvals for nuclear power plants".
[3] An ESP is an approval of a site for one or more nuclear facilities under 10 CFR 52, Subpart A.
[4] A standard design certification is a Commission approval of a final standard design for a nuclear power facility under 10 CFR 52, Subpart B.
[5] See 10 CFR Part 51 for the NRC's environmental regulations.

adjudicatory hearing by the Atomic Safety and Licensing Board. The Board makes an initial decision, after which the Commission will make it's decision.

1. Site Selection Lessons Learned from Site Safety Reviews

The updates to the regulations and regulatory guidance documents, described above, laid the groundwork for the staff's review of the first early site permit applications in 2003. In the area of geology and seismology, the applicants followed the guidance in 10 CFR Part 100.23 and specifically described in RG 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion." In order to characterize the seismic hazard, RG 1.165 recommended the use of probabilistic seismic hazard analysis (PSHA) for determining earthquake inputs for seismic design of nuclear power plants. Previously, Appendix A to 10 CFR Part 100 specified deterministic seismic hazard analyses (DSHA) for determining the Safe Shutdown Earthquake (SSE) ground motion levels. Under DSHA, an earthquake scenario, often a worst-case or maximum credible event is assumed in terms of magnitude and location. In contrast, PSHA incorporates the effects of all the earthquakes capable of affecting the site and includes the uncertainties in the earthquake size, location, rate of recurrence, and ground motion amplitude in the analysis.

RG 1.165 specifies a "reference-probability" hazard-based approach for specifying the SSE ground motion levels. However, of the three early site permit applications received by the NRC staff in 2003, two of the applicants chose not to use the reference-probability approach outlined in RG 1.165. Both of these applicants considered that the reference probability value was based on outdated seismic hazard evaluations and resulted in overly conservative site SSE ground motion levels for their sites. Rather than using the RG 1.165 approach, these two applicants adopted the seismic performance-based approach for determining the design level ground motion, which was under development as part of ASCE Standard 43-05. The adoption of this new approach resulted in considerable additional review time for the NRC staff and a re-evaluation of the use of the reference-probability approach for determining the SSE. The major difficulty with the use of the reference-probability approach is that as the hazard evolves with new data, models and research, it is difficult to evaluate the effect of these changes on the reference probability. The NRC staff's approval of the performance-based approach in place of the reference-probability approach led to the replacement of RG 1.165 with RG 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion."

The NRC staff is currently reviewing several Combined License (COL) applications that reference RG 1.208 and implement the performance-based approach. RG 1.208 also specifies that the seismic source characterizations developed by applicants for sites in the Central and Eastern United States (CEUS) may reference the Electric Power Research Institute (EPRI) seismic source models, developed in the 1980s, as a starting point for their site PSHAs. Recognizing that many new studies have resulted in re-evaluation of the seismic hazard for the CEUS, each of the ESP and COL applicants have examined these new studies before either using the original or updating the EPRI seismic models. Currently the staff spends a considerable amount of effort validating the continued use of the older EPRI source models, as well as revisions to the models proposed by the applicants.

In the area of hydrology, during its review of recent ESP and COL applications, the staff identified recurring issues involving inconsistencies and gaps between guidance provided in SRP Section 2.4.13 and SRP Section 11.2 with Branch Technical Position 11-6 relating to on-site hydrogeologic testing and measurements, conceptual model development of radionuclide transport in groundwater, and analysis of the radiological consequences of releases. To address the inconsistencies the staff developed two Interim Staff Guidance (ISG) documents. The first ISG (ISG-013) emphasizes the definition of the location and conditions of the assumed release, the role of mitigating design features,

the definition of exposure scenarios, and potential technical specifications limiting radioactive tank contents. The second ISG (ISG-014) provides additional guidance on analyzing the aqueous transport of radionuclides through the subsurface with groundwater through the use of a structured hierarchical approach. This approach begins by determining the basic conditions for the analysis such as hydrogeologic characteristics, release location, groundwater pathways, travel time, and release volume. If mitigating design features are present and acceptable, the analysis is concluded, otherwise, contaminant transport analysis is performed using progressively more complex modeling techniques, as needed.

Lessons learned in the area of meteorology have also resulted in an ISG to clarify the NRC position on identifying winter precipitation events as site characteristics for ESP and COL applicants and site parameters for DC applicants for determining normal and extreme winter precipitation loads on the roofs of Seismic Category I structures. 10 CFR Part 52 requires that the meteorological characteristics of the proposed site should be identified with consideration for the most severe of the natural phenomena that have been historically reported for the site and surrounding area with sufficient margin for limited accuracy and period of time. The staff's ISG clarifies that not only should the historical maximum snowpack be identified, but also the historical maximum snowfall event should be determined as it might exceed the historical maximum snowpack. The ISG also provides guidance on how data reported as snowfall or snow depth should be converted to an equivalent weight or load on the roof of a structure. Finally, the ISG specifies the appropriate loading combinations to determine the design live load on the roof.

The examples cited above with regard to seismology, hydrology, and meteorology illustrate that the staff has proactively addressed the lessons learned from its reviews of ESP, COL and DC applications. As additional issues arise during the review of siting and design applications, the staff will continue to update its guidance documents in order to resolve inconsistencies and/or gaps.

2. Site Selection Lessons Learned from Environmental Reviews

The staff has identified a number of regulatory issues during its reviews. The information provided in the applications has presented problems in various respects. For example, a number of applicants have chosen to rely on old data or data from nearby sources. However, the basis for the applicability of this data is often unclear. The staff has also found that, in some cases, information and data provided by the applicant to other agencies differs in critical aspects from information and data provided to the NRC. In addition, in many cases applicants have provided data and a conclusion, but failed to make a case that the data supports the conclusion. We sometimes refer to this as "telling the story" – applicants need to provide a clear path from the data to the conclusions.

