

HECTAR: High Temperature Gas-cooled Reactor for Industrial Heat Application

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Beyond Electricity

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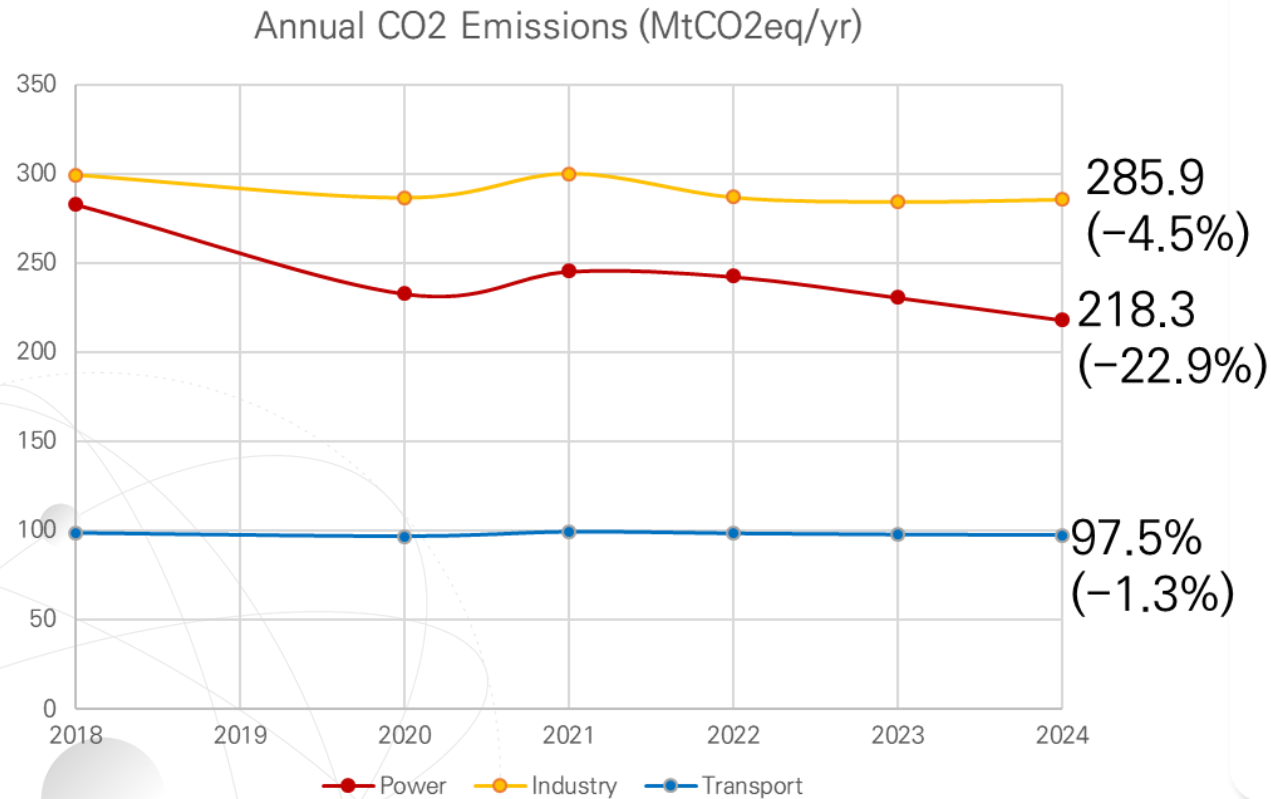
한국원자력연구원
Korea Atomic Energy Research Institute

