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U.S. Regulatory Perspectives on High-Temperature Gas-Cooled Reactors

Remarks by The Honorable Peter B. Lyons
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It is my great pleasure to have been invited to join you today and to provide some thoughts on the past, present, and possible future activities of the Nuclear Regulatory Commission with respect to gas-cooled reactor technology. Before I begin, I must stress that my remarks today are my own personal thoughts and not necessarily those of the entire Commission.

Today I have several key messages for you, but also one challenge question. We'll get to my key messages momentarily, but let me pose my question to you first.

There are a number of so-called "grand challenges" in science. For example, recent news regarding the Large Hadron Collider at CERN has created excitement among nuclear physicists that its first experiments might find the hypothetical and elusive Higgs Boson to finally verify the Standard Model. Not in any way to diminish this grand challenge, I also believe that the challenge that lies before you is equally exciting, with potentially greater near-term practical benefit.

To frame my challenge question, let me take you back to the year 1961. In that year, with tremendous scientific, intellectual capability at our disposal and motivated by the Russians' early success with their Sputnik satellite, President Kennedy energized the best scientific and engineering minds of our nation when he asked, "What will it take to put a man on the moon in 10 years?" Some 20 years later, our nation was poised to take advantage of the leading wave of what rapidly became unprecedented advances in computing technology. It was then that Bill Gates energized his relatively new startup company by asking, "What will it take to put a computer in every home?" Thus, the grand challenge of the 1960s and beyond has been to explore space, and the grand challenge of the 1980s and beyond has been to build a global information network.

I believe that one of the greatest challenges of the 21st century will be to create additional safe, secure, and environmentally sound energy sources. What I see before me in this room today are representatives of a tremendous scientific and engineering capability. Further, we as a nation

and a world have become highly motivated toward this energy challenge. Finally, we are poised on a leading wave of technology advances that hold the promise of realizing new energy sources. So my challenge question for you is this: "What will it take to build a low environmental impact nuclear energy source so safe and secure that it would require little or no offsite emergency response?" This is not an unreasonable goal for this audience. In addition, included in this challenge is the notion of developing new nuclear fuel cycles that reduce environmental impact by reducing, reusing, and recycling nuclear fuel and waste. This goal, I would argue, rivals those I just described in importance to global peace and well being.

I'll now turn to discussion of three key messages. As I begin, I stress that as a Commissioner with the NRC I am not an advocate for any particular reactor technology, including high-temperature (gas-cooled) reactors (HTRs). Rather, I am coming from the perspective of NRC's regulatory mission of safety, security, and protection of the environment. The first step in achieving this mission, of course, is that *you* must bring together many technical disciplines and synergistically optimize safety, security, and environmental impact. You are the technical experts in the materials, thermal-hydraulics, reactor physics, and other technical specialties that must work together in harmony. I urge you to continue and expand your collaborations with others, both within and outside of your specialty, both nationally and internationally, and constantly consider these big-picture goals in your work. I recently noted that a 2007 OECD Nuclear Energy Agency study of nuclear safety research stated, "Due to the importance of fuel performance to (HTR) safety, the long lead time and the cost of fuel testing, this is one area where international collaboration should be strongly considered." In this vein, I have had two opportunities to tour both the HTR facilities in Tsinghua, China, and Tokai, Japan. Although I don't know how initial efforts at collaboration are advancing, based on my visits and strong South African and U.S. interests, there are plenty of opportunities. As a Commissioner I have been a consistent advocate of such collaborations, across all of our technical and regulatory disciplines.

You have many technical challenges still ahead, but the HTR technology has some promising safety characteristics. Collaborate throughout the design process to ensure such characteristics are optimized and validated. This is my first key message.

