

PRIDE

(PyRoprocess Integrated inactive
DEmonstration facility)

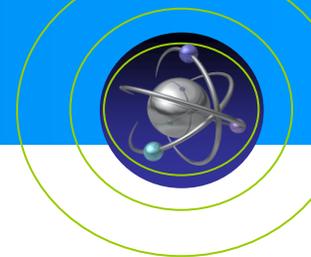
Aug. 27, 2012

Hansoo Lee

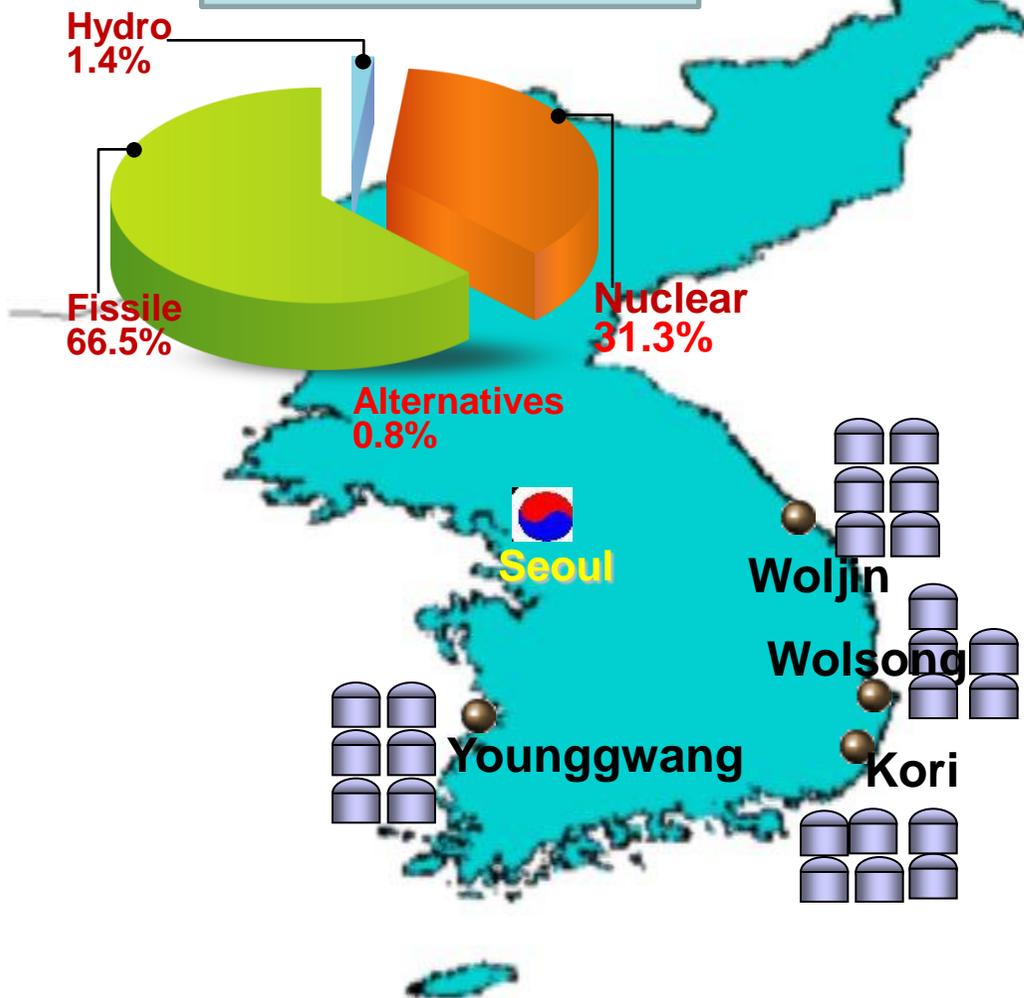


Korea Atomic Energy
Research Institute

Nuclear Power Plants in Korea as of '12.08



Electricity generation
in 2010
KEPCO in Brief, 2011.03

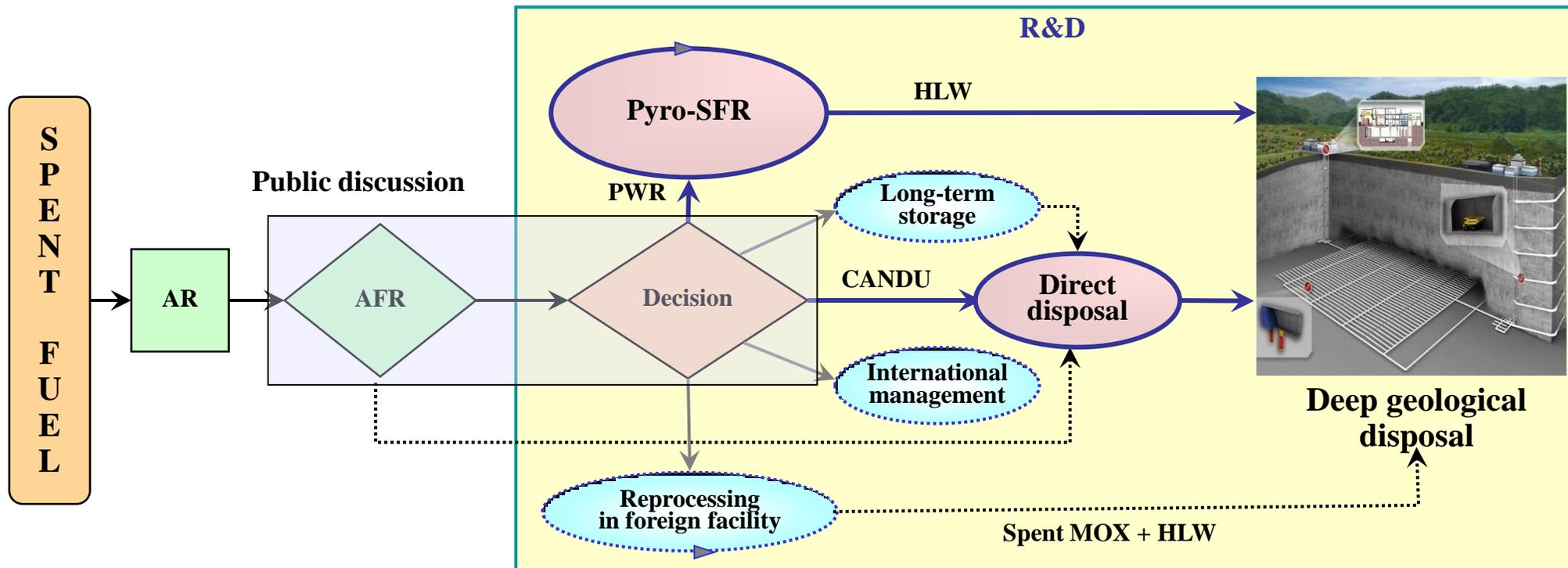


- ◆ 23 units in operation
 - 19 PWRs
 - 4 PHWRs
- ◆ Planned(National Energy Committee, 2008)
 - 10 APR+ (~2030)
 - Target: 59% share in 2030

R&D on SNF Management

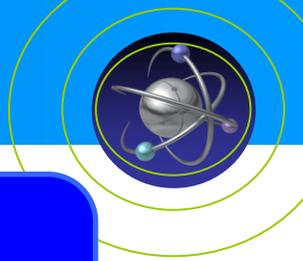


- On-site SF storage limit will be reached from 2016
- Spent fuel management policy will be determined after formulating a nation wide consensus through full spectrum open discussions

