U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

PI: **S. Modro** **Proposal No.: 99-0129**

Institution: **Idaho National Engineering and Environmental Laboratory**

Collaborators: **Bechtel Corporation, Oregon State University**

Title: **Multi-Application Small LWR**

The objective of this project is to develop the concept of a safe and economic multi-application LWR (light water reactor) design, and to test the design feasibility. A light water reactor technology is proposed to utilize extensive existing industrial experience and to assure quick design development and deployment within the next decades. It is proposed to conduct this project as a collaborative effort of a national laboratory, industry and academia. Each of the partners brings to the project experience and facilities, which makes a successful project highly probable. The Idaho National Engineering and Environmental Laboratory (INEEL), with decades of experience in reactor safety analysis, experimentation and reactor design, will lead the proposed research. Bechtel National Inc. has vast experience as nuclear power plant engineer-architect and will provide engineering and economic insights to the project. The Oregon State University (OSU) has been involved in thermal-hydraulic and safety research on behalf of industry and government and will provide experimental support.

A small, natural circulation pressurized light-water reactor is proposed with the goal of various applications, primarily electric power generation, but flexible enough to be used for process heat and deployed in a variety of locations. Through economic and engineering analyses we will address the design and safety attributes of the concept and through testing, using an integral test facility, we will demonstrate its technical feasibility.

Recently a significant amount of experience was gathered in defining requirements for advanced LWR systems, design and licensing of such systems. One of these advanced designs, the Westinghouse AP600, was recently certified by the US Nuclear Regulatory Commission (USNRC). INEEL and Oregon State University were heavily involved in the evaluation and certification of this reactor. INEEL supported through the certification process the USNRC with analyses and OSU with conduct of integral system tests. Bechtel had a major architect-engineer role in the design of the AP600 nuclear island and Balance-of-Plant (BOP) systems. We will use all this experience, and build on it in our project. An important approach to reducing capital costs is to simplify the design and to introduce passive systems. The AP600 design included simplification and passive safety systems. Despite this, the predicted generation costs are higher than those of a natural gas plant. Obviously, we need to take a next step in the area of simplification and passivity. In our project we will perform system analysis to identify design variables to be considered for simplification. Again, capital costs, operational issues and safety will be considered together.

The proposed work will be carried out over a three-year period with the focus of each year as follows:

- Year 1: Baseline concept development
- Year 2: Concept optimization
- Year 3: Concept finalization, experimental testing and documentation

The functional requirements and design criteria will be established during the first year to develop the baseline concept for a 1000MWth power generation unit. Analysis and calculations will be performed in support of the concept development to establish basic dimensions and operation parameters. Plant arrangement will be developed and drawings prepared as an essential part of this effort to highlight the basic component interfaces and to help identify areas that will affect the design and cost of the unit. A series of top level performance and safety analyses will be carried out at this stage to provide firmer support for the baseline concept. Initial estimates of the capital cost and busbar cost for this concept will be developed as a guide for the concept optimization to be carried out in the second and third year. Based on the design criteria and the developed baseline concept, preparation will be made to test safety performance of the concept. Scaling analyses will be performed to develop the basis for modification of the APEX experimental facility at the Oregon State University. The APEX facility is a scaled model of the AP600 system. Under this project, it will be modified to address the required natural circulation component elevation changes, including characteristic components of the proposed reactor concept such as the horizontal steam generators, high pressure accumulators, and necessary instrumentation.

In the second year, the work will focus on identification and selection of those areas having the greatest potential for cost reduction, followed by the creation of preliminary designs that promise to achieve these cost reductions while maintaining the safety and other desired features of this concept. An economic model will be developed for life cycle cost analyses. Initial capital costs and life cycle costs will be evaluated with this simple economic model that captures the essential bounding assumptions and the general site conditions. The relative merits of modular design, few moving parts, highly automated operation, a more secure fuel source, and long plant life will also be investigated. These results will be used to update the baseline plant concept to a more optimal version, with accompanying analyses to verify performance and safety requirements. The arrangement drawings will also be updated to reflect these improvements and a revised version of the capital and busbar costs will be estimated. Modifications to the APEX facility will be completed and testing will be initiated.

The third year will emphasize efforts to complete the experimental testing and to finalize the optimal baseline plant concept. At this point the function requirements and system design requirements will be revised to reflect the latest version of this concept, and the second revision of the arrangement drawings, appropriate to the early stage of the development of this concept, will be prepared. Similarly, the capital and busbar costs will be estimated in a form compatible with these revisions. An effort to develop a 400 MWth design as a scale-down from the baseline plant concept will be carried out with the intention of identifying those component areas that scale easily, and those that do not because they must retain much of their original multiplicity or complexity in favor of good maintenance and safety characteristics. Also, an effort to explore purely process heat applications and co-generation (heat plus electricity) applications will be carried out at the 1000 MWth size to determine their particular merits. These results will be used to conclude this first phase of concept evaluation, and to identify the most attractive of these alternatives. Assuming that one or more of these baseline alternatives meets the competitive requirements of the marketplace in terms of safety, ease of use, non-proliferation features, and costs, a follow-on proposal for more detailed design and analysis will be recommended. The project will be completed with a report summarizing the work performed, major findings and with functional and design requirements for concept evaluated.