Perspectives on the Role of JAEA towards Industrial Application of HTGR

OECD/NEA WS High temperature reactor and industrial heat application
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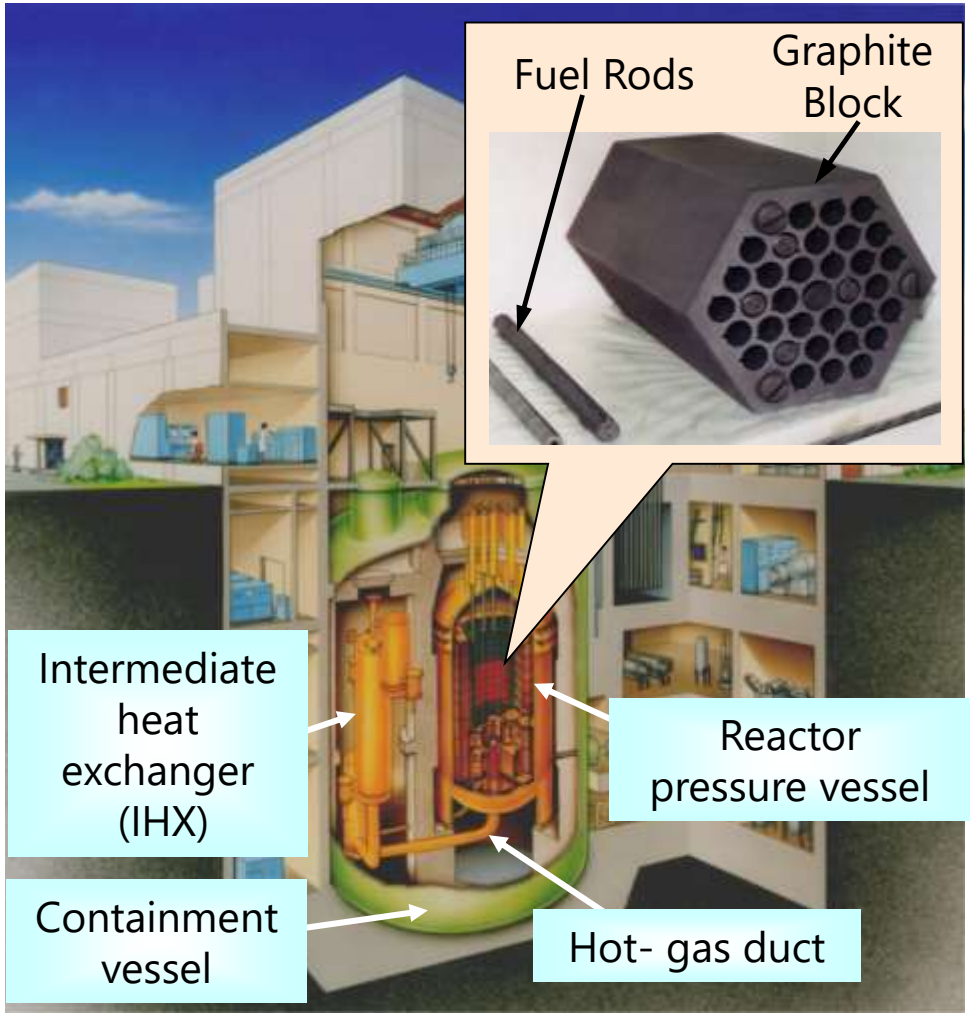
Document Overview

- HTTR Technical Features, Operation & Licensing Experience, Future Tests
- Perspectives on the role of JAEA towards Industrial Application of HTGRs

HTTR: High Temperature Engineering Test Reactor

The only prismatic-type High Temperature Gas-cooled Reactor (HTGR) in operation in the world