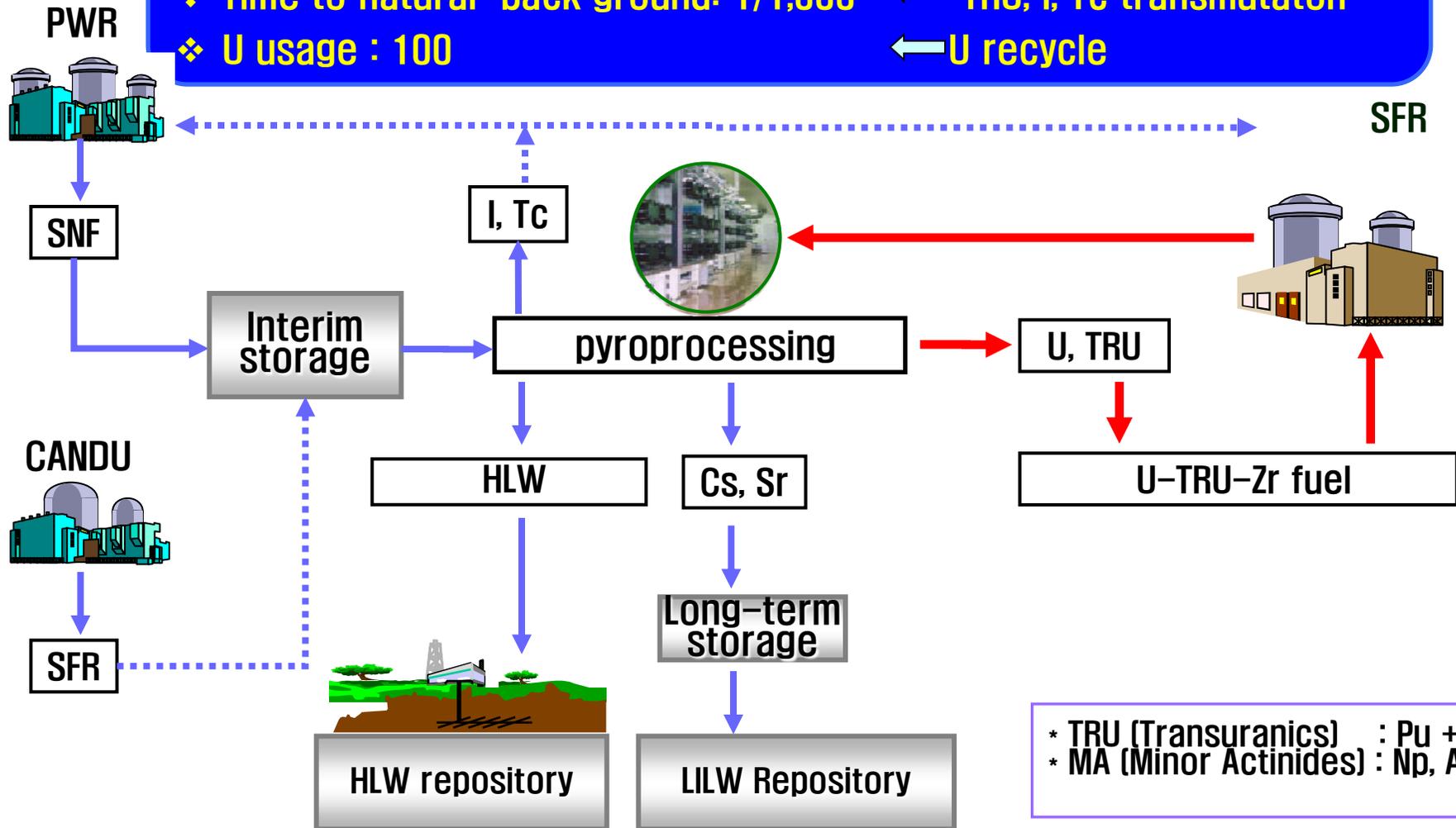


- Ongoing Projects on SF Management (MKE-KRMC)
 - Expert Consensus Development Project
 - Development of Long-term Project Plan

Pyroprocessing – SFR closed fuel cycle

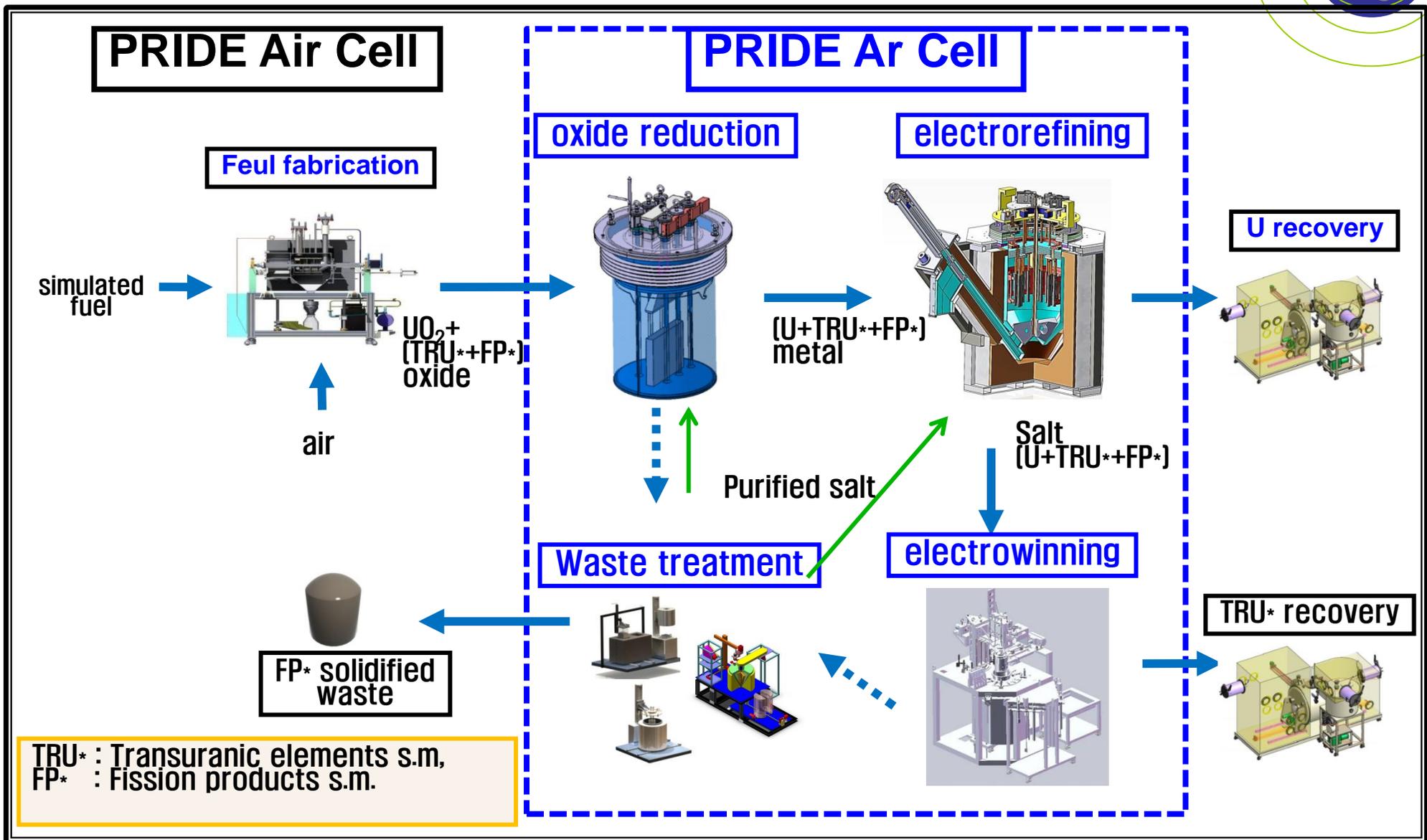
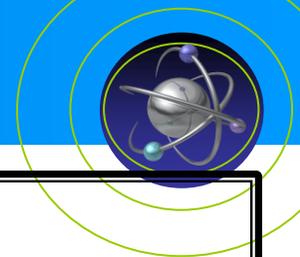


