POLICY ISSUE
(INFORMATION)

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FOR: The Commissioners

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SUBJECT: LICENSING AND REGULATORY RESEARCH RELATED TO ADVANCED NUCLEAR REACTORS

PURPOSE:

To provide the Commission with (1) information regarding the staff's current licensing, technical review, and regulatory research activities associated with advanced reactors, (2) an update on industry projections as to when advanced reactor designs will be submitted to the U.S. Nuclear Regulatory Commission (NRC) for licensing reviews, and (3) the staff's plans to develop programmatic and organizational strategies that will position the NRC to effectively and efficiently support the licensing and technical reviews that are anticipated for advanced reactor designs.

SUMMARY:

The NRC staff is currently assessing how to respond to an increasing number of requests from potential advanced reactor applicants and vendors, as well as the U.S. Department of Energy (DOE), to initiate preapplication interactions and potentially conduct licensing reviews of their planned applications. The designs involve high-temperature gas-cooled reactors (HTGRs), a helium-cooled very-high-temperature reactor (VHTR), sodium-cooled fast reactors (SFRs), a potassium-cooled hydride reactor, and small light-water reactors (LWRs).

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The NRC Office of Nuclear Regulatory Research (RES) was in charge of conducting the project management and technical interactions for the preapplication reviews of non-LWR advanced reactors, with support by the Office of New Reactors (NRO) and other offices on a limited basis. The interactions and requests from vendors and DOE for the Next Generation Nuclear Plant (NGNP) program are related to licensing, technical, policy, and safety research issues associated with the licensing of these designs. These interactions are expected to transition from the preapplication review phase to a licensing application review phase in the next few years and become focused on licensing review and policy issues. Accordingly, the staff is realigning the licensing project management responsibilities for current preapplication interactions to NRO and focusing RES efforts on the technical aspects of preapplication reviews and on NRC research and development (R&D) activities, as documented in the Advanced Reactor Research Plan (ARRP), needed to support the staff's technical review of licensing applications for these next generation reactors. RES will maintain lead responsibility for developing and documenting the NGNP licensing strategy.

In fiscal year (FY) 2008, NRO assumed licensing project management responsibilities from RES for non-LWR advanced reactors and continues to be responsible for small LWRs under the Advanced Reactor Program (ARP). Centralizing the licensing and project management responsibilities in NRO will enhance the scheduling of preapplicants and license applicants for these plants, as well as for addressing policy issues that will need to be addressed for these designs. Although the uncertainties associated with specific advanced reactor projects remain high, numerous indications of interest in non-LWR advanced reactors continue to surface and the staff expects that the ARP will need to grow over the next several years.

Based on current projections, in FY 2009, the staff foresees creating an Advanced Reactor Project Directorate that will report directly to the NRO Deputy Office Director. The current plan is that the organization will be led by a Senior Executive Service (SES) manager and expanded to two branches if the workload materializes. One Branch will be responsible for project management and policy functions, and one responsible for technical review work. In FY 2010, the staff anticipates that the directorate could grow into a division (e.g., the Division of Advanced Reactors) if necessary to support an increased workload. The specific resource needs for the organization will be developed during the FY 2010 budget process. The evolution of the ARP as a standalone organization within NRO will minimize adverse impacts on ongoing and near-term LWR reviews.

Additionally, based on its current assessment, RES anticipates that it will need to increase the focus, priority, and level of resources directed at the ARRP in order for the NRC to establish its technical review infrastructure, including independent analysis capabilities, for the anticipated non-LWR applications in the timeframes that they will be needed. The current priority is on developing the technical review infrastructure, including independent analysis capabilities for HTGRs and VHTRs. During the FY 2010 budget process, RES will develop the specific resources that will be needed to effectively implement a complete R&D plan associated with the ARRP. RES will also further assess the need for additional resources to effectively implement the ARRP in the required timeframes and communicate the results to the Commission.

BACKGROUND:

Since 2001, a range of advanced reactor designs and technologies has emerged. The NRC expects to receive applications for staff review and approval of these designs as early as FY 2010. These include (1) a licensing application for construction of a VHTR in connection with the NGNP project established by the Energy Policy Act of 2005, (2) a design approval application and possible combined license application for the Super-Safe, Small and Secure (4S) SFR, (3) a design certification application for the Pebble Bed Modular Reactor (PBMR), and (4) a design certification application for the International Reactor Innovative and Secure (IRIS) design. Other advanced reactor design development activities could lead to the submission of additional applications to the NRC sometime in the next 10 years. These could include (1) a license application for a commercial SFR, known as an advanced burner reactor (ABR), as part of the Global Nuclear Energy Partnership (GNEP), (2) a potential license application for a low-power HTGR, known as the High-Temperature Teaching and Test Reactor (HT3R), (3) a potential manufacturing license application for a small uranium hydride-fueled, potassium-cooled reactor, known as the Hyperion reactor, (4) a potential manufacturing license application for the Safe and Green nuclear plant, and (5) a potential licensing application for the Multi-Application Small Light-Water Reactor (MASLWR).

Additionally, by Staff Requirements Memorandum COMSECY-05-0024, "FY 2007 Budget Proposal," dated August 19, 2005, the Commission directed the staff to begin developing the technical and review infrastructures for licensing HTGRs and, to a more limited extent, SFRs. Accordingly, on April 9, 2007, the staff issued the draft NRC Advanced Reactor Research Plan (ARRP), which focused on the safety research that the NRC will need for the review and licensing of HTGRs, such as the PBMR, the Gas-Turbine Modular Helium Reactor, the HT3R, the NGNP VHTR, and (to a limited extent) SFRs (such as the Toshiba 4S reactor and the GNEP ABR). Since that time, the staff has begun limited implementation of selected high-priority research tasks documented in that plan.

In order to provide an initial assessment of the potential increased resource requirements to support the licensing activities under the ARP, the staff considered the schedule for NGNP and the expressions of interest by vendors for advanced reactors and small LWRs. The staff developed proposed work priorities based on the information obtained from industry and DOE. Preliminary resource estimates for the ARP licensing activities are taken from SECY-01-0188, "Future Licensing and Inspection Readiness Assessment," dated October 21, 2001 (hereafter referred to as the FLIRA report).

