

R&D FACILITIES OF KOREA, PLANNED IN ITER ERA

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Operating Definition of K-DEMO

Milestones



Staged Development

1st Phase : To validate technical feasibility

2022	2024	2025	2029	2033	2035	2036
Construction permit	Start excavation	Select materials	Start installation of major components	Start commissioning	Start operation	First electric power generation

2nd Phase : To prove economic feasibility

2030	2033	2037	2038
Select a new set of DEMO materials (2030)	Complete design improvements (2033)	Second stage DEMO construction permit	Start improvement of DEMO plant

Design Parameters

Pressurized Water Cooled Reactor	1 st Stage	2 nd Stage
Rated Power	60 MWc	600 MWc
Availability	~10 %	> 50 %
K-DEMO reactor	Fusion power	0.2 GW
	Major radius	8.14 m
	Plasma minor radius	2.8 m
	Elongation (95% flux)	1.8
	Tri-angularity (95% flux)	0.35
	Plasma current	9 MA
Fusion gain	> 13.5	> 30
Normalized beta	≥ 4	≥ 4
Magnetic field	6 T	TBD
Average neutron wall load	0.2 MW/m ²	2 MW/m ²
Divertor peak heat load	1 MW/m ²	10 MW/m ²
RCS* temperature / T _{in} (°C) / T _{out} (°C)	290 / 330	TBD
Thermal cycle	Rankine / Saturated Steam	
Irradiation damage	4 dpa	200 dpa

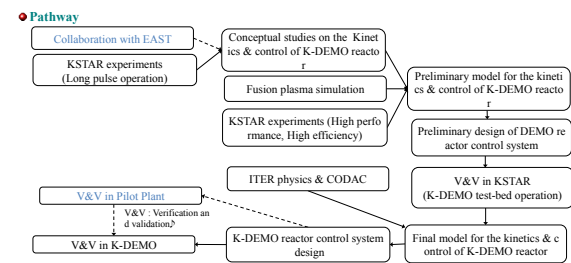
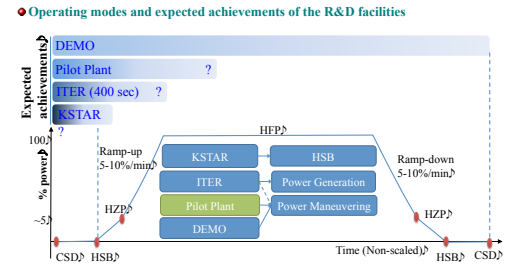
* RCS : Reactor coolant system of K-DEMO reactor?

Gaps and Pathways to the 1st Stage K-DEMO

Fusion Reactor Control

- Postulated operating modes of K-DEMO**
 - Cold shut-down (CSD) : Reactor coolant system (RCS) at atmospheric pressure and below boiling temperature; Magnets and H&CD not energized ; Vacuum not established.
 - Hot stand-by (HSB) : Pressure and temperature at or near that of power operation; Vacuum fully established; Magnets and H&CD in operation; D-D plasma in operation.
 - Hot-zero-power (HZZ) : D-T reaction triggered; Reactor power 3~5 % of the rated power
 - Hot-full-power (HFP) : Reactor power at the rated power
- Desired Goal**
 - Heat-up from CSD to HSB and cool-down to the reverse direction in a controlled way
 - Indefinitely sustaining HSB condition ;
 - Maneuvering from HSD, HZZ to HFP and vice versa in a controlled way;
 - Thermo-hydraulic (T-H) loads and MHD loads, incurred by the reactor operation, to the piping systems K-DEMO reactor shall not exceed stress allowable limits both instantaneously and cumulatively
- Current Status**
 - Carrying out KSTAR experiments to find a way to get HSB.
 - DEMO-reactor-control study just began

Fusion Reactor Control (Continued)