- ❖ waste : 1/20 ← U, TRU recovery
- ❖ HLW disposal area : 1/100 ← Cs, Sr separation
- ❖ Time to natural back ground: 1/1,000 ← TRU, I, Tc transmutaton
- ❖ U usage : 100 ← U recycle

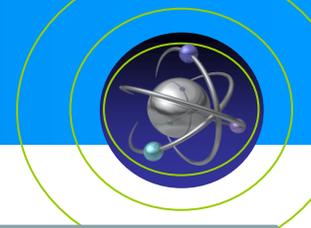


* TRU (Transuranics) : Pu + MA
 * MA (Minor Actinides) : Np, Am, Cm

PRIDE Process Equipments



Head-end process : Decladding/Voloxidation



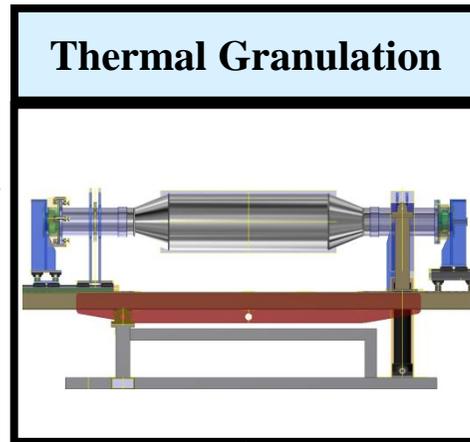
Lab-scale (200g-U/batch) off-gas trapping test

- Development of off-gas filters for trapping Cs, Tc(Re), I
- Hot test of selective off-gas trapping for high temp voloxidation



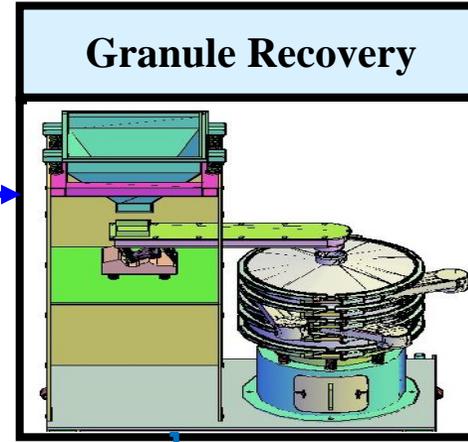
SIMFUEL pellet

- Burnup : 55,000 MWd/tU
- Cooling time : 10 yrs.



Thermal Granulation

SIMFUEL particle



Granule Recovery

SIMFUEL granule

To electrolytic reducer



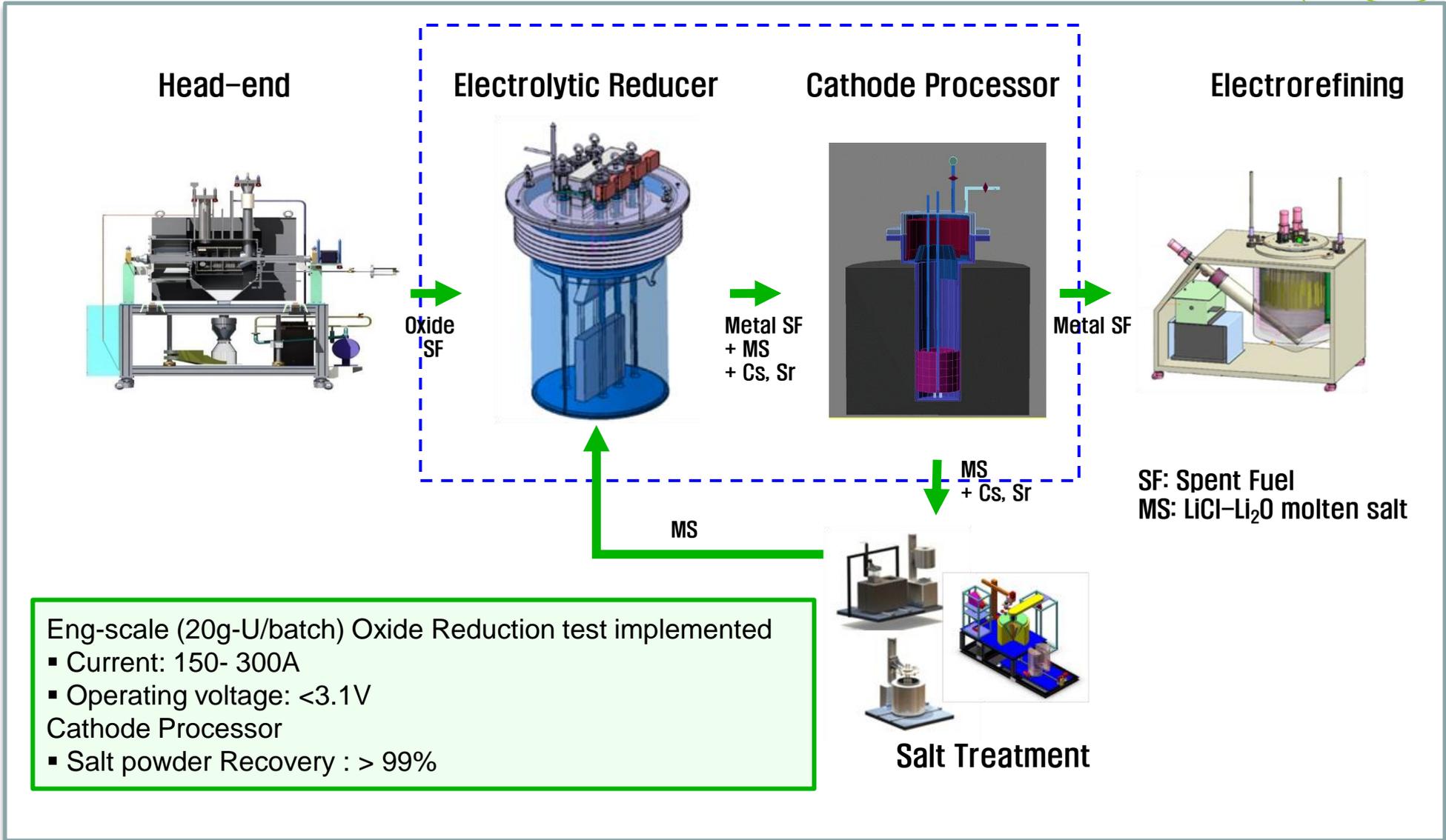
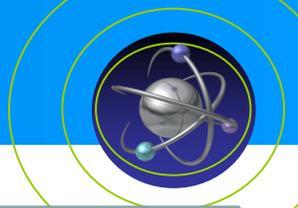
Recycling

Particle size :
> 20mm, < 1 mm

Lab-scale (200g-U/batch) voloxidation test by Rotary motion

- Recovery ratio of >1mm granules : ~84%
- Electro-reduction ratio of UO_2 granules to U : > 99%

Oxide Reduction (Electrolytic Reduction)