DISCUSSION:

The Commission's Statement of Policy on the Regulation of Advanced Nuclear Power Plants (59 *Federal Register* 35461; July 12, 1994) encourages the earliest possible interaction between applicants, vendors, other government agencies, and the NRC to allow early identification of regulatory requirements for advanced reactors and provide a timely independent assessment of the safety characteristics of advanced reactor designs. The Commission's policy statement also indicates that the Commission intends to develop the capability for timely assessment and response to innovative and advanced designs that might be presented for NRC review. In this

regard, the Commission's policy statement further explains that NRC research is conducted to provide the technical bases for rulemaking and regulatory decisions, support licensing and inspection activities, and increase agency understanding of phenomena for which analytical methods are needed in regulatory activities.

Description of Current Activities

Consistent with the Commission's policy, potential applicants for advanced reactor designs (both LWRs and non-LWRs) have requested preapplication discussions with the NRC staff. These interactions introduce the proposed designs to the staff and allow discussions with potential applicants about licensing, technical, policy, and safety research issues associated with the licensing of these designs. The staff has met with potential applicants on a selected basis and conducted limited technical reviews of advanced reactor designs when mandated by statute, when directed by the Commission, or when priorities and resources allowed. In addition, in recognition of the anticipated applications, the staff has drafted and begun limited implementation of the ARRP to support the effective and timely review of several of these designs. However, because of limited resources allocated in the FY 2008 budget for advanced reactor activities, the staff has not conducted the level of interaction or review requested by the vendors during the preapplication periods to address these issues for the advanced reactor designs.

Several potential applicants have indicated that they wish to increase their interactions with the staff early in the design development process or are planning to submit a licensing application within the next several years. However, the staff has not committed to conduct many of these activities because of other higher priorities and limited resources, including limited staff expertise with these new and innovative designs. As a point of reference, the FLIRA report estimated that preapplication discussions for a reactor such as the PBMR would take approximately 11 full-time equivalents (FTE) and $1 million in contract assistance, and the review of a combined license application for a PBMR would take approximately 120 FTE and $8.5 million in contract assistance over a 33–60 month review period. This includes approximately 33 FTE and $4.5 million for RES to develop the tools and data needed for the PBMR licensing review. These estimates will need to be reassessed for each of the advanced non-LWR plants. For example, the staff expects that a substantially more comprehensive and detailed preapplication review will be needed for NGNP than for PBMR to meet the schedule constraints for NGNP licensing. It is important to note that given the lead time required for technical tool development, the staff would not be able to develop independent technical tools before the currently projected review of a PBMR design certification application in early FY 2010.

The following advanced reactor activities are currently under discussion or in progress, and are discussed further in the enclosure to this paper:

- HTGR and VHTR Review Activities
  - NGNP licensing strategy development
  - NRC active participation in the NGNP project
  - NGNP preapplication review
  - NGNP licensing application review

- PBMR preapplication review
- PBMR design certification review
- HT3R preapplication discussions

- Sodium-Cooled Fast Reactor Review Activities
  - GNEP ABR regulatory gap analysis
  - NRC interactions with DOE on the GNEP ABR
  - 4S preapplication review
  - 4S design approval review
  - Galena, Alaska 4S site suitability preapplication review

- Hydride Reactor Review Activities
  - Hyperion preapplication communications
  - Hyperion manufacturing license review

- Small Light-Water Reactor Review Activities
  - IRIS preapplication review
  - IRIS design certification review
  - Safe and Green reactor preapplication communications
  - MASLWR preapplication communications

- Advanced Reactor Technical and Review Infrastructure Development Activities
  - HTGR and VHTR technical and review infrastructure development
  - SFR technical infrastructure needs assessment and development

Advanced Reactor Program

Although the staff has met with potential applicants and conducted limited technical reviews of certain future reactor designs, these interactions have been limited to those mandated by statute, when directed by the Commission, or when priorities and resources allowed. The staff is establishing the ARP to conduct these interactions in a more focused, integrated manner. NRO will serve as the primary focal point for these future reactor reviews and will rely on technical support from RES and other offices. NRR will serve as the primary focal point for future test and research reactor reviews. Significant contractor technical support will also be needed to effectively implement the program.

The staff is establishing the ARP at this time because some of the advanced reactor licensing applications are projected to be submitted in 2–3 years and potential applicants are increasingly requesting preapplication interactions with the staff to allow for the early identification of policy and key technical issues and safety research needs for licensing their specific designs. The staff believes that increasing the attention of NRO and supporting offices to these future reactor designs will serve to (1) allow the technical review staff sufficient time to become familiar with advanced reactor design concepts, (2) provide timely and consistent feedback on key design, technology, safety research, and licensing issues, (3) identify interrelated or cross-cutting regulatory safety issues, such as GNEP reprocessing/recycling impact on the ABR safety basis,

(4) begin identifying reasonable resolution paths for these key issues, (5) begin identifying technical skills necessary to review these designs and, as appropriate, hire staff and identify potential contractors who possess the requisite knowledge, skills and abilities, and (6) enhance the effectiveness and efficiency of ARRP activities. The staff believes that the NRO infrastructure and its policy and licensing expertise related to Title 10 of the *Code of Federal Regulations*, Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," (10 CFR Part 52) makes it the logical center for ARP development and implementation. This realignment allows RES to focus primarily on developing the needed technical and analytical infrastructure documented in the ARRP and also allows the Office of Nuclear Reactor Regulation to remain focused on regulatory activities for current operating power, test, and research reactors. However, based on prior reviews of non-LWR preapplications and licensing applications (e.g., Power Reactor Innovative Small Module, Modular High-Temperature Gas-Cooled Reactor, Clinch River Breeder Reactor), the staff believes that RES staff and contractor expertise will be needed to supplement review resources for the licensing of advanced reactors. In addition, other offices will also need to participate in advanced reactor reviews to address issues such as fuel cycle, high-level waste, security, and emergency preparedness.

It is the responsibility of applicants to conduct the research and provide the data needed to support their safety case, including the technical basis for the safety analysis of the particular design under licensing review. However, the non-LWRs currently under discussion employ technologies that are significantly different from LWRs. Most of the tools and data needed to conduct the NRC's independent analysis will either have to be updated or developed and will require long lead times. This will include using experimental facilities worldwide, and may require building new experimental facilities to provide the data needed to develop and validate NRC models. In the ARRP, the staff identified the tools and data that will be needed to license HTGRs and VHTRs and conducted an initial limited-scope survey of the infrastructure, including the technical areas for tools and data that will be needed to review an SFR license application. To avoid duplicating applicant research, NRC independent tools and data will be identified once the staff completes its assessments of an applicant's research program so as to capitalize on its test facilities to develop any additional data that the staff may need for codes assessment. In addition, upon budget availability, the staff will enter into national and international collaborations to acquire needed tools and data in a cost-effective and timely manner.