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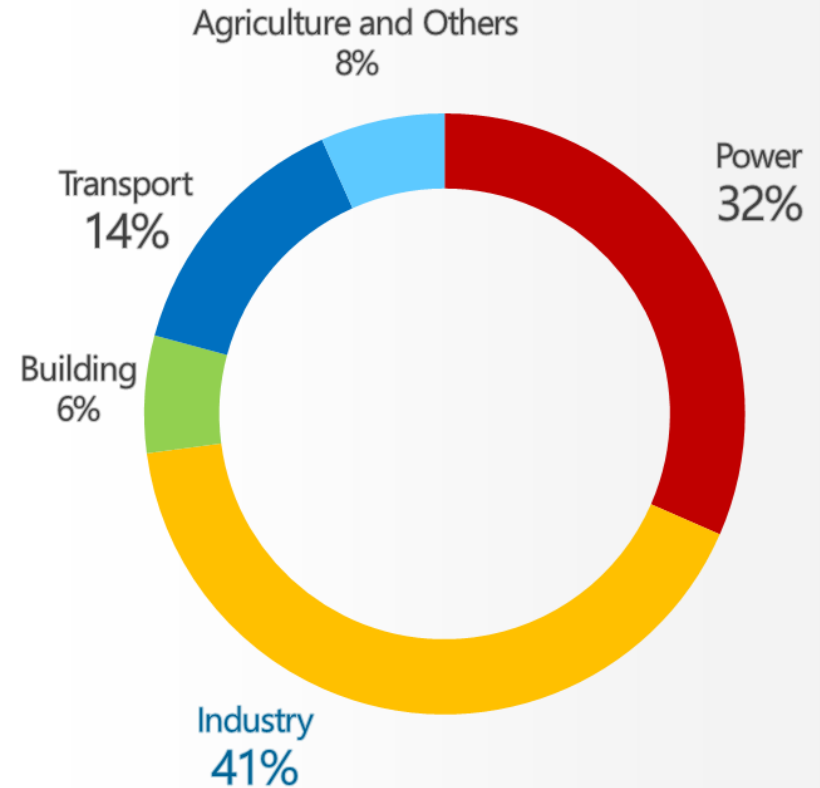
- Green House Gas Emissions in Korea
- Korean SMR Policies
- HTGR R&D Products (2004~2024)
- HTGR Development Status (2024~)
- Summary

Korean Greenhouse Gas Emissions (`18~`24)

Total (2018→2024)
783.9 MtCO₂eq/yr → 691.6 MtCO₂eq/yr (−11.8%)



Korean energy-related CO₂ emissions by sector, 2024



Source: MCEE

*Notes | Emissions from the industry sector include process emissions and district energy

*Source | Greenhouse Gas Inventory and Research Center, 2025

Finalization of 2035 NDC (11 Nov, 2015)

2035 NDC and Fourth Emissions Trading Allocation Plan Finalized at Cabinet Meeting

- 2035 Nationally Determined Contribution (NDC) finalized at 53%~61%
- Established the "National Emissions Allowance Allocation Plan for the Fourth Planning Period" to normalize the fourth emissions trading scheme for achieving the 2030 NDC

Total (2030 NDC → 2035 NDC)

