Status of Fast Reactor Development Program in Korea

International Conference on Fast Reactors and Related Fuel Cycles (FR22)

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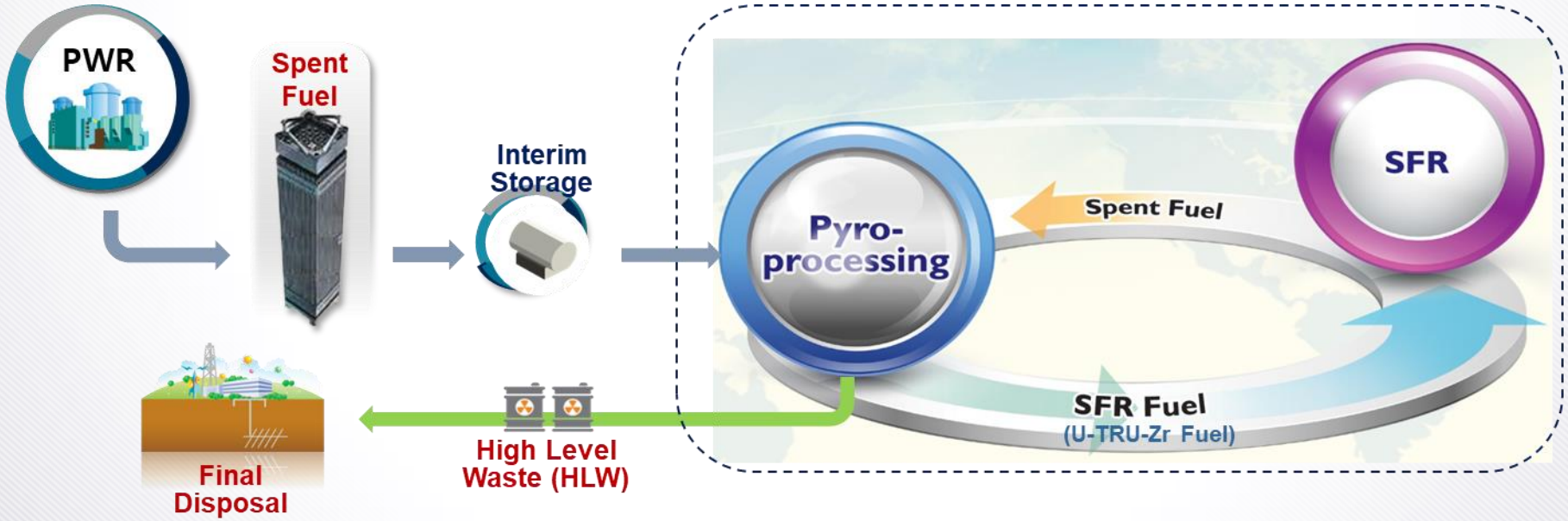
CHAE YOUNG LIM

