Proposed Plan for
Preparation for a Certification Review of the PBMR

INTRODUCTION

In a letter dated December 5, 2000, to William Travers, Exelon Generation Co. has requested preapplication interactions with NRC directed toward assessing the viability of certification of a pebble bed modular reactor (PBMR) in the U.S. Informally, Exelon has stated that they desire to certify the PBMR design in the U.S. beginning as early as Cy 2002. The PBMR is a high temperature gas cooled reactor (HTGR), utilizing helium as the coolant and with online refueling capability, similar to that developed in Germany in the 1970s and 1980s. The current design is being developed in South Africa where a prototype module may be built and demonstrated. In addition to being a non-LWR reactor, the PBMR has other unique features that make its approach to protecting public health and safety very different than currently licensed designs. Chief among these features are:

- coated UO_2 fuel particles designed to contain the fission products and to be demonstrated to withstand very high temperature

- passive decay heat removal that is to be demonstrated to perform, even under loss of coolant conditions

- no conventional containment building

- proposed reduced EPZ

- multi-modular site concept (each module being approximately 110 Mwe)

- the use of actual plant testing, using a prototype reactor module, to verify analytical tools and safety in support of design certification.

The Commission's Policy Statement on Advanced Reactors encourages early interactions on such advanced designs so as to facilitate the resolution of safety issues early in the design process.

For NRC to be prepared to review the PBMR in a timely fashion, initial work is proposed beginning in early 2001 consistent with the Commission's Advanced Reactor Policy. The objectives of this initial work would be to:

- ensure early interactions with Exelon on the PBMR
- educate a nucleus of staff in HTGR technology and safety
- identify key safety issues and an approach for their resolution
- identify and solicit Commission guidance on policy issues
- address infrastructure needs to support a licensing review

PROPOSED PLAN

This paper describes a plan for this initial work directed toward preparing the agency for a possible application to certify the PBMR in the U.S. consistent with the above objectives. The plan is based upon the assumption that an application for certification will be made in late CY2002 and thus the preparatory work should be completed in approximately 18 months. The plan describes preapplication activities and consists of the following elements:

- familiarization with the design, safety and research issues via:
  - interaction with Exelon
  - interaction with foreign partners and organizations with HTGR experience
  - interaction with the South African regulatory organization
  - interaction with potential U.S. contractors with HTGR experience
- identification of current requirements which may not be applicable to the PBMR and areas where new requirements may be needed.
- identification of safety and policy issues and a proposed approach for their resolution
- infrastructure and contractor support
- staffing, training, schedule and resources

Each of these elements is discussed below:

Familiarization with Design, Safety and Research Issues

Initial staff efforts will be directed toward becoming familiar with the PBMR design, technology, safety issues and research needs. This will be accomplished first through discussions and interactions with Exelon and others with PBMR and HTGR experience. An initial meeting has been scheduled with Exelon for January 31, 2001, at NRC to discuss the PBMR design, safety issues and proposed Exelon schedule and approach for pre-application interactions. It is expected that additional followon meetings will be scheduled on an as needed basis to discuss specific issues. In parallel with interactions with Exelon, the staff will contact others with HTGR experience relevant to the PBMR to obtain their insights and views on safety issues and

technology. These contacts are discussed below and include international as well as domestic organizations.

NRC has a number of agreements with foreign countries that provide a mechanism to cooperate on a wide variety of safety matters. Some of our foreign partners have HTGR experience and also have currently operating HTGRs (which utilize Helium coolant and coated fuel particle designs.) Specifically, Germany has had many years experience with small (~46 Mwt) and large (~750 Mwt) scale HTGRs, including those of pebble-bed design. Although the German HTGRs are no longer operating, their experience is relevant to the PBMR. Japan currently has an operating research HTGR (~30 Mwt), although not of the pebble-bed design. It does, however, utilize coated fuel particles, He coolant and operates at high temperatures. China has recently begun initial startup of a small (~10 Mwt) pebble-bed research HTGR, from which experience should be obtained. In addition, they are developing a larger (200 Mwt) modular design. The U.K. operates 14 Advanced Gas Reactors (AGRs). Although they are different than the PBMR (i.e., they use CO_2 as a coolant and the fuel is not the coated particle design); they are graphite moderated and some experience may be relevant to a PBMR. Russia has had some HTGR development efforts in the past and is currently engaged in a joint effort with General Atomics (sponsored by DOE) to develop a modular HTGR(although not a pebble-bed) for Pu disposition. In addition to the above, IAEA has some activities (in both the development and safety areas) looking at the PBMR design and safety. We would also build upon and utilize their work in our activities. Finally, we would plan to discuss with the South African regulatory authorities their views on the PBMR design, safety and research issues. In 2001, we would intend to arrange interactions with our international partners to discuss their experience with HTGRs and their views on safety issues. Whenever possible, these

interactions would be arranged in conjunction with other scheduled meetings so as to limit the need for additional foreign trips.

Domestically, there remains some HTGR expertise, primarily at ORNL (in support of the joint U.S./Russian project to develop an HTGR for Pu disposition) and at General Atomics. Preliminary discussions have been held with ORNL regarding the feasibility of drawing upon their expertise. Relevant experience at the other DOE labs will also be determined. Access to expertise at GA may be limited due to their being an NRC licensee. In addition, for the past several years MIT has lead an effort to design a modular HTGR. Their experience will also be sought. Finally, previous NRC experience with HTGRs (e.g., Ft. St. Vrain and the NRC review of a DOE sponsored modular HTGR in the late 1980s) and the ALWRs would be utilized to help identify issues, research needs and approaches to their resolution.