Second, I challenge each of you to reflect occasionally on your work from the perspective of the NRC and other nations' regulators. The NRC will look objectively at the technical aspects of each submitted design that we accept for review. We will render our safety judgments based on sound science and an appropriate validation of your safety analyses. However, you must first provide the information that demonstrates the NRC's requirements are met. The NRC will provide an independent review, and you should be prepared to answer our questions with solid rationale and relevant data where appropriate. Where uncertainty exists, in your data or analyses, be prepared to clearly demonstrate how designed safety margins account for such uncertainties.

I urge you to appreciate the overall value in having an objective, technically competent, and independent regulator like the NRC involved in oversight of nuclear issues in each of your countries. The NRC works hard to ensure our regulations are clear, realistic, and risk-informed. This has created a relatively stable regulatory framework that enables the benefits of nuclear technologies while providing the necessary assurances to the public that its health and safety and the environment are being protected. So I strongly encourage you to 'begin with the end in mind' by considering the regulatory process from the start and be prepared to support it.

Third, carefully consider and improve your public communication efforts. The NRC maintains and values strong public information and outreach processes that provide public input to our decisions. It appears to me that today's public is interested and open to new energy solutions. That means that you potentially have a receptive audience for your work and your message. How and what you communicate in that message will be crucial in determining your ultimate success. You must not forget that public support is a necessary pre-requisite for enabling Congressional and financial support for your work.

As Admiral Rickover once said, "The professional person's standing in the community depends, in the final analysis, on the public's insight of his work, that is, on the educational level of the man in the street. When specialized knowledge of professional people is incomprehensible to the average man, he is apt to flounder between frustrated suspicion and excessive awe, leading him either to interfere unduly with professional independence or to accept naively every claim made by anyone who calls himself a professional."

As you might expect, the NRC also gets a lot of input from Congress as well as the public. In the Commission's environment, technical arguments understandable only to specialists are not sufficient. And by way of a compliment, I note that your efforts to communicate with the U.S. Congress are showing results in that the Members have provided significant budget increases for Next Generation Nuclear Plant (NGNP) activities in recent years.

We must all communicate in clear and direct terms how safety and security will be achieved. As an example, one of the Generation IV International Forum Safety Goals for "Gen IV" nuclear energy concepts is to "eliminate the need for offsite emergency response." From a safety improvement perspective, this is a worthy goal and one that I drew from to formulate my challenge question. However, current NRC regulations and policy require emergency preparedness to continue as an important element of defense-in-depth. I believe that, from a safety perspective, it can be appropriate to support the goal of eliminating the need for offsite emergency *response*, while still requiring some degree of emergency *preparedness*. Being clear and direct on this point would ensure that the public recognizes that defense-in-depth, that is, a "multi-layered" approach to safety, continues to underlie our requirements, even as the potential hazards of nuclear technology continue to be reduced. In the future, the Commission may consider modifying our requirements for advanced reactor designs regarding the size of the emergency planning zone or the emergency preparedness requirements. If that occurs, I am quite sure it would inspire a great policy debate with input from many stakeholders.

Another example of the need for clear communication with the public is in being careful with what you promise. Touting any reactor design as unconditionally "meltdown proof" or "inherently safe" invites skepticism and debate, and this has already begun, for example, with the PBMR. This particular debate is closely tied to the question of whether a leak-tight containment structure is necessary for such reactor designs. Whether any particular reactor design is safe *enough* to remove the requirement for a containment is, for the NRC, a question related to our defense-in-depth policy, and one that the Commission has not yet decided. Therefore, I make no judgment on it now. However, to help address defense-in-depth questions such as containments and emergency preparedness requirements, last year, the Commission directed the staff to draft a policy statement on defense-in-depth. I am hopeful that the Commission will approve a draft policy statement for public comment early next year. In any case, I agree with my former colleague on the Commission,

Jeff Merrifield, who, speaking two years ago at the 3rd International Topical Meeting on High-Temperature Reactor Technology, stated that "in the United States. and possibly much of the world – particularly in a post-9/11 security posture – the notion of building a nuclear power plant without a containment structure would engender a significant public policy debate."