40.0% → 53.0~61.0%

Electricity

45.9% → 68.8~75.3%

Industry

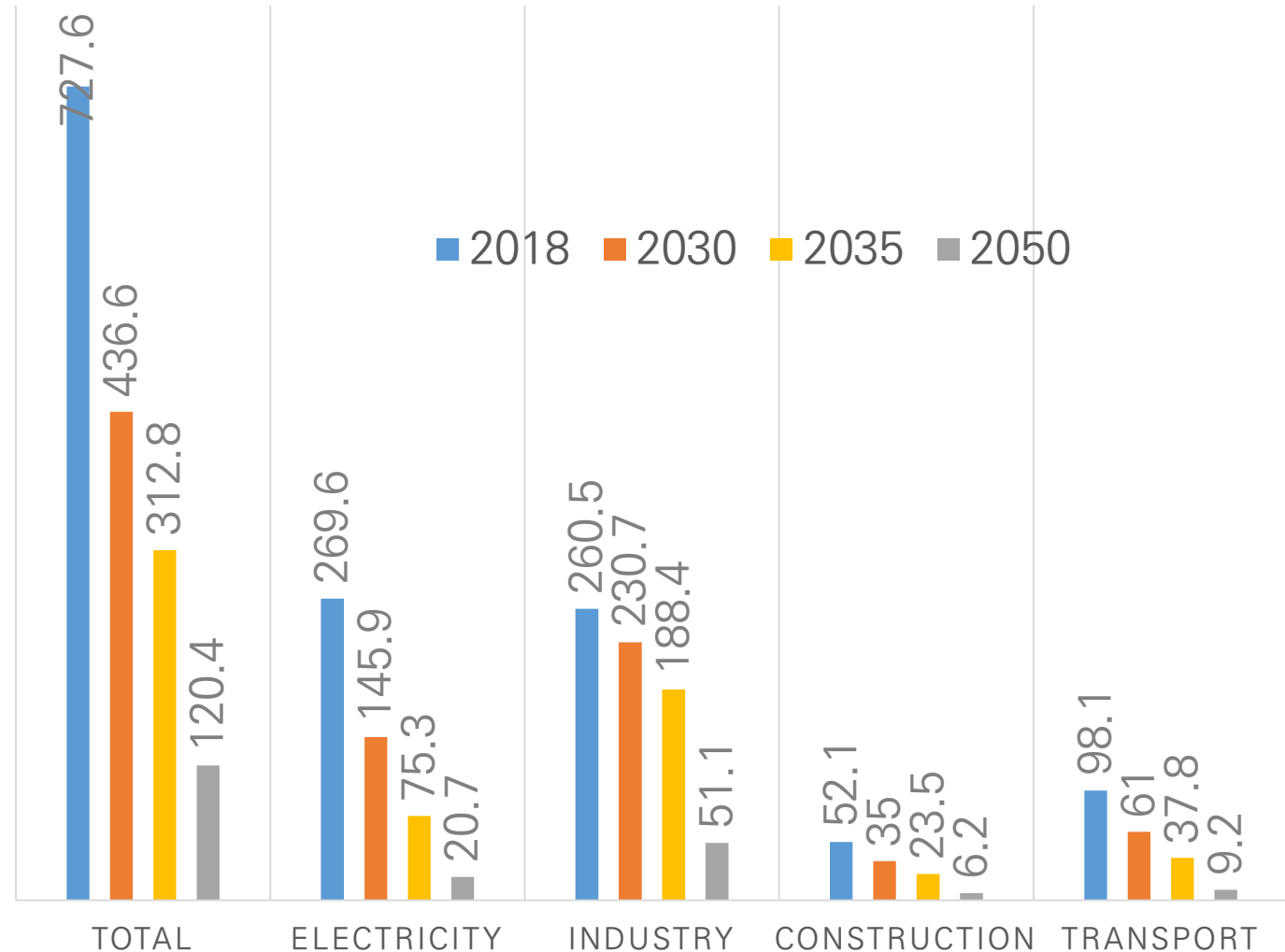
11.4% → 16.7~24.0%

Construction

32.8% → 44.5~47.7%

Transport

37.8% → 59.7~62.3%



Source: MCEE

Paradigm Shift for Advanced Reactor

Paradigm Shift: Public Initiative → Private Sector-led

Existing Publicly-led Large-scale NPPs

Led by National Lab. and Public Enterprises

Reactor Design

Nuclear Fuel Supply

R&Ds

O&M / Export

Private sector
(Limited Participation)

Equipment

Construction



Electric power



**Market
Diversification**

After Private Sector-led SMRs

Cooperation
(National Lab. & Public Enterprises)

Public-Private Col'n

IP Transfer, Infra

Led by Private Sectors

New Value Chain

Design Capability

Equipment Supply

Business Models

Procur't / Const.



Electric power



Heat Supply



H2 Production



NRHES



Fuel Cycle

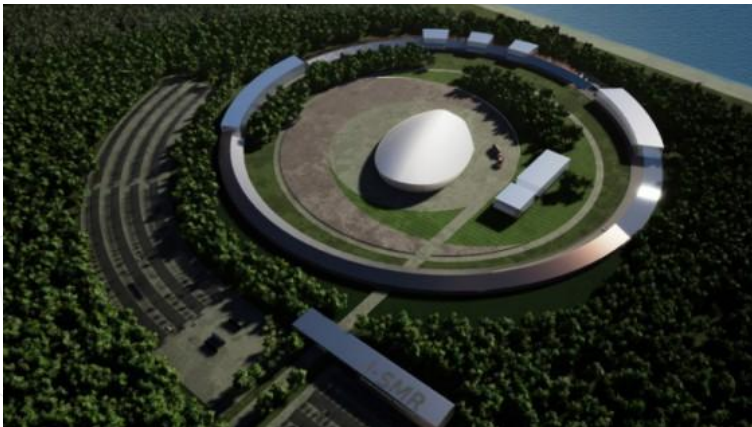


Ocean / Space

SMR Special Act (12 Feb., 2026)

"Heading for SMR Leadership"... SMR Special Act Passes National Assembly, National Control Tower Launched

Five-year master plan and Promotion Committee established... Full-cycle support for R&D, demonstration, special zones, and human resource development



Regulation Roadmap for SMR(12 Feb., 2026)

Nuclear Safety Regulation Roadmap for Establishing SMR Regulatory System

-  2026-2nd Meeting on the Nuclear Safety and Security Commission
-  Legal Framework for Various SMRs by 2030
-  Joint Creation of NSSC and Developers for AMR: SFR, MSR, HTGR

Current

- Power-generation, Research, Education
- Large LWR-based Technical Standards Rules
- Demonstration of Compliance with the Presented Criteria

Improvement

- Maritime, Hydrogen Production, Heat Supply
- Enactment of Technical Standard Rules for SMR and AMR
- Demonstration of Compliance with Unique Technical Standards

Heat Energy Innovation Strategy (15 Apr, 2026)

Gov't to distribute 3.5 million eco-friendly temperature control systems by 2035

High-T Process Heat

- Large-Scale, High Temperature Heat Pump
- Small Modular Reactor for Heat Supply
- High Temperature Thermal Storage
- Industrial Process: CCUS

48%

Share of heat energy in Korea's final energy consumption

3.6→35%

Renewable heat share (current → 2035 target)

