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Climate Change Spurs Interest in Small Modular Nuclear Reactors

Climate change concerns have helped fuel a nuclear revival and have sparked what has been called an "explosion of interest" in small reactors in the United States, as well as globally. These small reactors, often referred to as small modular reactors (SMRs), were originally envisioned by many to be deployed in isolated locations or in developing countries due to the limited grid capacity in such countries. Interest in deploying SMRs in developing countries remains high, especially in light of climate change concerns and the projected increases in energy demands in developing countries. This strong interest was demonstrated by the recent October meeting of the Global Nuclear Energy Partnership (GNEP) in Beijing. The GNEP, which is comprised of 25 partner and 31 observer nations, has as one of its objectives the development, demonstration and deployment of SMRs and medium sized reactors in developing countries.

In addition, the mounting concerns over carbon emissions and the projected high capital costs of large nuclear reactors have resulted in significant recent interest in deploying SMRs in the United States. This interest is due primarily to two of the advantages that SMRs may offer over large reactors: the shorter construction times and lower capital costs of SMRs, and their potential to be used in cogeneration facilities for process heat for various applications such as chemical production and desalination.

The concept of SMRs is not new. The International Atomic Energy Agency (IAEA) has estimated that globally there are some 50 different designs for such reactors. Although no SMR has yet been commercially established, the IAEA projects that by 2040 there will be up to 1,000 SMRs producing electricity in perhaps 30-40 countries. One U.S.-based company has stated publicly that there is serious interest in more than 100 units of its SMR.

The recent interest in the United States in SMRs is reflected both in the number of companies now pursuing SMRs and by the support, and in some cases public endorsement, of the Department of Energy (DOE), the American Nuclear Society (ANS), the Nuclear Regulatory Commission (NRC) and even Capitol Hill. Several companies have begun pre-application discussions with the NRC regarding the licensing of their SMR designs, which as described below will require adjustments to certain existing NRC requirements.

U.S. Interest in SMRs Increases

After publicly indicating only a year ago its reluctance to address SMR licensing issues [PDF], the NRC in 2009 undertook several initiatives that are predicates to the licensing of SMRs in the United States. Foremost among these was a two-day workshop on October 8 and 9, 2009 with stakeholders to discuss the generic issues associated with the licensing of SMRs. At its workshop, the NRC noted that it will hold additional workshops beginning in early 2010 and will coordinate the formation of an industry group to assist in developing regulations for the licensing of SMRs. Richard Black, of the DOE's Office of Nuclear Energy, emphasized at the conference that DOE is prepared to devote substantial attention to bolstering the development of such reactors, including cost-sharing of research and development and NRC licensing fees. He also announced that DOE will hold a workshop in 2010 on funding opportunities for SMRs. The Nuclear Energy Institute (NEI), which is working with the NRC to form the SMR industry group, also participated in the NRC workshop. In addition to expressing its support for the development of SMRs, the NEI announced that it would be holding an SMR conference in February 2010.

Similarly, in 2009 the American Nuclear Society (ANS), both at its meetings and in the columns of its new president in the ANS newsletter, highlighted the important role of SMRs in the nuclear industry. Several sessions of the ANS biannual meeting this past November, for example, were devoted to the status and licensing of SMRs, plus the theme for the ANS President's Special Session was "Global Opportunities for Right-Sized Reactors". At the meeting, the ANS announced that SMRs will be a focus at its upcoming Annual Meeting in June 2010.

Members of the U.S. Senate also have recently demonstrated their interest in the development and deployment of SMRs in the United States. The following three bipartisan Senate bills to amend the Energy Policy Act of 2005 have been introduced during the past two months:

- Senate Bill 2052, the Nuclear Energy Research Initiative Improvement Act of 2009, was introduced on October 29, 2009 and would provide funding for research on SMRs with the goal of reducing nuclear reactor costs.
- Senate Bill 2812, The Nuclear Power 2021 Act, was introduced on November 20, 2009 and would establish a program to achieve the goal of designing and certifying two SMR designs by 2018 with the SMRs themselves to be operational by 2021.
- Senate Bill 2776, The Clean Energy Act of 2009, was introduced on November 16, 2009 and would mandate a number of nuclear and other clean energy policy initiatives, including funding to support license reviews for SMR designs.

These SMR legislative proposals are in addition to any that may be included in the bipartisan nuclear title being crafted by Senators John Kerry, Lindsey Graham and Joe Lieberman that is to be added to the Senate's climate and energy bill.

SMR Characteristics and SMR Advantages

SMRs are relatively small in power output, on the order of 25 megawatts electrical (MWe) to 350 MWe, as compared to large-scale reactors that can have a power output of more than 1,200 MWe. SMR designs are typically compact and several are integral designs, with the steam generator and pressurizer housed in the same vessel as the reactor. Most designs have inherent and passive safety features. In addition, two of the chief safety risks of large reactors—the buildup of decay heat and breakage of major piping in the primary loop—are of significantly less concern in SMRs. Unlike traditional reactors, some SMRs would be manufactured and assembled at the factory and shipped to the site as a nearly complete unit. Most SMRs also would either require no refueling or have long intervals between refuelings. As a result of these characteristics, SMRs are expected to offer the following advantages:

- Shorter construction times and reduced capital costs due to their smaller size, simpler designs and, in some cases, complete factory assembly.
- The alternative of smaller, incremental additions to baseload electrical production due to their smaller output. Such incremental

additions are often desirable from a financial standpoint or because of reduced transmission costs or grid management concerns.

