

Synergies between Generation-IV and Advanced Fusion Power Plants

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For the first time since the early 1990's, the U.S. Department of Energy has long term research and development programs in both nuclear fission and nuclear fusion, the Generation IV research and development program and the ARIES program, respectively. Moreover, they are both working towards energy sources with ambitious sets of constraints and a great deal of promise. The synergies created by these increasingly parallel programs open the door for new collaborations that will increase the total effectiveness of research needed in both. This paper reviews some of the most important opportunities.

Materials

The most obvious, and arguably the most important, area of collaboration is that of materials research and development. While advanced fusion power plant studies have, for some time, required low-activation materials that can operate at extreme temperatures (700-1000°C) in a high energy radiation environment, most fission power plants developments have been content to limit their environments to the lower temperatures and thermal fluxes of a light water reactor environment. The Generation IV program changes that with an emphasis on very high temperature cycles combined, in some cases, with faster spectra. Innovations in materials research such as computational materials design and novel materials testing capability will benefit both communities as they attempt to achieve longer component lifetimes and more benign waste streams.

Safety and Regulation

The ARIES fusion power plant studies have long included a constraint that leads to an enhanced safety philosophy: no off-site emergency response to any design basis accident. The Generation IV program adds this constraint to the development of future fission reactor systems. At the same time, the regulatory framework, currently focused on the safe operation of light water reactors, will require changes to accommodate the Generation IV fission reactors and ultimately the fusion power plants. Similarly, new approaches to the classification of waste streams to minimize the amount of material destined for geologic disposal will assist both communities in meeting their waste management goals. The process of enacting those changes, as well as the specific changes in some cases, both represent an opportunity for mutual benefit.

Economics and Energy Products

It is difficult to predict the energy markets of the future, but most fusion and fission systems can be expected to be deployed at large power levels and require large capital investment in order to facilitate a competitive cost of electricity. As future energy markets develop, some of the economic analysis for advanced nuclear systems will be common to all systems. This is particularly true when considering the role of nuclear systems in alternative/emerging energy markets such as the production of hydrogen fuels.