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

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Title: **Supercritical Water Nuclear Steam Supply System: Innovations in Materials, Neutronics and Thermal-Hydraulics**

A nuclear reactor cooled by supercritical water would have a much higher thermal efficiency with a once-through direct power cycle, and could be based on standardized water reactor components (light water or heavy water). The theoretical efficiency could be improved by more than 25% over that of other water reactors and could be simplified with higher reliability; e.g., a boiling water reactor without steam separators or dryers. Such improvements could also be accompanied by a corresponding decrease in the nuclear plant levelized electricity cost, and thus, could make this nuclear steam supply system quite competitive in a deregulated electric power market as a large central power source. However, to make such a system technologically feasible, advances are required in high-temperature materials to improve corrosion and wear resistance (cladding and pressure structural boundaries), in neutronics to improve fuel-cycle versatility with these advanced materials as well as in neutronics and thermal-hydraulics to insure passive safety and stability. Our objective in this proposal would be:

1) Employ innovative ion implantation surface modification techniques to improve material compatibility at supercritical conditions. Plasma Source Ion Implantation techniques will be used to modify clad materials and demonstrate improved corrosion/wear resistance under supercritical thermal-hydraulic conditions.

2) Neutronics analyses would identify ranges of alternative fuel cycles, including variations in enrichment, refueling schedules, recycling and conversion/breeding. These analyses would focus on coolant density effects at supercritical conditions to verify passive safety with comparisons from the standpoint of fuel burnup, flexibility, proliferation resistance as well as sustainable development, using quantitative metrics.

3) Thermal-hydraulic studies would focus on heat transfer and flow stability issues associated with coolant density changes for natural circulation of supercritical water. Scaled simulant experiments are to be designed and performed to provide heat transfer and stability data to be used in developing predictive tools.