Organizational Strategy

NRO is currently positioned as the lead for licensing new reactors under 10 CFR Part 52. In addition, NRO has successfully established its corporate infrastructure, organizational culture, and project management tools to manage the resources (FTE and technical assistance funds) needed to plan, project manage, and execute the technical work required to certify multiple LWR design certifications and issue combined licenses. NRO is unique in that it has the primary responsible for policy development and determinations related to 10 CFR Part 52. The current NRO philosophy and corporate model for licensing new LWR reactors can be readily adapted to certify advanced reactor designs and license them accordingly.

RES has established plans to conduct the regulatory research needed to support the technical review and licensing of HTGRs and VHTRs through implementation of the ARRP and the planned development and implementation of a regulatory research plan for SFRs. Successful implementation of these plans will require adequate resources between FY 2008 and FY 2012.

Staff is proposing the following organization and program development strategy.

FY 2008

NRO is assuming the licensing project management activities from RES for non-LWR advanced reactors and continues these activities for small LWR reactors. Total NRO resources dedicated to supporting advanced reactor work in FY 2008 will be approximately 4 FTE given staff availability. RES will continue to provide technical support for preapplication discussions and could, following the realignment of project functions, focus more of its attention on the ARRP. Total RES resources assigned to ARRP activities and support for advanced reactor review activities will be approximately 5.8 FTE and $3.2 million for contractor support. Because of the long lead time required for the development of codes and data, RES would need an additional 8 FTE and $1 million in FY 2008 in order to initiate the research required to be prepared for an NGNP design certification application in FY 2013.

In support of this transition and implementation of the ARP, NRO has adopted the following guiding strategies for integrating this program into its organization:

- Project management and technical resources will be dedicated to the program.
- Resources allocated to LWR licensing and technical reviews will not be diverted to support advanced reactor licensing and technical review activities. However, available NRO technical staff will be used as appropriate.
- Current corporate infrastructure (i.e., project planning and scheduling, contract planning and management, and other support functions) will be used to support the program.
- NRO environmental expertise will be leveraged for the review of reactor sites.
- LWR construction and vendor inspection programs can be adapted to support inspections of advanced reactor component and plant construction.
- Region II infrastructure and inspection resources can be leveraged for construction and component manufacturing oversight for advanced reactor facility aspects that are similar to LWRs.
- NRC headquarters and regional expertise will be used for developing inspection methods for construction and component manufacturing oversight for advanced reactor facility design and technology aspects that are new and unique to specific non-LWR designs.

FY 2009

If current projections and schedules for advanced reactors hold, NRO envisions that the initial advanced reactor organization (Advanced Reactor Project Directorate) will, if resources are available, consist of an SES manager and two branches reporting directly to the NRO Deputy Office Director. Resources for the directorate will include 15 FTE and $4 million in technical assistance funds. The directorate would engage in the following work activities:

- development of FY 2010 organizational framework and program-required infrastructure (management structures and staffing requirements)
- interactions with potential applicants and liaison with DOE
- development and resolution of policy issues
- evaluation of regulatory issues and possible licensing strategies
- development of program roles and responsibilities
- coordination of technical reviews and confirmatory research requests
- coordination/communication with the Commission, the Office of the Executive Director for Operations (OEDO), and other NRC offices related to program development and resource growth plans to meet FY 2010 program objectives

Additionally, RES envisions that the staff and contractor support needed to implement the ARRP for HTGRs and VHTRs will need to increase significantly if the regulatory research to support the licensing review of the non-LWRs is to be completed in time to support projected licensing activities. For example, for the NGNP licensing strategy alone, RES estimates it will need 8 FTE and $8 million to develop the analytical tools and conduct other R&D to support the NGNP licensing review. Similar resources will also be needed to develop the analytical tools and to conduct other related R&D to support the licensing review of SFRs. In addition, resources estimated for RES technical support to advanced reactor preapplication reviews in FY 2009 are approximately 8 FTE and $1 million.

The NRC's FY 2009 budget request does not reflect the above-mentioned resources in support of needed ARP activities. The current Office of Management and Budget (OMB) Passback necessitates pushing back FY 2009 licensing review application workload plans by approximately 8 months. Therefore, NRO cannot reallocate currently budgeted resources to support advanced reactors. In addition, given the new technology involved in advanced reactors, the agency should consider reevaluating the relative priority of related activities. For example, the long lead-time research that is necessary to allow for the licensing of the advanced reactors may be more important than low-priority research to support other agency programs. Without additional funding for the review of and for the preparation of needed infrastructure for advanced reactors in FY 2009, the staff's ability to conduct meaningful

preapplication interactions will continue to be very limited, resulting in preapplication activities being pushed out to FY 2010.

FY 2010

Depending on the work and the resources being committed to the ARP, NRO and RES will continue to develop the resources they need to support the program in FY 2010. Predicated on the workload materializing, staff predicts that the creation of a new division, which includes both licensing and technical review responsibilities for the non-LWR and LWR advanced reactors, will be the most effective and efficient organizational solution for NRO and ultimately the NRC.

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As the staff continues to acquire information regarding industry plans to submit licensing applications, specific resource needs will be honed and incorporated within the FY 2010 budget request. Based on current projections, the resource needs will continue to grow beyond FY 2010 and the agency may need to consider additional organizational changes (e.g., creation of a new office) if the advanced reactor projects proceed as currently anticipated and LWR activities also continue to expand.

RESOURCES:

For FY 2010 and beyond, the staff expects that the workload for NGNP, interactions with prospective applicants, and applications for design certifications will result in an increase in the resources needed for advanced reactor activities. Although the specific schedule for some of the interactions involves a high degree of uncertainty, the overall program will likely grow in FY 2010 and continue to grow for several years thereafter. The staff, as part of the FY 2010 budget formulation process, will develop its resource estimates for the ARP. The estimates will build upon those described in the FLIRA report, a recent assessment prepared by RES, and the planning assessment to be undertaken as part of the ARP.