KAERI Korea Atomic Energy Research Institute

Objectives of SFR Development in Korea

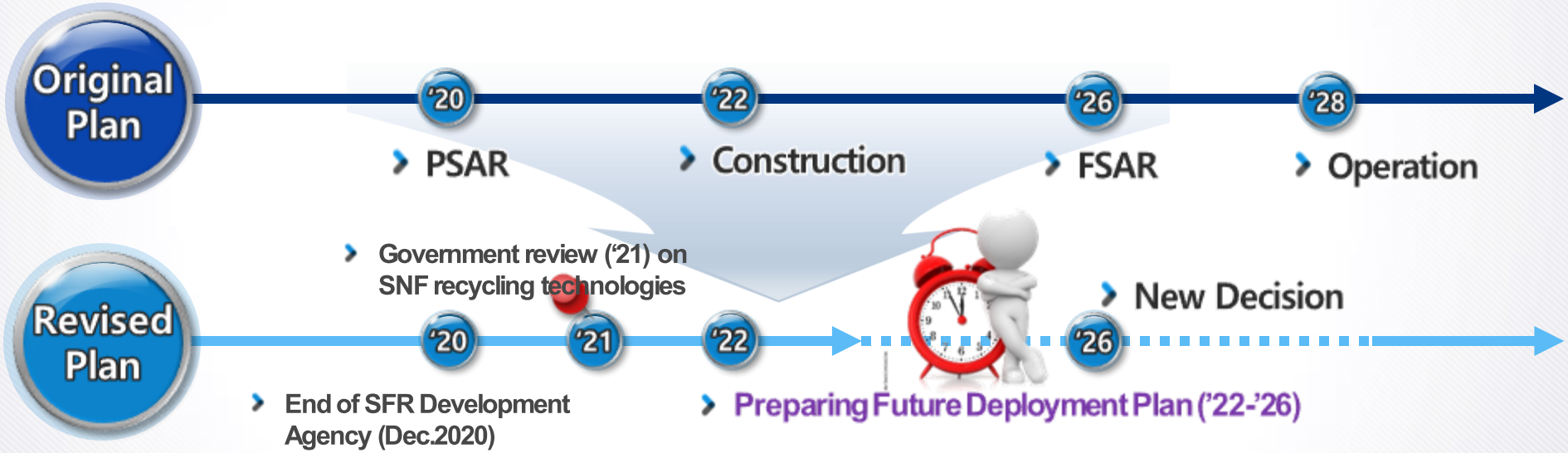
- Pending issues on long-term Spent Nuclear Fuel (SNF) management
  - One of options for SNF management
  - **Sodium-cooled Fast Reactor** (SFR) coupled with pyro-processing
- Being developed as a TRU burner to solve the SNF management issues



TRU: TransUranics (Pu+MA), MA: Minor Actinides (Np, Am, Cm), FP: Fission Products

Milestone of SFR Development in Korea

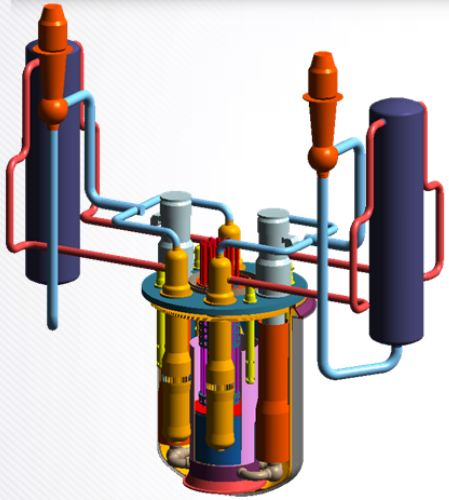
- Original plan for demonstration of TRU-burner SFR has been suspended since 2018
- General R&D direction of Pyroprocessing-SFR technology has been set in 2021 with the Government peer review on SNF management policy



- Korean SFR program has been steadily going toward technology demonstration of TRU transmutation as well as SFR safety, but specific plan for deployment needs to have further decision with the Pyroprocessing technology development

Evolution of SFR Development in Korea

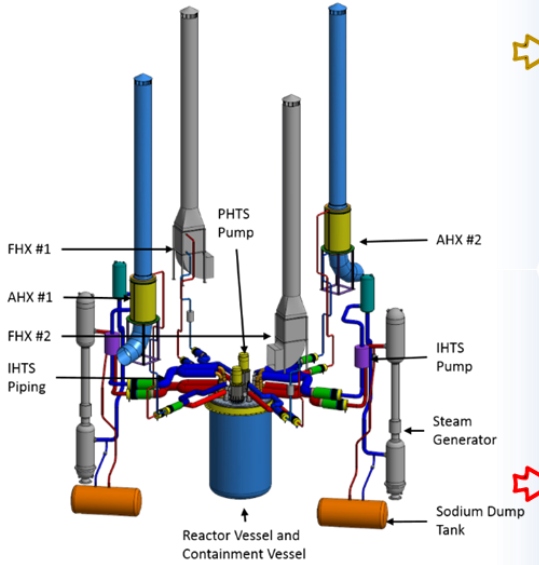
KALIMER-600



- 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)

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PGSFR Construction (TBD)

Track 1

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

SFR-based Power Rx.

