On Korean Strategy for Fusion Energy

International Workshop on MFE Roadmapping
in the ITER Era
7-10 September, 2011
Princeton, NJ, USA

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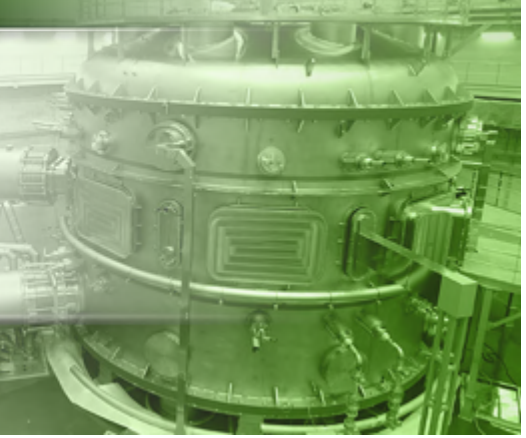

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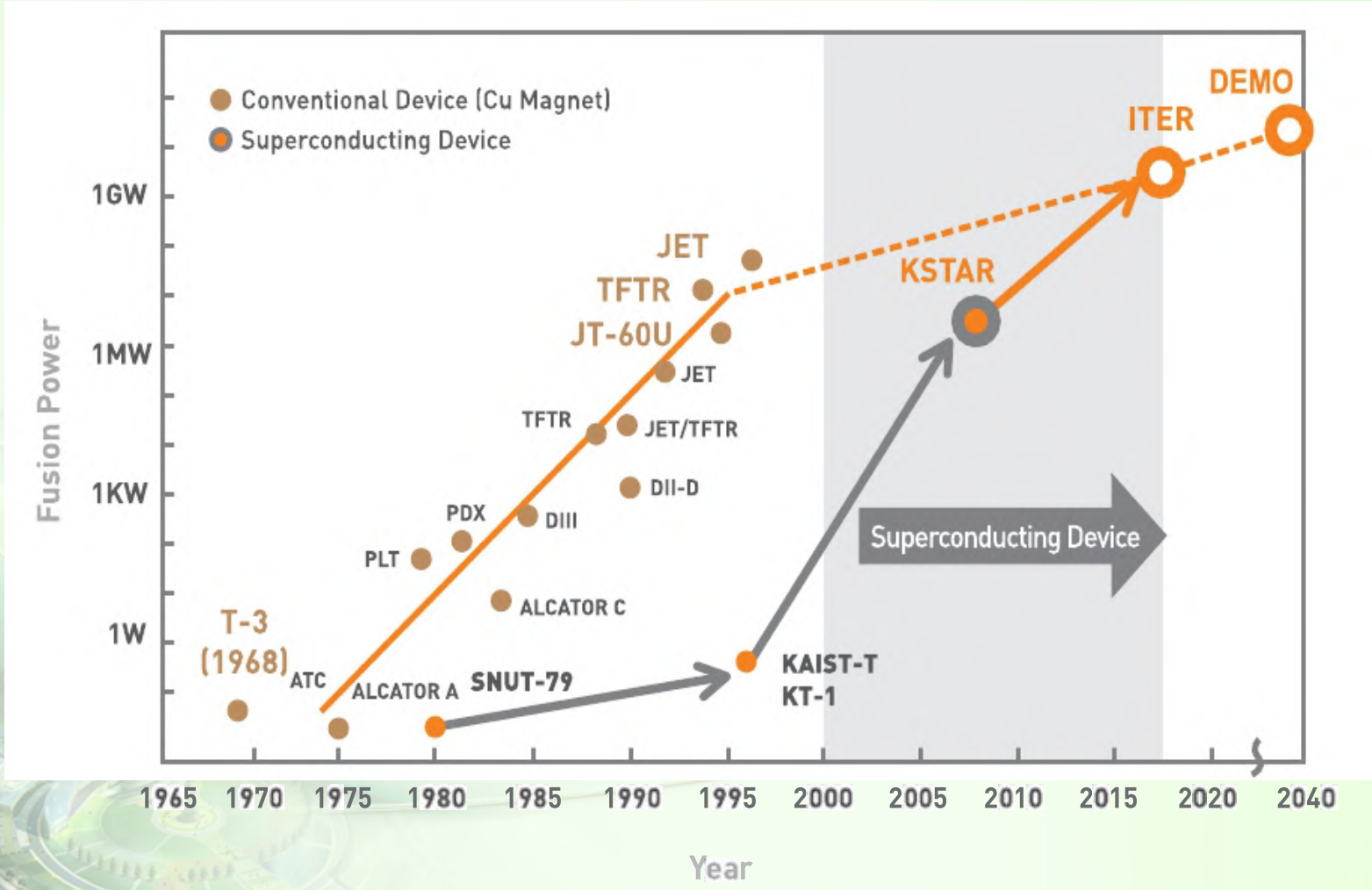
Ⅰ. Background

- R&D Programs
- Supporting Law and Program
- Planning for DEMO

Initiation of KSTAR Project based on “Mid-Entry Strategy”



KSTAR Construction-Technology Development

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1995
Launch of KSTAR Project

1996 - 1997
Basic Design and R&D

1998 - 2001
Engineering Design
and Facility Construction

2002 - 2007
Construction of KSTAR

June 2008
First Plasma

Success of KSTAR is based on dedication and Technological Advancements of Korean Industries!