CONCLUSION:

The staff is currently realigning roles and responsibilities to implement the ARP. The ARP includes project management and overall coordination by NRO and allows RES to focus primarily on developing the needed technical and analytical infrastructure documented in the ARRP. The staff will perform a planning assessment and make recommendations to the Commission regarding the direction and resource needs for the program, including possible revisions to plans for FY 2009. The planning assumptions and budget estimates submitted for FY 2010 and beyond will also reflect the need for increasing ARP resources.

COORDINATION:

This paper has been coordinated with the Office of the General Counsel, which has no legal objection, and with the Office of the Chief Financial Officer.

We request that this document be withheld from public disclosure because it contains predecisional information and information related to staff resources and the potential for contracting actions.

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Enclosure:
Licensing and Regulatory Research
Related to Advanced Nuclear Reactors

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Licensing and Regulatory Research Related to Advanced Nuclear Reactors

I. Introduction

Since 2001, a range of advanced reactor designs and technologies have emerged that may be submitted to the U.S. Nuclear Regulatory Commission (NRC) within several years seeking certification of a design, a manufacturing license, or as part of a combined license application. These include (1) a licensing application for construction of a helium-cooled very-high-temperature reactor (VHTR) in connection with the Next Generation Nuclear Plant (NGNP) project as established by the Energy Policy Act of 2005 (Public Law 109-58, hereinafter referred to as the EPAct), (2) a design approval application and potential license application for a sodium-cooled fast reactor (SFR) known as the Super-Safe, Small and Secure (4S), (3) a design certification (DC) application for a high-temperature gas-cooled reactor (HTGR) known as the Pebble Bed Modular Reactor (PBMR), and (4) a DC application for a small-scale advanced light-water reactor (LWR) known as the International Reactor Innovative and Secure (IRIS). In addition, other advanced reactor design development could lead to submission of additional applications to the NRC sometime in the next 10 years. These could include (1) a license application for a commercial SFR known as an advanced burner reactor (ABR) as part of the Global Nuclear Energy Partnership (GNEP), (2) a potential license application for a low-power HTGR, known as the High-Temperature Teaching and Test Reactor (HT3R), (3) a potential manufacturing license application for a small uranium hydride-fueled, potassium-cooled reactor, known as the Hyperion reactor, (4) a potential manufacturing license application for a small reactor plant, known as the Safe and Green nuclear plant, involving two small LWRs, and (5) a potential licensing application for a small LWR known as the Multi-Application Small Light-Water Reactor (MASLWR).

II. Advanced Reactor Prioritization Scheme

The staff's current proposed priorities for the advanced reactor activities documented in this enclosure are based on the following considerations, in order of priority from highest to lowest:

- high priority — congressionally mandated or Commission-directed activities for advanced reactors
- high priority — advanced reactor activities where there is a confirmed domestic partner
- medium priority — advanced reactor activities where the potential applicant has formally announced its intent to submit a licensing application within 3 years but does not yet have a domestic partner
- medium priority — advanced reactor activities concerning DOE non-LWR initiatives that are not congressionally mandated

- low priority — advanced reactor activities where the potential applicant has not formally announced its intent to submit a licensing application within 3 years

A high priority means that the activity will be executed with an established schedule and defined resources. A medium priority means that the activity will be executed with an extended and flexible schedule determined by available resources. A low priority means that the activity will be executed only when staff and funding are available and without an established schedule.

The staff will prioritize the advanced reactor activities as part of the planning assessment to be performed during the FY 2010 budget planning process. The planning assessment will consider preapplication interactions related to specific designs, resolution of known policy issues, and development of needed agency infrastructure to perform reviews of next generation reactor designs.

III. Current Advanced Reactor Activities

The following paragraphs provide information about the advanced reactor activities that are currently underway. The planning assessment to be completed as an initial activity under the Advanced Reactor Program (ARP) will evaluate each of these activities as well as other designs that might be proposed for possible certification or licensing. Preliminary resource estimates for the ARP licensing activities will build upon those reported in SECY-01-0188, "Future Licensing and Inspection Readiness Assessment," dated October 21, 2001 (hereafter referred to as the FLIRA report). For example, the FLIRA report estimated that preapplication discussions for a reactor such as the PBMR would take approximately 11 full time equivalents (FTE) and $1 million in contract assistance, and the review of a combined license application for a PBMR would take approximately 120 FTE and $8.5 million in contract assistance. The staff will use the resource estimates, availability of staff and contractors, and other factors to develop proposed schedules for the major activities within the ARP.

Next Generation Nuclear Plant

In Subtitle C of the EPAct, Section 641 states that the Secretary of Energy shall establish the NGNP project, which will consist of research, development, design, construction, licensing, and operation of a prototype nuclear plant, including a VHTR, that can be used to generate electricity and/or hydrogen. The NGNP demonstration project is intended to form the basis for an entirely new generation of advanced nuclear power plants. As defined by the EPAct, the NGNP will be a full-scale prototype plant that will be reliable, safe, proliferation resistant, and economical and will demonstrate the commercial potential of the VHTR and associated technologies. The mission of the VHTR includes providing high-temperature process heat for the chemical industry, refining petroleum, extracting oil from shale and tar deposits as an alternative to natural gas, producing hydrogen, and serving as a central electric power station. The EPAct establishes a target date of September 30, 2021, to either (1) complete construction and begin operation of the prototype nuclear reactor and associated energy or hydrogen facilities or (2) submit to Congress a report establishing an alternative date for completion. In addition, Section 644(a) of the EPAct states that the NRC shall have licensing and regulatory authority for any reactor authorized under Sections 641–645 of Subtitle C of the EPAct, while Section 645

directs that resources for NRC activities pursuant to Section 644(a) shall be transferred to the NRC from funds appropriated to DOE.

In Subtitle C of the EPAct, Section 644(b) requires that the DOE Secretary and the NRC Chairman jointly develop and submit to Congress a licensing strategy for the NGNP prototype nuclear reactor within 3 years of the date of enactment (i.e., by August 7, 2008). Toward that end, the NRC staff is working with DOE staff to develop and document the NGNP licensing strategy. The licensing strategy document is nearing completion and will soon be distributed for review and concurrence by NRC and DOE management, in preparation for transmittal to the Commission and the DOE Secretary for approval prior to submission to Congress.