Track 2

- With keeping similar design concept of PGSFR except nuclear fuel and core design
- Demonstration program of PGSFR can be mostly used to the reactor design

Domestic SFR Development Program

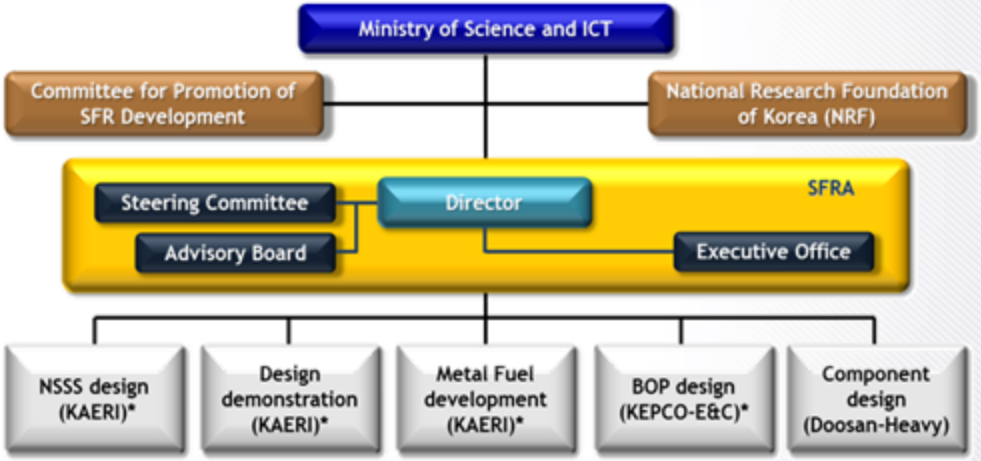
**PGSFR: Prototype Generation IV Sodium-cooled Fast Reactor*

PGSFR* Project (2012~)

- PGSFR has been developed by Korea Atomic Energy Research Institute (KAERI) with the grant from Korean Government since 2012
- Originally developed as TRU transmutation demonstrator to solve the Spent Nuclear Fuel management issue in Korea

Domestic and int'l cooperation

- KEPCO-E&C and Doosan Heavy Industry
- Joint work with Argonne National Lab. since 2012



< Organization of PGSFR Development >

Current status of PGSFR development

- Completion of system design & analysis documents that are equivalent to Safety Analysis Report (SAR)
- Waiting for further Government decision to deploy domestic TRU transmutation demonstrator as one of the key SNF management options

Design Capabilities and Completeness

Utilization of design capabilities of PGSFR

- Completion of detailed system design & analysis reports equivalent to Safety Analysis Report
  - ~2,000 technical documents to support the design completeness
- Topical Reports for key technologies for safety design issues

Infrastructure for validation

- Test facilities constructed for safety validation of SFR (Total 35 validation programs have been completed by 2020)
- Domestic infrastructure for manufacturing metal fuel, components, and fuel assembly component

Human resources and technical expertise

- Human resources experienced for SFR nearly 200 MY
  - Research engineers from KAERI for R&D areas
  - Engineers for industrial support from KEPCO-E&C, Doosan Heavy Industry, etc.

Neutron Irradiation Test of Fuel Rod and Cladding

- Validation of irradiation performance for **KAERI-fabricated** metal fuel rod and cladding (BOR-60, Russia)
  - Irradiation test of **metal fuel rod** (U-10wt%Zr)
    - Irradiation test (7 at.%) was completed in May 2020
    - Pursuing an extension of fuel rod irradiation test to achieve 10 at.% target burnup including NDE
  - Irradiation test of **cladding** (Test cladding materials: FC92, HT9)
    - Irradiation test (75 dpa) was completed in May 2020
    - FC92 cladding has proved 30 % higher creep strength than HT9