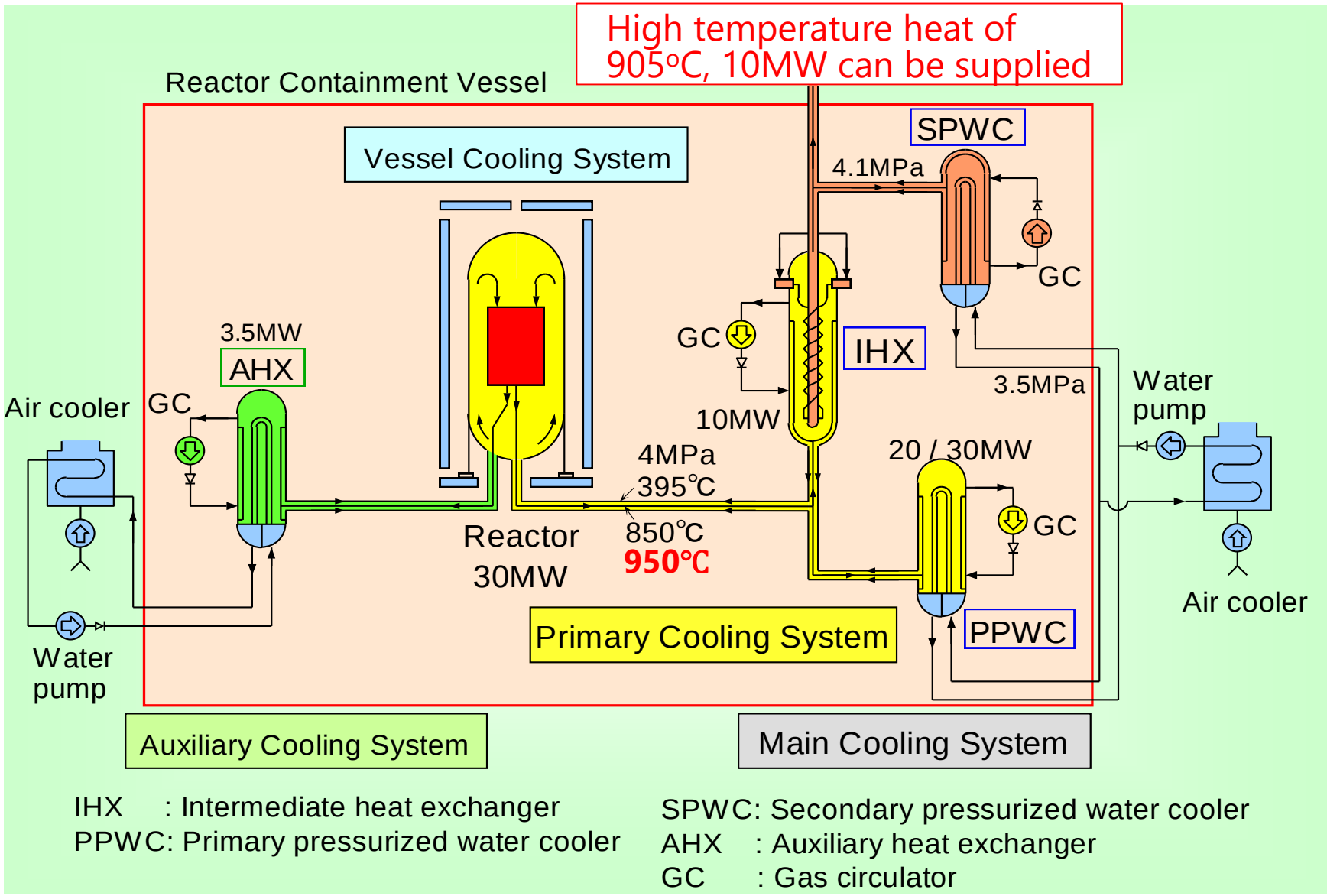
Major Specifications

Thermal power	30 MW
Fuel	Coated fuel particle / Prismatic type
Core material	Graphite
Coolant	Helium
Inlet temperature	395°C
Outlet temperature	950°C
Pressure	4 MPa

Major Achievements

First criticality	: November, 1998
Full power operation	: December, 2001
50 days continuous 950°C operation	: March, 2010
Obtain permission of changes to reactor installation in conformity to New Regulatory Requirements	: June, 2020
Restart operation	: July, 2021

