Chung Hwa Nuclear Society Meeting
Dec. 16, 2024

Center of Nuclear Technologies for a Better World
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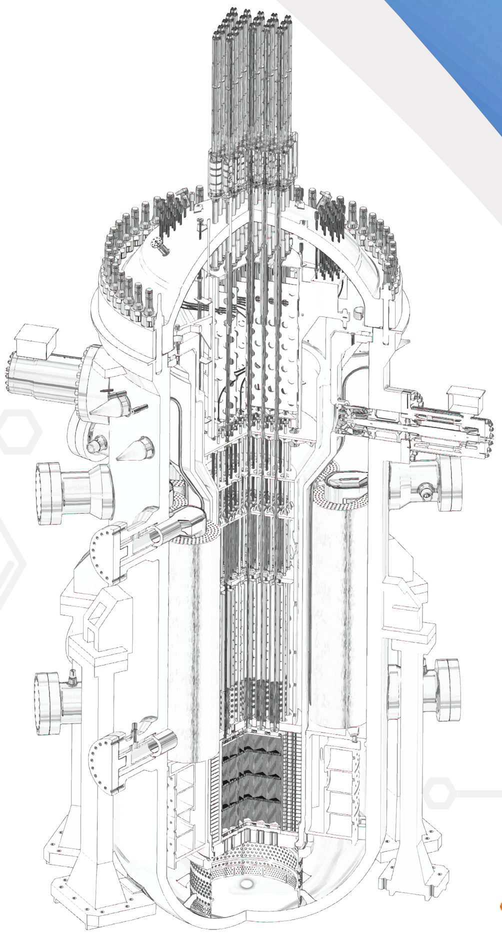
SMART100 Integral Reactor and Other SMRs under Development in Korea



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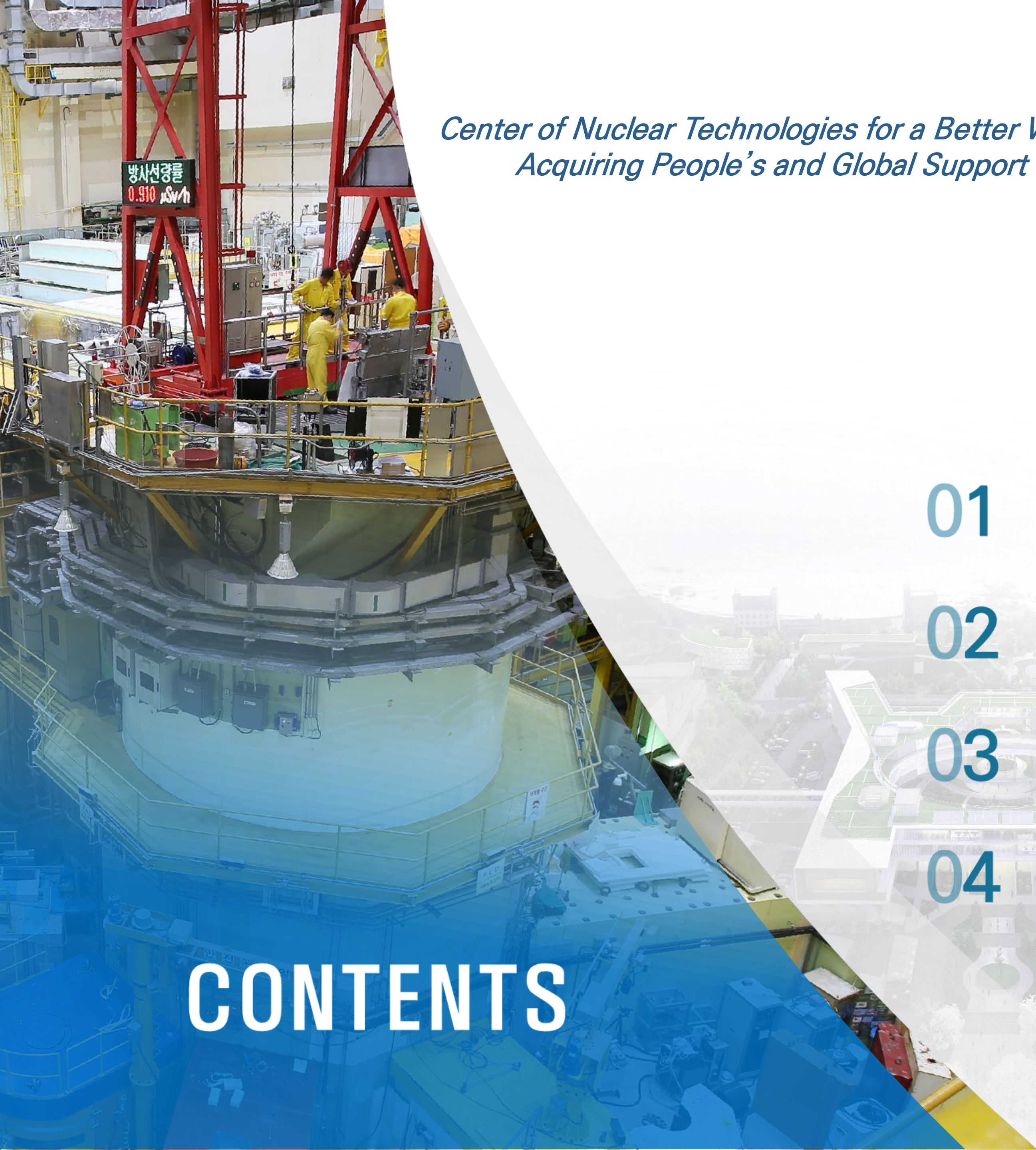