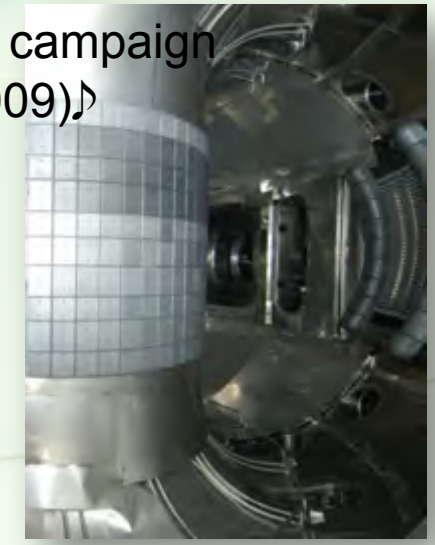
- 1,510 Participants from 69 Companies

KSTAR Operation - Device Evolution

1st campaign (2008)♪

PFC coverage : 1.54m^2

2nd campaign (2009)♪

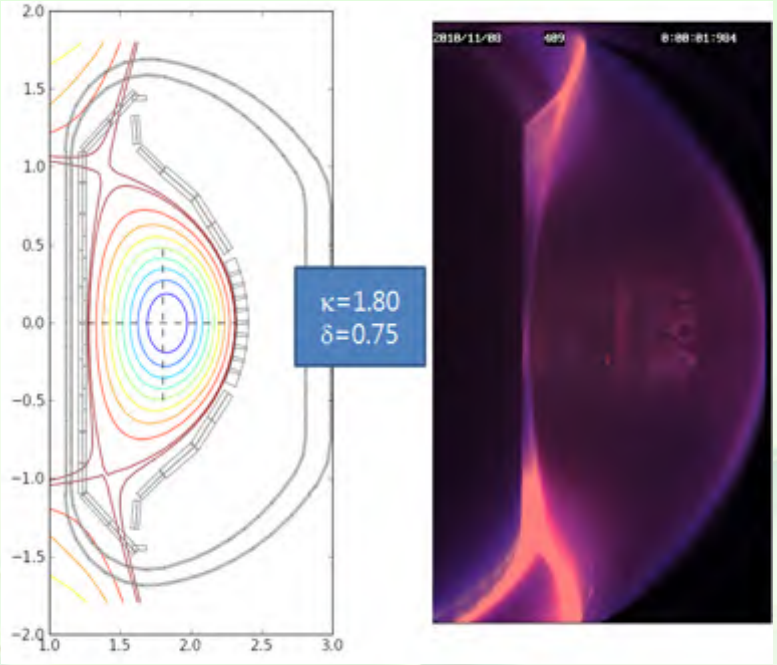


PFC coverage : 11.08 m^2

3rd campaign (2010)♪

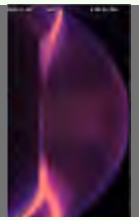
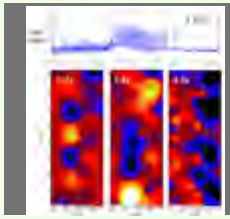
PFC coverage : 52.94 m^2 + IVCC+Cryopump♪

