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

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Institution: **Argonne National Laboratory**

Title: **Particle-Bed Gas-Cooled Fast Reactor (PB-GCFR) Design**

This project will develop a conceptual design of a particle-bed gas-cooled fast reactor (PB-GCFR) core that meets the advanced reactor concept and enhanced proliferation resistant goals of the U.S. DOE NERI program. The key innovation of this project is the application of a fast neutron spectrum environment to enhance both the passive safety and transmutation characteristics of the advanced particle-bed and pebble-bed reactor designs. The attractive features of Eskom's Pebble Bed Modular high temperature reactor (PBMR) project, will be retained in our design. The PB-GCFR design is expected to produce a system with a high efficiency and a low unit cost. It is anticipated that the fast neutron spectrum would permit small sized units (~ 110 MWe) that can be quickly built, packaged into modular units, and readily expanded as the demand grows. Such a system could therefore be deployed globally. The goals of this project are:

(a) Design a reactor core that meets the future needs of the nuclear industry, by being passively safe with reduced need for engineered safety systems. One of the major issues arising from previous gas-cooled fast reactor designs is the poor heat removal properties of the helium coolant at low pressure. This issue was previously addressed by the use of highly reliable redundant coolant circulators. Passive-safety-in-the-design is however the major goal of this project. The ability to remove decay heat through conduction pathways, mainly, for station blackout and depressurization conditions and the capacity to tolerate failure to scram without reaching core disruption will be the focus. This will entail an innovative core design incorporating new fuel form and type. Novel designs for fuel elements and configuration will be developed.

(b) Employ a proliferation resistant fuel design and fuel cycle. This will be supported by a long-life core design that is refueled infrequently and hence reduces the potential for fuel diversion. The application of a fast neutron spectrum environment makes this design feasible since it permits compact core designs and fuel burnup characteristics that reduce the burnup reactivity control requirements. A low burnup reactivity swing also implies a low control rod worth requirement, which aids passive safety. The high neutron fluence inherent in the fast spectrum design coupled with the high operating temperature (for high efficiency) however provides challenges that have to be resolved. This would necessitate the investigation of materials that can withstand the high temperature and flux environments of the system. Additionally, core studies that would result in an optimum compact core design with a low cost will also be pursued.

(c) Incorporate design features that permit use of the system as an efficient transmuter that could be employed for burning separated plutonium fuel or recycled LWR transuranic fuel, should the need arise. The fast spectrum is attractive here because it readily accommodates the destruction of both plutonium isotopes and minor actinides. The high burnup of fissile material is another approach for enhancing proliferation resistance.

(d) The fuel cycle should minimize waste and should also be evaluated for the possibility of direct fuel disposal. The application of particle-bed fuel provides the promise of extremely high burnup and fission product protection barriers that may permit direct disposal. Under this item, a core having both fast and thermal zones that could be used for targeted burning of minor actinides and plutonium isotopes, respectively, can be studied. Alternatively, feasibility studies could also be performed for a dual strata system that gives a high fuel burnup.

This project will require various research and development tasks in the area of core neutronics, thermal-hydraulics, safety, fuel reliability, proliferation resistance, waste form and economics. These items are expected to be valuable in attracting and training new nuclear engineers, a component that is vital to the future of nuclear energy development.