Following the preparation of the licensing strategy basis document and report to Congress, the staff will actively participate with DOE in discussions regarding conceptual plant designs, research and development (R&D), testing, risk assessments, and licensing processes and guidance. The NRC and DOE plan to establish a memorandum of understanding (MOU) to provide the framework for interactions during the early phases of the design.

To support an aggressive licensing schedule for NGNP construction and operation by 2021, the NRC and DOE have agreed to increase the effectiveness of the preapplication phase of the NGNP project to resolve policy and key technical issues. The preapplication discussions are expected to begin in fiscal year (FY) 2010 to support a combined license application in 2013.

Pebble Bed Modular Reactor

The PBMR is a 400 megawatt thermal (MWt) high-temperature helium-cooled reactor, which is primarily designed for use as an electric generating power plant with an electrical power output ranging from 165 megawatt electric (MWe) (i.e., one reactor module) to 1320 MWe (i.e., eight reactor modules). The PBMR also has the potential to produce high-temperature process heat for use by the chemical industry and petroleum refineries, to extract oil from shale and tar sand deposits, and to produce hydrogen. The PBMR is designed to rely on inherent characteristics and passive safety features to mitigate design-basis accidents (DBAs). Its design for electric power generation has progressed from the preconceptual design stage through conceptual and preliminary design, and it is currently in the final design and development phase. However, PBMR (Pty) must still conduct significant safety-related R&D to fully support the technical basis for a combined license safety analysis, including the resolution of potential licensing safety issues. PBMR (Pty) has stated that it plans to submit the PBMR DC application in calendar year (CY) 2009 and to market the PBMR in the United States. The first PBMR demonstration plant is to be constructed in the Republic of South Africa for ESCOM, the South African national electric utility, which is also a major investor in PBMR (Pty). To date, PBMR (Pty) has not identified a confirmed domestic customer for the PBMR.

At the request of PBMR (Pty), the NRC began a limited-scope pre-DC application review of the PBMR in FY 2005, building on an earlier PBMR preapplication review with Exelon. This review is currently focused on key aspects of the fully risk-informed and performance-based approach that is being proposed for PBMR DC and licensing under 10 CFR Part 52. The current focus topics, documented in four PBMR (Pty) white papers, involve plans for probabilistic risk

assessment (PRA) quality and completeness; how the PRA would be used to select licensing basis events (LBEs); the proposed approach for safety classification and special treatment of the PBMR structures, systems, and components (SSCs); and the proposed approach for providing adequate defense in depth. The staff is reviewing the white papers and has transmitted requests for additional information to PBMR (Pty). A small interoffice review team from the Office of Nuclear Regulatory Research (RES), the Office of New Reactors, and the Office of Nuclear Reactor Regulation accomplished this task as resources were available.

By letter dated March 22, 2007 (ADAMS Accession No. ML070890084), PBMR (Pty) asked the staff to significantly expand the scope of its PBMR preapplication review to include all focus topics that are important to preparing a complete, high-quality DC application. Toward that end, PBMR (Pty) would like to submit up to 15 additional white papers to support its DC application. Additionally, PBMR (Pty) expects that the staff would need to complete the preapplication review phase by the latter half of CY 2009, when the company intends to submit its PBMR DC application for NRC review and approval. PBMR (Pty) further stated that it would derive the DC application from the safety analysis report for the South African demonstration project. On October 15, 2007 and November 26, 2007, respectively, PBMR (Pty) submitted a fifth and sixth white paper on the PBMR fuel performance envelope and test program and the PBMR evaluation model development and assessment process.

The risk-informed and performance-based approach that PBMR (Pty) proposes for certifying and licensing the PBMR design raises a number of licensing policy issues. Many of these issues are expected to be very similar, if not identical, to those that would be raised by the proposed NGNP licensing strategy (i.e., a partially risk-informed licensing approach). In particular, the PBMR licensing policy issues include the basis for ensuring adequate defense in depth; emergency planning requirements; containment functional performance requirements; requirements for an acceptable siting source term; the scope, depth, and quality of the plant PRA; how the PRA should be used to select LBEs (e.g., DBAs); whether the PRA will need to be submitted for staff review; and the extent to which the plant PRA would become part of the PBMR licensing basis. However, the risk-informed approach proposed by PBMR (Pty) involves a number of additional licensing policy issues, including an acceptable approach for making greater use of the plant PRA (with reduced reliance on deterministic engineering judgment) for selecting LBEs (e.g., anticipated operational occurrences, DBAs, beyond DBAs), safety classification of SSCs and establishment of special treatment requirements.

If resources are available, the NRC staff may expand the scope of its PBMR preapplication review to include additional technical focus topics and associated white papers of importance to the PBMR DC. However, the staff is not committed to reviewing all of the requested additional white papers or to completing the review by the end of CY 2009. The staff will continue to conduct the review on an as-available basis, in order to avoid any adverse impact on the review of new LWR plant applications and higher priority non-LWR activities. However, the staff will place increased emphasis and priority on PBMR preapplication review focus topics that have generic applicability to HTGRs (especially the NGNP VHTR). This increased priority will include identifying licensing policy issues, particularly those that are common to both the PBMR DC and the NGNP licensing strategy. The staff will also develop and document policy options for the Commission's decisions regarding these policy issues. In addition, the staff will conduct the

PBMR preapplication review in accordance with the Commission's priority, scope, pace, and resource requirements.

Super-Safe, Small and Secure Reactor

The 4S reactor is a small, 30 MWt SFR, designed by the Toshiba Corporation, that is intended for use in remote locations to operate over a 30-year design lifetime without the need for refueling. The 4S reactor is also designed to operate without plant operators and to rely on inherent safety characteristics and passive features to achieve all safety functions for all LBEs. The reference 4S reactor produces 10 MWe, although both larger and smaller 4S reactor designs exist. For deployment in the United States, the major components of the 4S reactor, including the fuel and reactor vessel, would be fabricated at a factory, shipped to the intended site, and assembled and installed underground in a below-grade civil structure. If fueled with uranium for licensed operation in the United States, 19.9-percent U-235 enrichment would be used, which is just below the 20-percent enrichment defined as high-enrichment uranium. To date, Toshiba has not identified a confirmed domestic partner for the 4S reactor although interactions with the town of Galena, Alaska are continuing.