- The latitude to increase electrical output as needed by installing more SMRs and linking them at a multi-modular site.
- The capability of being cogeneration sources for process heat due to their size and output, safer designs and siting flexibility, including closer proximity to the production or processing facility. The range of cogeneration applications includes desalination, chemical and hydrogen production, petroleum refineries, and the extraction of oil from tar sands.
- More proliferation-resistant safeguards due to their longer refueling intervals and, in some cases, factory assembly and factory-to-site shipment. This proliferation resistance, along with the simplified operations of SMRs, could be of critical importance for the broad deployment of SMRs in developing countries.

For the reasons indicated above, SMRs may serve as ideal power sources for discrete locations that require an uninterruptible source of power independent of the electrical grid. These would include remote locations unconnected to the grid or key military installations. The recently passed National Defense Authorization Act (PL 111-84) requires that a study be conducted on the feasibility of building new reactors at military sites, in part because of the "potential energy security advantages" of not being dependant on the grid in times of war or natural disaster.

NRC Licensing Considerations

Most SMRs are not merely scaled down versions of large-scale reactors, but are new in design, siting, construction, operation and decommissioning. The legal and regulatory issues associated with these units thus are not merely scaled down versions of the issues faced by their much larger brethren. The NRC's new reactor licensing regulations in 10 C.F.R. Part 52 are designed to provide a more streamlined process for new generation large-scale reactors. Some facets of this new process will be equally advantageous to SMRs, while others will range from unnecessarily cumbersome to nearly unworkable when applied to the licensing, construction and operation of SMRs. Creative navigation of the existing regulations by both the NRC and licensees will solve some problems, but others can be solved only by amending the regulations.

For example, under 10 C.F.R. Part 171 the NRC's annual fee to operate each licensed nuclear reactor is $4.5 million, an amount that would pose financial problems for the development of many SMRs. In March 2009 the NRC published an advanced notice of proposed rulemaking that contemplates a variable fee structure based on thermal limits for each power reactor. (74 FR 12735; March 25 2009). This or a similar change will be necessary to make SMRs financially viable. Likewise, the size of the decommissioning fund, insurance and other liability issues could make SMRs uneconomical if not tailored to the smaller units. Moreover, the form of the combined operating and construction license (COL) must take into consideration that certain sites will initially host a single SMR but with the plan to add multiple SMRs later as electricity demand grows. Flexibility is one of the primary benefits of SMRs, and the governing regulatory structure most allow (and preferably embrace) that flexibility, while simultaneously ensuring the safety of these reactors, including any risks from interactions between SMR units at a multi-modular site.

Another issue to consider is that the current Emergency Planning Programs, based on the size of existing large-scale reactors, require a 10-mile Emergency Planning Zone (EPZ) for all reactors. This requirement is almost certainly unjustifiable for an SMR. These smaller reactors are much less powerful, have safer designs and in many cases the actual containment/reactor system will be placed underground. A smaller EPZ is not without precedent. The NRC required only a two-mile EPZ for large-scale reactors prior to the Three Mile Island accident in 1979.

Another aspect of SMRs that will require new, or substantially revised, regulations is the likely combination of the SMR power generation system with the process heat applications in cogeneration facilities. Proper consideration will need to be given to ensuring that potential accidents at the production

or processing portion of the facility do not adversely affect the safe operation of the SMR.

Other characteristics of the proposed SMRs will create unique legal and regulatory challenges, including: import/export requirements for technology, materials and equipment; design certification; operating license restrictions; accident consequence analysis; maintenance programs; environmental programs; safeguards and security; non-proliferation; foreign country regulations; foreign ownership; IAEA standards; Price Anderson Act; insurance and liability; financial qualifications; decommissioning funding; license duration; inspection programs; and staffing, especially for passive operation plants.

Regulatory resources present one of the greatest challenges to a robust SMR program in the United States. The NRC, which has begun pre-application discussions with several SMR companies, is already overburdened working on the licensing of a number of large-scale reactors. Even if the recent congressional interest results in greater funding for SMR reviews by the NRC, the NRC will still need to hire a number of additional personnel to conduct such reviews, a significant challenge in light of the current shortage of nuclear engineers and technicians. DOE has a special and possibly essential role in helping to overcome the regulatory challenges. Encouragingly, DOE has stated that it intends to support the industry's efforts to bring SMRs to domestic markets. Included among DOE's proposed efforts is a cost-share partnership for first-of-a-kind SMR design and licensing that may be initiated as early as 2011. DOE also intends to work with the NRC and the industry to evaluate unique licensing issues for SMRs, and to work on enhancing the regulatory framework and licensing process with the NRC.