Technical Features of HTTR

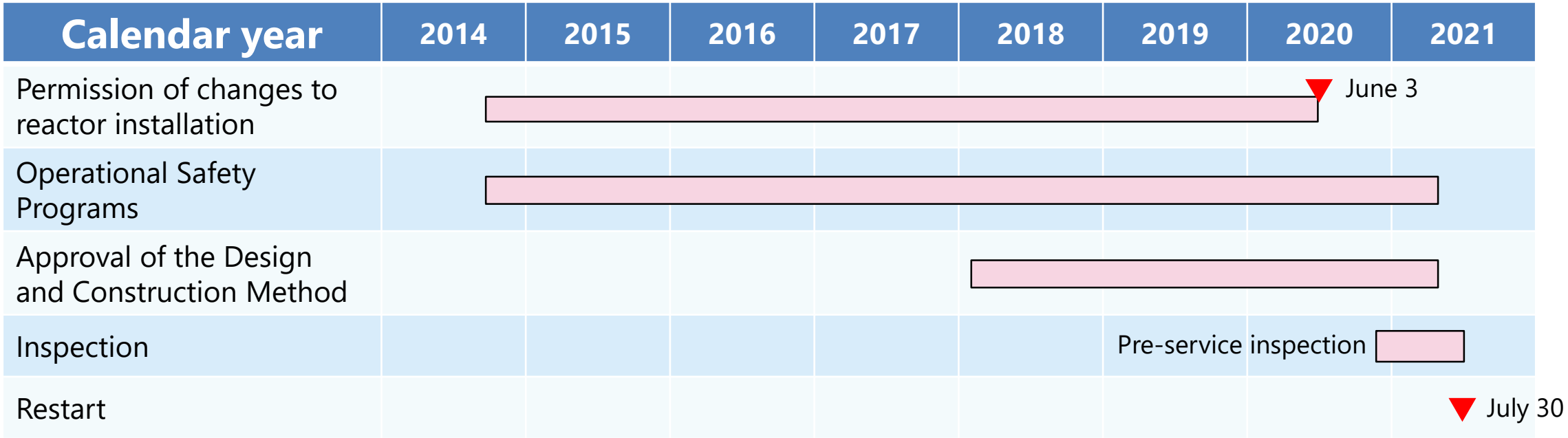


- **Capable to supply high temperature heat**
  - 50 day continuous operation at 950°C reactor outlet temperature demonstrated
  - Maximum 905°C, 10MW high temperature heat can be supplied by modification of the secondary helium cooling system
- **HTGR safety feature demonstration tests licensed by regulator**
  - Key safety features of HTGR can be demonstrated by actual test
    - intrinsic shutdown without control rod insertion, passive decay heat cooling from outside of reactor, etc.

Nuclear Applied Heat Technology Division, Proc. 1st JAEA/KAERI Information Exchange Meeting on HTGR and Nuclear Hydrogen Technology, August 28-30, 2006, Oarai. Japan.

Licensing Experiences of HTTR

- Following the nuclear accident at the TEPCO's Fukushima Daiichi nuclear power station on March 11, 2011, revised regulatory requirements were issued by the Nuclear Regulation Authority (NRA) in July 2013.
- JAEA had submitted the application including evaluation results satisfying the New Regulatory Requirements to the Nuclear Regulation Authority (NRA) on November 26, 2014.
- Through many discussions with the NRA, on June 3, 2020, JAEA obtained the permission by the NRA for changes to Reactor Installation of the HTTR.
- HTTR has restarted its operation on July 30, 2021.