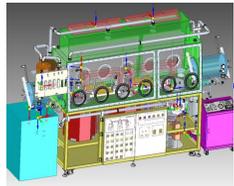
Electrorefining



30 kg/batch, 30 mol% UCl_3

- $Cl_2 + Cd \rightarrow CdCl_2$
- $CdCl_2 + U \rightarrow UCl_3 + Cd$

U-chlorinator



Reduced SF

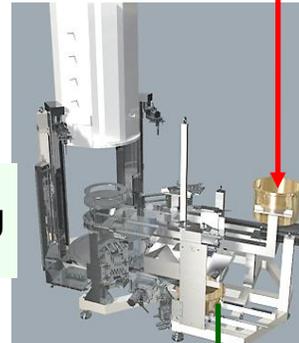
Oxide Reduction

UCl_3

Salt Recycle

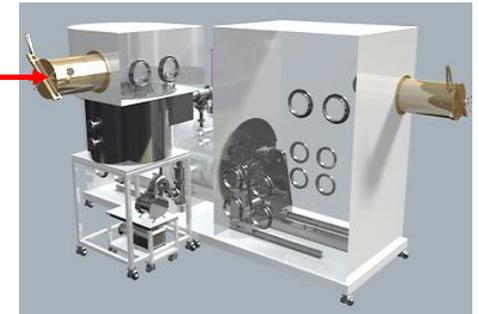
Deposit (U+Salt)

- 65 kg/batch
- Dendrite: 50 kg
- Salt: 15 kg



Salt distiller

- 33 kg U+Salt / batch
- 850°C
- 0~5 torr



Ingot casting furnace

- 50 kg/batch
- Gas-cooled induction heater
- Tilting & turntable crucibles

Electrorefiner

- 50 kg/batch
- Graphite cathode
- Bucket receiver

Used salt (TRU/RE)



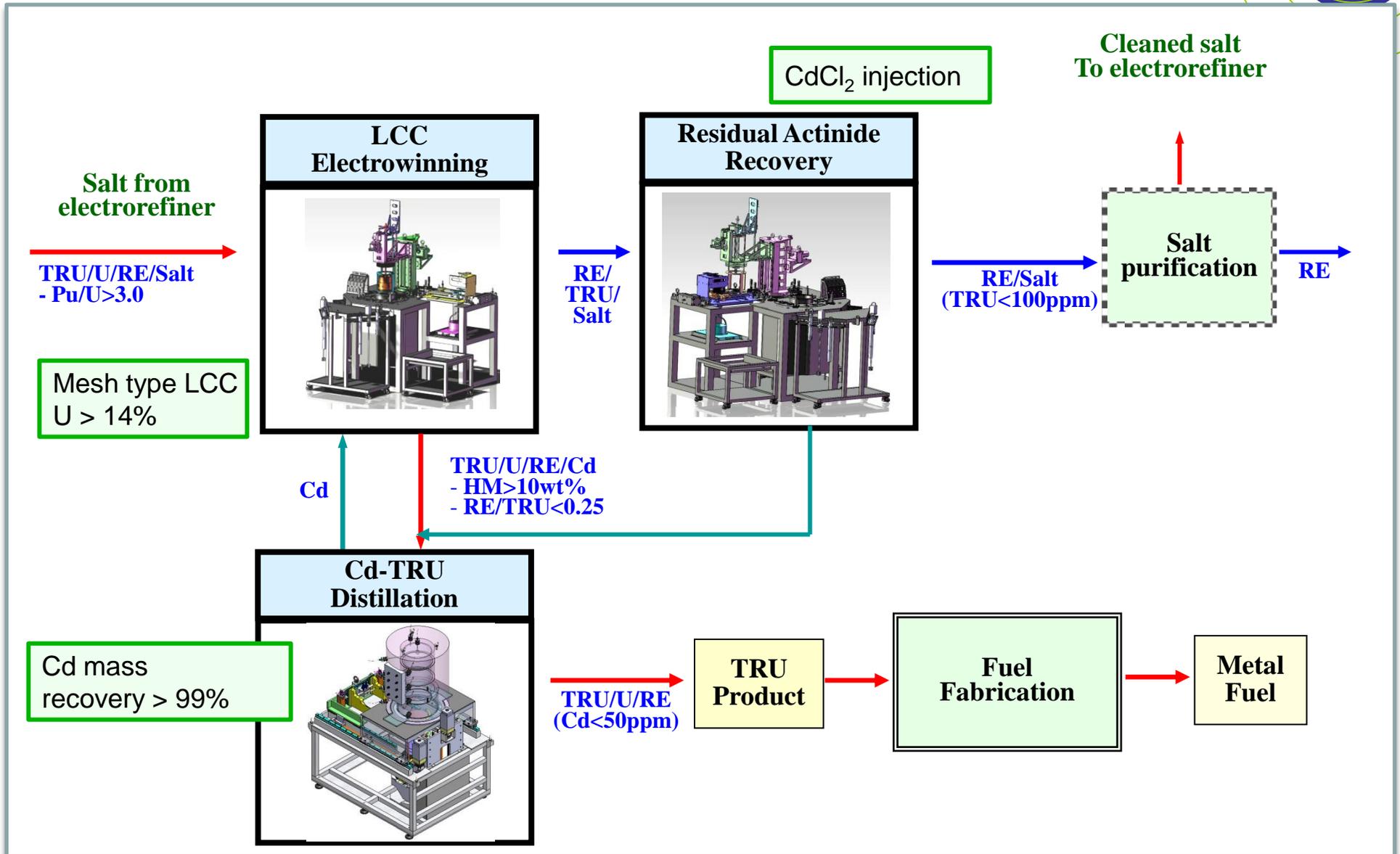
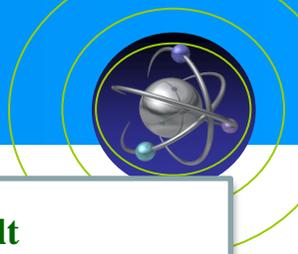
Salt transfer

- 300 kg-salt /camp.
- Pu/U > 3.0
- Salt + TRU/RE/U

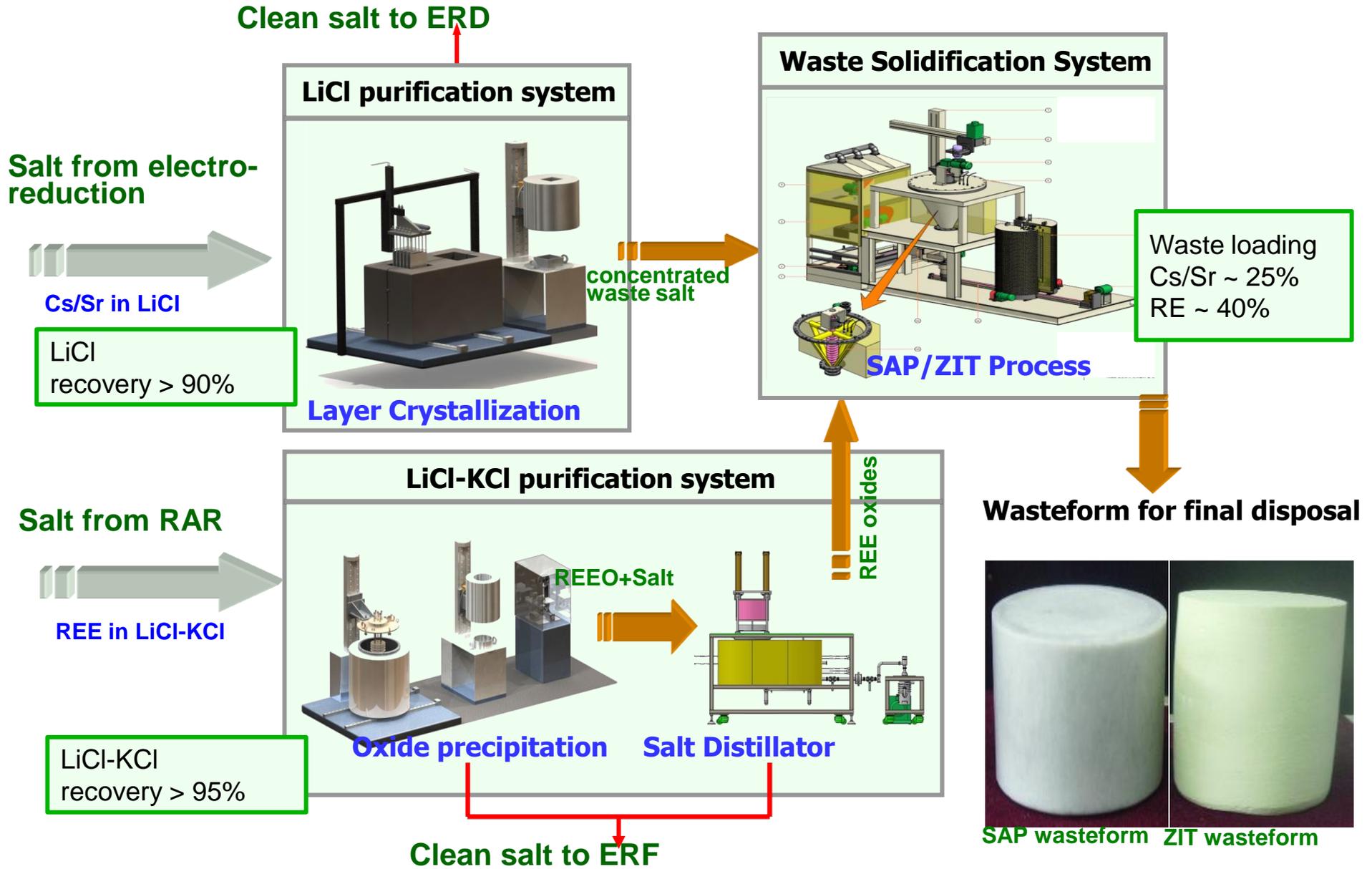
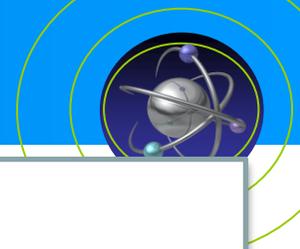
Electrowinning