KSTAR Operation – Science Development

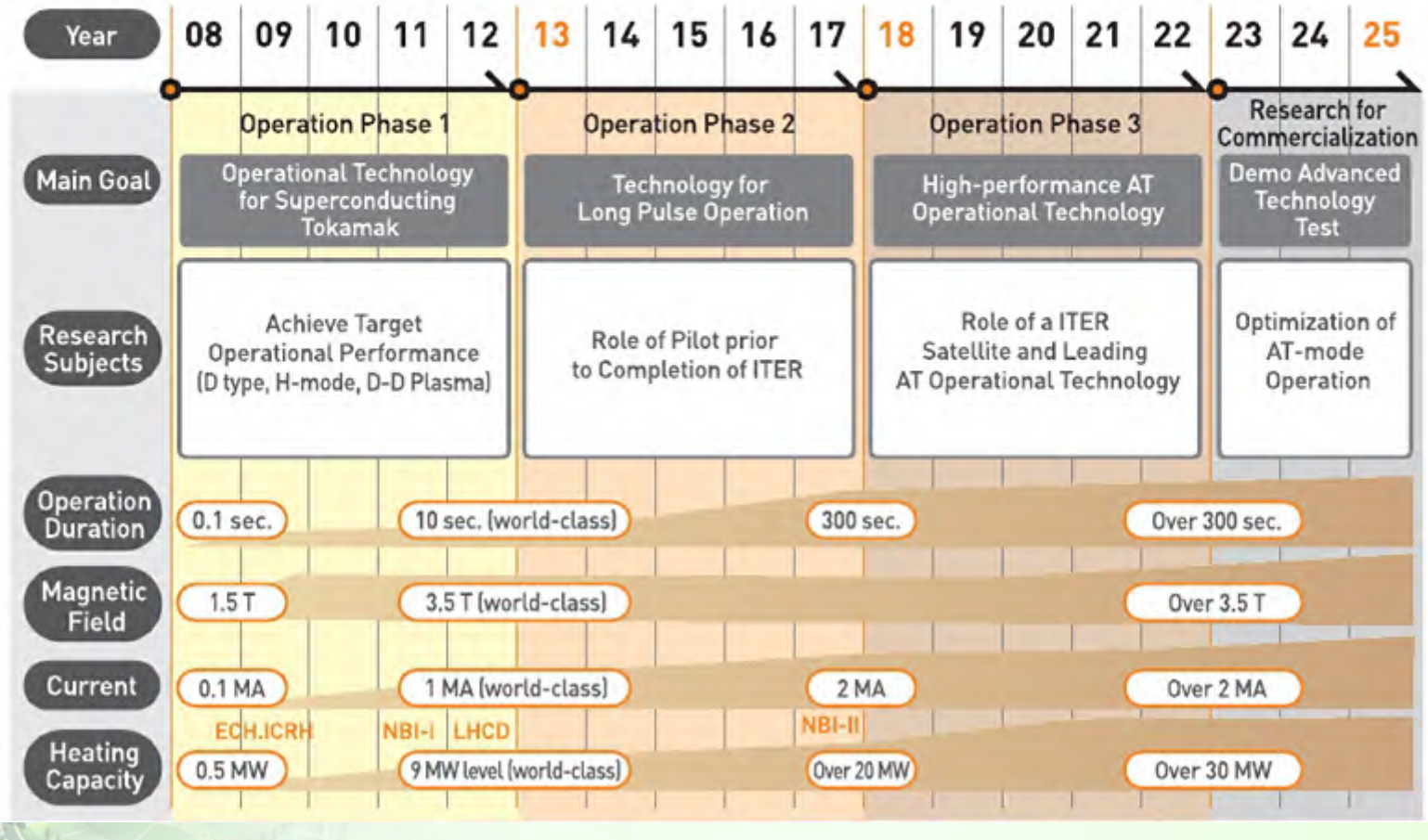


R&D for DEMO beyond ITER

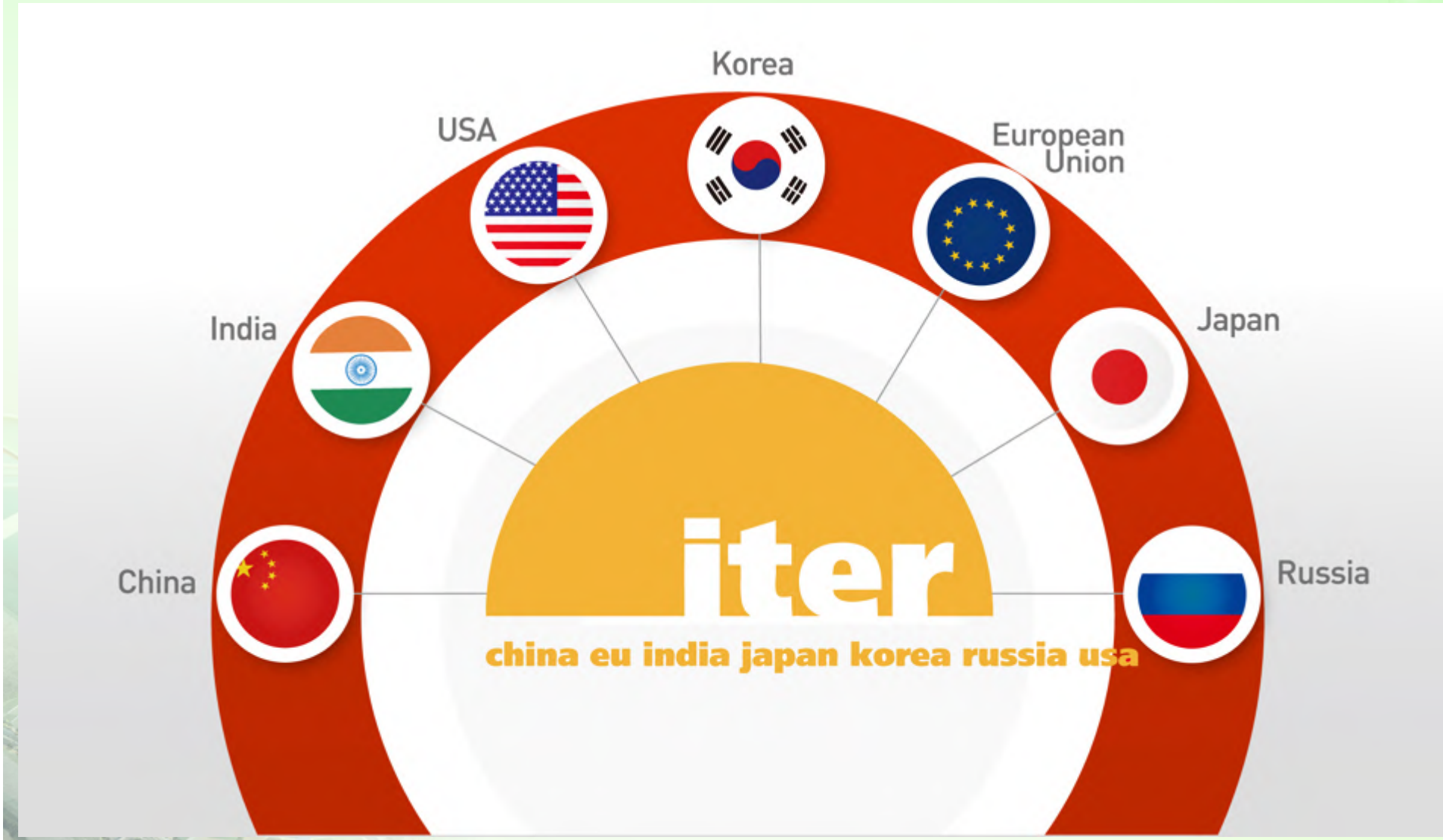
- Enhanced Plasma performance eventu ally to continuous operation
- Plasma-Material Interaction
- Diagnostics
- …

First Plasma (‘08)	Second Campaign (‘09)	Divertor Plasma (‘10)	H-mode Plasma (‘11)
			
133kA 0.25sec 1.5 T♪	320kA 3.6sec 3.0 T♪	720kA 5.2sec 3.0 T♪	1000kA 12.5sec 3.0 T♪

KSTAR Operation Plan



The Seven Parties of the ITER Project



ITER – Contribution of Korea

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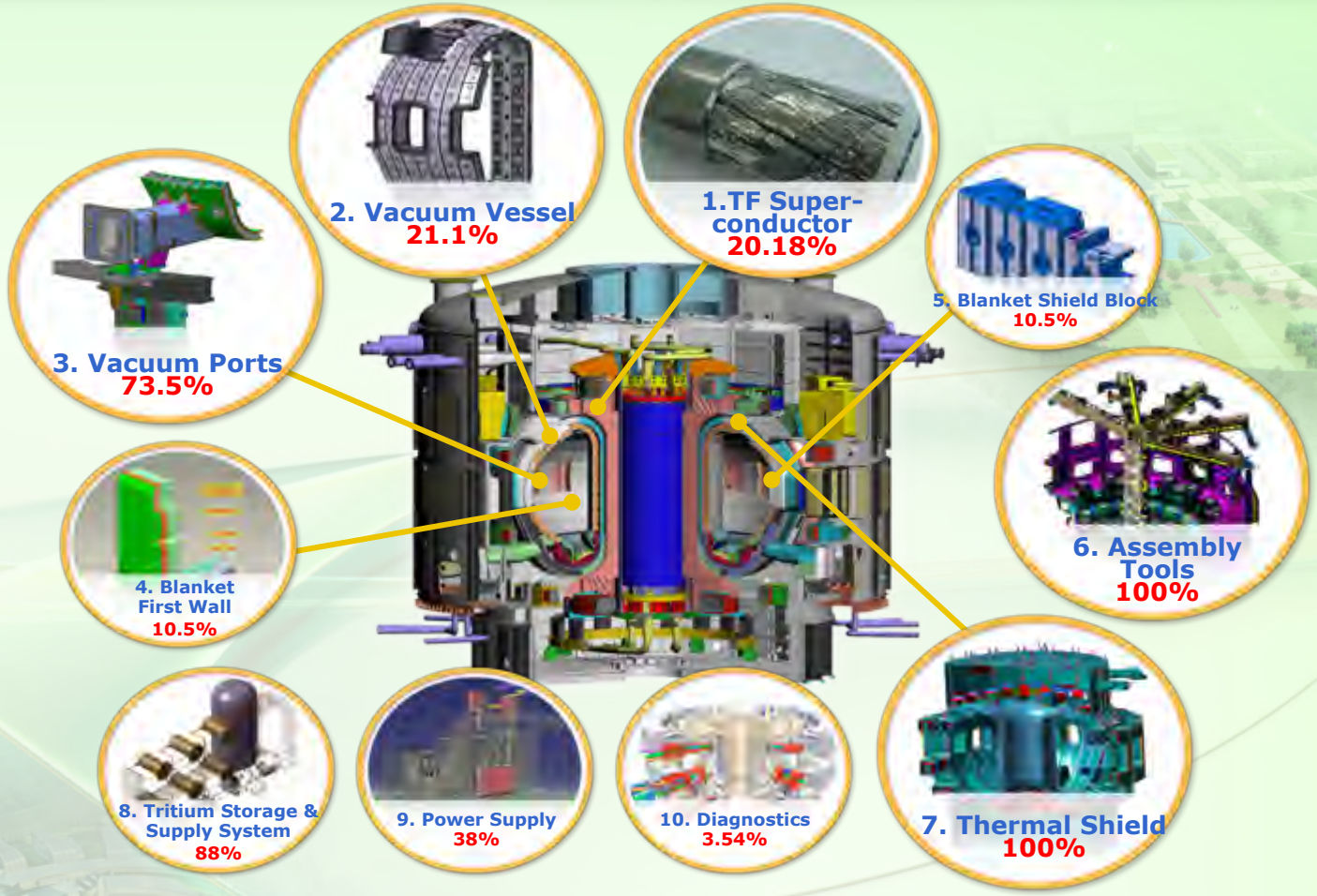