By letter dated August 24, 2007, the Toshiba Corporation asked the NRC to conduct a preapplication review of the 4S reactor and stated its intention to apply for design approval once the detailed design is sufficiently complete. Pursuant to that request, the NRC staff met with Toshiba representatives on October 23, 2007, to discuss the scope and schedule for a potential preapplication review of the 4S reactor design and Toshiba's plans for submitting a DC application for NRC approval. The purpose of the preapplication review would be to familiarize the staff with the 4S reactor design, operation, and safety design features; the proposed technical and safety approaches for design approval; Toshiba's technology development plans; and the proposed requirements for security and emergency planning. A preapplication review of the 4S reactor would also provide Toshiba with NRC feedback on important technical, safety, and licensing policy issues for design approval, as well as a path forward for resolving those issues. Toshiba stated that Westinghouse will provide assistance during the preapplication and design approval reviews and will serve as the licensing interface during those activities. Preapplication review of the 4S reactor is anticipated in FY 2008-2009 and design approval review in FY 2010-2014.

The staff anticipates that the 4S design approval may raise several licensing policy issues, including reactor plant operation with significantly reduced onsite operating staff, defense-in-depth requirements, emergency planning requirements, security requirements, and requirements for an acceptable siting source term. These issues would need to be identified and addressed as part of either the preapplication review or the design approval review.

The staff currently has very limited technical and review infrastructures, including the knowledge, skills, abilities, analytical tools, standard review plans, codes, and standards, to review an application for an SFR. Most of the NRC technical staff members who participated in the most recent SFR reviews—namely, the Clinch River Breeder Reactor license review and the Power Reactor Innovative Small Module reactor preapplication review—have either left the NRC or will not likely be available to participate in the technical review of an SFR. However, over

time, the NRC may reestablish the core knowledge, skills, and abilities needed to review an SFR application through staff participation in (1) NRC SFR knowledge management activities, including DOE-sponsored seminars on SFRs, (2) the assessment of the GNEP ABR design and development program plans and activities under the recently signed NRC/DOE MOU, (3) the 4S reactor preapplication review; and (4) development of NRC SFR technical and review infrastructures. Additionally, the NRC is sponsoring the development of advanced reactor safety and engineering curricula at selected universities. The staff also anticipates that the agency will need additional specialized contractor support for selected engineering audits and confirmatory analyses to support the NRC's safety conclusions.

Preapplication Interactions with the City of Galena, Alaska

Near the end of 2004, officials from the City of Galena, Alaska, began discussions with Toshiba to investigate building a 4S reactor to provide the city's electricity. The NRC staff met with the city manager and vice mayor of Galena on February 2, 2005, to discuss the city's possible plans to build a 4S reactor. In a subsequent letter, dated September 26, 2007, the City of Galena informed the NRC of its intentions to continue evaluating the suitability of siting a 4S reactor near the city and indicated that an NRC review of the design and site suitability would enable the city to assess the feasibility of using a 4S reactor to meet its electrical energy needs. Toward that end, the City of Galena asked the NRC to resume discussions on the potential deployment of a 4S reactor at a Galena site, including several planned white papers on selected siting suitability focus topics. Burns & Roe Engineering and Pillsbury Winthrop Shaw Pittman are preparing the papers for submittal to the NRC, and the City of Galena requested an opportunity to meet with the staff to discuss the evaluations. These preapplication interactions are anticipated in FY 2008-2010.

International Reactor Innovative and Secure

IRIS is a 1000 MWt (about 335 MWe) modular pressurized-water reactor with an integral configuration. All primary system components (pumps, steam generators, pressurizer, and control rod drive mechanisms) are inside the reactor vessel. A power station could be built with a single or multiple modules. IRIS has an extended core life of up to 48 months. An international consortium, led by Westinghouse and including over 20 organizations from nine countries, is developing this design. IRIS is designed to rely on passive safety features to mitigate DBAs. Its design for electric power generation has progressed to the integrated testing phase, and it is currently in the final design and development phase. Westinghouse has stated that it plans to submit the IRIS DC application around FY 2010. The vendor has also stated that IRIS is uniquely suited for smaller and/or developing countries with limited electric grid, infrastructure and/or financial resources, and therefore it meets the GNEP goal of providing a grid-appropriate reactor for export. However, to date, Westinghouse has not identified a confirmed domestic customer for IRIS.
By letter dated August 12, 2003, Westinghouse requested the NRC to conduct a preapplication review of the IRIS design. As a result, the staff began a limited evaluation of topical reports concerning IRIS DBA analysis, phenomena identification and ranking table evaluations, and its testing program. The staff would need to review the IRIS integrated testing program to verify that the proposed tests will demonstrate satisfactory system performance of the IRIS safety features.

In addition, the staff may need to conduct a certain amount of confirmatory testing during the preapplication and DC reviews. In its letters dated September 7, 2006, and September 26, 2007, Westinghouse asked that the NRC review its integrated testing program and conduct a preapplication review in FY 2007 through FY 2010. In its letter dated December 19, 2007, Westinghouse provided an updated schedule of early 2012 for submission of a DC application. As a result, the staff anticipates preapplication review in FY 2008-2011 and DC review in FY 2012-2016.

Global Nuclear Energy Partnership Advanced Burner Reactor

The DOE plans to develop and demonstrate an ABR as a key element of a new, integrated U.S. recycling capability. The ABR is to be an SFR, which would consume transuranic elements (plutonium and other long-lived radioactive material), thereby significantly reducing the long-term heat load associated with high-level waste destined for disposal in national geologic repositories, such as the planned repository at Yucca Mountain, Nevada. Toward that end, DOE intends to work with international partners on the design, development, and demonstration of the ABR. The current DOE strategy for the project is to commercialize the ABR technology as a full-scale plant that would require NRC licensing and regulation.

The NRC and DOE have signed an MOU that establishes the framework for the NRC to participate in the GNEP. This participation includes exchanging information with DOE, as well as interacting with DOE and its national laboratories in the development and demonstration of GNEP technologies and facilities. This cooperation will provide the NRC staff with input that would be used in developing and implementing a regulatory structure for the GNEP facilities, including the ABR. Potential NRC interactions include (1) obtaining information on advanced recycling technologies, (2) providing feedback to DOE on the licensablity of the GNEP technologies and processes, (3) reviewing reports and engineering studies and providing feedback to DOE, (4) participating in periodic meetings and information exchange workshops, (5) observing and participating in tests, simulations, and demonstrations, (6) reviewing literature and participating in facility tours, and (7) submitting annual reports to DOE on the work that the NRC performs under the MOU.