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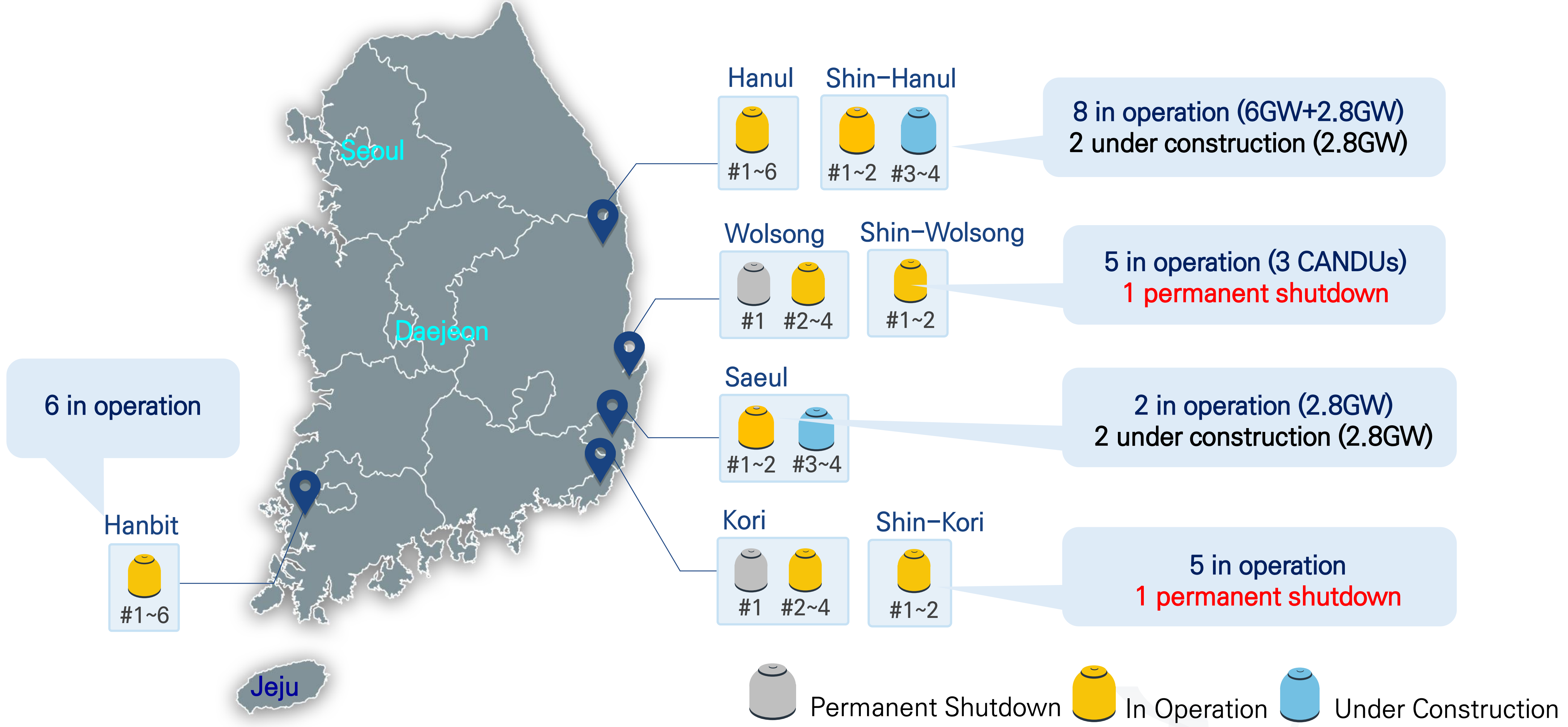
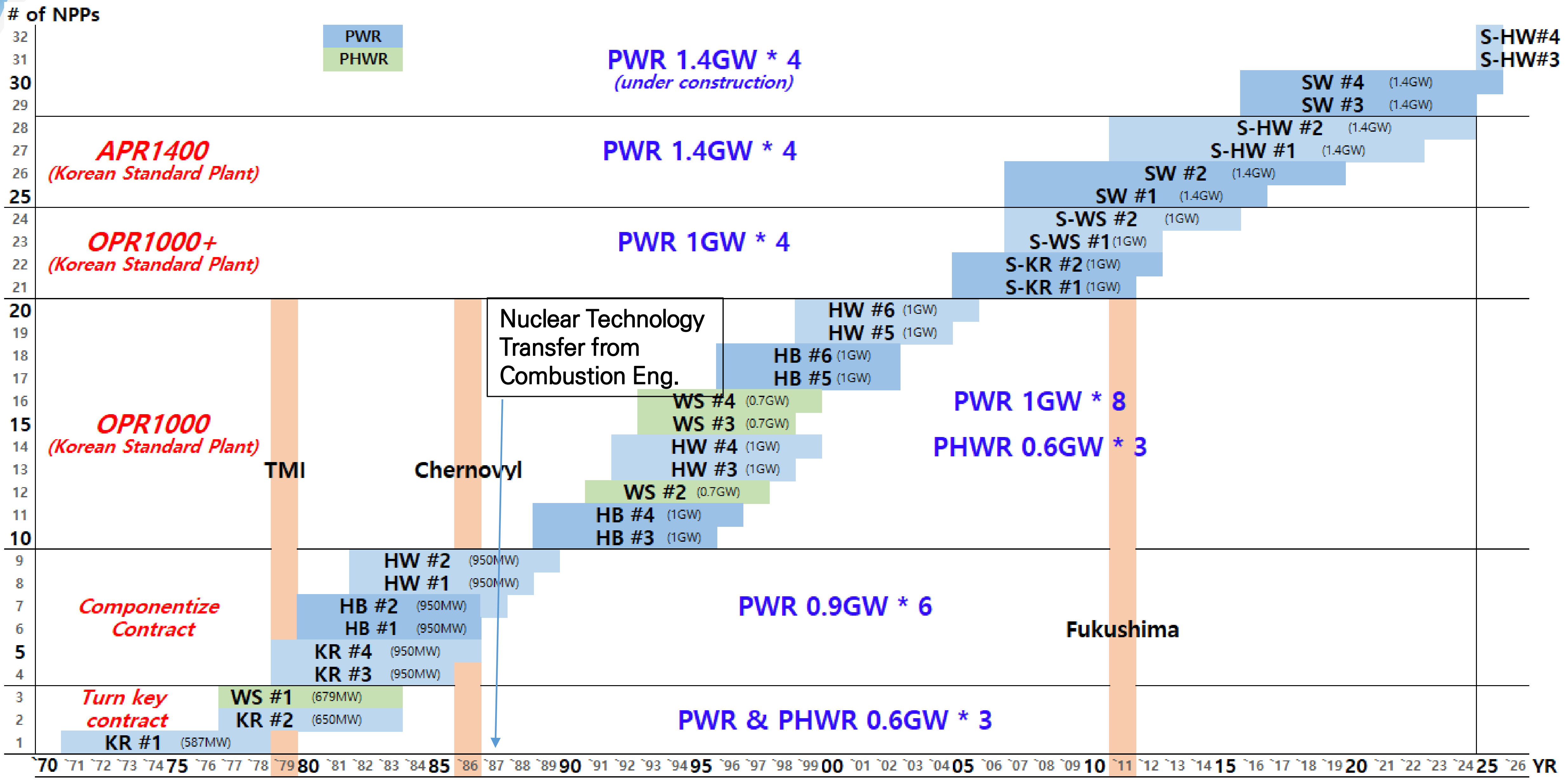
Status of Nuclear Power Plants in Korea