- Strengthen Industry base for DEMO

Legal Basis of Government Support for Fusion Energy

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Fusion Energy Development Promotion Law

- To establish a long-term and sustainable legal framework for fusion energy development phases.
- To promote industries and institutes which participating the fusion energy development by supports and benefit.
- One of the strength of the Fusion Energy development of Korea (2007. 3 ~)

Fusion Energy Development Promotion Program

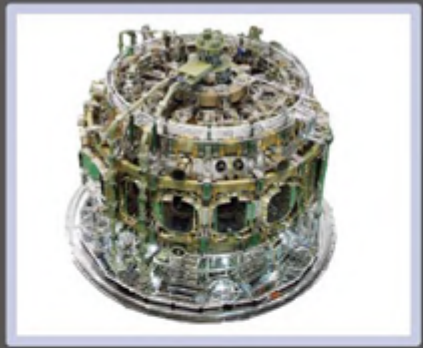
- The Government of Korea to issue at every five years from 2007
- To Publicize the R&D Strategies and Implementing Plans for Fusion Energy
- Reviewing the current program in 2011 and preparing for the 2nd program active in 2012 ~ 2017

Korean Roadmap for Fusion Energy

Role of KSTAR and ITER

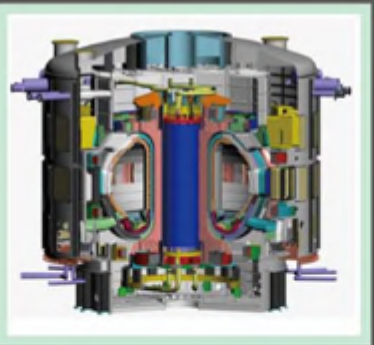
2010' KSTAR

- High-Beta, Steady-State
- Integrated Control
- Optimum Fusion Reaction



2020' ITER

- Reactor Engineering
- DT Burning Plasma
- Blanket, Divertor

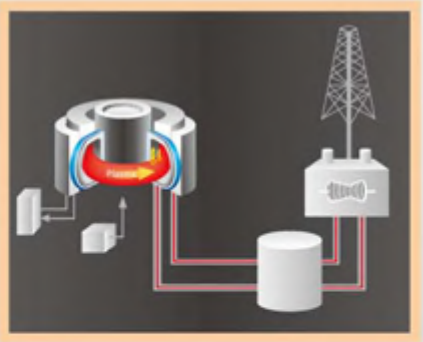


2030' DEMO

- Reactor System Optimization
- Electricity Production

2040' Fusion Plant

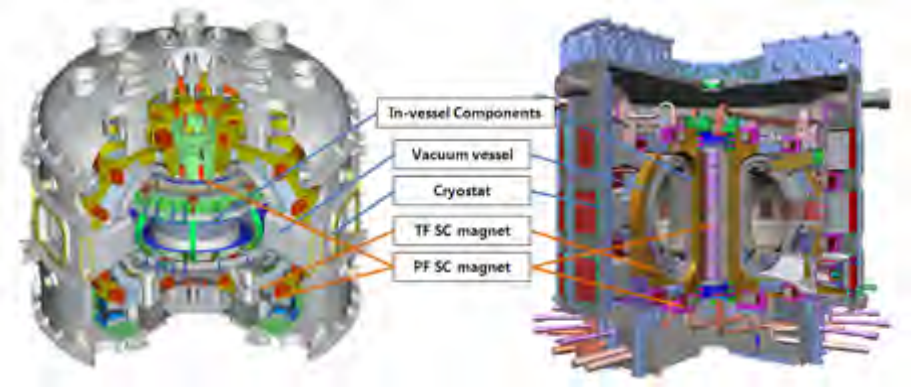
- Completion of Fusion Plant Engineering
- Commercialization of Fusion Energy



DEMO – Activity Initiation

- DEMO Planning and R&D Activity Initiation by National Fusion Research Institute by installing Advanced Project Division since 2009

KSTAR & ITER



DEMO

Toward DEMO

- Gap study R&D Portfolio & Cross-cutting
- Required R&D Facilities and Infrastructure
- DEMO Planning & Design
- Government, Industry, International collaboration