U

Electrowinning



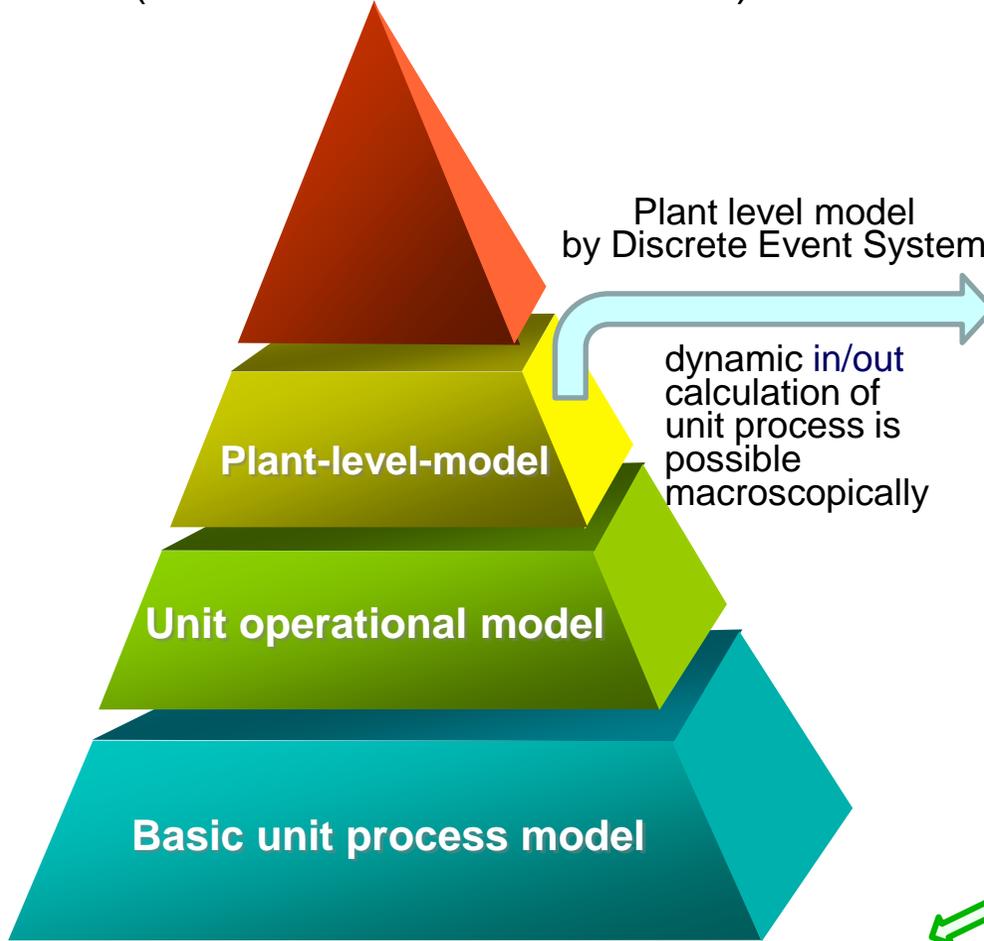
Salt Treatment



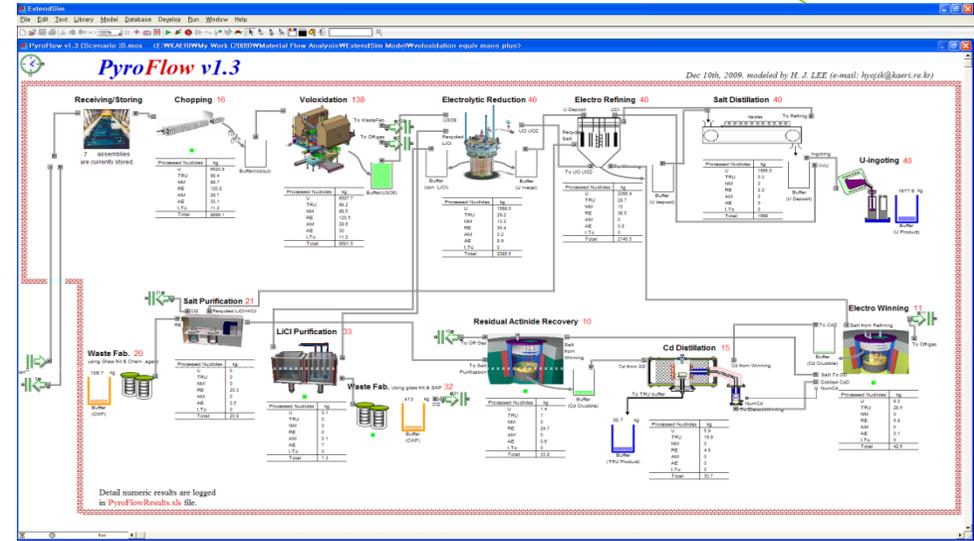
Approach for Pyroprocess Modeling & Simulation



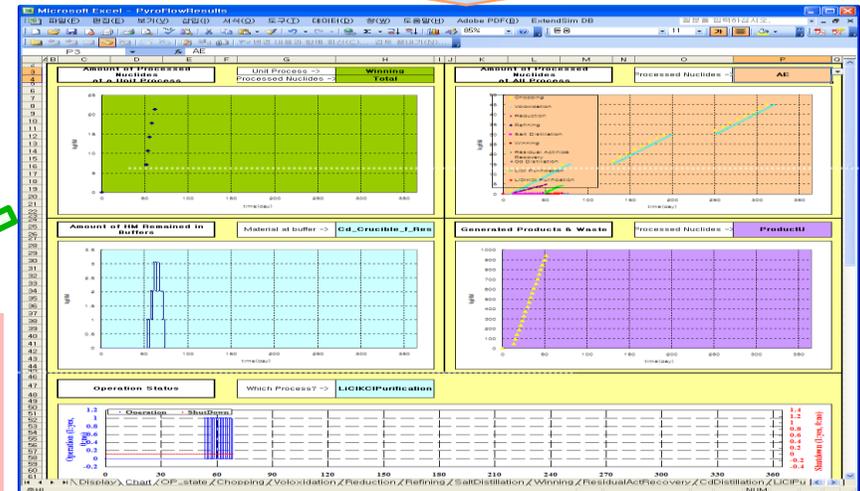
(3 level Architecture for M&S)



