

Offsite Power Requirements for Small Modular Reactors and Other New Technologies

Introduction

The purpose of this paper is to discuss generic policy and technical issues associated with the U.S. Nuclear Regulatory Commission (NRC) requirements for offsite power for light-water small modular reactors (SMRs) and other new technologies, such as non-light-water reactors (non-LWRs). This paper identifies the need for the NRC to establish guidance for designs that do not rely on an offsite supply of power to provide adequate protection of the public health and safety. This paper proposes an approach for offsite power requirements for these designs, including appropriate acceptance criteria.

Background

Under the provisions of 10 CFR 52.47, 52.79, 52.137, and 52.157,¹ an application for a design certification, combined license, design approval, or manufacturing license must describe the electrical systems and include the principal design criteria for a proposed facility. The principal design criteria establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety; that is, structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. 10 CFR 50 Appendix A, General Design Criteria (GDCs), establishes minimum requirements for the principal design criteria for water-cooled nuclear power plants similar in design and location to plants for which construction permits have been issued by the Commission, and provides guidance to applicants in establishing principal design criteria for other types of nuclear power units. As stated in 10 CFR 50 Appendix A, *“The General Design Criteria are also considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the principal design criteria for such other units. ... In particular, it is expected that additional or different criteria will be needed to take into account unusual sites and environmental conditions, and for water-cooled nuclear power units of advanced design. For plants such as these, departures from the GDCs must be identified and justified.”* (emphasis added)

General Design Criterion 17 in Appendix A of 10 CFR Part 50 establishes the generally applicable requirements for the design of electric power systems of nuclear power plants. The underlying purpose of GDC 17 is to ensure the plant has sufficient power to accomplish safety functions.

As stated in GDC 17, the purpose of the electric power system is to “permit functioning of structures, systems, and components important to safety.” Specific to the offsite electric power system, GDC 17 requires that “Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions.”

Inherent in the requirements of GDC 17 is the assumption that reliance on electric power from offsite sources is needed in order to “provide sufficient capacity and capability to assure that 1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not

¹ This paper discusses the requirements related to certifying designs and licensing facilities pursuant to 10 CFR Part 52. There are similar requirements in 10 CFR Part 50 for licensing facilities pursuant to that part.

Offsite Power Requirements for Small Modular Reactors and Other New Technologies

exceeded as a result of anticipated operational occurrences and 2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.” However, this assumption may not be valid for SMRs and other new technologies that incorporate enhanced passive safety features. In fact, it is expected that some of these designs will be designed to achieve these performance-based standards without the need for offsite power.

The NRC has previously approved exemptions to the GDC 17 requirements for offsite power supply. Most notably the NRC approved the Westinghouse AP1000 design with a single offsite power source (see SECY 05-0027 *Final Rule – AP1000 Design Certification*, December 14, 2005, and NUREG-1793 *Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design*, Initial Report, September 13, 2004). The NRC cited the following as being important to the basis for this exemption:

1. “Providing safety-related passive safety systems for core cooling and containment integrity”
2. “Passive safety-related systems [for core cooling and containment integrity] only require electric power for valves and the related instrumentation”
3. “Class 1E DC and uninterruptible power supply (UPS) system is the only safety-related power source required to monitor and actuate the safety-related passive system”
4. “Non-safety related AC power is not relied upon to maintain core cooling or containment integrity”
5. “Design does not require AC Power sources to mitigate design-basis events”
6. “Designed with reliable non-safety-related offsite and onsite AC power sources that are normally expected to be available for important plant functions”
7. “If no offsite power is available, it is expected that the non-safety related onsite diesel generators would be available for important plant functions”

Further details on the NRC’s position relating to the requirements for offsite power supply and the conditions of prior exemptions permitting only one source of offsite power are contained in Regulatory Guide 1.206, Section C.I.8, Electric Power, and Standard Review Plan NUREG-0800, Section 8.2, Offsite Power System. Regulatory Guide (RG) 1.32, *Criteria for Power Systems for Nuclear Power Plants*, endorses IEEE Standard 308-2001, *Criteria for Class 1E Power Systems for Nuclear Power Generating Stations*, as one acceptable approach to comply with GDC 17.

Issue Description

Some SMRs and advanced reactors are being designed for use in non-traditional applications, such as remote deployment, supply of mission-critical and micro-grid loads at important sites, supply of power during regional blackouts, and supply of non-electricity generation such as process heat and desalination.² These designs may need to have an electric power system that is entirely self-sufficient, in that all of the power sources required to perform safety functions, startup, shutdown and operations will be located on-site. Self-sufficient designs will have independence from the grid, by not relying on power from any offsite source, and may not even be connected to the electric grid at all.