26 Units (26GW, 4 APR1400s) In Operation	4 Units (4 APR1400s) Under Construction	4 Units (1 SMR) Planned



Nuclear Power Plant Construction History



Nuclear Industry Infra Structure

Self-sustaining Nuclear Power Eco System with Full Technology Independence

NSSC (Nuclear Safety & Security Commission)

KINS

- Licensing
- Nuclear Safety
- Inspection

KEPCO

- Contract
- Planning
- Overseas Business

KHNP

- Utility Project Management
- Commissioning
- O&M

Small and Medium Scale Supply-Chain Companies (~600)

KAERI

Research and Development

KEPCO E&C

Design and Engineering

KEPCO NF

Nuclear Fuel

KEPCO KPS

Maintenance and Services

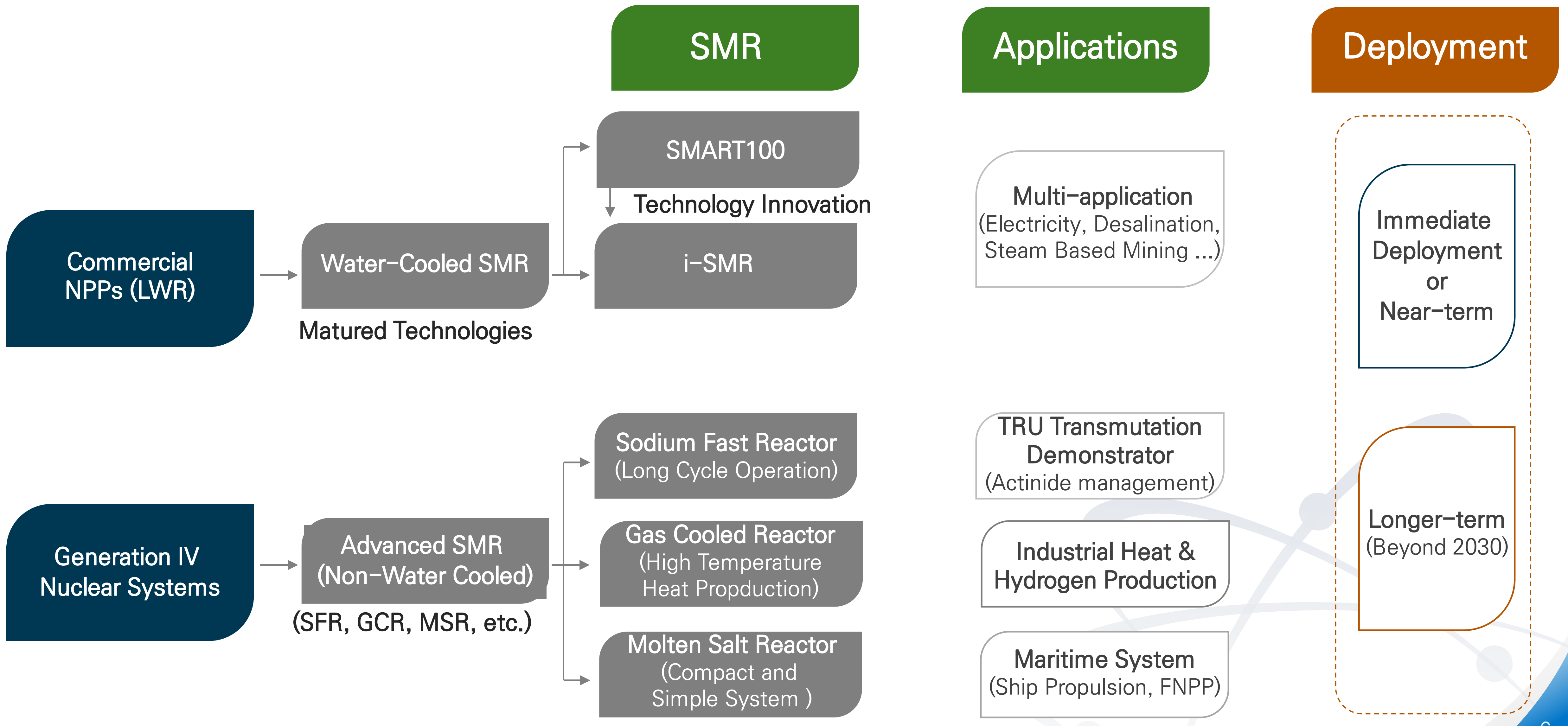
DOOSAN

Equipment Manufacturing

DOOSAN, DAEWOO E&C, SAMSUNG, SK 건설, HYUNDAI, DAELIM, GS E&C

Construction

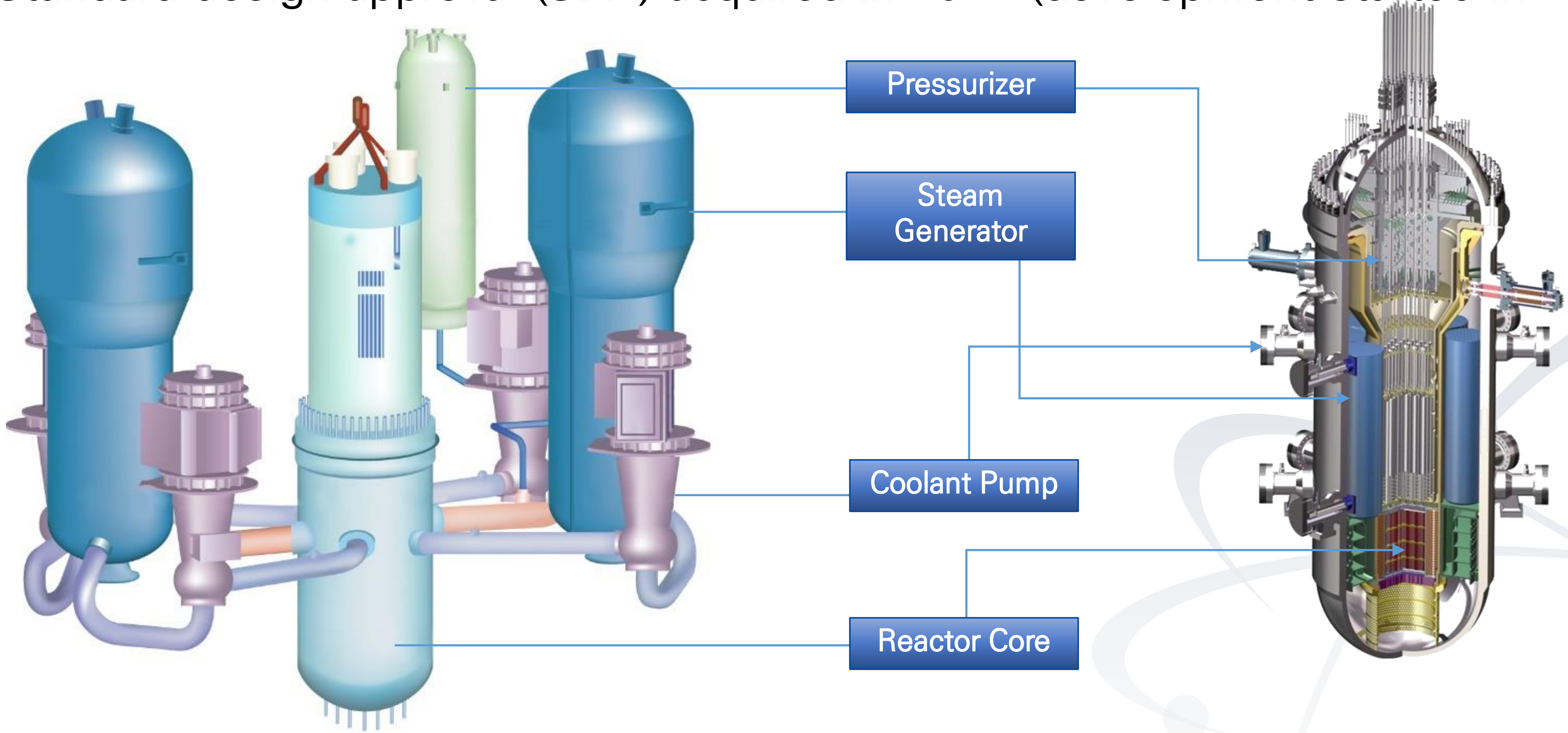
Advanced Reactor Development Program of Korea