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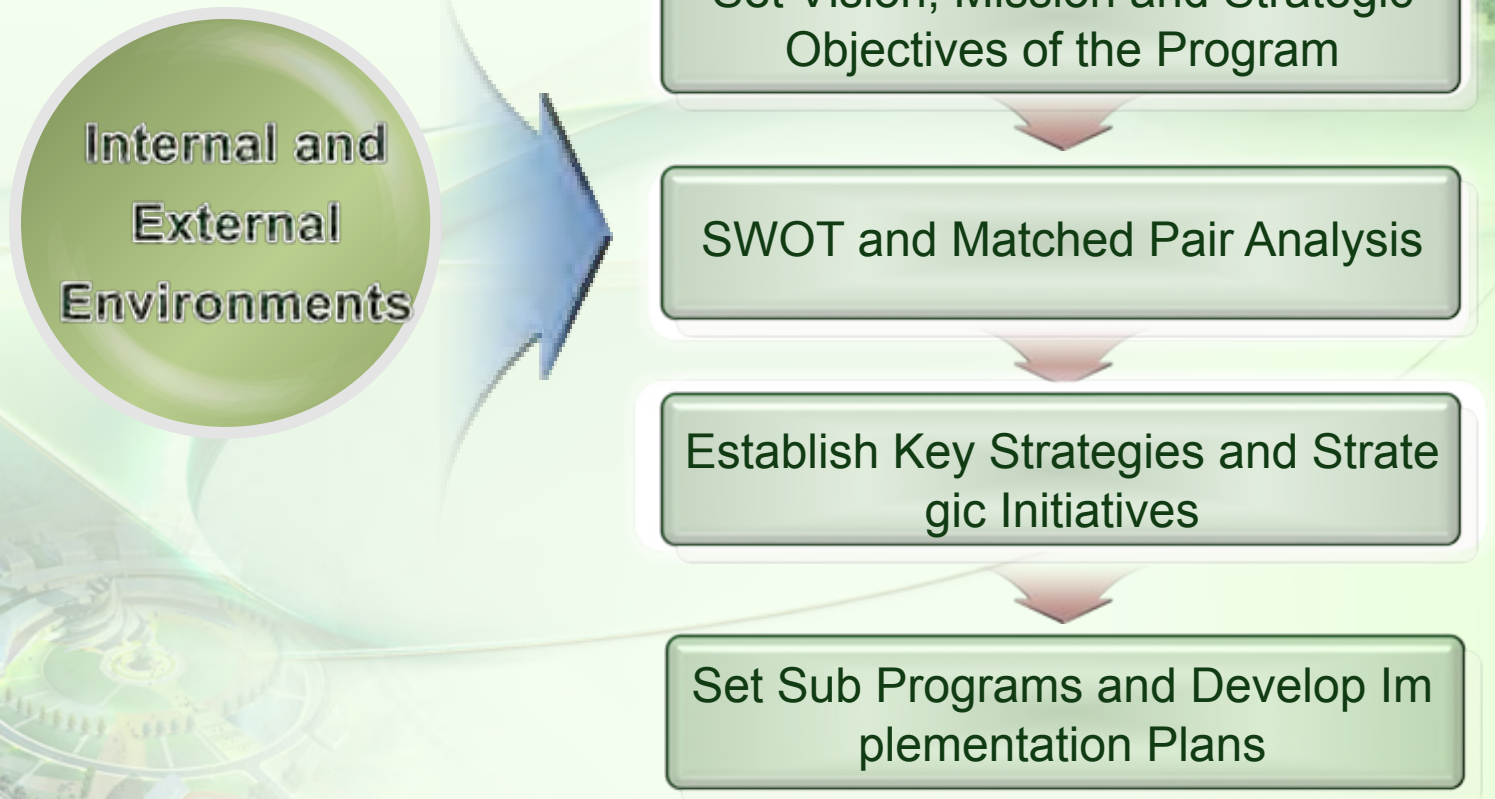
II. A Strategy for K-DEMO

- A Process for Strategic Planning
- Scopes for each Staged Program

A Process for Strategic Planning



Strategic Initiatives & Implementing Measures (I)

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Strategic Initiatives	Implementing Measures
Start DEMO with Immature Technologies and Staged Licensing	• Utilize NPP technologies to cross-cut the design study of DEMO Plant; • Incorporate fusion research outcomes immediately and continuously; • Make the best use of IT technologies; • Prove the inherent safety; • Early involvement of the licensing body
Enhance International Collaboration	• Form or join a multi national DEMO Program; • Get the feed backs from ITER, IFMIF, CTF, etc through international collaboration.
Implement Open Innovation in the Global Contexts	• Carry out R&D portfolio management and cross-cutting in the global contexts; • Operate VR, ubiquitous, real-time Fusion DEMO Research Center

Strategic Initiatives & Implementing Measures (II)

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Strategic Initiatives	Implementing Measures
Deploy Strategic Science Business Activities with Interim R&D Deliverables	• Share the research plan with the industries to discover the science business activities; • Deploy strategic co-research projects with the plant industries with the deliverables
Mitigate the Risks	• Develop an economic feasibility evaluation model for the fusion energy development; • Delay the Investment until the feasibility will be verified with IT based FEED study • Implement the DEMO Program with phased Sub-Programs; • Carry out risk mitigation in the global contexts.

Phased Development Program for K-DEMO

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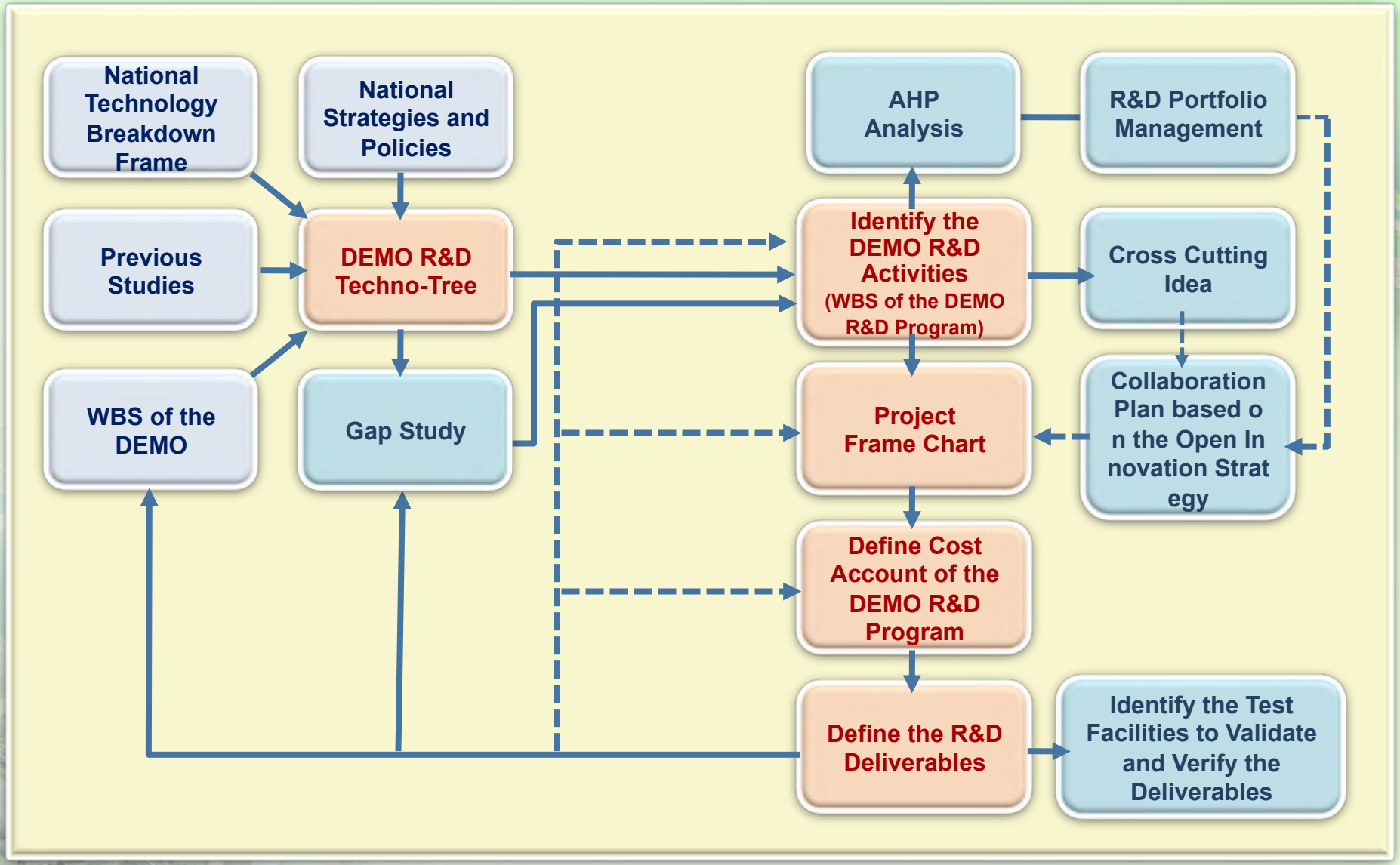
Strategic Plan of the Program