3.5M units

Cumulative high-efficiency heat pumps (2035 target)



기후에너지환경부

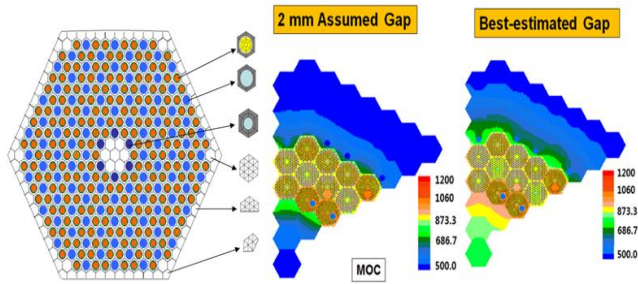
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Korean HTGR R&D History

Year	2004~2019	2020	2021	2022	2023	2024	2025	2026	2027
R&D Projects	VHTR Key Technologies	Advanced Reactor Key Technologies(VHTS)							
	- VHTR Code V&V - Code Validation Tests - IHX PCHE - Materials and TRISO - SI Process (Hydrogen)	- VHTR Code Improvement - Materials and TRISO							
		Coupled Technologies between VHTR & HTSE (Hydrogen)							
System Development							HTGR DESIGN		
							- Conceptual Design (~'25) - Basic Design (~'27) - Business Plan (~'27)		
International Collaboration	GIF VHTR System (SSC, CMVB, HP, FFC, Materials, NECA WG)								
	GEMINI+				GEMINI 4.0				
	IAEA TWG-GCR								

HTGR R&D Products



Design Technologies

- Neutronics (DeCART/CAPP), Core TF (CORONA), Safety Analysis (GAMMA+)
- TRISO (COPA), FPs (POSCA, TROPY, MENTAS)
- NGNP, MMR Chalkriver, UKNNL...

Helium Loop & Tests

- Very High Temperature Operation (~950°C)
- High Temperature Compact Heat Exchanger, CORONA Validation Test
- HTSE Module Test

TRISO and Materials

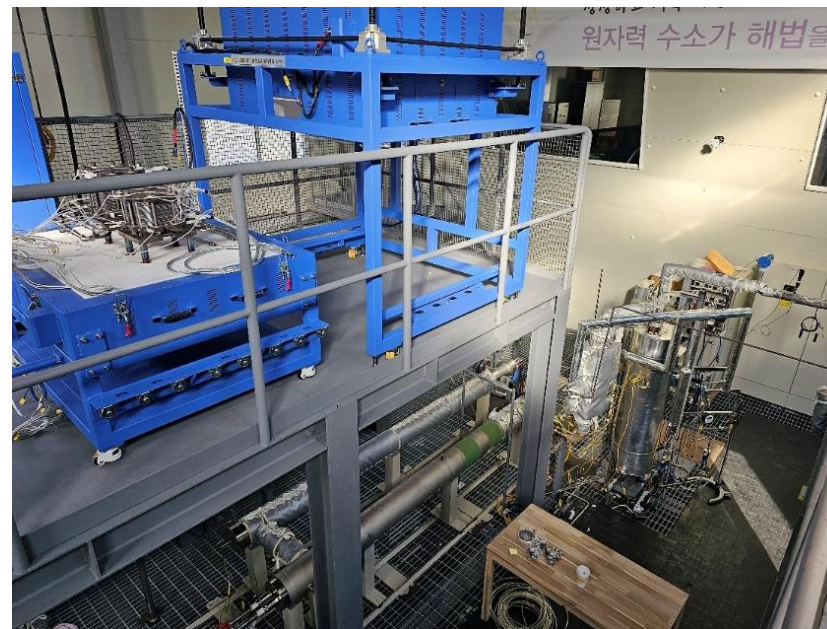
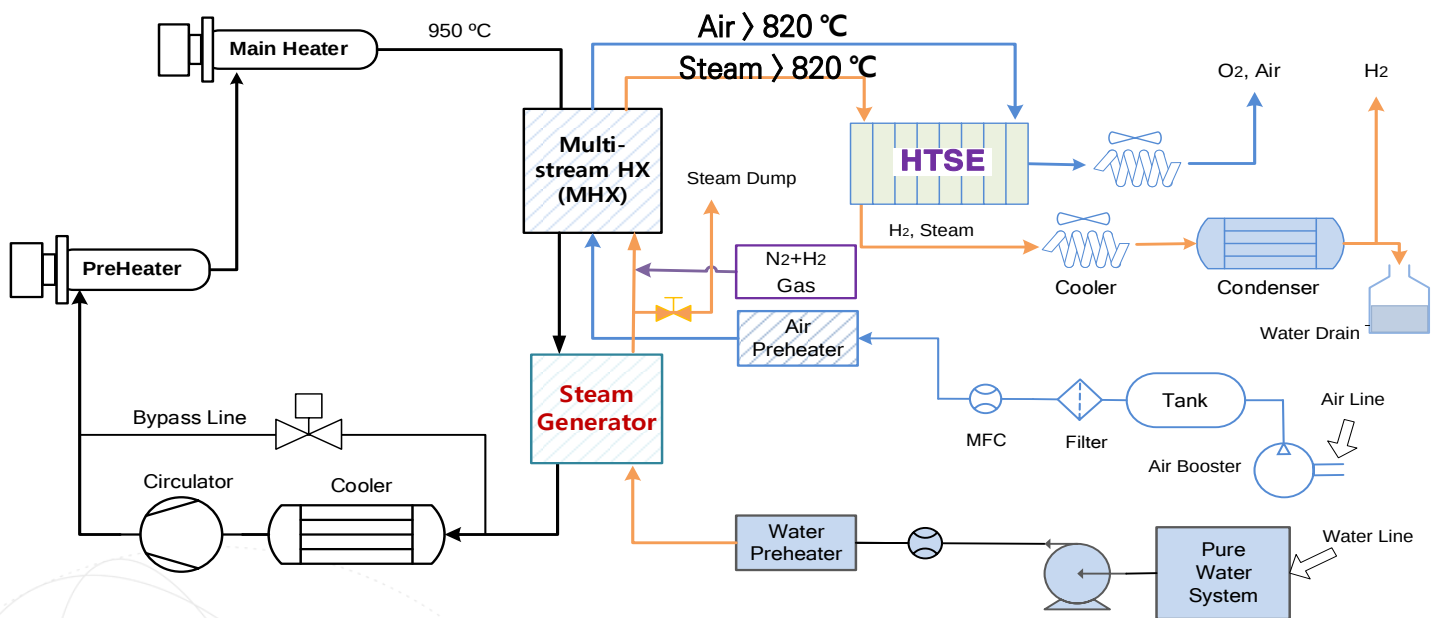
- Lab-scale UO₂ TRISO Fabrication Technologies
- TRISO Irradiation Test using HANARO
- Material Database of Graphite and Ni Alloys for Gen IV Contribution