SMART (System-integrated Modular Advanced ReacTor)

Integral Reactor with 330 MWth and 100 MWe Suitable for Small Grids

- Integration of major components into a vessel to prevent potential leak
- Standard design approval (SDA) acquired in 2012 (development started in 1997)



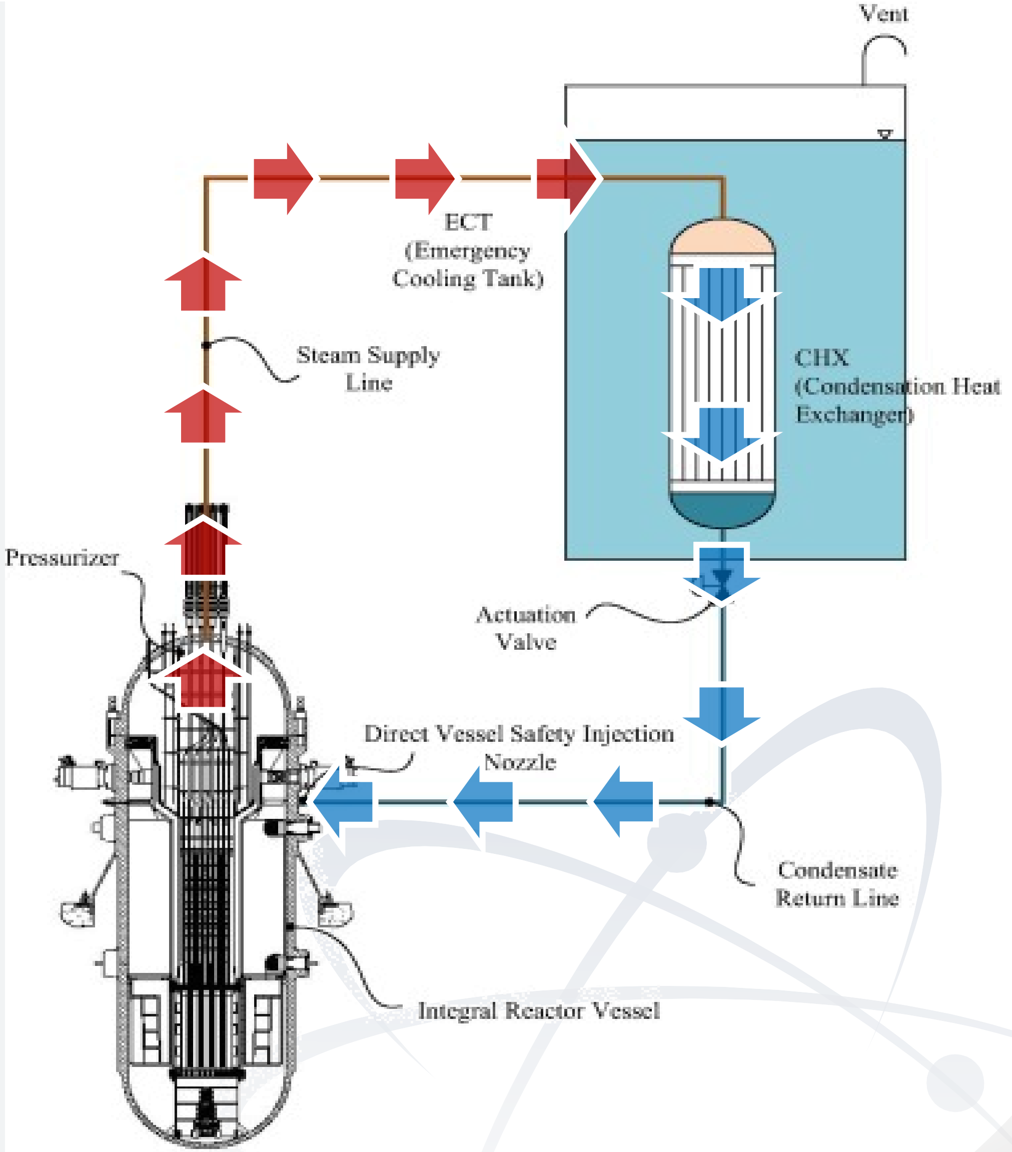
SMART100: Enhanced Version of SMART

Enhanced Passive Safety
- Passive heat removal by natural circulation in accident conditions

Collaboration with Saudi Arabia
- Pre-project engineering started in 2016

Versatile Use with Increase Capacity
- Electricity Generation and Desalination
  - 100MWe and fresh water of 40,000 ton/day with 365 MWth
- Steam supply for mining

Immediately deployable SMR
- SDA obtained in Sept. 2024
- Manufacturability confirmed by Doosan