- Program Definition
- Environmental Analysis
- SWOT Analysis for Open Innovation
- Key Strategies & Strategic Initiatives
- Portfolio Management/Cross-Cutting Ideas

Staged Implementation Plans for the Phased Programs

- Preparatory Sub-Program ('07~'11)
- DEMO R&D Sub-Program ('12~'21)
- DEMO Construction Sub-Program ('22~'36)
- FPP Sub-Program ('37~'50)

Process for Developing Implementation Plans



the 2nd phase - DEMO R&D Program (I)

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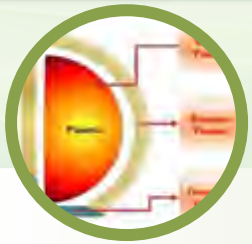
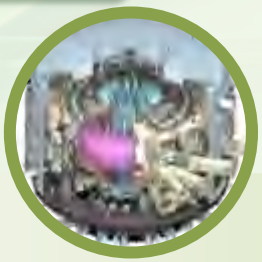
Scope of the Program

- Develop Technologies for the Design, Fabrication and Construction of DEMO Systems and Components
- Complete DEMO FEED and Prove Economic and Technical Feasibilities;
- Construct the Validation Test Facilities and Validate the Design Methods

Milestones Forecast





2014

- Define DEMO Design Concept
- Front-end DEMO R&D Activities

- DEMO Reactor System Design Study
- DEMO Plant System Design Study

2018

- DEMO FEED & Prove Feasibilities
- Site Selection

2021

Start DEMO Design

the 2nd phase - DEMO R&D Program (II)

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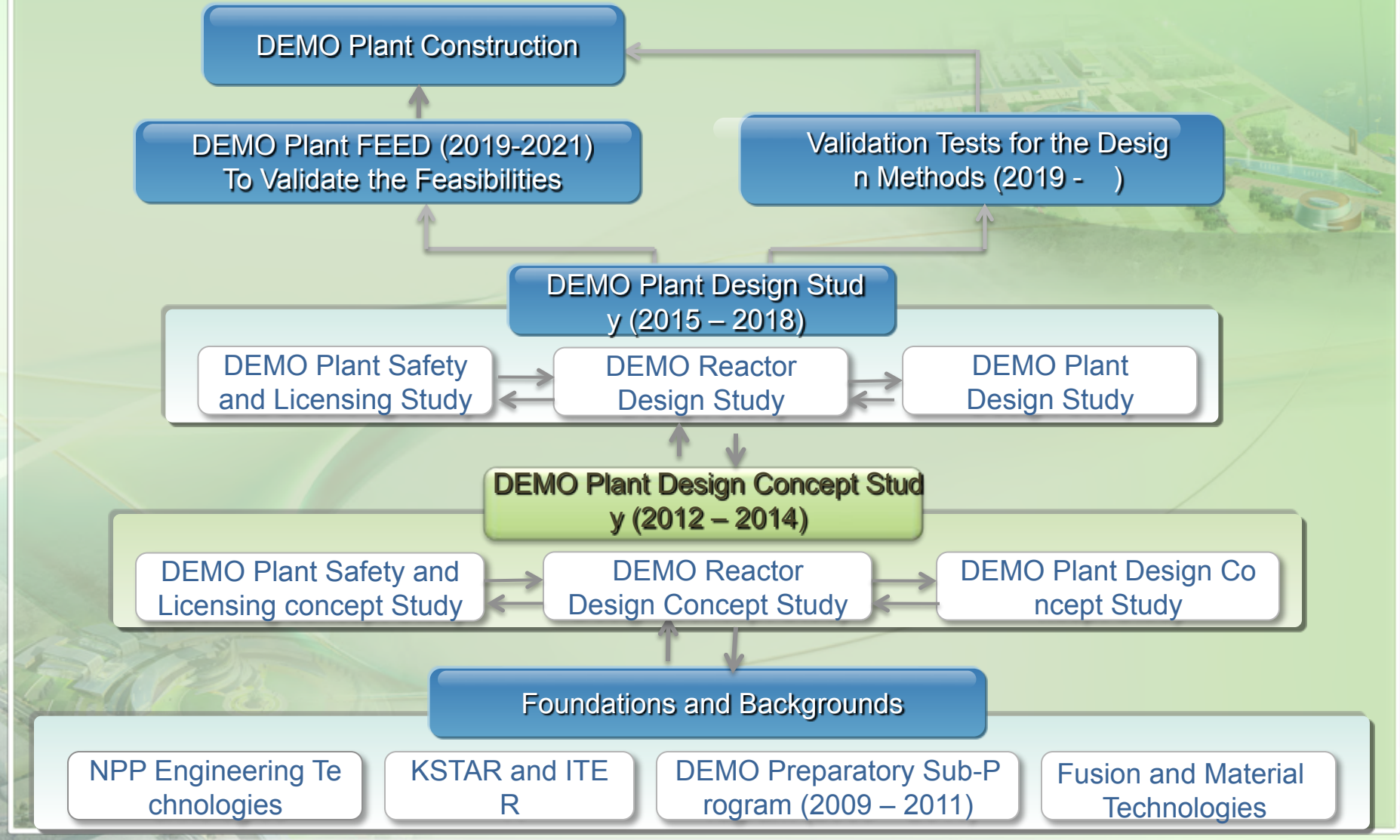
Phased R&D to Facilitate Portfolio Management



