Closed Fuel Cycle with Fast Reactors

Over a period of two years, eight countries joined forces to assess a nuclear energy system based on a closed fuel cycle with fast reactors (CNFC-FR) with the INPRO methodology. The objective of this "Joint Study" was to determine whether a CNFC-FR would meet criteria of sustainable development, to define milestones for deploying nuclear energy and to establish areas which would require future collaborative R&D work. The countries were Canada, China, France, India, Japan, the Republic of Korea, the Russian Federation, and Ukraine. A near-term CNFC–FR system based on proven technologies, such as sodium coolant, MOX pellet fuel and aqueous reprocessing technology was used as a reference system.

A general observation was made that an optimized future for nuclear energy deployment may not be entirely consistent with current national planning. With the goal of making the CNFC-FR a viable alternative to conventional sources of power, the Joint Study identified some weak points in current national approaches that must be resolved. This refers specifically to economics and safety, where further research is necessary to achieve a lower level of risk of severe accidents.

The design of currently operating nuclear energy systems with CNFC–FR may not meet economic competition requirements. Simplifying the design, increasing the fuel burn up and reducing costs through targeted R&D, along with small series constructions, could make the costs of nuclear power plants with fast reactors comparable to those of thermal reactor and fossil fuelled power plants.

In some countries, the introduction of fast reactors might contribute to an efficient use of nuclear fuel resources by increasing the use of plutonium fuels and denaturated uranium fuel, to be generated in the fast reactor blankets, if needed.

By developing and introducing novel technologies for an optimal management of nuclear fission products and minor actinides, the CNFC–FR system would have the potential for a 'breakthrough' in meeting all of today's requirements of waste management.

Due to the technological features of the CNFC–FR system, its proliferation resistance could be comparable to, or higher than that of a once-through fuel cycle. The CNFC–FR system is a key technology for the balanced use of fissile materials.

A CNFC–FR system requires a regional or multilateral approach to front and back end fuel cycle services and the transition to a global nuclear architecture.

Since the Joint Study conclusions also called for an inter-disciplinary approach and international collaborations wherever possible, as a follow-up, several INPRO collaborative projects were initiated which address the issues identified:

- Global architecture of nuclear energy systems based on thermal and fast reactors including a closed fuel cycle (GAINS);
- Integrated approach for the design of safety grade decay heat removal system for liquid metal cooled reactor (DHR);
- Assessment of advanced and innovative nuclear fuel cycles within large scale nuclear energy systems based on CNFC concept to satisfy principles of sustainability in the 21st century (FINITE); and
- Investigation of technological challenges related to the removal of heat by liquid metal and molten salt coolants from reactor cores operating at high temperatures (COOL).