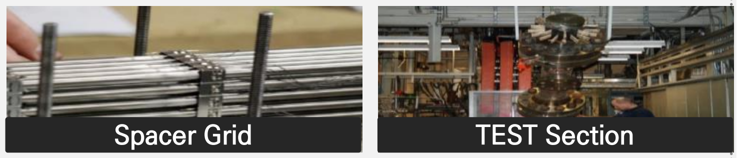
Comprehensive SMART Technology Validation Experiments

to Verify Systems, Components and Design Tools for Licensing

Fuel Thermal–Hydraulics Tests

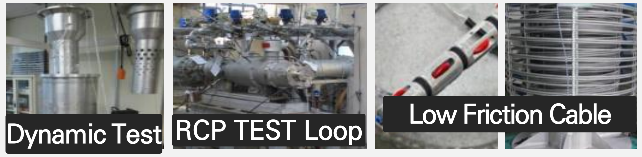
- Fuel Performance Tests

- CHF Measurement Test

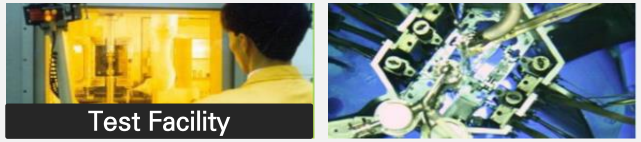


Mechanics and Components

- RPV Dynamics Test, RCP Mockup Test and Helical ISI Test



- SG Tube Material (A690) Irradiation Test



System Thermal–Hydraulics Experiment

SMART – Integral Test Loop

- World's Unique and Largest Full Scope Accident Simulation

1:1 Height, 1/49 Volume

SMART – Main Control Room Simulator

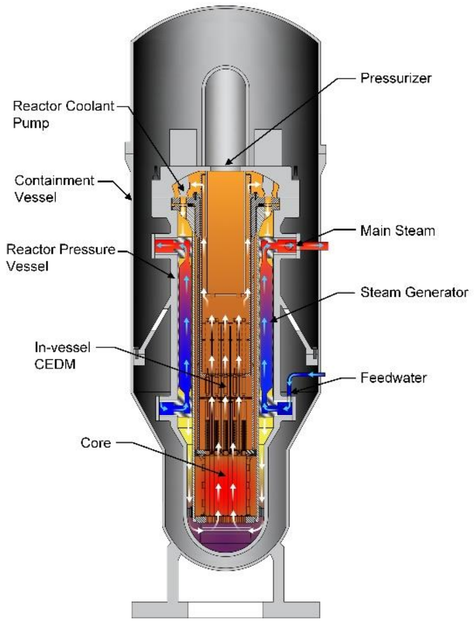
RPV : Reactor Pressure Vessel
RCP : Reactor Coolant Pump
ISI : In–Service Inspection
PRHRS: Passive Residual Heat Removal System
VISTA: Experimental Verification by Integral Simulation of Transient and Accident
ITL : Integral Test Loop
MCR: Main Control Room

i-SMR to Enhance Safety Further as well as Economics

- Innovative Technology and System Design to Achieve the Top-Tier Requirement for Safety (CDF* ~ 10^{-9}) and Economic (3500$/kWe) Goals I

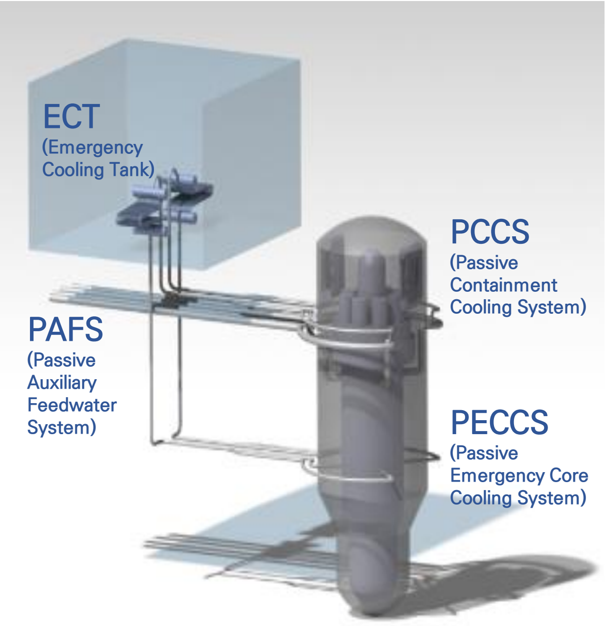
Primary System

- Monoblock Steam Generator
- Steel Containment Vessel to Retain Potential Leakage Water



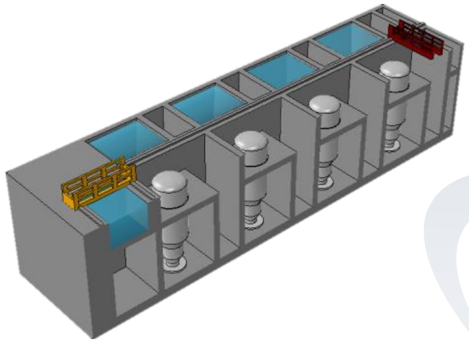
Safety System

- Indefinite, Unattended, Unpowered Safety System
- Whole Covered System from AOO to Severe Accident



4 Module System

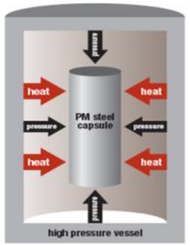
- Bigger Module of 170 MWe
- 4 Modules to 680MWe
  - Adequate for Coal Power Replacement



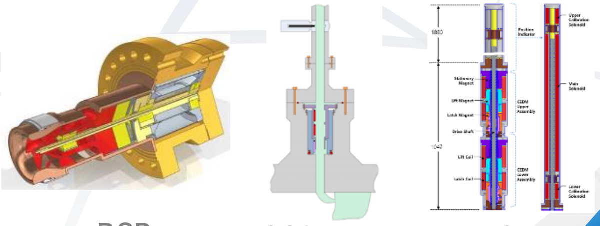
* CDF : Core Damage Frequency

Innovative Tech.

