(KEYNOTE SPEECH)

OVERVIEW OF PRINCIPLES AND CHALLENGES OF FUSION NUCLEAR TECHNOLOGY

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ABSTRACT

Fusion offers very attractive features as a sustainable, broadly available energy source: no emissions of greenhouse gases, no risk of severe accident, and no long-lived radioactive waste. Significant advances in the science and technology of fusion have been realized in the past decades. Seven countries (EU, Japan, USA, Russia, S. Korea, China, and India) comprising about half the world population are constructing a major magnetic fusion facility, called ITER, in France. The objectives of ITER are to demonstrate self-sustaining burning fusion plasma and to test fusion technologies relevant to fusion reactor.

Many challenges to the practical utilization of fusion energy remain ahead. Among these challenges is the successful development of Fusion Nuclear Technology (FNT). FNT includes those fusion system components circumscribing the plasma and responsible for tritium production and processing, heat removal at high temperature and power density, and high heat flux components. FNT components face a new and more challenging environment than experienced by any previous nuclear application. Beyond plasma physics, FNT has most of the remaining feasibility and attractiveness issues in the development of fusion as an energy source. The blanket, a key FNT component, determines the critical path to DEMO. The blanket is exposed to an intense radiation environment. Radioactivity and decay heat can be produced in the structure and other blanket elements. Hence, material choices have a large impact on safety and environmental attractiveness. The unique conditions of the fusion environment include high radiation flux, high surface heat flux, strong 3-D-component magnetic field with large gradients, and ultra-low vacuum. These conditions, together with the requirements for high-temperature operation and tritium self-sufficiency, make blanket design and development challenging tasks.

The blanket concepts being considered worldwide can be classified into solid breeders and liquid breeders. Solid breeder concepts use a lithium ceramic as breeder, beryllium as neutron multiplier, and helium or water as coolant. The liquid breeder can be: a) liquid metal (lithium or ^{83}Pb ^{17}Li), or b) low-conductivity molten lithium salt. Self-cooled, separately-cooled, and dual-coolant concepts are options for liquid breeder blankets. Ferritic steel is considered the primary structural material for almost all blanket concepts for DEMO. There are many advantages and feasibility issues for all blanket concepts. Examples include MHD and insulators, tritium permeation barriers, tritium control, materials interactions and compatibility, thermomechanics interactions, reliability, and synergistic effects. An R&D program is being pursued worldwide that includes testing in non-fusion facilities such as laboratory experiments and fission reactors. Testing of blanket modules in the fusion environment is one of the key objectives of ITER. The

ITER Parties are presently developing a detailed plan for testing several blanket options on ITER. In addition to ITER, a specialized plasma-based facility for testing and development of FNT is being considered.