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

PI: **Mario Carelli** **Proposal No.: 99-0027**

Institution: **Westinghouse Electric Company**

Collaborators: **University of California-Berkeley, Massachusetts Institute of Technology, Polytechnical Institute of Milan, Mitsubishi Heavy Industries, British Nuclear Fuels, Japan Atomic Power Company, Commissariat a l'Energie Atomique, Tokyo Institute of Technology, Bechtel Corporation**

Title: **The Secure Transportable Autonomous Light Water Reactor--STAR-LW**

This program proposes to develop a novel type of water cooled nuclear reactor which is responsive to the needs for reasserting nuclear power worldwide as a safe, economical and environmentally friendly power source. This is one of the reactor concepts to be investigated by a team of national laboratories, industry and universities under the STAR (Secure Transportable Autonomous Reactor) program. The light water cooled reactor (STAR-LW) we propose:

- Is proliferation resistant. The core lifetime is projected to be of the order of 15 years without fuel shuffling or refueling. Maintenance of the nuclear system is minimized and the goal is to design a reactor island which does not need to be accessed by the operator over the 15 years lifetime.

- Features enhanced safety systems with high degree of inherent safety which make impossible severe accidents leading to core damage. An integral pool configuration is selected, thus eliminating the possibility of loss of coolant accidents of significant entity, and the reactor is designed for a very high level of natural circulation, possibly up to 100% of full power, thus eliminating the loss of flow accident. Effort will also be focused on implementing passive systems to cope with reactivity insertion and loss of heat sink accidents.

- Is simple and economical. The capital cost is reduced because of the elimination of entire systems such as refueling, soluble neutron absorber, and emergency core cooling; the use of a single, integrated, self-pressurized vessel; elimination of control rod drivelines and most vessel penetrations; and, simplifications throughout the plant, e.g. reduction in piping and valves. The O&M cost is substantially reduced because of the minimized maintenance, no refueling (which will also increase the availability factor), and the use of modular, easily replaceable components.

- Is environmentally friendly. Because of the very long life of the core the amount of radioactive waste spent fuel is drastically reduced (of the order of five times less than current reactors). A possibility which will be considered is to dispose of the vessel "in toto" (i.e., without removing the fuel) which would provide an additional barrier to the escape of radioactive products.

Among the very innovative features which are incorporated in STAR-LW, the most notable are:

- A water cooled core with a hard neutron spectrum (epithermal or even soft fast) to provide a high internal conversion ratio necessary for long life. To minimize the coolant moderating effect, a very compact triangular pitch configuration typical of fast reactors is adapted.

- Boiling is allowed in the upper part of the core. This will increase the natural circulation head and has also a secondary effect of increasing the overall efficiency, because of the higher temperature achievable (at the same operating pressure) with respect to current PWRs.

- Novel fuel design configurations to increase the surface heat transfer area.

- The use of stainless steel for cladding material, made possible by the hard neutron spectrum, provides a very high degree of reliability

- The possibility of using a heavy liquid metal as fuel/cladding bond to decrease the gap resistance and consequently the fuel temperature

- A novel "internal" control and shutdown system which significantly reduces the penetrations to the vessel by eliminating the drivelines.

Development activities to address key feasibility issues will be identified and scoped out. Expected technical and economic performance characteristics will be determined. These studies will be completed within the first 18 months and to a degree of depth sufficient to establish with confidence whether the project merits to be pursued in full detail, according to the down selection procedure of the STAR system. Assuming that the concept is selected, a preliminary design of the reactor system will be completed in the remaining 18 months.

We believe that we have a very high probability of success because this innovative reactor design builds upon the combination of proven technologies: on one side light water reactors with over four decades of experience in component design and performance and on the other fast breeder reactors with extensive development in core design and fuel/cladding irradiation and operation experience. Westinghouse has been in the forefront of both technologies. Forty percent of the light water reactors built worldwide and 50% of those in the U.S. are based on Westinghouse developed technology. In addition to water reactors, Westinghouse has been the premier developer of fast reactors in the U.S., having designed, built and operated the FFTF, and been the lead designer of the prototype Clinch River Breeder Reactor.

The two U.S. team member universities, UC Berkeley and MIT have performed fundamental studies in the neutronics and thermal hydraulics of both water cooled and fast reactors. MIT has also studied maintenance and calibration requirements for existing LWRs as part of its study of extended operating length cycles. UCB has performed fundamental studies of compact water cooled lattices for long life cores and has developed accurate and efficient codes for neutronic analysis of fuel assemblies of any geometries.

Finally the U.S. team is significantly augmented by the participation of the Polytechnic of Milan (POLIMI), Italy, one of the top nuclear engineering schools in Europe. For several years POLIMI has been developing the advanced passive water cooled NILUS reactor, which will provide a third major data base to this development.