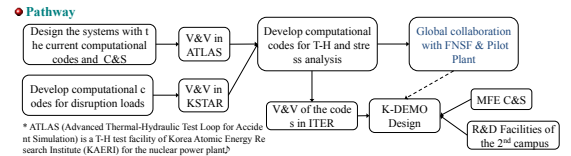


Tritium Breeding

- Desired Goal:** Self-Sufficiency
- Current Status:** Self-sufficient with the current computational codes & databases (Need V&V)
- Pathway**
 - Current computational codes lead to Design & manufacturing of ITER TBM and DEMO blanket proto-typing.
 - ITER TBM tests and DEMO blanket proto-typing lead to ITER TBM tests and In-pile Test as necessary (Global collaboration with FNSF, Pilot Plant).
 - Both lead to V&V of computational codes & databases and K-DEMO Blanket.

Fusion Reactor System Design

- Desired Goal**
 - V&V of computational T-H codes in the T-H test facilities
 - Stress analysis completed in compliance with the MFE C&S (ASME Section III Division IV)
 - Engineered-safety features designed in accordance with the regulatory requirements and safety analysis
 - Improvement in H&CD and magnets
- Current Status:** Conceptual design of fusion reactor systems just initiated
- Pathway**
 - Design the systems with the current computational codes and C&S
 - Develop computational codes for disruption loads
 - V&V in ATLAS and V&V in KSTAR
 - Develop computational codes for T-H and stress analysis
 - V&V of the code in ITER
 - Global collaboration with FNSF & Pilot Plant
 - MFE C&S and R&D Facilities of the 2nd campus



Structural Integrity of In-Vessel Components

- Desired Goal:** Structural integrity of the in-vessel component with irradiation damage of 4 dpa
 - Current Status:** Database of irradiation damage for the structural materials insufficient
 - Pathway**
 - Development of DEMO structural materials (Primary candidate: RAFM steel)
 - Irradiation Tests in HANARO (4dpa in 16 months)
 - Prototyping of DEMO In-Vessel Components
 - FNSF Pilot Plant
 - ITER TBM and TBM Tests
 - DEMO In-Vessel Component Design & Manufacturing
- * HANARO (High Flux Advanced Neutron Application Reactor) is a multi purpose research reactor of KAERI?

Radiation Protection

- Desired Goal:** V&V of source terms
 - Current Status:** Experimental data on tritium behaviors insufficient
 - Pathway**
 - Study on hydrogen leakage in the piping system
 - Hydrogen leakage test facility
 - Global collaboration with FNSF & Pilot Plant
 - Current source term analysis codes of NPP and ITER
 - Source term analysis codes for Fusion DEMO
 - V&V of source term analysis code
 - ITER tritium behavior research
 - Study on the tritium behavior in the Fusion DEMO with WTRF
 - K-DEMO Radiology analysis
- *WTRF (Wolsong Tritium Removal Facility) is the facility to reduce tritium inventory in the CANDU type reactor?

Safety & Licensing

- Desired Goal**
 - V&V of inherent safety and safety analysis methods
 - PWI and severity of dust explosion quantified
 - Regulatory Requirements and C&S for K-DEMO prepared
- Current Status**
 - Studies on PWI and dust explosion underway
 - Development of regulatory requirements and C&S for MFE just initiated
- Pathway**
 - Development of regulatory requirements
 - V&V in collaboration with Pilot Plant
 - Development of MFE C&S for K-DEMO in collaboration with ASME, IEEE, ...
 - Classification Criteria & ESF Requirements (Preliminary)
 - DEMO Plant design
 - DEMO Classification & ESF Requirements (Final)
 - 1st Phase K-DEMO PSAR/ Construction permit
 - 1st Phase K-DEMO PSAR/ Operating license
 - KSTAR (High performance operation and DEMO test bed)
 - Prove inherent/ Passive safety
 - V&V T-H analysis codes
 - ITER operation data - Crud activation - Tritium migration - Burning plasma physics
 - V&V inherent/ Passive safety and source terms
 - Collaboration with pilot plant and FNSF

R&D Facilities of Korea in ITER Era