E. Ishitsuka, "Experience of HTTR Licensing for Japan's New Nuclear Regulation," GIF Webinar Series 52, April 21, 2021.

Licensing Experiences of HTTR – Seismic Classifications

Safety characteristics of the HTTR

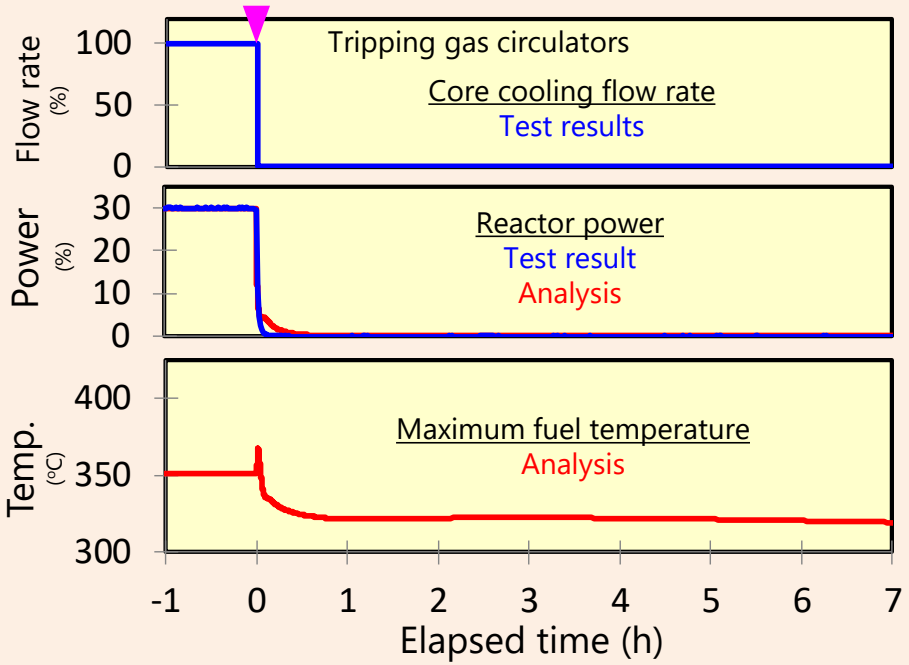
Because of the inherent characteristics of basic elements, i.e. refractory coated fuel particles, inert, single-phase helium coolant and graphite moderator with large heat capacity, the HTTR can maintain in a stable state under loss-of-cooling and/or reactivity control conditions.

Obtained permission from NRA to reclassify seismic classification of SSCs to lower class

- Core heat removal: S class to B class
- Reactor internal structure: S class to B class.

HTTR safety demonstration test

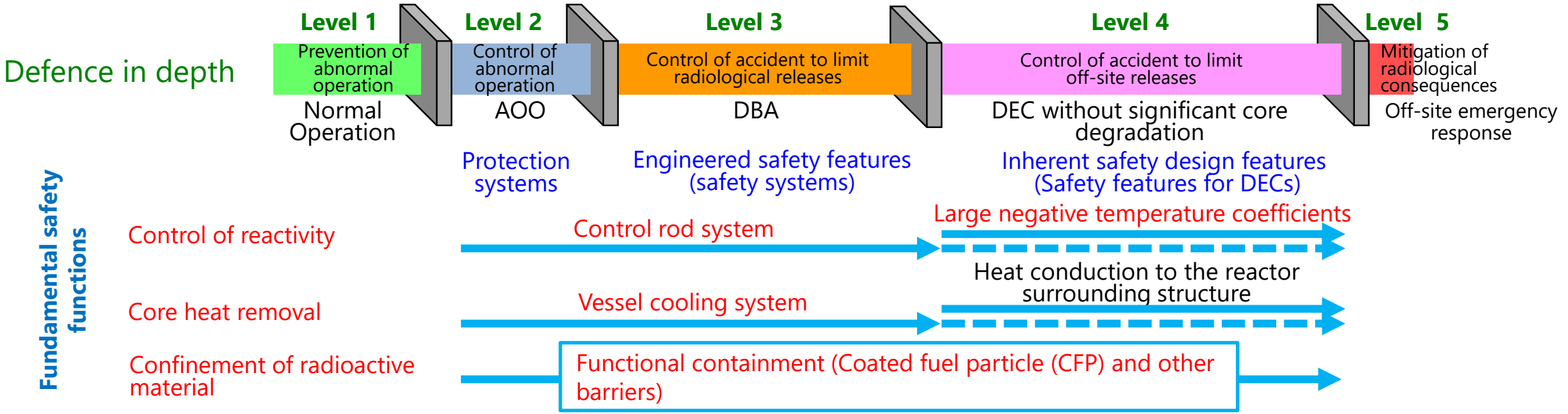
- Initial power 30% (9MW)
- Reducing core flow rate to zero by tripping all circulators
- VCS operation maintained
- No scram operation (No CR insertion)