- Innovative Manufacturing Tech to Reduce Construction Period



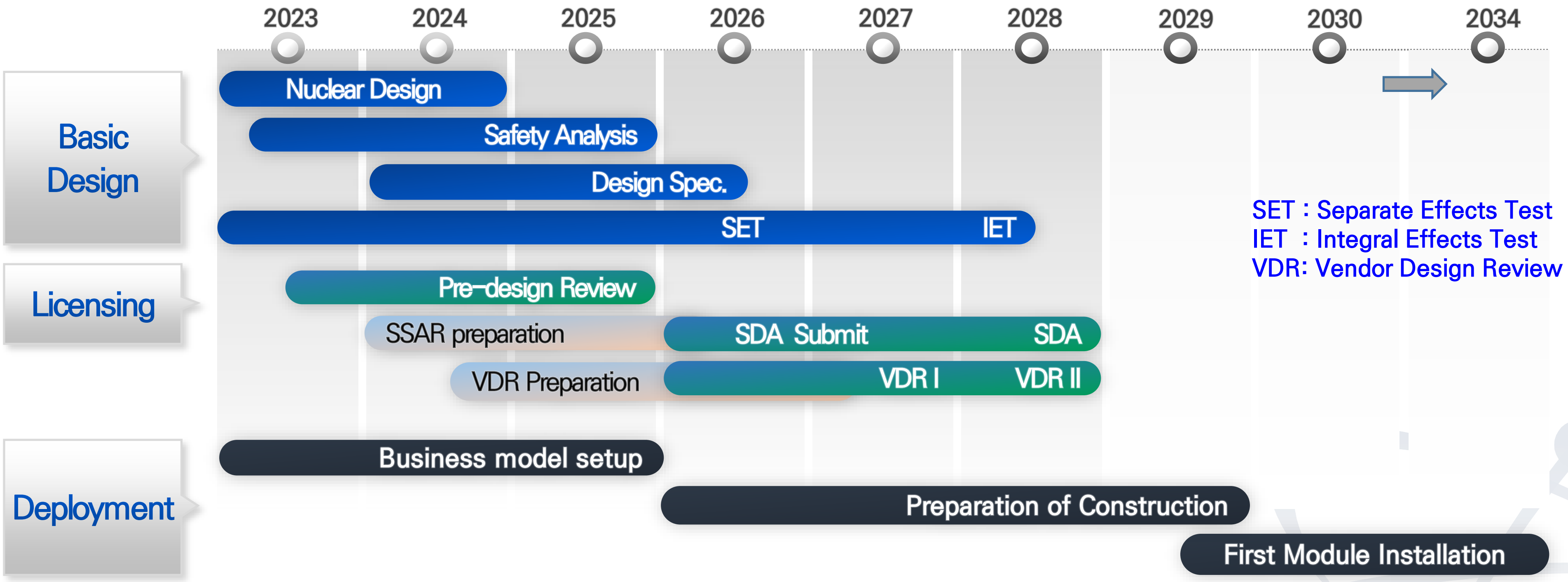
- Three Major Components:
  - Pump, Valve, In-Vessel CEDM



RCP ECCS Valve IV-CEDM

i-SMR Development and Construction Plan

- Government funding has been started for standard design program in 2023.
- SDA acquisition by 2028 and first module installation by not later than 2034



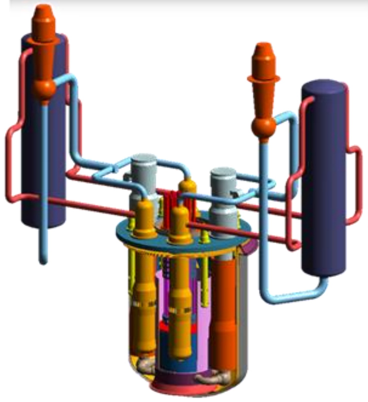
Sodium-cooled Fast Reactor

Development History

PGSFR: Prototype Generation-IV Sodium-cooled Fast Reactor
SALUS: Small, Advanced, Long-cycled and Ultimate Safe SFR

- Conceptual design (2007) of KALIMER-600 (Pool-type, Metal fuel, Passive safety features, etc.)
- Engineering design (2020) of PGSFR, TRU-transmutation demonstrator with pyroprocessing
- Basic design of SFR-based SMR with a long fuel cycle core (SALUS-100), in progress

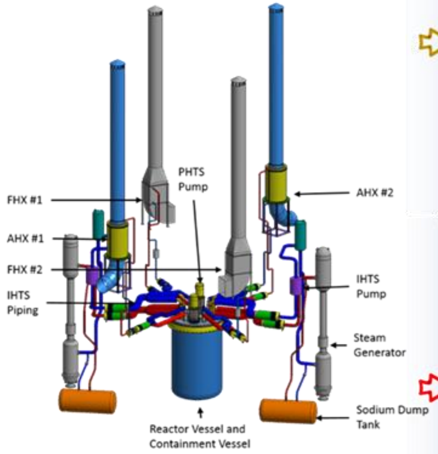
KALIMER-600



- Fundamental SFR technology development
- Target SFR design for TRU transmutation
- Advanced design options to meet the GIF goals

PGSFR ('12-'20)

- [Track 1] Technology demonstrator for TRU transmutation



- [Track 2] SMR features with U-10%Zr fuel for initial loading (Spin-off technologies from the PGSFR concept)

'21 → (TBD)

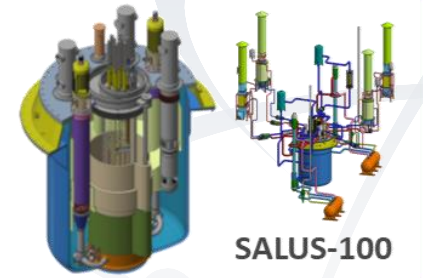
Track 1

PGSFR Construction

- Domestic technology demonstration for TRU transmutation
- Specific plan for resumption would be prepared by 2025

Track 2

SFR-based Power Rx.



SALUS-100 and Future SFR Development Plan

General Features of SALUS-100

- Spin-off from the PGSFR Development
  - Based Prototype Gen IV SFR which was for transmutation tied with pyro-processing halted in 2022
  - Longer cycle (20year) with lower power density
- Integrated pool-type SFR with Metallic alloy fuel (U-10%Zr) & FC92 cladding
- Electric output: 100 MWe (267 MWt) with core Inlet/Outlet Temps. of 360/510 °C
- Enhanced safety features for a long-term cooling capability with Active and Passive DHRS

Progress

DHRS: Decay Heat Removal System

- Technical Safety Review by IAEA on-going
- Public-Private Partnership Project for SFR-based advanced SMR development
  - Scheduled to begin in 2025 based on a matching fund system with the private company
- HDEC signed an MOU with KAERI dedicated to SFR development

HDEC: Hyundai Engineering and Construction

- Planning a new project of comprehensive advanced nuclear reactors development encompassing all from design and validation to demonstration

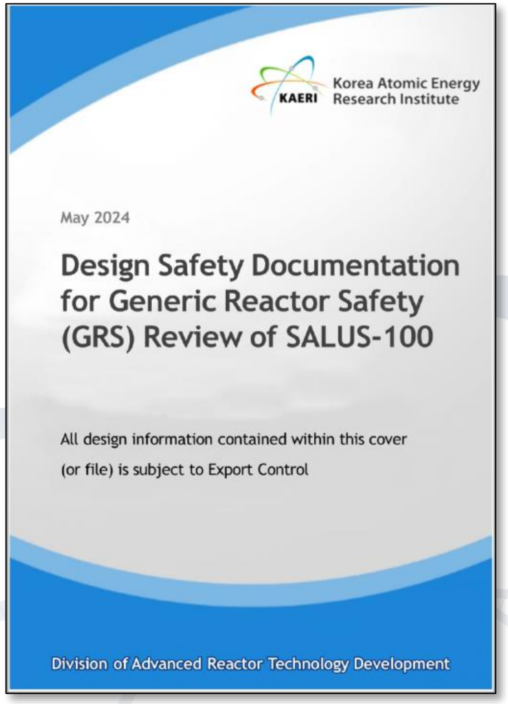
(June 11th, 2024)