NRC participation in the GNEP, including the design and development of the ABR, is expected to broaden, deepen, and accelerate the development of the staff's technical knowledge, skills, and abilities related to the SFR design, technology, safety, and safety assessment, particularly as it relates to the ABR and to the interrelated or cross-cutting regulatory safety issues such as GNEP reprocessing/recycling impact on the ABR safety basis. In addition, NRC participation would significantly improve the staff's readiness to effectively and efficiently develop the agency's technical and review infrastructures, a potential regulatory structure for ABR licensing, potential preapplication review of the ABR design and safety basis, and potential review of an ABR license application. Under the terms of the MOU, resources for the activities that the NRC performs for DOE in connection with the MOU will be transferred from DOE appropriations.

Separately, by Staff Requirements Memorandum SECY-07-0081, "Regulatory Options for Licensing Facilities Associated with the Global Nuclear Energy Partnership," dated June 23, 2007, the Commission directed the staff to conduct a gap analysis for existing NRC regulations

to identify changes in regulatory requirements that would be necessary for licensing a reprocessing facility and the ABR. This work involves the identification of the regulatory requirements for licensing an ABR, including the consideration of relevant areas such as fuel qualification and quality assurance, waste management, physical security and material safeguards, and environmental protection.

High-Temperature Teaching and Test Reactor

The HT3R is a 25 MWt test reactor concept based on the key reactor design characteristics of the gas-turbine modular helium reactor (GT-MHR). The HT3R relies on passive and inherent safety characteristics similar to those proposed for large modular HTGRs, such as the GT-MHR and PBMR. The University of Texas of the Permian Basin (UTPB) seeks to develop the HT3R from a preconceptual design into a final reference design, with the related engineering analysis, licensing activities, construction cost analysis, and project schedule. The HT3R is intended to be a key research facility within the planned UTPB state-of-the-technology nuclear engineering teaching and research center to address current energy and environmental issues. Specifically, the plans include establishing an engineering and nuclear physics teaching program incorporating an HTGR. The HT3R may potentially be used for (1) testing and demonstrating HTGR technology, with electric power generation based on the Brayton cycle, (2) producing hydrogen, (3) desalinating water, (4) generating high-temperature process heat, (5) producing isotopes, (6) conducting basic research, (7) teaching, and (8) conducting operator training.

On May 11, 2006, the NRC staff met with UTPB and General Atomics (GA) representatives to discuss the UTPB plans to design, build, and license the HT3R. The UTPB representatives indicated that preliminary plans included submitting a license application in FY 2009, starting construction by FY 2010, and completing construction and licensing by the end of FY 2012. To support HT3R project planning during the preconceptual design phase and NRC review of the licensing plan developed during the conceptual design phase, the UTPB and GA representatives asked the staff to provide input on the NRC licensing process. The staff has had limited interactions with UTPB and GA since the meeting in May 2006.

Hyperion Reactor

The Hyperion reactor is a 25-MWe reactor based on a hydride reactor concept developed at Los Alamos National Laboratory. The Hyperion reactor is a small, self-regulating hydrogen-moderated and potassium-cooled reactor, which is fueled by powdered uranium hydride. The core power is self-regulated by the dissociation of hydrogen with increasing core temperature and the recombination of hydrogen with decreasing core temperature. The design concept does not involve control rods, shutdown rods, or coolant pumps. Heat removal from the core is achieved through liquid potassium heat pipes. The Hyperion reactor is also designed to rely on inherent safety characteristics and passive features to achieve all safety functions for all LBEs.

For U.S. deployment, the reactor would be fabricated in a factory, shipped to the intended site, and installed underground in a below-grade vault, where it would be operated for about 5 years before being returned to the factory for refueling. The Hyperion reactor design is intended to be

used to produce electricity at remote sites or to produce high-temperature process heat for extracting heavy oil from shale and tar sand deposits.

Purple Mountain Ventures (PMV) has established Hyperion Power Generation (HPG), which is evaluating whether to invest in fully developing the Hyperion reactor and whether to apply for an NRC manufacturing license to market the reactor in the United States and other countries. On May 30, 2007, the staff met with PMV representatives to discuss licensing processes that could potentially be applied to the Hyperion reactor. Subsequently, by letter dated June 15, 2007, HPG asked the staff to engage in preapplication discussions and stated that it might pursue a manufacturing license application. Pursuant to that request, the staff held a follow-up meeting with HPG representatives on August 22, 2007, to further discuss a potential preapplication review and obtain additional information regarding the reactor design and HPG plans. HPG has indicated that it will submit technical reports for preapplication review in late FY 2009.

The staff anticipates that a Hyperion reactor manufacturing license review would involve significant technical, safety, and licensing policy issues. Issue areas include using uranium hydride as the fuel form, materials concerns, capability of the heat removal pipes, provisions for defense in depth, physical security, and reactor module transportation. These issues would need to be addressed as part of a preapplication review. Preapplication review activities are expected to continue through FY 2011 with subsequent review of a manufacturing license in FY 2012-2016.

Safe and Green Reactor

The Safe and Green reactor is a 30 MWe pressurized-water reactor based on the Russian KLT-40S naval propulsion reactor used on icebreakers. Thus, the 60-MWe Safe and Green nuclear power station concept proposes to use two KLT-40S reactors, each of which is stated to have three passive and two active shutdown systems. Electrical power conversion involves the use of conventional steam generators and a steam turbine-generator. The nuclear electric power station also envisions modular reactor power plants, which would be manufactured in a factory. The design includes a reactor containment.

Novel Assets International Company (NAIC), a venture company, has developed a business plan to design, manufacture, and license Safe and Green power stations and is seeking to raise capital to implement the venture. NAIC has not identified a confirmed domestic customer for a Safe and Green nuclear power station. Representatives from NAIC have contacted the staff regarding the company's plans to develop and license Safe and Green power stations in the United States. However the staff has not yet received a formal written request from NAIC for preapplication discussions on the reactor.

Multi-Application Small Light-Water Reactor

The MASLWR is a 150 MWt natural circulation LWR that consists of a self-contained assembly with the reactor core and steam generators located in a common reactor vessel. Electrical power conversion involves the use of steam generators and a steam turbine-generator. These modular units would be manufactured at a single centralized facility; transported by rail, road, and/or ship; and installed as a series of self-contained units, each with a 5-year refueling cycle.