- Reactor intrinsically shut down as soon as the core cooling flow rate to zero.
- Reactor is kept stable long after the loss of core cooling

E. Ishitsuka, "Experience of HTTR Licensing for Japan's New Nuclear Regulation," GIF Webinar Series 52, April 21, 2021.

Licensing Experiences of HTTR - BDBA -



The NRA review concluded that (1) significant core degradation including core melting may not occur by postulated BDBAs* and (2) specific SSCs are not required to cope with BDBAs*

- **HTTR has restarted its operation without significant additional reinforcements due to the inherent safety features**
- **Safety design established through the licensing can be used in commercial HTGR**

<u>Remaining items</u>

Establishment of safety standards for commercial HTGR including requirements for coupling heat application system to the nuclear facility and the use of PRA in safety management

High expectation OECD/NEA CSNI/WGRISK activities related to advanced reactors

*HTTR BDBAs DBA + failure of reactor scram
DBA + failure of heat removal from the core
DBA + failure of containment vessel

E. Ishitsuka, "Experience of HTTR Licensing for Japan's New Nuclear Regulation," GIF Webinar Series 52, April 21, 2021.

HTTR Future Tests

2022 - 2029 -

Restart operation

HTTR

Safety demonstration tests, Other tests

Other tests

Other tests

HTTR Heat Application Test

HTTR modification design/modification

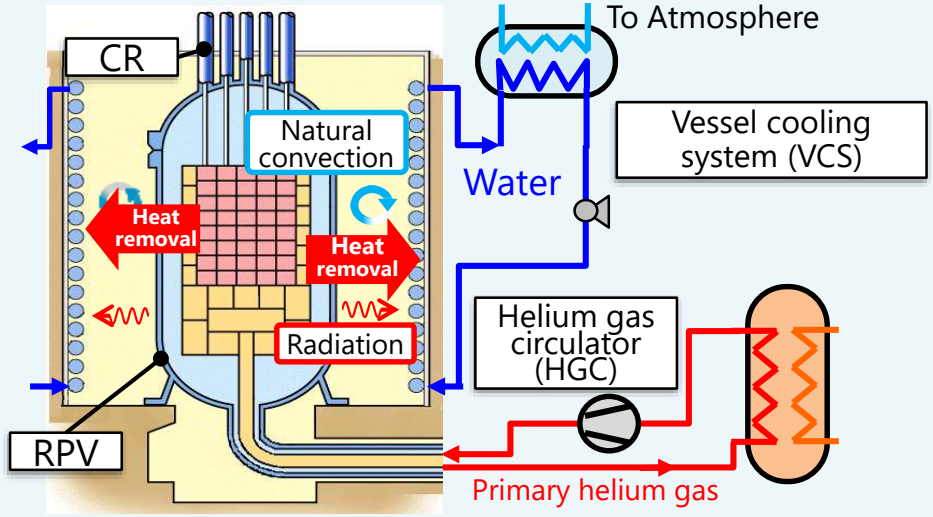
H_2 plant design/construction

Commissioning

H_2 production test

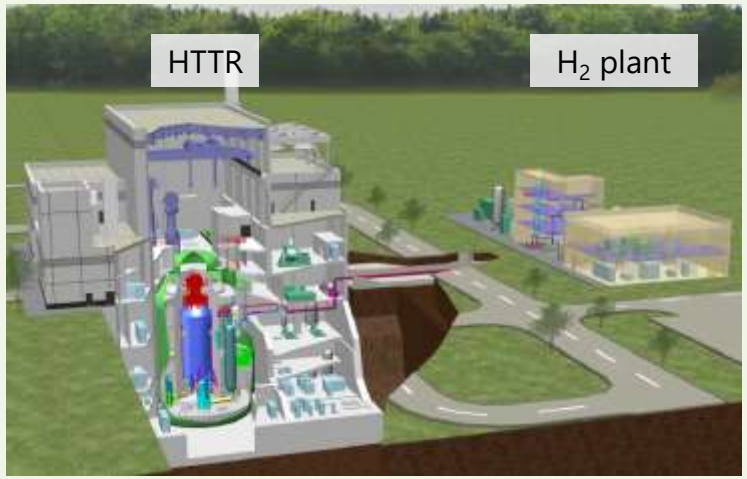
HTTR Safety Demonstration Test (OECD/NEA CSNI LOFC Project)