Technical Safety Review of SALUS-100 by IAEA

Specific Achievements

* Technical Safety Review

- Completion of IAEA TSR*-DS (Design Safety) in 2024
  - Assessment of SALUS-100 design to identify key regulatory issues earlier to avoid or minimize risks that the developer may encounter during the actual licensing phase
  - Generic safety review service to support NPP deployment based on the IAEA safety standards
- TSR Review area of SALUS-100
  - Compliance of international requirements and standards
  - Safety concerns and Potential issue for licensing
  - Adequacy to undertake pre-licensing review
- Key Milestones
  - IAEA TSR Preparatory Meeting (26-Feb-2024)
  - TSR Design Review and Technical Discussion (07-Oct-2024)
  - Official draft of the IAEA TSR report (01-Nov-2024)
    - Final TSR report scheduled for publication in February 2025

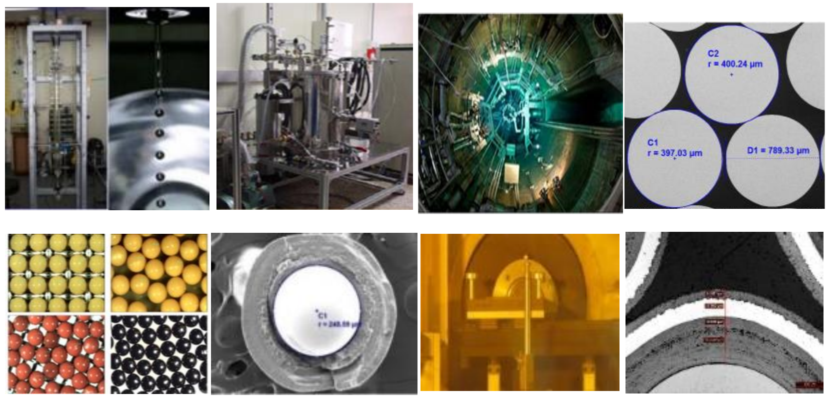


TSR document set of SALUS-100

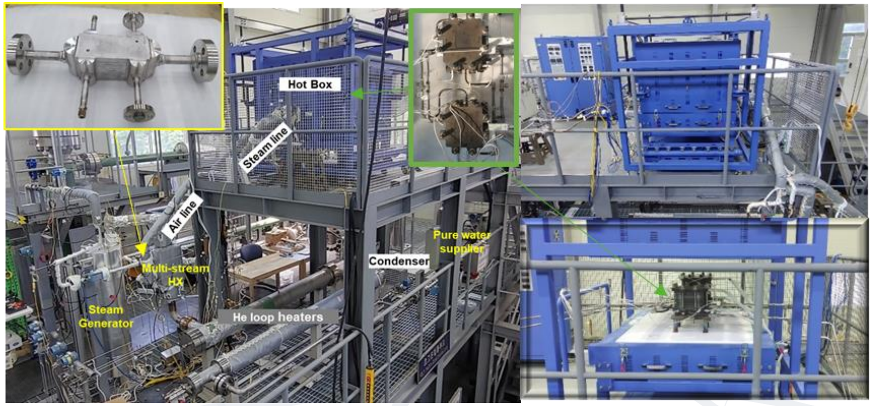
HTGR for Industrial Heat Supply and Hydrogen Production

Major R&D Products for GCR Development ('04~'19)

- Computational Tools and Modeling Technologies
  - Neutronics (DeCART/CAPP) and Core T/H Code (CORONA), Safety analysis (GAMMA) and TRISO (COPA) developed
  - Used in the design analysis of MMR of USNC
- Development of TRISO Fuel and High-temperature materials
  - Completion of HANARO Irradiation Test
  - Graphite, Ni-base alloy for Gen IV
- Helium Loop
  - Compact heat exchanger test above 900℃
  - Coupled HTSE (2Nm^3/hr, 6kWe) tests



〈 TRISO Fuel Manufacturing Technology〉



〈 Helium Loop and HTSE 〉

High Temperature Gas-cooled Reactor

Overview
- Development of essential technologies since 2004
- Collaborative study with end-users
  - Nuclear HTSE MOU, Alliance of nuclear heat utilization
- Public-Private Partnership project for HTGR system development since 2024

Target Plant
- 90 MWth, UCO-TRISO, Graphite moderated, Helium coolant
- Core outlet temperature: 750℃
- Non-electric applications for process heat

Specific Characteristics
- Inherent safety
- Alternative industrial heat source to fossil fuel

GCR Public-Private Partnership Participants & Roadmap

KAERI Korea Atomic Energy Research Institute	Core Design / System Design / Safety Analysis Fuel Design / Core Structure Design
posco E&C	Project Management / Plant Design (BOP)
SMART POWER	Electrical System Design for Plant
DAEWOO E&C	Radiation Protection System Design Radioactive Waste Management System
SK ecoplant	SOEC System Design / Hydrogen Business Plan
LOTTE CHEMICAL	Process Heat System Design/ Process Heat Business Plan

PPP Project for Basic Design of HTGR & Process Heat Plant

Yr	~'24	'24	'25	'26	'27	'30 ~	'35~
Classification	Government R&D	PPP Development Project				Demonstration Project	Commercialization Project
Leading Organizations	Government	Government 50 Private Sector 50					Private Sector
Project Details	Development of Technologies	(1st Phase) Conceptual Design		(2nd Phase) Basic Design		• PSAR · EIA, FSAR • Site Selection · CP · OP	Business

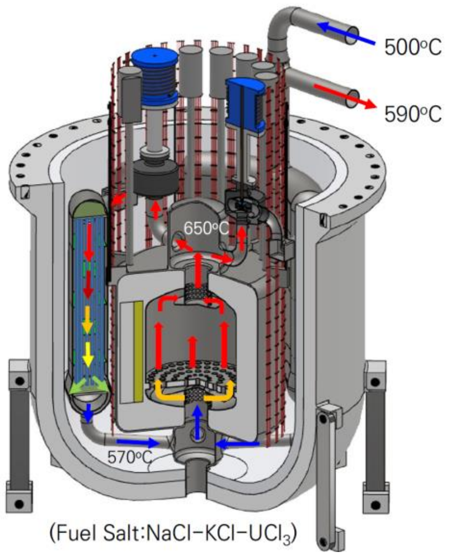
URECA – Molten Salt Reactor for Ship Propulsion