Recapping my main points so far, I challenged you with the question, "What will it take to build a low environmental impact nuclear energy source so safe and secure that it would require little or no offsite emergency response?" I also provided some thoughts on how, in part, this could be answered. These were: strengthen collaboration among technical fields and across geographical boundaries, support the regulatory process, and work to improve your public communications.

I'd like to turn now to give you a brief update on NRC's activities, starting with the NGNP initiative. I'm pleased that the Commission and the Department of Energy (DOE) have recently submitted to Congress a joint licensing strategy for the NGNP. This strategy takes advantage of the 10 CFR Part 52 licensing process. In large measure, Part 52 is a process regulation and refers to our Part 50 technical requirements that were primarily based on the light-water reactor designs that comprise the current operating plants. However, many of these Part 50 technical requirements will be useful for an HTR design. New regulatory requirements to address unique aspects of the NGNP technology and design will be established using deterministic judgment and analysis, complemented where appropriate by NGNP-specific probabilistic risk assessment (PRA) information. The initial use of PRA can only be commensurate with its initial completeness and quality, which would be expected to improve as NGNP technology is demonstrated and more data become available.

The aggressive and many say optimistic, schedule to achieve the Congressionally mandated NGNP fuel load and operation in 2021 will require full funding in accordance with NRC and DOE budget requests and a continuing high priority. The licensing strategy requires an applicant to submit a combined construction and operating license application (COL) but does not require the use of a Part 52 Standard Design Certification. Instead, the COL application must contain final design information at a level of detail sufficient to resolve all safety issues, equivalent to a design certification application.

Based on our ongoing reviews of the first LWR COL applications already submitted under Part 52, much has been and continues to be learned about the level of detail necessary for a COL and of the importance of finalizing the design early in the process. I anticipate that these lessons will apply equally to the NGNP. To ensure that the NRC has sufficiently detailed information for review, the licensing strategy requires DOE to choose a single design no later than March of 2009 and submission of a high-quality COL application by 2013.

Also, as the National Research Council recently pointed out in its 2007 review of DOE's Nuclear Energy Research and Development Program, "the current disconnect between the base NGNP program plan and the complementary public/private partnership initiative must be resolved." In other words, a public/private partnership either must be established to coordinate all the program elements, or DOE may need to consider alternatives such as a smaller industry contribution or a more basic technological approach. The NGNP joint licensing strategy itself does not intrinsically require a public/private partnership and, theoretically, it could be accomplished by DOE without a public/private partner. However, even in the best case scenario with an adequately funded public/private partnership, the greatest technical challenge to meeting the schedule appears to be the fuel and materials testing necessary to validate the analytical codes and models.

If this experimental work and demonstration testing does not sufficiently conclude in time to support the intended schedule, the joint licensing strategy offers options for the applicant to add compensatory measures to address the remaining uncertainties. Such measures may include things like supplemental safety or containment systems (perhaps for the initial full-scale test unit), or process limitations like a staged startup with data collection at various power levels for confirmation of analyses, or other limitations imposed on operations. The important point here is that options exist for NGNP licensing and construction to proceed without fully completing long-term fuel or materials testing. However, I feel the need to emphasize that under a Part 52 type licensing process, the staff needs to have enough information to reach a safety conclusion that supports operation prior to the issuance of the COL. In the absence of some information, the proposed application must adequately compensate through additional physical measures or operational limitations.

The NRC has also reported to Congress our need to identify critical skills and develop the necessary hiring, training, and qualification processes to close the gaps. In addition, we will need to develop regulatory guidance, standard review plans, codes and standards, and oversight and inspection processes that are unique to the NGNP. I have been a consistently strong advocate for appropriate experimental validation of NRC's licensing codes and models. We will perform regulatory research, where necessary, to independently confirm significant aspects of the applicant's analyses and possibly our own codes and models in areas to include thermofluids, neutronics, accident analyses, fuel behavior, fission product transport, and high-temperature materials and structural analyses. Research is also being conducted by the DOE. To ensure that such efforts are coordinated, the NRC and the DOE have a Memorandum of Understanding to assure that research activities are coordinated and results are shared.