- **Development of safety analysis code system**
- **Demonstration of HTGR safety features**
  - Loss of forced cooling test (All HGC tripped, 100% power)
  - Loss of core cooling test (All HGC + VCS tripped, 30% power)



HTTR-heat Application Test

- **Development of coupling technology between HTGR and H_2 plant**
- **Demonstration of nuclear hydrogen production**
  - Continuous H_2 production test
  - Transient simulation test



Perspectives on the role of JAEA

Role of JAEA

- Develop key technologies needed by commercial HTGR
- **Provide R&D test beds of unique experimental and computational capabilities, as well as knowledge and databases to industry**
- Promotion of international standardization of technologies and standards through international collaboration

JAEA

Experiment capabilities

Facility use request

Data

Computational capabilities

- Core neutronic analysis
- Core thermal-fluid analysis
- Fuel performance analysis
- Safety analysis
- Core seismic analysis
- System analysis

Validated code systems

Model, Knowledge

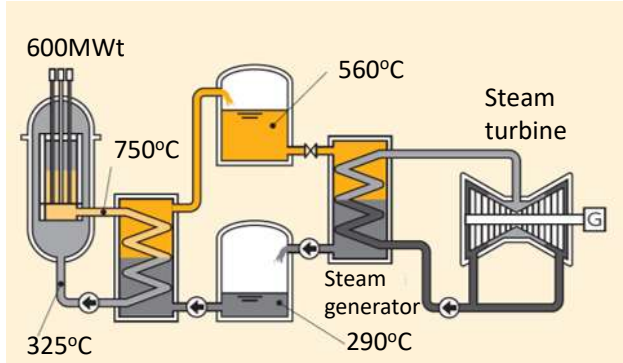
IPs, Knowledge, Databases

- Core design
- Safety design
- System design
- Fuel design
- Reactor seismic design
- Component design specific to HTGR, He-GT, H_2 plant
- Operation and maintenance

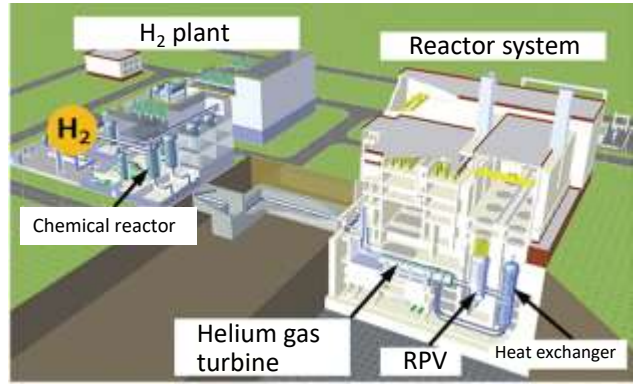
Knowledge, Data

IPs, Knowledge, Databases

HTGR Vendors



Commercial HTGR power plant with TES[*1]



Commercial HTGR cogeneration plant[*2]

TES: Thermal storage Energy System

*1: Fuji electric, Fuji Electric Journal, 93(2), 122 (2020).

*2: Y. Kimura, Journal of the Atomic Energy Society of Japan, Vol.62, 3, 144 (2020).

Summary

- The HTTR is the only prismatic-type HTGR in operation in the world.
- The HTTR can provide valuable data including coupled neutronic/thermal-fluid characteristics, integrated nuclear and chemical plants characteristics, etc. that can be used for validation of safety analysis tools and demonstration of key technologies needed by commercial HTGR.
- JAEA established safety design through licensing process by NRA for changes to Reactor Installation of the HTTR in conformity to the New Regulatory Requirements.
- JAEA can provide R&D test beds of unique experimental and computational capabilities, as well as knowledge and databases to industry.