Requirements, Safety and Policy Issues

An important output from the preapplication interactions will be identification of applicable requirements, key safety and policy issues. This will be done by looking at the requirements in 10 CFR (and their supporting Reg Guides) and identifying those that are unique to LWRs (and thus not applicable to the PBMR) as well as by looking at the PBMR design, technology and safety issues and identifying unique aspects that are not covered by current requirements. The interactions with Exelon, our foreign partners and domestic experience described above, as well as the experience with the Ft. St. Vrain reactor, the review of a DOE sponsored modular HTGR in the late 1980s, and the ALWR reviews would be utilized. With the gaps identified, a risk-informed approach (building upon the current work to risk-inform 10 CFR 50 as well as previous

experience with HTGRs, the ALWRs, and the knowledge gained from the interactions described above) would be utilized to establish a framework for developing requirements applicable to the PBMR. It is expected that this will lead to the identification of certain safety and policy issues needing resolution in order to proceed with a review. For example, the criteria for determining the acceptability of a design without a conventional containment building is likely to be a major issue. These would be provided to the Commission for guidance.

It is expected such safety and policy issues could be developed and provided to the Commission in approximately 18 months. This would include interactions with ACRS and other stakeholders. As an interim step a preliminary set of the key safety and research issues associated with the PBMR would be provided to the Commission for information in approximately 9 months.

Expertise and Infrastructure Needs

Along with the identification of key technical and safety issues associated with the PBMR, the staff will also identify the in-house and contractor expertise needs, analytical tools needs and a plan as to how to obtain them. Currently, NRC does not maintain any analytical tools, data bases or activities on HTGRs. The most recent efforts in this regard were approximately 10 years ago when the agency had underway a pre-application review of a DOE sponsored modular HTGR (MHTGR) design in accordance with the Commission's Advanced Reactor Policy Statement. A draft pre-application safety evaluation on the MHTGR was issued in 1989 for comment (NUREG-1338); however, a final NUREG was never issued since DOE canceled the program. In developing NUREG-1338, the staff utilized contractor support and analytical tools from ORNL and BNL. Since that time, ORNL has remained active in the HTGR field and

currently supports DOE sponsored work on HTGRs for Pu disposition. Accordingly there is expertise at ORNL (including analytical tools) which the agency can draw upon to assist in the PBMR review, and it is our intent to utilize ORNL in this preparatory phase to assist the staff in the identification of issues and approaches for the PBMR review, as well as getting the staff familiar with the available analytical tools, their basis and how to use them. In this regard, ORNL has available the ORECA code (a three dimensional T/H code with point kinetics reactor physics) that they are using in assisting DOE and that was used in the staff's review of the DOE modular HTGR ten years ago. Other codes are also available and those would be reviewed for their applicability and need.

A complete identification of infrastructure needs (codes and data) is, to some extent, dependent upon the identification and nature of the safety issues. However, it is desirable for the agency to have an independent tool to calculate the plant response to accidents, particularly, those related to loss of coolant, decay heat removal and reactivity insertion. Such independent capability is valuable in providing a deeper understanding of plant behavior under a wide range of off-normal conditions, which can result in insights that contribute to the quality and thoroughness of the staff review and determine confidence in information provided by the applicant. Expertise needs (both in-house and contractor) not currently available will also be identified and recommendations for obtaining them will be made. It is expected that the expertise needs will be in those areas unique to HTGR technology and include:

- fuel design, fabrication and performance
- high temperature materials
- accident analysis
- risk analysis

Staffing, Training, Schedule and Resources

The preparatory work is directed toward having a small nucleus of staff (5-6) familiar with the unique attributes of the PBMR such that they can participate and formulate a plan for the review, if and when an actual application is received. The unique expertise to be covered by this small nucleus would include:

- fuel technology, performance and disposal
- high temperature materials
- transient and accident analysis
- HTGR risk-analysis

This nucleus would include staff from RES, NRR and NMSS.

The preparatory phase will be a joint RES/NRR/NMSS effort with RES having the overall lead. Assuming that an application for design certification of the PBMR is received in late 2002, the preparatory work should begin as soon as possible. If approved by the Commission the staff would begin additional interactions with Excelon, our foreign partners and ORNL. Initial activities would be directed toward familiarization with the PBMR and the identification of key safety and policy issues. A high level schedule for the activities described above is shown in the attached figure. It is recognized that this is a very preliminary schedule and is dependent

upon many factors. However, it does represent the approximate time necessary to accomplish the preparatory work.

A training program will be developed. The training program will consist of information on basic HTGR technology, design, operation and experience. Contractor assistance will be used to develop the training program which will be targeted to be available in approximately one year.

To accomplish the preparatory phase, it is expected that 3 to 4 FTE will be necessary. This will include two full time FTE in RES and some staff time in NRR and NMSS. Also, for contractor support in providing training, identifying safety issues and research needs as well as making available analytical tools and providing assistance to the staff in the use of those tools, it is estimated that 500K will be needed in each of FY2001 and FY2002.

Preliminary Schedule for PBMR Preparatory Activities (calendar-year)