There are also likely to be several policy issues that the Commission will need to resolve prior to NGNP licensing, and those decisions may require additional regulatory infrastructure development. These issues will likely include the required degree of defense-in-depth measures (including containment and emergency preparedness), the extent to which PRA insights can be used, and the source term for assessing whether design basis dose criteria will be met. As you can see, we have our work cut out for us.

I have already noted my strong support for international collaboration, including regulatory research. The NRC has been and continues to be very active in this regard. We have ongoing interactions with the AVR (Arbeitsgemeinschaft Versuchsreaktor) and THTR (Thorium Hochtemperaturreaktor) research projects in Germany, the prismatic HTTR (High-Temperature Engineering Test Reactor) in Japan, and the pebble bed HTR-10 (10 MWe High-Temperature Reactor) in China. One of the goals of this interaction is to gain access to international operating experience, data on fuel and fission product behaviors, and research on materials. We have collaborated with the members of the European Commission's "Raphael Project" and are exploring future collaboration in this area. We participate in coordinated research project meetings under IAEA, including code-to-code and code-to-data validation of data from the ASTRA advanced gas reactor at the Kurchatov Institute in Russia and from the gas reactors in Japan and China. We work closely with the Republic of South Africa regulator, NNR, to exchange information on PBMR licensing in that country. Finally, we are working with the OECD Nuclear Energy Agency to develop cooperative research programs.

Again, I will continue to remain a strong supporter of such collaboration, among both industry and regulatory counterparts, to share knowledge and cost burdens and to compare and exchange good practices. In facing global challenges, global collaboration has become a necessity.

Before closing, I'd like to note that the NRC has other vendors with innovative small reactor designs knocking at our door. These include the Toshiba 4S sodium-cooled fast reactor, the Hyperion hydride reactor, the Westinghouse IRIS reactor, and the NUSCALE reactor. Our Advisory Committee on Reactor Safeguards recently reviewed NRC's research programs and commented that, for such new designs, the uncertainty in whether these applications would ever be submitted makes it very difficult to assign priority and allocate NRC resources for the relevant research needs. In addition, although a vendor might ultimately submit an application, current Commission policy gives priority to applications that have a corresponding domestic applicant for a COL. Thus, in a budget-constrained environment, these innovative small designs, with the exception of the Congressionally mandated NGNP, are at the bottom of the NRC's priority list.

It is interesting to note that, in 1964, the U.S. Atomic Energy Commission developed a small pamphlet, one of a series, entitled "Power Reactors in Small Packages." At that time, a lot of thought was being given to (and in some cases actually produced) portable reactors for remote location service such as polar exploration and radar stations and for disaster recovery operations. Although we all know that the history of such power plants was very short, these ideas are now being re-generated, revitalized by advancing technology and a continuing need.

Although strong NRC attention is currently on supporting the NGNP, I, as one Commissioner, continue to support NRC's funding to keep alive an advanced reactor research program to preserve our capability to license these advanced technology designs that may hold promise for improved safety and security.

My interest prior to joining the Commission, and now, is that HTR technology be seriously evaluated and, if the apparent promise can be realized in commercial-scale units with adequate safety, proceed with demonstrations that can lead to a strong licensing case and possible commercial use.

To close, I'll remind you of the challenge I have laid before you: to collaborate extensively, to consider the regulatory process from the start, to improve your public communications, and to keep safety, security, and low environmental impact foremost in your thoughts as you go forward.

I've enjoyed talking with you today and, my schedule permitting, I hope to continue to engage you in further dialog over the duration of the conference.

Thank you very much, and I hope you have a productive and enjoyable conference.