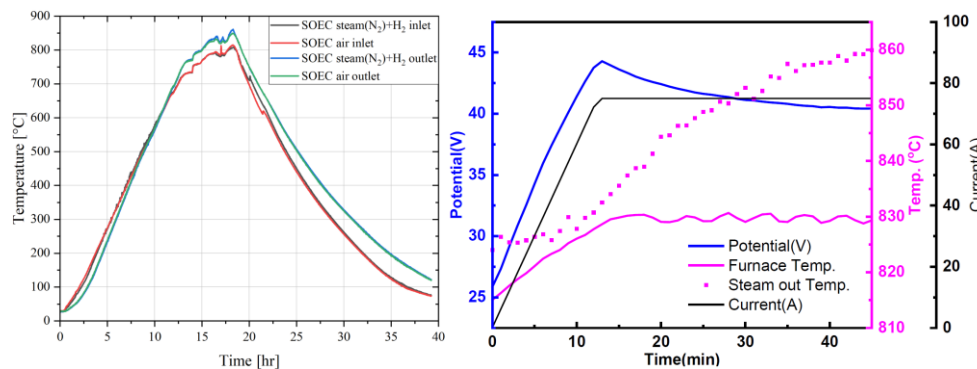
HTGR Design and Analysis Code System



HTSE Module Test with Helium Experimental Loop



6 kWe SOEC stacks (POSCO Holdings)



Module Temperature: 800°C
Electricity: 6kWe
H₂ Production: 4.06 kg/day
Efficiency: 35.8 kWh/kgH₂

HTGR: HECTAR



HECTAR

■ Helium Cooled Thermal Application Reactor

■ Project Duration

- Jul. 2024 ~ Dec. 2027

■ Budget: 33M USD

- Public 17 / Private 16



Specification

■ Power: 90MWth

■ Outlet Temperature: 750°C

■ Application: Industrial Heat (steam)

HTGR: Project Organization



- Reactor core design
- Fluid system design
- Nuclear fuel design
- In-core structure design



- SG vessel (integral design)
- Cross vessel design
- PIRT (Reactor Design)



- Blower design



- SG and HX design



- Project Management
- Plant BOP design
- License planning
- Fuel Handling Machine



- Radiation protection
- Radioactive waste management



- On-site power supply



- Spent fuel storage system design in the reactor building
- Fresh fuel handling process



- Fuel supply chain, including HALEU and TRISO
- Process heat requirement for steel making plant