PyroFlow
(With ExtendSim platform)



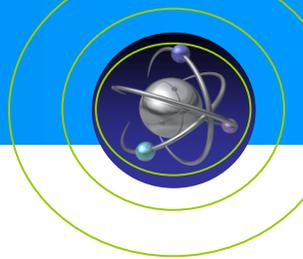
data export



1. Processed qty of grouped element in unit process
2. Number of batch operations
3. Accumulated qty in buffers
4. Generated qty of product and waste
5. Equip op status (op, failure, idle)

PyroFlowResults

PRIDE Technology Development



Key technologies

- Structure & Component Design
- Operation Utilities Design
- Remote Handling System Design
- Remote Handling & Operation Technology
- System Operation & Remote Maintenance
- Safety Analysis & Design Optimization

Start of PYRO Facility Design Research (2001)



α - γ Type Hot Cell (ACPF)

Design and Construction of ACPF

ACPF : Advanced spent fuel Conditioning Process demonstration Facility
 PRIDE: PyRoprocess Integrated inactive DEMonstration facility



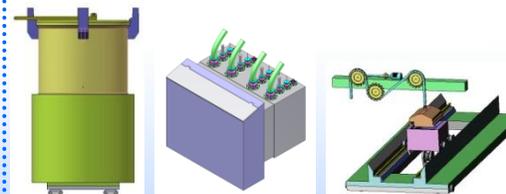
Large Argon Cell and auxiliary systems



PRIDE Facility



Construction of PRIDE and Install Operation Equipments



Design of PRIDE and Cell Operation Equipments

'01

'07

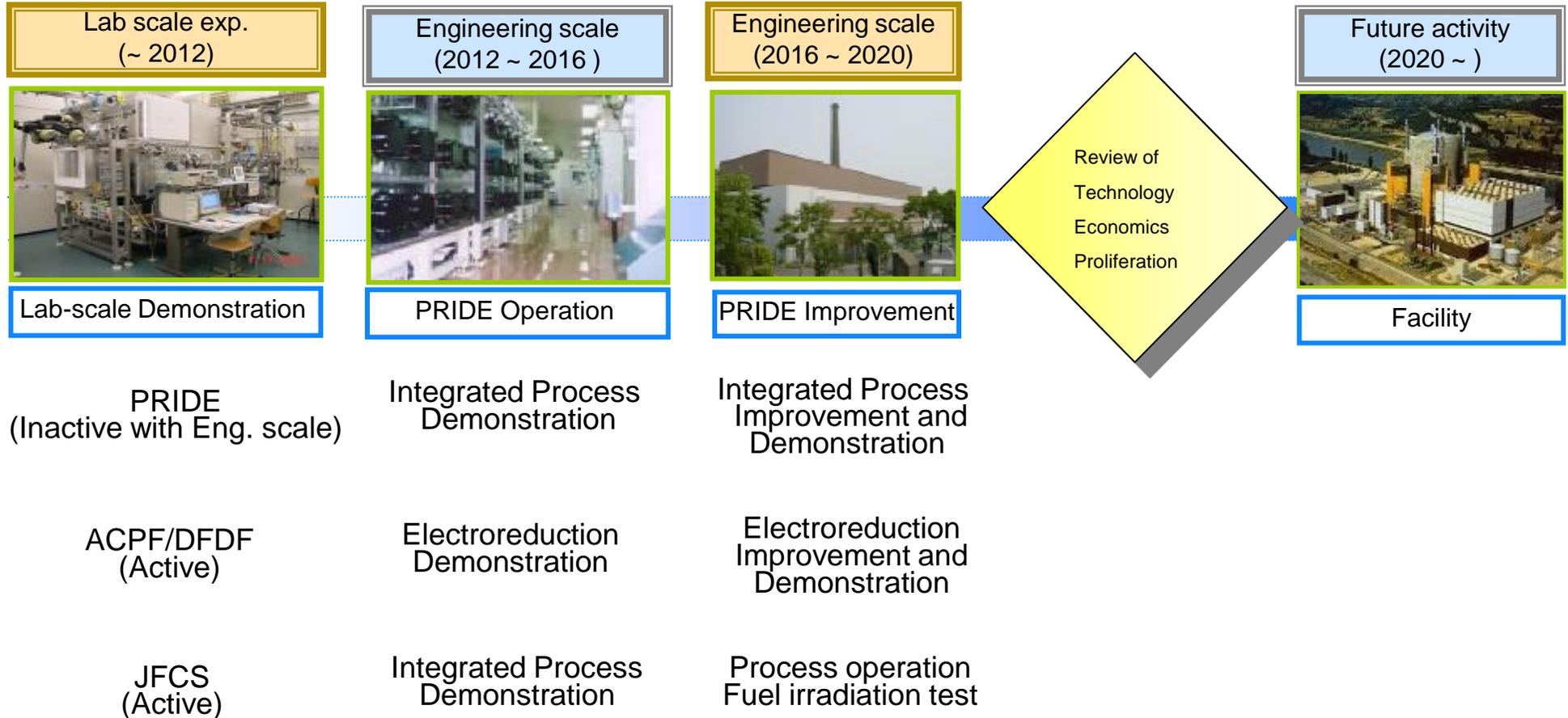
'10

'12

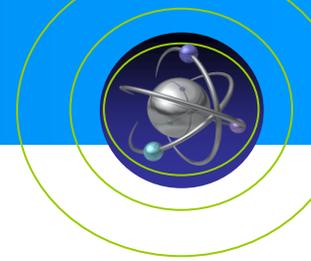
Long-term Plan for Pyroprocess Technology Development



Long Term R&D Plan



Pyroprocessing R&D Facility - PRIDE



PRIDE(PyRoprocess Integrated inactive Demonstration facility)

◆ Purposes

- Test facility to evaluate performance (cold-run) and scale-up issues of full-spectrum pyroprocessing technology

◆ General Features

- Pyroprocess test & demonstration with depleted uranium or surrogate up to engineering scale
- Inside dimension of argon cell: 40mL x 4.8mW x 6.4mH

◆ Near-term schedule

- Test in-cell handling systems and utilities
- Test engineering scale process equipments and remote operability