R&D Plan toward DEMO

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Fusion DEMO R&D

GAP Study

Present Fusion R&D

<KSTAR>

<ITER>

DEMO R&D Plan

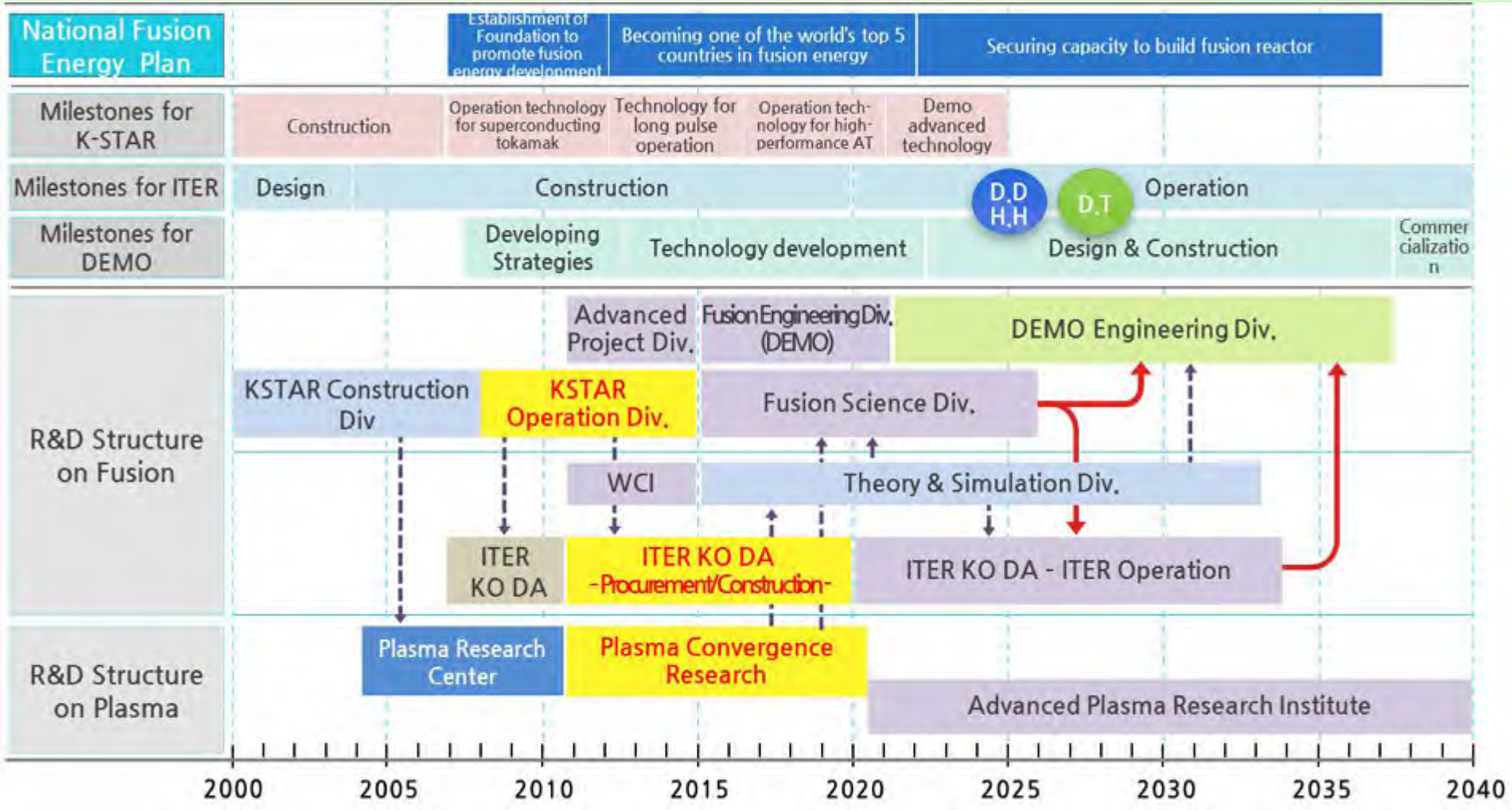
Open Innovation

International Collaboration and Post-ITER Coordination

Broader Approach JA-EU

Other collaboration scheme

Detailed Strategy for Mid to Long-term R&D for Commercialization of Fusion Power



Korean Demonstration Fusion Rector (K-DEMO) aimed for another Success following KSTAR and ITER

Perfect Location for DEMO

- Heavy water reactor producing a large supply of tritium
- Low to intermediate-level radioactive waste repository site nearby
- Equipped with large-capacity power transmission facilities for test

DEMO R&D Facilities for Design Validation Test

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R&D and Test Facilities Plan to be Proposed

the 3rd phase - DEMO Construction Program (I)

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Scope of the Program

- Design and Construct the Fusion DEMO Plant;
- Test Materials, Components and Systems;
- Demonstrate Power Generation

Milestones Forecast

‘2022	‘2024	‘2025	‘2029	‘2033	‘2035	‘2036
Construction Permit	Start Excavation	Select the Materials	Start Installation of Major Components	Start Commissioning	Start Operation	First Electric Power Generation

the 3rd phase - DEMO Construction Program (II)

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A Hypothetical View of Fusion DEMO Plant

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Ⅳ. Issues for Consideration

- Parallel Approach & Plant Engineering
- Fusion Reactor Materials & Component
- Licensing of DEMO
- Other Issues

Parallel Approach

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DEMO Research including Plant Engineering in parallel with KSTAR and ITER.

Discussion Issues

- From ITER to DEMO, Substantial Engineering Works Expected;
- More than 10 years to Complete these Works;
- Coolant & operating temperature and Thermal Cycle of DEMO Plant
- Design & Regulatory requirement for DEMO Plant
- Risks Associated with Investments to the Immature Technologies.