- SOEC Hydrogen production system



- Process heat system for petrochemical plant

HECTAR Design Features

Ultimate Heat Sink(Air)

Air Cooling System

Nuclear Island

He flow →

Control Rod Driven
Refueling Penetrations

Reactor Vessel

Main Circulator

Steam Generator
Vessel

Steam (Hot)

Core

Shutdown Cooling
Heat Exchanger

Shutdown Cooling
Circulator

Steam Generator

Reactor Cavity
Cooling System

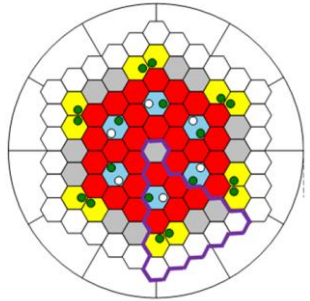
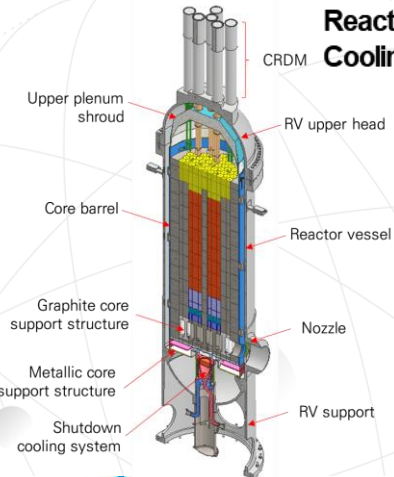
CRDM

RV upper head

Reactor vessel

Nozzle

RV support



Core and Fuel

- > Hexagonal prism block
- > TRISO fuel compact
- > Once-through fuel cycle – 48 months

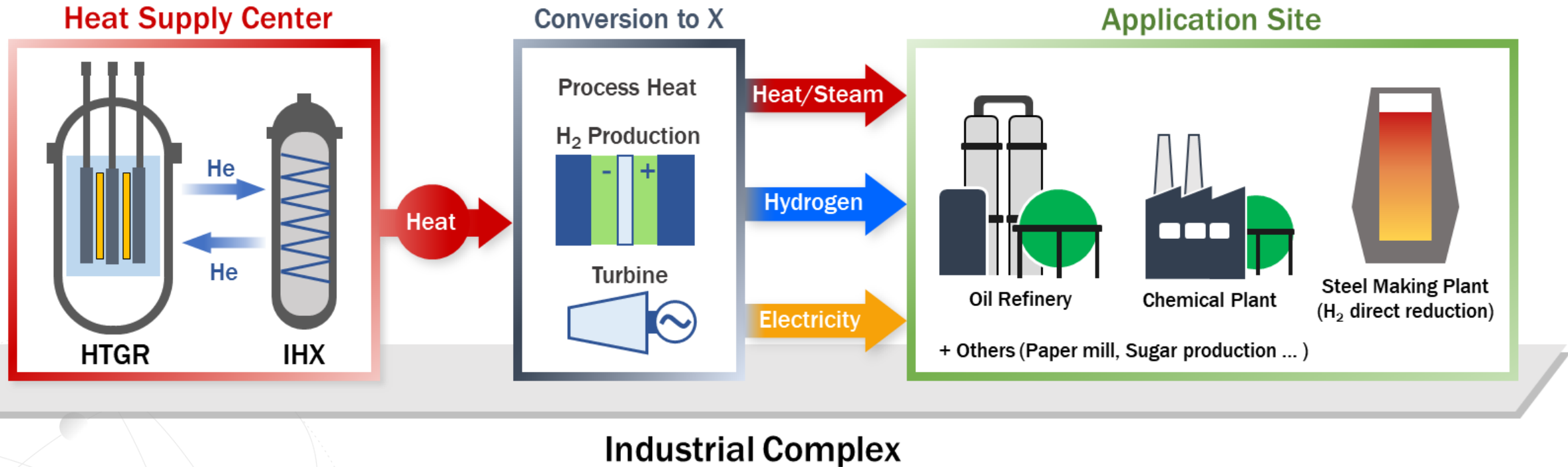
Fluid System

- > Helium – Intermediate Steam – Industrial steam supply
- > Reactor cavity cooling system (water-cooled, passive)
- > Shut-down cooling system

Safety features

- > Inherent Safety
- > Vented low pressure containment
- > Providing delay in the transport of fission product

