Development Scenario of Fusion Energy following the ITER Project

Background

A development scenario of fusion energy by the three stages (i.e. the experimental reactor, the demonstration reactor, and the commercial reactor) is discussed in the world. In order to construct the feasible development scenario, it is necessary to evaluate qualitatively which component of reactor technology should be developed to what extent. Furthermore, for the realization of fusion energy, it is also important for the fusion energy to be recognized as one of the energy source as soon as possible. Form the viewpoint of the future electric supplier, we proposed the conceptual design of a commercial reactor, which is named CREST, and this design is considered to be one of the Japanese development goals of fusion energy in the atomic energy commission of Japan. On the other hand, the project of the experimental reactor, i.e., International Thermonuclear Experimental Reactor (ITER) is underway, and its experimental plant and R&D activities such as large superconductor technology are almost completed. Hence, in order to complete the development scenario of the fusion energy, it is the most important to investigate the demonstration reactor following ITER.

Objectives

A conceptual design of the demonstration reactor “Demo-CREST” followed by CREST is carried out, and a development scenario of the fusion energy is constructed. Accordingly, we make the suggestion for the Japanese development policy of fusion energy.

Principal Results

1. The development scenario of three stages, i.e., ITER (the experimental reactor), Demo-CREST (the demonstration reactor), and CREST (the commercial reactor), is constructed in order to realize the demonstration of a fusion power plant in 2030’s earlier than usual for the first time in the world, and is was proposed in the fusion expert group of the atomic energy commission of Japan (Figure-1). This scenario is characterized by a single device, into which the demonstration reactor and the proto-type reactor are combined.

2. In the Demo-CREST operation, the improvement of plant performance is steadily explored by the following two phase, (i) the demonstration phase, and (ii) the development phase. In the demonstration phase, a net electric power of 50MW is achieved based on the results from the ITER project. In the following development phase, a net electric power of 100MW is feasible by the advanced plasma and reactor technology (improvement of thermal efficiency more than 40%, and so on) applied to CREST. Consequently, the demonstration of the key technology required for improving economic performance in Demo-CREST leads to the prospect of CREST (Table-1).

3. In the Demo-CREST design, the high efficiency of neutron usage by the large blanket modules enables to achieve the high tritium breeding ratio. Accordingly, the replacement method of a large blanket module is proposed, and it enables to shorten the maintenance period and to replace modules according to the neutron wall load (Figure-2). Consequently, the supply of tritium and plant maintainability is insured in Demo-CREST, which leads to the stable operation inevitable to the demonstration reactor.

Further Developments

On the basis of this development scenario, the objective parameter of each development stage will be precisely evaluated, and the development guideline of fusion energy to the user-friendly power plant will be constructed.

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Reference

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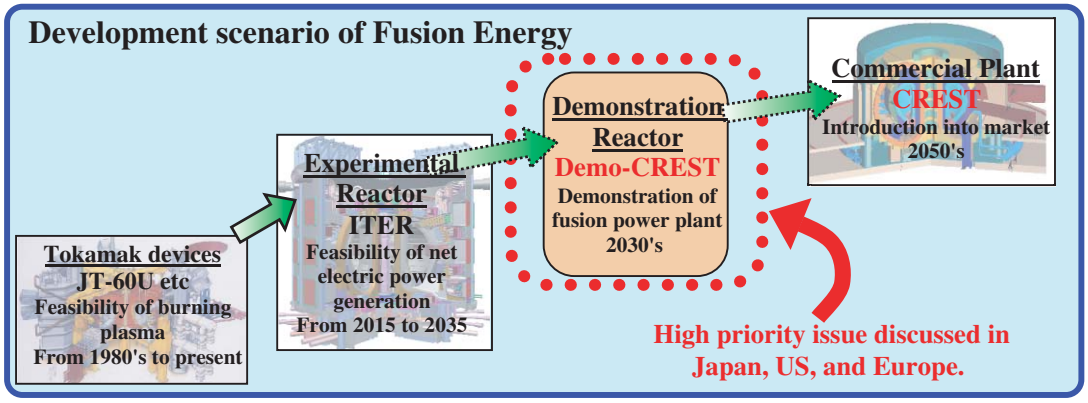

Fig.1 Outline of fusion energy development and the role of Demo-CREST

Table 1 Development of net electric power in Demo-CREST

		Development of reactor technology			
		ITER Major radius 6.2m Max. magnetic field 13T	**Demo-CREST** Major radius 7.3m Max. magnetic field 16T		**CREST** Major 5.4m Max. magnetic field 13T Thermal efficiency 41%
			Demonstration phase Thermal efficiency 30%	**Development phase** thermal efficiency 40%	
Development of plasma	**ITER Reference plasma**	(demonstration of burning plasma)	**0MWe**		
	ITER Advanced plasma	(development of the plasma required for a power plant.)	**500MWe**	**900MWe**	
	CREST Advanced plasma			**1100MWe**	**1200MWe** (COE:60mill/kWh)

In ITER, demonstration of burning plasma and development of plasma required for a power plant are carried out. In the demonstration phase of Demo-CREST, 500MWe of electric generation is demonstrated by the ITER advanced plasma. In the development phase, theimprovement of plasma and thermal efficiency by replacement of blanket enables to generate more than 1000MWe, and that lead to the prospect of CREST.

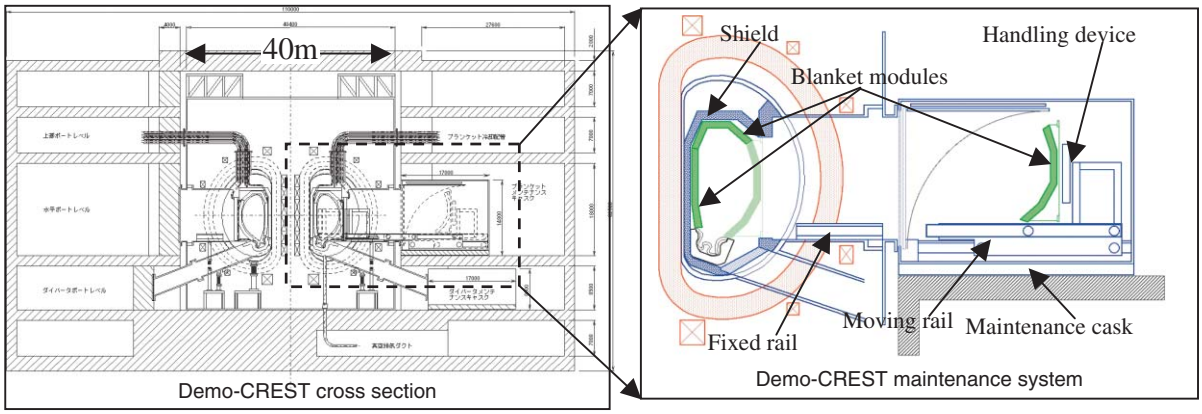

Fig.2 Cross section of Demo-CREST and its maintenance system

The blanket system, which is divided into three modules, is replaced by a handling device. The handling device moves on the fixed rail on the maintenance port and on the moving rail in the cask.
(blanket: the component for the thermal output and tritium breeding. In Demo-CREST, the division of the blanket system into three modules leads to the efficient maintenance.)