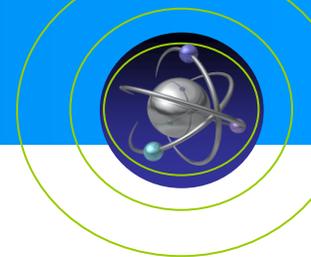
PRIDE



Bird's-eye view of argon cell



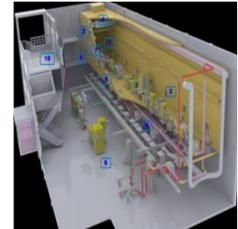
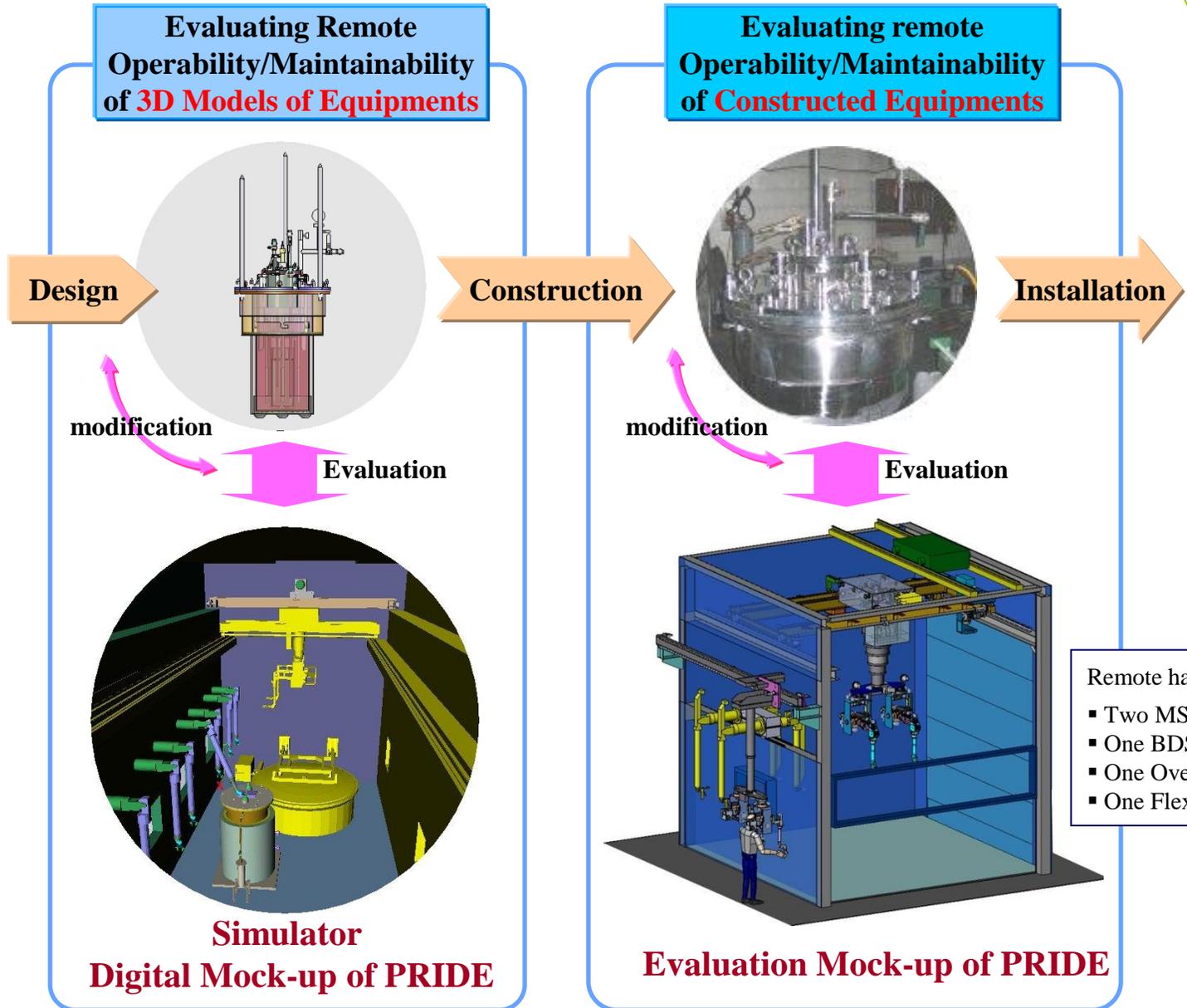
Scenarios for Development of equipments



3D models of Equipments in Pyroprocessing

Evaluating Remote Operability/Maintainability of 3D Models of Equipments

Evaluating remote Operability/Maintainability of Constructed Equipments



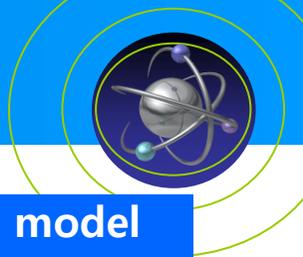
PRIDE

**Simulator
Digital Mock-up of PRIDE**

Evaluation Mock-up of PRIDE

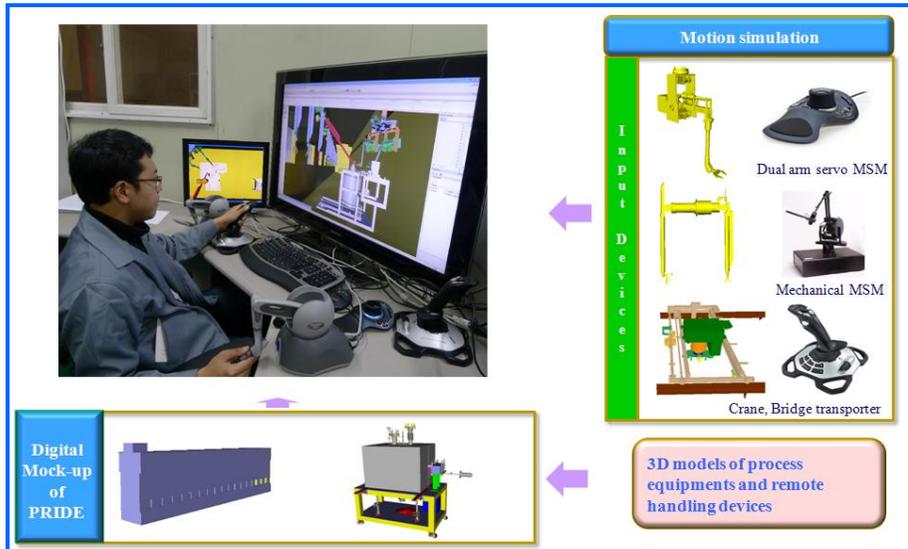
- Remote handling systems
- Two MSM
 - One BDSM
 - One Overhead Crane
 - One Flexible window

1. Simulator – Digital Mock-up of PRIDE

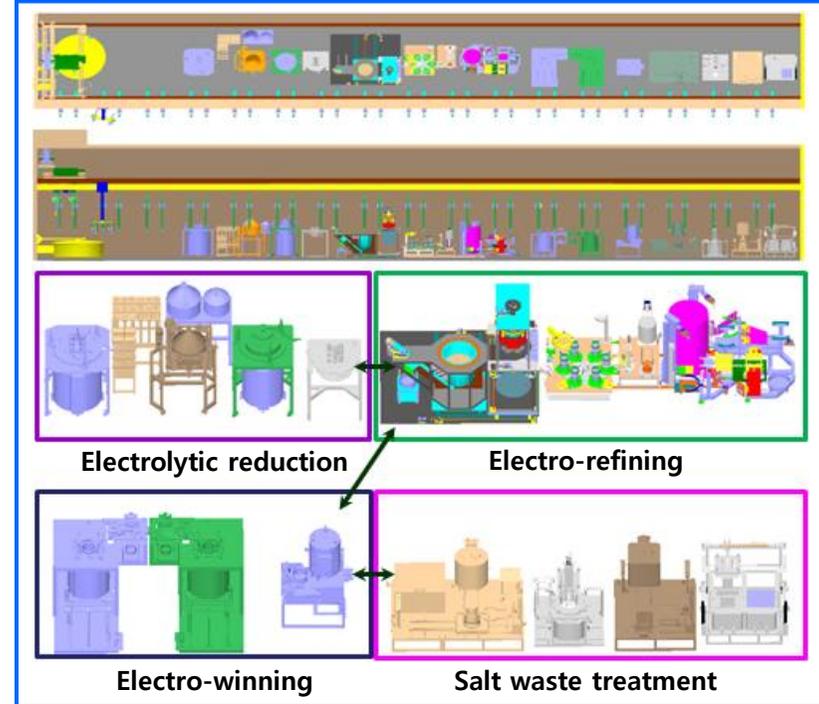


- A full scale digital mock-up (virtual facility) of the PRIDE
- Provide an efficient means for simulating and verifying the conceptual design, design developments, arrangements and rehearsal of pyroprocessing equipment in a virtual environment in advance