Strategies Recommended

- Launch DEMO Design study immediately not to lose the opportunities
- With the Risk Mitigation Measures: Until the Economic and Technical Feasi bilities verified with Front End Engineering Design
- Design methods and safety analysis methods for DEMO Plant

Discussion Issues

- Need 14 MeV high neutron flux with a large irradiated area to Test DEMO Reactor in-vessel Components;
  - ⇒ Impossible to generate without DEMO;
    - ⇒ Component Tests in DEMO
- Average thermal load of DEMO Reactor ~ 4.5 MW/m^2;
  - ⇒ Not easy to generate this heat load continuously;
    - ⇒ Validation Tests for DEMO Reactor Coolant System in DEMO
- Need a large amount of and long-term investment to develop Materials and build Irradiation Test Facilities;
  - ⇒ Material Irradiation Tests in DEMO

- A Perspective to consider as a pathway to DEMO.

  The global collaborations for this issue is necessary!!

Staged Licensing of DEMO Reactor (I)

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Issues of DEMO Licensing

- Need 14 MeV high neutron flux with a large irradiated area to Test DEMO Reactor In-vessel Components;
- Need a heat source of 4.5 MW/m^2 at average to verify DEMO Design methods ;

⇒ Hard to get these prerequisites without DEMO;

⇒ DEMO need the Components and Materials Tested.

Staged Licensing Concept

- Build DEMO with an achievable Licensing and regulation.
- Test Materials, Components and Systems with DEMO;
- Upgrade the Components and Systems as Necessary.

Staged Licensing of DEMO Reactor (II)

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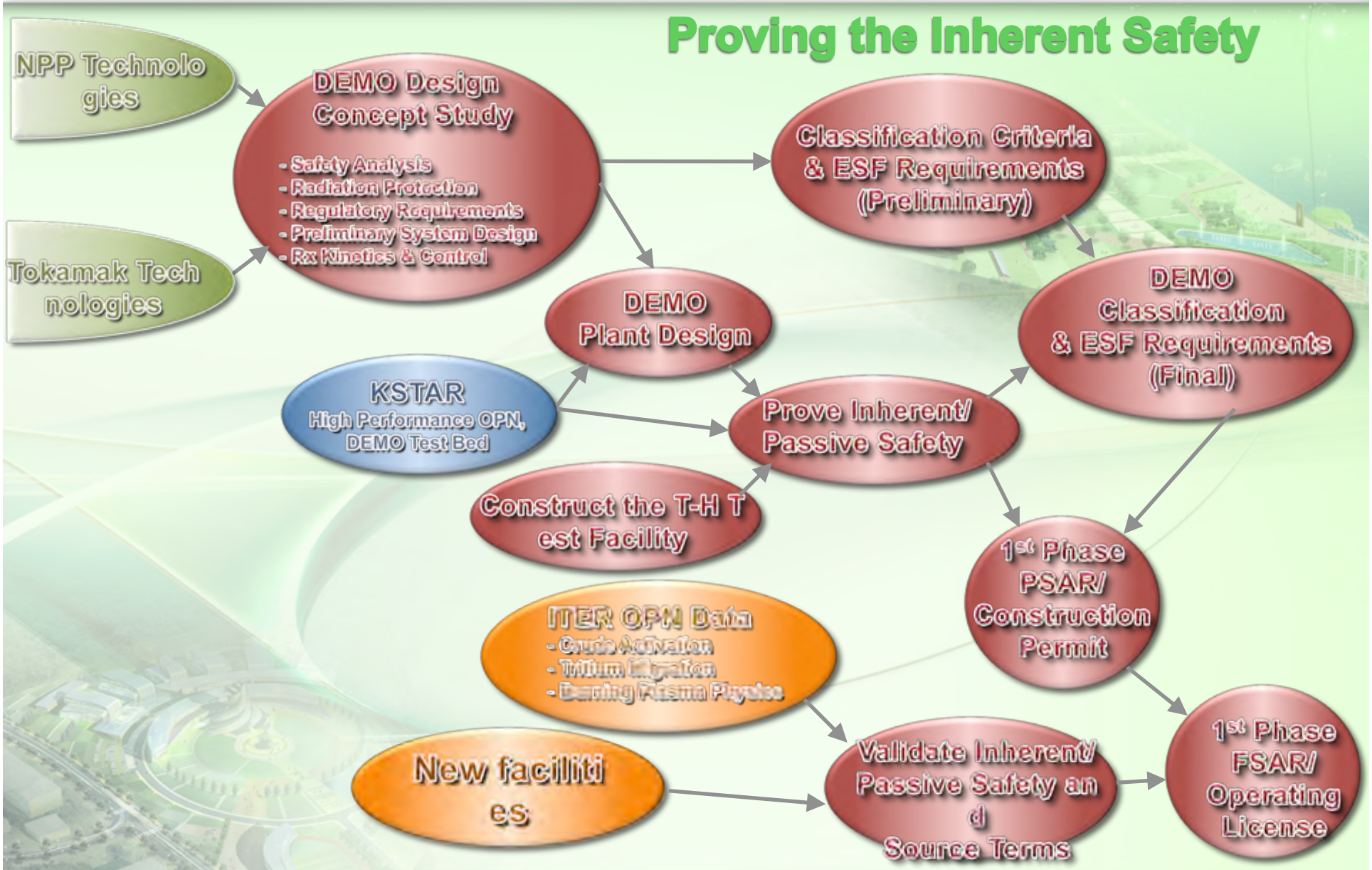

Other Issues

Coolant Selection

- Supercritical Water vs. He gas vs. Liquid Metal
- Compatible with Engineering Feasibility and Advances in Technology

Thermal Cycle

- Maximum exploitation of proven Technologies and Experiences from NPP
- Design basis for Power Plant Design

DEMO Reactor vs. DEMO Plant

- Design of DEMO Reactor cannot be isolated from the Plant supporting systems
- Systems Engineering Approach

KSTAR as DEMO Test Bed

- Burning Plasma control learned from successful control of D-D plasmas
- Focused studies on the Demo-relevant engineering subjects such as PFC

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IV. Summary and Prospect

Summary and Prospect for DEMO

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- A K-DEMO Development Plan is in preparation for reviews to s et up the National Strategic Plan.
  - Preparing the 2nd Fusion Energy Development Promotion P rogram active in 2012 ~ 2017
  - Planning DEMO R&D portfolio and required R&D Facilities based on Open Innovation
  - Promoting collaboration with Nuclear Power Plant industry f or Plant Engineering - Maximum exploitation of Nuclear Po wer Plant technology and experience.
- Initiating DEMO design study - focused study to make the best use of proven technologies for realizable pathway to K-DEMO achievable as early as possible.
- A coordinated resource spending and integrated support and p articipation necessary for early realization of FE in KO

National Fusion Research Institute realizes Gre
en Korea getting joined with human beings, envi
ronment and technology

Thank You

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