Nu Scale Power Inc. is the developer of the MASLWR. The MASLWR project is being conducted under the auspices of the DOE Nuclear Energy Research Initiative. Testing to support the conceptual design is being conducted at Oregon State University, which is supporting an assessment of the feasibility of developing the design. Representatives from Nu Scale Power have contacted the staff regarding their initial plans to develop the MASLWR power stations in the United States or abroad and to obtain information regarding licensing options for the design.

By letter dated January 23, 2008, Nu Scale Power notified the NRC they are ready to begin preapplication review of the MASLWR design in August 2008. Should the NRC begin preapplication review at that time, Nu Scale Power expects the preapplication review to be completed in 18-24 months, with formal submittal of a design certification application for review and approval in FY 2010.

IV Advanced Reactor Technical and Review Infrastructure Development

By Staff Requirements Memorandum COMSECY-05-0024, "FY 2007 Budget Proposal," dated August 19, 2005, the Commission directed the staff to begin developing the technical and review infrastructures for licensing HTGRs and, to a more limited extent, SFRs. Accordingly, on April 9, 2007, the staff issued the draft NRC Advanced Reactor Research Plan (ARRP), which focused on the safety research that the NRC will need for the review and licensing of HTGRs, such as the PBMR, the GT-MHR, the HT3R, the VHTR, and (to a limited extent) SFRs (such as the Toshiba 4S reactor and the GNEP ABR). Since that time, the staff has begun limited implementation of selected research tasks documented in that plan.

To ensure effective and timely implementation of the Commission's direction to begin developing NRC technical and review infrastructures for licensing non-LWRs, RES updated the ARRP, which was originally documented in SECY-03-0059, "NRC's Advanced Reactor Research Program," dated April 18, 2003. The draft updated research plan (ADAMS Accession No. ML070600065) primarily focuses on HTGRs and VHTRs and, to a limited extent, SFRs. The specific HTGRs addressed in the updated research plan include the NGNP VHTR, PBMR, GT-MHR, and HT3R. Potential SFRs addressed in the plan include the Toshiba 4S reactor and the GNEP ABR.

The technical infrastructure reassessment for HTGRs rebaselines and updates the earlier assessment, which was documented in SECY-03-0059. As such, the reassessment includes consideration of safety-related foreign and domestic R&D activities that have been planned or implemented since the NRC issued SECY-03-0059, as well as the new HTGR designs and the NGNP VHTR application (i.e., electric power generation, hydrogen production, and process heat). The reassessment for HTGRs includes technical infrastructure development and safety research in generic arenas (e.g., human performance, advanced instrumentation and controls (I&C)) that are considered applicable to HTGRs, SFRs, and LWRs. In addition, RES performed the reassessment in sufficient depth and detail to identify the safety-related R&D that the NRC would need to conduct in order to support the review of an HTGR application, as reflected in the update.

The applicant for a new reactor design has the primary responsibility to conduct R&D in order to establish an adequate technical basis for the safety analysis for the design. Accordingly, the proposed HTGR and VHTR safety R&D plans (ADAMS Accession No. ML070740607) are directed at one or more of the following four criteria:

(1) developing adequate staff technical knowledge, expertise, and capabilities to independently review and effectively evaluate the acceptability of the application, including the safety analysis and the technical basis for the safety analysis

(2) independently confirming the technical basis for requirements and criteria needed for plant licensing and the regulatory guides and standard review plans needed for developing an acceptable application and an effective and efficient staff review

(3) developing an independent analytical capability to confirm safety analysis evaluation methods and results and the adequacy of proposed resolutions of safety issues and/or the development of the technical basis for staff-proposed safety enhancements

(4) adequately confirming or interpreting existing technical information, for which there is significant uncertainty or adequately validating and scoping out technical issues involving significant safety or risk implications in order to justify the need for follow-up resolution by the applicant

For SFR designs, the staff surveyed NRC technical infrastructure needs. That SFR infrastructure survey is at a higher level than the HTGR infrastructure reassessment and identifies the relevant safety-related and technical issue areas. As such, the survey is intended to provide a starting point for a follow-up, in-depth SFR technology infrastructure needs assessment. Such a follow-up assessment would need to be of sufficient depth and detail to identify the specific safety-related R&D that the NRC would need to conduct in order to support the review of an SFR application, such as the 4S reactor or the GNEP ABR.

The key topics included in the HTGR infrastructure needs assessment and associated R&D plans are (1) technical review infrastructure development based on risk-informed, performance-based principles, (2) accident analysis (PRA methods and assessments, human factors, and advanced digital I&C), (3) reactor/plant analysis (thermal-fluid analysis, nuclear analysis and, analysis of fission product transport and release), (4) fuel performance analysis;,(5) materials performance analysis (graphite and metallic component performance), (6) structural analysis, (7) consequence analysis (dose calculations, environmental impact studies), (8) hydrogen production plant hazards analysis, (9) nuclear materials safety and nuclear waste safety, and (10) nuclear safeguards and security.

The staff recognizes that the NRC need not perform all of the proposed work and that the agency can obtain some of the information through domestic and international cooperation as well as through work done by developers, including DOE.

The Idaho National Laboratory (INL) NGNP Division of Research and Development (on behalf of DOE), the NRC Advanced Reactor Technical Advisory Group, and the NRC Advanced Reactor

Steering Committee (ARSC) have reviewed the draft research plan. The highest priority tasks in the draft R&D plan began in FY 2007, consistent with NRC budget decisions.

The RES staff plans to revise and issue the final ARRP to address and resolve the comments provided by INL, the ARSC, and the program offices. The staff will also meet with the NRC Advisory Committee on Reactor Safeguards to solicit its input and advice on the plan. The staff will continue those R&D tasks to completion and will begin additional high-priority R&D tasks in FY 2008 and FY 2009, consistent with the agency's advanced reactor budget decisions. In addition, to ensure that the staff is sufficiently prepared to effectively and efficiently review either the VHTR construction permit application or the PBMR DC application, the staff will strive to expeditiously complete as many of the needed R&D tasks as possible.

At this time, the staff proposes not to conduct an infrastructure needs assessment for either a hydride reactor (such as the Hyperion reactor) or a small LWR (such as the Safe and Green reactor). The staff will reconsider conducting a design-specific infrastructure needs assessment and associated R&D plans for these reactor concepts once the vendors' design, development, and application plans are better established.