² The requirements for offsite power supply are also related to the NRC expectation that electricity production is part of the applicant’s purpose and need statement. Interim Staff Guidance (ISG) 027, dated 8/25/2014, provides specific environmental guidance for light-water SMR reviews and acknowledges that light-water SMRs may have additional purposes and needs beyond production of electricity. However, the NRC goes on to say that the purpose and need must include the production of electricity. Thus, for technologies that are designed to operate without the need for offsite power supply, there may also be a need to take exception to NRC’s position on acceptable purposes and needs for the project.

Offsite Power Requirements for Small Modular Reactors and Other New Technologies

For example, an SMR project could be proposed, in response to a Federal policy goal, to supply enhanced reliability to a DOE mission-critical facility. In fact, in a recent letter from the Department of Energy (DOE) to the Tennessee Valley Authority,³ DOE expressed the need for more reliable power at DOE and Department of Defense facilities with national security and mission critical activities. DOE stated that SMRs are specifically being considered in response to U.S. Executive Orders directing Federal agencies to take actions regarding reducing greenhouse gas emissions and the ability of these designs to continue operations during widespread and extended loss of the grid. To meet this objective, designs would be required to have the ability to continue to operate in the event of a complete loss of offsite power. Therefore, proposed technologies would need to be designed, and approved by the NRC, to operate without reliance on offsite power for performing safety functions and without the need to shutdown if the grid were no longer capable of supplying power to the nuclear facility. This could only be accomplished with a departure from GDC 17 that permits operation without supply of power from any offsite sources.

Industry Proposed Approach

The regulatory framework needs to be updated in order to clarify how designs that provide reasonable assurance of adequate public health and safety without reliance on offsite power can be certified and licensed. This includes 1) providing clarity to applicants as they develop the principal design criteria related to electrical power, and 2) establishing performance-based criteria that would justify not having a supply of power from any offsite source.

SMRs and other new technologies differ from the water-cooled nuclear power plants for which construction permits have been issued by the Commission in the past. In these circumstances, consistent with 10 CFR Part 50, Appendix A, the GDC would be used as guidance for establishing the principal design criteria. For these designs, a principal design criterion that does not include a requirement for an offsite power source would be considered a departure from GDC 17.⁴ These departures would not require exemptions as contemplated by 10 CFR 52.7 and 10 CFR 50.12. Rather, these departures would be described and evaluated in the application.

A performance based Design Criterion (DC) for electrical power that is more appropriate for SMRs and other new technologies should be established to provide clarity to applicants in developing their principal design criteria. We propose the following SMR-DC, to be used in lieu of GDC 17, for light-water SMRs with enhanced passive safety systems:⁵

SMR-DC 17 – An electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for the electric power system shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences

³ Letter from J.E. Kelley, Department of Energy, to J. Grimes, Tennessee Valley Authority, dated February 17, 2016.

⁴ Conforming departures from GDCs 33, 34, 35, 38, 41 and 44 would also be necessary as they reference offsite power systems.

⁵ Technology specific DC for non-LWR designs has been proposed by DOE (ML14353A248 and ML14353A246). Due to the differences in design and safety-functions between LWR SMRs and non-LWRs, it is not practical at this time to propose a technology neutral DC 17. However, further discussion on the proposed SMR-DC in this paper, and the proposed AR-DC by DOE for non-LWRs may identify the ability to establish a single technology-neutral DC.

Offsite Power Requirements for Small Modular Reactors and Other New Technologies

and (2) the core is cooled and the containment integrity and other vital functions are maintained in the event of postulated accidents. The electric power system shall have sufficient independence, redundancy, and testability to perform its safety functions, assuming a single failure.

In order to provide clarity to applicants on how to demonstrate compliance with the SMR-DC 17, guidance is needed for applicants to develop a technical basis that would justify designs with no offsite power supply. We believe the following proposed acceptance criteria would provide sufficient justification for no offsite power sources for SMRs and other technologies, based on enhanced safety features of these designs. In essence, designs that meet these criteria would be entirely self-sufficient, in that they provide their own power to perform safety-related and other important plant functions, eliminating the need for any offsite power sources. For these designs, the preferred power supply would be from the onsite electrical system. These criteria have been extrapolated from the NRC's basis for previous departures for evolutionary LWR designs that rely on passive safety systems and were approved with only one offsite power source.

1. The performance of safety-related functions (e.g., safe shutdown, core cooling and containment integrity for LWRs) for all design-basis accidents and events, can be performed entirely by passive safety-related systems, without the use of AC power.
2. Any transition of safety-related valves or other safety-related SSCs to their safe state does not rely on AC power.
3. A reliable non-safety-related onsite power system (e.g., batteries, diesel generators) is available to perform other functions important to safety, such as post-accident and pool monitoring, emergency lighting, prevention of unnecessary challenges to the passive safety-related systems, and spent fuel pool cooling.
4. A reliable non-safety-related onsite power system is normally expected to be available and capable of performing important plant functions in all modes of operation (including operations and startup while all onsite reactors are shutdown) without reliance on an offsite power supply.