The importance of international collaboration and parallel licensing for advanced nuclear reactors

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Executive Summary: Due to the urgent requirement for clean energy technologies to address climate change, advanced nuclear reactor designs have been developed rapidly in recent years worldwide. These designs have a number of advantages over traditional reactors such as significant overall safety and less nuclear waste. However, such first-of-a-kind technologies are facing challenges when licensed through regulatory bodies such as the U.S. Nuclear Regulatory Commission whose current framework is optimized for traditional Light Water Reactors. There is an increasing demand for international collaboration in helping establish a unified licensing framework across regulatory organizations in different countries to facilitate future new builds and increase deployment speed. The possibility of using parallel licensing in the U.S. and in other countries would offer advantages to advanced reactor companies by lowering licensing costs, decreasing financial risks, increasing potential international markets and attracting investors worldwide, and providing reliable and low-carbon energy from nuclear for a cleaner energy future.

I. Introduction

The U.S. Energy Information Administration has predicted that world energy demand will increase 48% from 2012 to 2040. Most of this growth will happen in developing non-OECD (Organisation for Economic Co-operation and Development) nations where economic and population growth and improvements in living standards will result in the largest increases in energy demand.[1] Concurrently, global leaders are also increasingly concerned with reducing carbon emissions to improve air quality and to reduce the effects of climate change, with many governments setting targets for reducing greenhouse gas emissions in line with The Paris Agreement within the United Nations Framework Convention on Climate Change.[2]

Fossil fuels currently provide the majority of the world's energy, but renewables (not including nuclear, hydroelectric, biofuels, or waste) are the fastest growing sector as government policies and incentives are promoting non- and low-carbon technologies.[1] However, energy from renewables remains only a very small fraction (1.4% in 2014) of the total energy production.[3] To quickly address climate change by reducing carbon emissions while reliably meeting increasing world energy demand, particularly in developing nations, nuclear power is a clear choice.[4,5] The baseload nature and high capacity factors of nuclear power coupled to its small footprint, scalability, and independence from volatile fuel costs support nuclear power's important role in sustaining economic growth.

As of mid-2016 some 30 countries were operating nuclear power plants to produce energy, and 58 new reactors were under construction worldwide. The majority are being built in China, but new reactors are also being constructed in Russia, India, and the U.S. amongst others.[6] Most reactors under construction are based on tried-and-tested Light Water Reactor (LWR) technology which account for the vast majority of the world's existing nuclear power plants. A 2014 report by the International Atomic Energy Agency (IAEA) found that a further 33 countries with no existing nuclear reactors are either considering, planning, or starting nuclear power programs for their energy needs.[7]

The new generation of nuclear power plant designs, including Small Modular Reactors (SMRs), has many advantages over traditional early generation power plants. SMRs are defined by the IAEA as being nuclear reactors which provide less than 300 MWe of power in comparison to larger reactors, many of which produce over 1,000 MWe. The SMR designation includes LWRs as well as advanced reactors that do not use water as a coolant.[8] The development of SMRs began in the 1950s to power naval units such as nuclear submarines, and today they are seen as a viable option to be part of the next generation of commercial power plants.[9] SMRs offer a range of benefits over large traditional reactors: such as simpler designs, smaller capital costs, passive safety features, and longer life cycles.[9] Most SMR designs envisage the modules being prefabricated and then transported to the required site, which would allow for a high level of standardization and shorter construction times. Hence they would be more easily integrated into small electricity grids.[9]

Non-LWR reactor designs are less mature and in general are not considered for near-term commercial deployment.[10] However, many different reactor designs are at different stages of development from companies worldwide.[11] LWR-SMR designers face technical challenges in demonstrating economic feasibility and safety without increasing reactor complexity, and non-LWR reactors face greater technical challenges with regards to licensing, construction, testing and operating these first-of-a-kind technologies. Vendors are facing licensing and construction times of a decade or more before the reactor would be operational. Hence there is a need to build worldwide regulatory frameworks to support the licensing of these advanced reactor companies.

II. Challenges with the current licensing process

The U.S. Nuclear Regulatory Commission (NRC) has a two-step process involving issuance of a construction permit and an operating license. After the NRC reviews and is satisfied with the safety of the preliminary plant design and the suitability of the prospective site, the agency issues a construction permit that allows an applicant (e.g. a utility) to begin building a plant. Sometime during construction, the utility submits an application for an operating license, which the NRC issues only if all safety and environmental requirements are met. The NRC's process has been optimized for LWRs, and is widely considered not-workable for advanced reactors.[12] Indeed, advanced reactor designs often use different materials, fuels and coolants, have different safety requirements with regards to emergency planning zones, utilize different emergency core cooling methods and infrastructure and have different fueling needs compared to LWRs. In addition, the initial development and licensing phase of a new design often requires a large investment of funding and resources to develop processes to study and license these designs. Furthermore, the current NRC design certification and license approval process requires large upfront investment for the design company without predictability or transparency with regards to a clear licensing schedule.