Advantages of Molten Salt Reactor
- Small and simpler structure due to fuel mixed with coolant salt
- No significant dispersion of radioactive materials due to solidification after leak in an accident condition

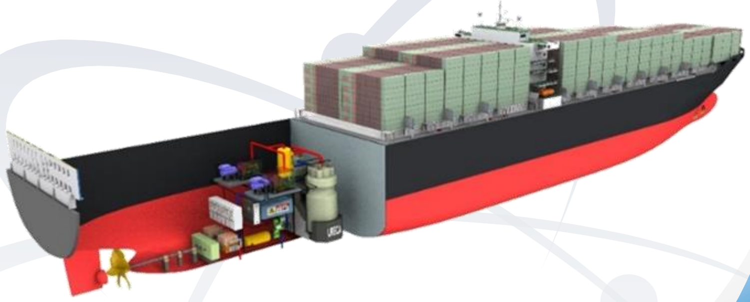
Technical Difficulties with Corrosion
- Cladding with corrosion resistant material layer
- Design with replaceable components

Small Scale R&D Going on after Selection as a National Innovative Challenge Project in 2022
- Comprehensive demonstration of key technologies by 2026
  - 3.5 year budget of ~29 M$
- Basic design and license application by 2035
- FOAK for ship propulsion by 2040

Experimental Facilities in Gampo Site Being Planned
- MOU signed with Seaborg
- Specific plan to build molten salt experimental facilities not yet fixed



(Fuel Salt:NaCl-KCl-UCl_3)



Feature of URECA and Partnership

Features of URECA

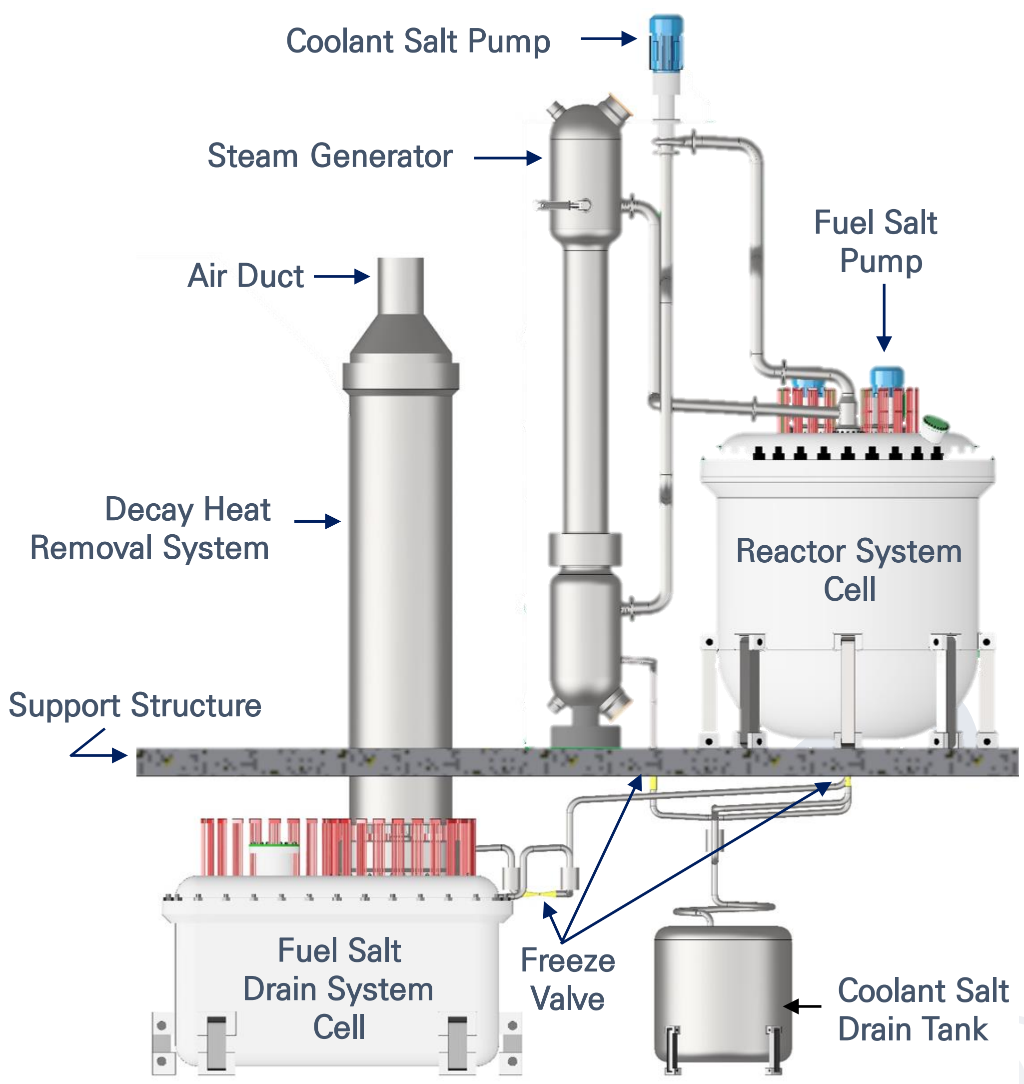
- Thermal Output: ~ 100 MWth
  - 15,000 TEU Container Ship Engine
- Outlet Temperature: over 600 ℃
  - Electricity, Hydrogen and Heat Production
- Fuel: NaCl-KCl-UCl_3
- Neutron Spectrum: Fast

MSR Partnership

KIMS Korea Institute of Materials Science — Materials and Manufacturing

INL Idaho National Laboratory — Thermophysical Properties of Molten Satl

"Supply Chain Map: domestic and international suppliers"



Concluding Remarks

Nuclear Power Technology Well Established in Korea

- Continued construction of 32 nuclear power plants for more than 50 years provided the self-sufficient complete nuclear power plant (NPP) supply system
- It became the base of efficient and low cost NPP construction as proved by the UAE Barakha project
- With the R&Ds of various new reactors being paralleled by construction, the nuclear power technology is well established in Korea

Various Advanced Reactors Under Development for Carbon Neutrality

- SMART for small electrical grids and resource mining in remotes sites
- iSMR primarily to replace coal power plants
- SALUS for long term operation in remote places
- HTGR for high temperature industrial heat supply and hydrogen generation
- MSR for ship propulsion

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