Another challenging aspect of the current reviews, for both the applicants and the reviewers, is the evolving regulatory environment. As an example, how far do we go in addressing global climate change[6]? Do we discuss reduced greenhouse gas emissions from nuclear plants? Which models do we use to predict changes in precipitation and temperatures? In a related topic, how do we manage "regulatory creep" (the tendency for reviewers to look for, and expect, more from each successive application)?

The staff has also experienced challenges regarding interagency coordination. For any review, there are a large number of Federal, State and local agencies that will have some role in licensing,

[6] See Commission Memorandum and Order CLI-09-20 dated November 3, 2009, in the matters of Duke Energy Carolinas, LLC, and Tennessee Valley Authority, regarding the consideration of greenhouse gas emissions and "carbon footprint" in licensing proceedings for new nuclear power plants.

permitting, or otherwise authorizing all or part of the project. And in many cases these agencies also consider site selection as a part of their review. At the outset it is useful to determine which agencies the applicant has already contacted and the extent of their interactions. The NRC staff has often been surprised by the relatively low level of communication and coordination between the applicant and affected agencies before the start of the NRC review. Once we've identified which agencies are involved, we need to determine each agency's role and authority. It's critical for each agency to understand what the other agencies are, and are not, going to be doing. From that point of understanding, we can coordinate review work to avoid duplication and potential conflicts.

After the first three early site permits, the NRC staff greatly expanded its efforts involving pre-application interactions. These efforts are aimed at both the applicants and the other agencies and have led to improved applications and better coordination with other agencies.

The NRC staff is also adapting to the evolution in the participation of public stakeholders. During the last big round of licensing for new plants, public access to data and information was difficult. And coordination among citizens had to be performed by phone, by mail, or in person. Today, the Internet, blogs, and other tools allow citizens instant access to information and provide the ability to rapidly share information and ideas with large numbers of people. Today's public interest groups are typically better informed and better organized, and they expect their Government agencies to keep up. Establishing a good web page for projects is only the beginning for us. We have to be more effective in reaching out to the groups and in working with them. We also need to plan for a much higher level of public involvement. But while we do this, we must not forget that there are still people who'll be affected by our decision who aren't linked in through the Internet. So we can't abandon the old-fashioned methods – paper documents in libraries for example – completely.

Finally, there are some technical matters that have arisen from the work to date. As I'm sure we've all seen, the Internet and Geographic Information Systems are great tools for our reviews. Just like the public interest groups, we can now access more information more quickly to get our jobs done. But it's a two-edged sword. Reviewers can face information overload or they can find themselves getting bound up in conflicting information from various sources. So it's important to manage the information flow and be selective regarding the sources used for the review.

An enormous challenge facing many of the proposed plants is access to and availability of water for cooling. Many parts of the U.S. are already challenged for water and adding big power plants with big heat loads exacerbates the problem. Access to a cooling water source is often the main driver when identifying alternative site locations. Applicants and regulatory agencies need to look for innovative solutions. Examples might include re-use of waste water or the use of dry, or a combination of wet and dry cooling systems. But keep in mind that every alternative brings with it new challenges.

The staff has also learned from recent experiences regarding the application of site selection process guidance, primarily the NRC staff's Environmental Standard Review Plan (ESRP)[7], and the Electric Power Research Institute's siting guide[8]. The staff has found that all of the applicants have deviated from the guidance in at least some respects. In some cases, the basis for the deviations is provided. But in most cases it isn't and the staff must request additional information to resolve the differences. The staff has also found in some cases that the applicant has not applied its siting criteria in the same way to all sites. This occurs most often when applicants attempt to use the results of older site

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[7] *Standard Review Plans for Environmental Reviews for Nuclear Power Plants,* U.S. NRC, NUREG-1555, March 2000, but including 2007 revisions. Site selection is addressed in Section 9.3.

[8] *Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application, Final Report*. Electric Power Research Institute (EPRI), 2002, Product ID: 1006878, EPRI, Palo Alto, California.

selection studies. But we have also seen this problem occur when an applicants' selection process "evolves" over time.

A number of applicants have selected sites where they already have operating nuclear units. While on the surface this would appear to make sense, we have to look closely at the basis for the choice and at other options. For example, if existing units are already withdrawing a significant amount of water from a river, adding one or more new units at that location may lead to unacceptable impacts to the river. The staff must also balance the search for good alternative sites with the amount of effort involved. Environmental guidance leads us to look for sites that are "among the best" that can be found[9]. This means that we have to show that we used a sound process that would be expected to find good sites. But we don't have to prove that the chosen site is the best site possible.

Finally, the staff has found the comparison of sites to be challenging because in most cases you're not comparing impacts to similar resources. So, for example, you might be impacting a commercial fishery at one site, and impacting a historic resource at another site. Or you might be impacting a school system at one site and groundwater quality at another. Balancing those impacts against each other is difficult. The staff uses a scale of impacts (SMALL, MODERATE, and LARGE[10]) in its reviews and this scale can help. But in the end, professional judgment must be applied across the affected resources to come to a conclusion.

[9] *Standard Review Plans for Environmental Reviews for Nuclear Power Plants,* U.S. NRC, NUREG-1555, March 2000, but including 2007 revisions. See Section 9.3, Revision 1, page 9.3-6.

[10] Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," Subpart A, Appendix B, Table B-1, footnote 3.