In the U.S., four light water SMRs have been developed to the point that the reactor vendors are discussing design certification and license application with the NRC. NuScale, the LWR-SMR design company farthest along in the licensing process, has offered expected timescales for applications and construction. The U.S. Department of Energy (DoE) is also offering support through a cost-sharing agreement with NuScale for design certification. However, due to the opaque and arcane U.S. licensing process, several U.S.-based advanced reactor (non-LWR) companies such as TerraPower and ThorCon have turned to countries with a more welcoming licensing environment for their first reactor. Naturally there must be a balance between the need to license designs cheaply and quickly with well-defined risks and the need for regulatory rigor in assuring the safety and security of designs, environmental impacts, decommissioning costs, etc. This is clearly a continuum that needs to be straddled carefully and often evokes discussion on regulatory capture and the role of the precautionary principle, which can become philosophical.[13]

III. Current efforts to optimize nuclear reactor licensing

In the United States, the Nuclear Energy Innovation and Modernization Act (S.2795) was introduced in 2016 to direct the NRC to develop a modern licensing process based on the current framework by 2018, and a technology inclusive licensing framework by 2023. The goal of this act is to modernize the regulation of nuclear energy, enable efficient licensing of advanced reactors, and to establish a DoE program to provide cost-shared grants to fund a portion of advanced reactor companies' pre- and application review activities during licensing to reduce the cost burden of NRC licensing.[14] Another proposed act in the U.S., the Nuclear Energy Innovation Capabilities Act (NEICA), would amend the Energy Policy Act of 2005 to restructure and modernize the NRC so that advanced reactor designs can be licensed.[15] The Nuclear Innovation Alliance, a nonprofit organization that assembles companies, investors, experts and stakeholders to advance nuclear energy innovation and enable innovative reactor commercialization through favorable energy policy and funding, has also set recommendations for the NRC to restructure their licensing procedure to accommodate advanced reactor designs. It suggests the NRC create a risk-informed, performance-based regulatory process which would allow for consideration of technologies based on function and risk criteria, rather than prescriptive specifications. They also suggest that the government should support allocating resources to develop guidance for advanced reactors to aid reactor designers and create a staged licensing pathway to give vendors early feedback, facilitate commitment of investors, and reduce risks for vendor companies.[16]

Several different organizations are working together to try to standardize nuclear reactor regulation so that each reactor can be ordered by a utility in any country and will meet national regulations without significant adaptation challenges. MDEP (Multinational Design Evaluation Programme) is made up of 15 national regulators from around the world within the OECD-NEA (Nuclear Energy Agency) to combine the resources and knowledge of national nuclear regulatory authorities that will be reviewing new nuclear reactor designs.[17] They have created working groups for specific reactor designs as well as for issue-specific activities (such as a codes and standards working group) to enhance multilateral cooperation within existing frameworks and increase the multinational convergence of codes, standards, guides, and safety goals.[18] However, MDEP is not currently considering advanced reactor designs.[10] CORDEL (Cooperation in Reactor Design Evaluation and Licensing) is a working group within the World Nuclear Association whose primary aim is to promote the achievement of a worldwide regulatory and industry environment where internationally accepted standardized reactor designs can be widely deployed without major design changes (except those dictated by site specific and minor local necessities). They do so by talking to nuclear industry vendors, operators and regulators about the benefits of convergence of reactor safety standards for designs.[19] Other international organizations such as the IAEA and the World Association of Nuclear Operators are also working on setting international standards and recommendations for safety guidance on reactor designs. However, all major work has been focused on LWRs. Although fragmented, competition between these efforts should prove beneficial to the emergence of an eventual consolidated international licensing and regulation framework. As individual countries begin to develop commercial fleets of advanced reactors, this international framework will most likely expand to include advanced reactor licensing. At this point, wide dissemination of advanced reactors will be streamlined.

IV. Need for immediate action

There is an opportunity now for national regulatory agencies, particularly experienced regulators such as the U.S. NRC, Canadian Nuclear Safety Commission, the United Kingdom's Office for Nuclear Regulation, and the Russian Ministry for Atomic Energy and less experienced regulators such as those in China and India, to cooperate in licensing these technologies, which will facilitate future builds and increase deployment speed. Parallel licensing of one design in more than one country simultaneously may help reduce the risks, costs, and time required for licensing and result in design licenses in multiple countries, therefore opening broader markets for these companies. Parallel licensing is a new proposal that advocates moving forward the licensing and commercial deployment of nuclear power reactors, particularly as advanced nuclear reactors reach commercial readiness. To be most effective, parallel licensing requires multiple national regulatory agencies to work together in licensing a reactor design. Cooperation at this level requires a high degree of political interaction with funding from the governments of the national regulators' host countries. There are potentially three main reasons as to why parallel licensing has never been implemented. First, national nuclear regulatory agencies have historically developed with their host countries' nuclear programs (military and civilian) and have since maintained their strong national identities. Second, nuclear activity regulation is also tied to national security interests as well as to the prestige of developing national nuclear science and technology programs and as such countries have preferred to maintain their independence. Third, international engagement necessitates additional cost with a perceived decrease in autonomy which has been considered undesirable. Although challenging, there are nonetheless examples of countries working together on nuclear challenges while their political relationship is otherwise strained, most strikingly between the U.S. and U.S.S.R during the cold war, and given the arguments in the earlier sections of this memo we believe there are strong universal motivations for cooperation despite the concerns above.[20]

To encourage the parallel pursuit of multiple reactor licenses internationally before a common standard is developed, we strongly urge U.S. policymakers to immediately mandate the U.S. NRC (with adequate funding) to reciprocally share information with other nuclear regulatory in an effort to license nuclear power reactor designs in multiple countries at once as well as to begin standardizing reactor safety regulations, in particular for the new generation of SMRs and advanced nuclear reactors. This will be a critical first step in modernizing and revitalizing nuclear regulation within the United States as well as in creating an international nuclear regulation standard to open all energy markets and countries to nuclear power's myriad of benefits. The U.S. NRC, currently considered the "gold-standard" of reactor regulating bodies by many other nuclear regulatory bodies and reactor vendors alike, has a responsibility to lead in this area. While there is currently information sharing between regulatory bodies, when it comes to safety data the U.S. NRC can act as a consulting body to countries who are beginning to structure their regulations.[21] These interactions, however, are "subject to outside funding".[21] By providing funding for these avenues of communications, greater steps towards unification of regulation may be made, leading to a market that allows for a simpler, lower risk, regulatory process which will help improve the implementation of next generation reactors around the world.

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