Cladding Test Rig

SFR Development toward SMR Market

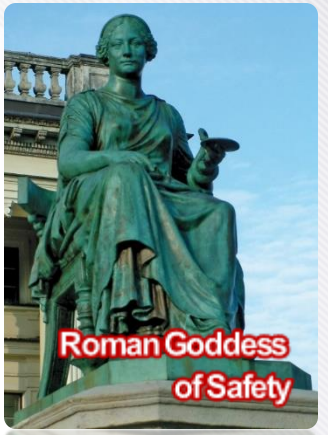
- Spin-off technologies and feedback from the PGSFR* program
  - Key SFR technologies in cross-cutting area have been selected for quicker technology advancement
  - Most design features of PGSFR have been incorporated
- CNL's* SMR Invitation (Mostly Non-LWR based SMRs)
  - KAERI is considering the pre-licensing Vendor Design Review (VDR) focused on the Canadian regulatory system
  - Planning to propose the VDR phase-1 for an advanced SMR design with 100 MWe long-cycled SFR concept (by the end of 2022)
    - review on licensing feasibility based on the Canadian VDR program for non-LWR based SMRs
- Development of Business Model to facilitate global demonstration
  - Cooperation with private sectors (e.g., domestic industries) for more efficient participation in Global SMR Project (`22~)