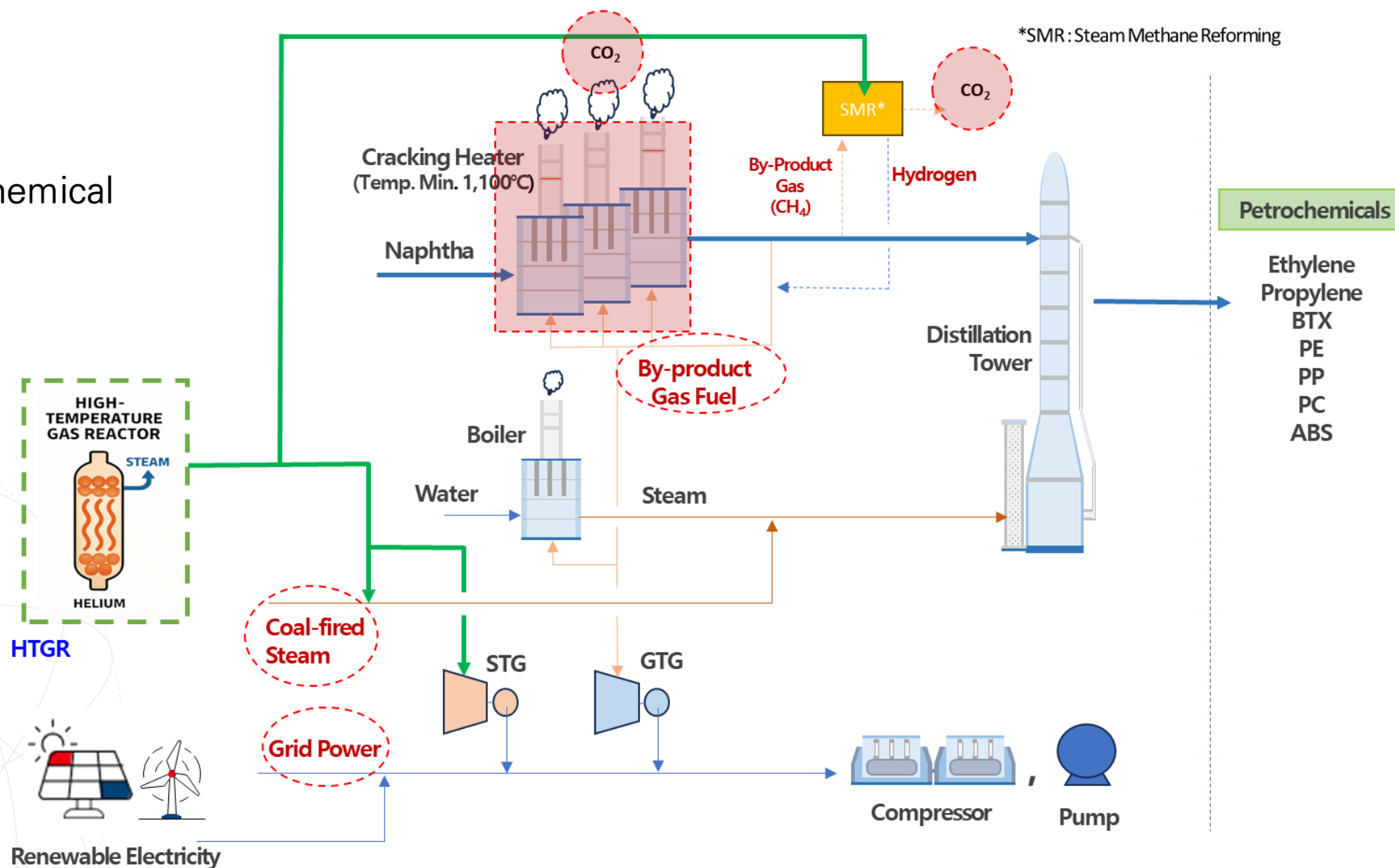
Nuclear Steam Business Model



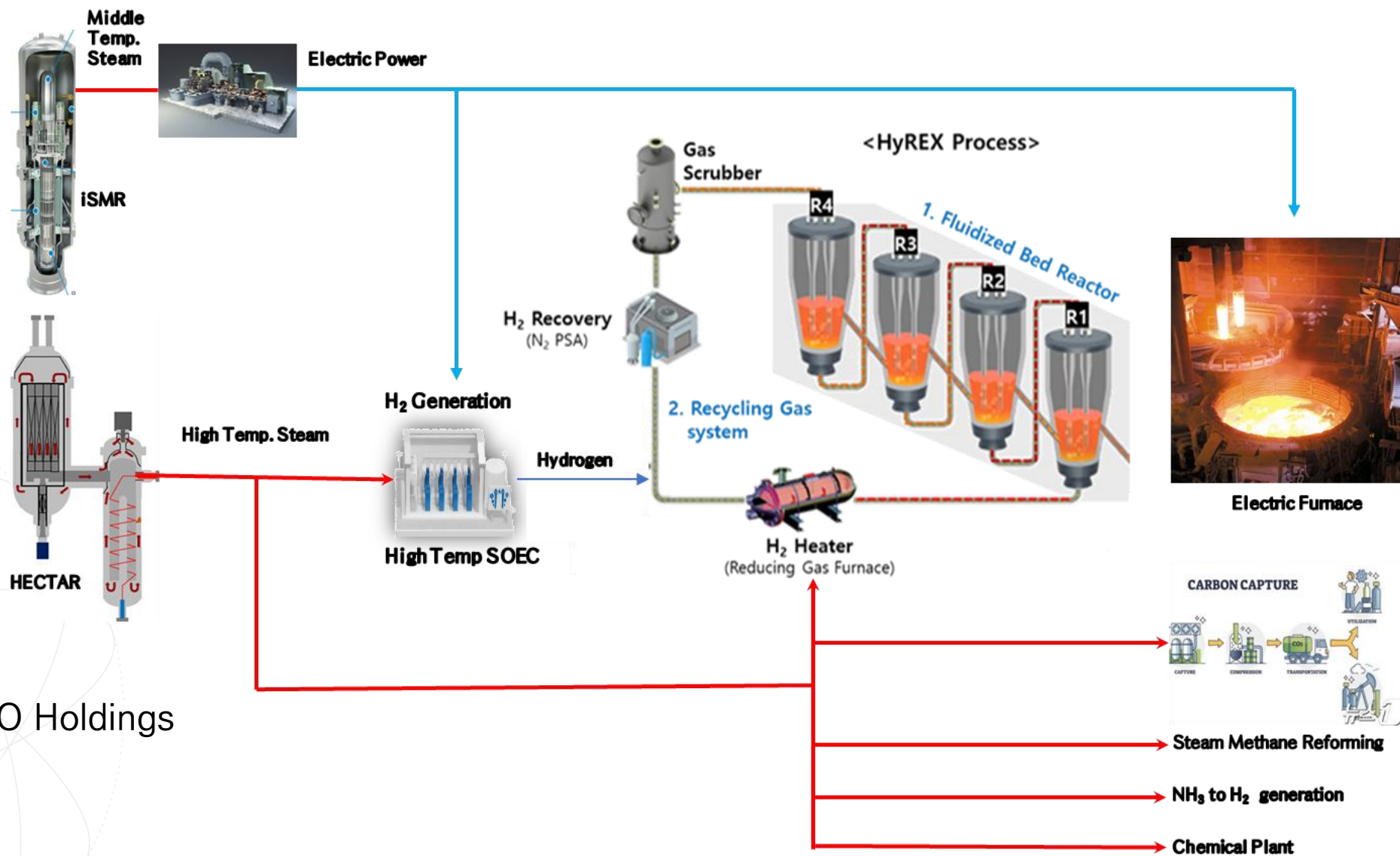
- End-user applications independent of nuclear regulation
- Long-term applications: He-heated cracking, Co-generation

HTGR for Petrochemical Industry

Source: Lotte Chemical



iSMR & HTGR for HyREX Process



Source: POSCO Holdings

Collaborations for HTGR and Non-Electric Applications

- MOU for HTGR Development
 - KAERI & POSCO E&C ('24~)
 - KAERI & Daewoo E&C ('23~)
 - KAERI & POSCO International ('25~): Fuel Supply

■ Collaboration with End-users

■ Nuclear HTSE MOU ('21~)

- KAERI, RIST, POSCO Holdings, Uljin-gun, North Gyeongsang Province, HEC
- Development, demonstration, and commercialization of nuclear hydrogen
- Collaboration study between KAERI & POSCO Holdings (HTSE module test with HELP)

■ Industrial Alliance of Nuclear Heat Utilization ('23~)

- 1 R&D, 1 Local government, 11 Private companies (EPC, chemical, hydrogen, steel)
- Information exchange and collaboration for nuclear heat utilization

■ MOU with Korean Chemical Industry Association ('26~)

- Decarbonization of the chemical industry using HTGR
- Networks between nuclear industries and chemical industries



Summary

- Korean government wants the private sector to lead Gen-IV reactor development and demonstration.
- KAERI developed key technologies for nuclear hydrogen production using HTGR.
- KAERI has designed HECTAR, HTGR for industrial process heat, with private companies including POSCO E&C, Daewoo E&C, SMART Power, SK Ecoplant, Lotte Chemical, POSCO International, Donghwa ENTEC, Hanhwa Power, Hanil Nuclear, and FNC Technology.
- End-Users will utilize HECTAR's high temperature steam independent of nuclear regulation.
- KAERI has collaborated the private sectors to activate the new nuclear process heat business.



Good bye~

Thank you for your attention.

