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

PI: **Ehud Greenspan** **Proposal No.: 99-0154**

Institution: **University of California**

Collaborators: **Westinghouse, Argonne National Laboratory, Lawrence Livermore National Laboratory**

Title: **STAR: The Secure Transportable Autonomous Reactor System, Encapsulated Fission Heat-Source**

The objective of this proposal is to assess the feasibility of a novel reactor concept that was recently invented by Ehud Greenspan and David C. Wade. The novel approach may accelerate the development of nuclear reactors for developing countries and may contribute to the re-vitalization of the nuclear energy option in the industrial countries.

The single most unique feature of this concept is that the fission-generated heat is transferred from the primary coolant to the secondary coolant through the reactor vessel wall, completely eliminating through-vessel fluid or mechanical connections. This enables the reactor to remain sealed throughout its lifetime. The reactor module and the steam generator modules can be easily installed and replaced. The reactor core is designed to have long life without refueling operations. We shall refer to the combination of a reactor module that is not mechanically connected to other components of the power plant and of a long-life core as the Encapsulated Nuclear Heat Source (ENHS) or as a “nuclear battery”. The ENHS opens new possibilities for the design, fabrication, construction, operation, maintenance and refueling of nuclear power plants. For example, the vendor manufactures and charges the nuclear battery in the factory, installs it in the “field,” uses it as long as it can deliver the required power, and replaces it thereafter with another factory-manufactured nuclear battery.

If the new ENHS proves practical to implement, it might significantly improve the economics, safety, proliferation-resistance and public acceptability of nuclear reactors:

Economics: Via (a) elimination of the IHX, DHRS, and many other components; (b) high degree of modularity, all modules can be factory manufactured; (c) relatively small, simple components that are easy to install, maintain and replace; (c) long-life core with no refueling operations; (d) small O&M cost; (e) possibility of using the reactor vessel as a storage “cask” because the Pb coolant will eventually solidify in the core; (f) Smaller nuclear island.

Safety: Via: (a) very small burnup and other possible reactivity swings; (b) relatively large negative coolant and void coefficients of reactivity; (c) large capacity heat sink; (d) very effective decay heat removal (via the large surface area of the reactor vessel inner wall); (e) eliminates the need for many active engineered safety features.

Proliferation Resistance: This energy system is expected to be highly proliferation-resistant, even when installed in developing countries. The fuel is brought to the country inside the sealed reactor module, and is taken out of the country in the same sealed module. It is never necessary to ship, store or handle fuel in the developing country except inside the reactor vessel, and the reactor vessel need not be opened at any time in the developing country. In addition, the long-life core can be designed with non-proliferating uranium (~ 15% enrichment) and the spent fuel need not be taken out of the vessel/storage cask for dozens of years.

Public Acceptability: Via all the above, plus the concept of a long-life nuclear battery.

There will be two 18 month parts to this project. In part 1 we will examine a number of issues which are critical to the feasibility of the ENHS concept. If this concept is found feasible, we will examine, in Part 2, the feasibility of a number of alternative embodiments of the ENHS. These embodiments will vary from small, autonomous power source using thermoelectric generator integrated with the reactor vessel for remote locations, to central power plants consisting of multiple ENHS modules.