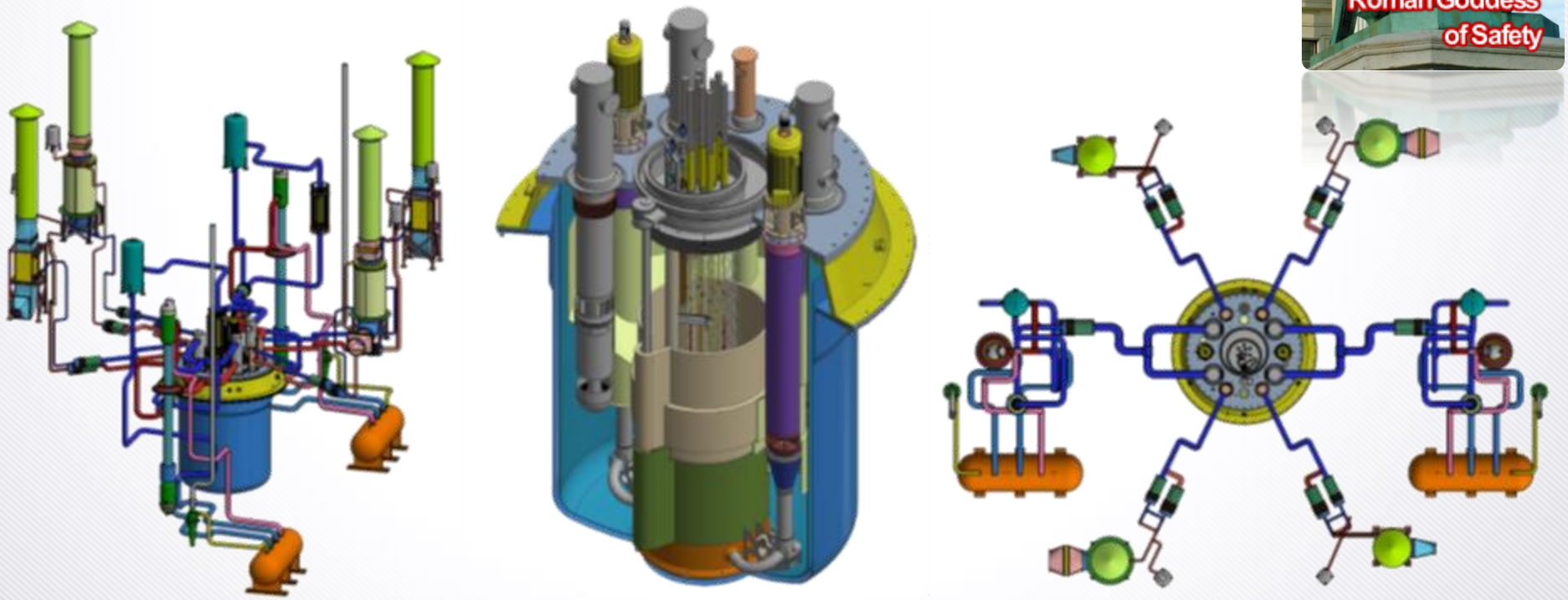
* Canadian Nuclear Laboratories

SFR-based Advanced Small Modular Reactor

- **Development of SALUS-100** (Government Grant, '22-'24)
  - **SALUS** (**S**mall, **A**dvanced, **L**ong-cycled and **U**ltimate **S**afe SFR)
    - Electric power output: 100 MWe
    - Development of Spin-off technologies from the PGSFR* concept
    - Pursuing a power generation reactor with a long fuel cycle

* Prototype Generation-IV SFR

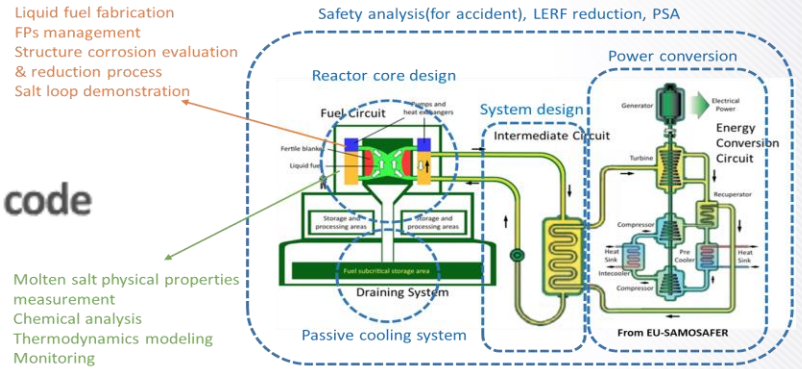




<SALUS-100 : Solid Modeling View (tentative)>

New program for MSR Technology Development

- **Objectives of MSR technology development for multiple applications** (2021~)
  - Application to the maritime engine (under discussion with domestic ship-builders)
  - Potential option for SNF management with fast neutron spectrum using Chloride-based coolant (MCFR)
- **Major R&D Activities**
  - Molten salt property measurement
  - MSR reactor core design/analysis code, safety analysis code
  - Liquid fuel fabrication process



- **Domestic R&D cooperation**
  - Organized MSR consultative group with universities (SNU, KAIST, UNIST, POSTECH, SCH) and industries (KSOE*, Samsung Heavy Industries, Hyundai Engineering) *: Korea Shipbuilding & Offshore Engineering
  - Signed an MOU with Samsung Heavy Industries on MSR for maritime application (June 9th, 2021)
- **International cooperation on MSR (under consideration)**
  - KAERI-INL Technology cooperation on the thermo-physical measurement of actinide-bearing salt
  - Future cooperation with World MSR developers mainly on Maritime applications
    - TerraPower, Moltex Energy, CorePower, Seaborg, Copenhagen Atomics, etc.

Summary

- National policy on spent nuclear fuel management is still Wait & See
  - Policy direction should be set on the basis of the feasibility of a back-end fuel cycle option
    - e.g., technical feasibility, safety, cost, etc.
- SFR deployment plan in Korea is still pending but is not abolished
  - Strongly coupled with the National SNF management policy
- SFR-based advanced SMR is developing with spin-off technologies and feedback from the PGSFR program
  - Pursuing not a TRU-burner but a power generation reactor with a long fuel cycle
  - Trying to facilitate global export targeting potential SMR market
- Development of cross-cutting technologies for SFR-based power Rx. as well as TRU burner has been underway
  - KAERI is expecting valuable technology impacts through an opportunity of international cooperation in the field of SFR design and correlated R&Ds

Thank you for your attention

CHAE YOUNG LIM (KAERI)

limcy@kaeri.re.kr

KAERI 한국원자력연구원 Korea Atomic Energy Research Institute