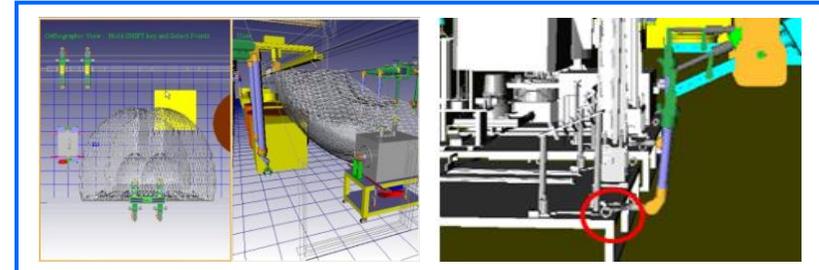
Constitution



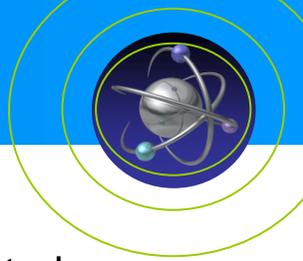
PRIDE & process equipments model



Analysis: workspace, operability



2. PRIDE Mock-Up Area



■ Usage

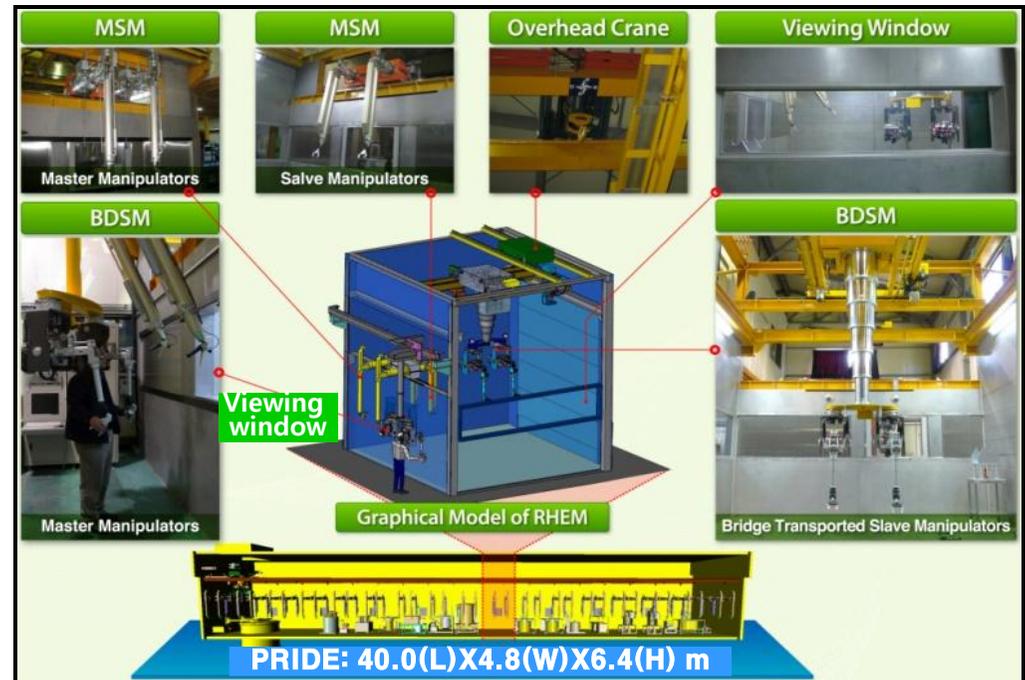
- Useful means for testing and evaluating the **operability and maintainability** of constructed pyroprocessing equipments **in advance** at the same operating conditions of the PRIDE from the remote handling viewpoint before they are installed in the PRIDE Upgrade from PC-based control system
- Utilization in **improving the completeness and reliability of the pyroprocessing equipments** to be used at the PRIDE

■ Features

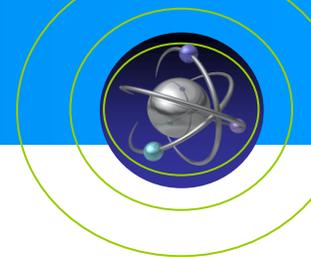
- **1/8 scale-downed** mock-up of the PRIDE in length with the same width and height as ones of the PRIDE, but air atmosphere
- Configuration of 5.0x4.8x6.4 (LxWxH) m

■ Consisting of

- One BDSM
- Two pairs of MSM
- One overhead crane (two tons)
- One flexible viewing window

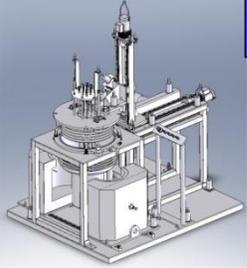


3. Remote handling evaluation in a mock-up



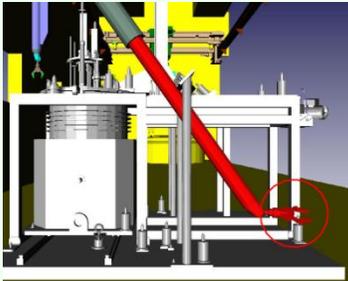
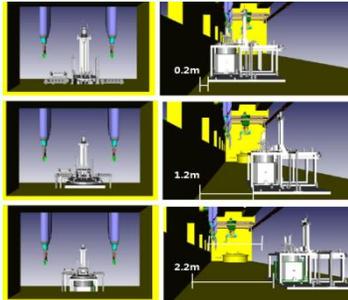
Evaluation of Remote Operability and Maintainability

A Case of 'Rare Earth Precipitation apparatus'

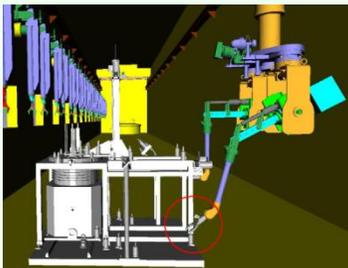


Arrangement of optimal location (Visibility should be secured)

Accessibility & Arrangements



Test of accessibility from the front face (using MSM)

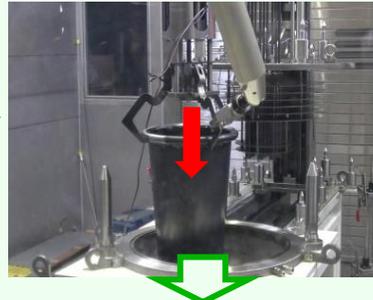


Test of accessibility for the rear side (using BDSM)

Simulator (Digital Mock-up of PRIDE)

Remote Operability-1

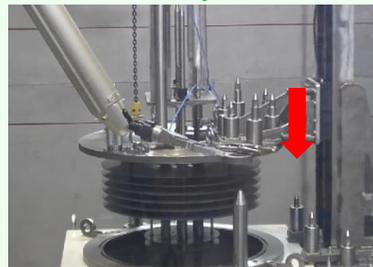
Moving of Material container using a crane and MSM



Part insertion for a chemical treatment using a crane and BDSM (Vision is secured remotely)



Motorized lid is closed by remote operation



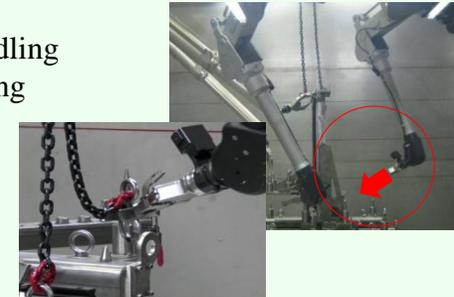
Mock-up of PRIDE

Remote Operability-2

Bolt fastening and releasing using an portable machine tool



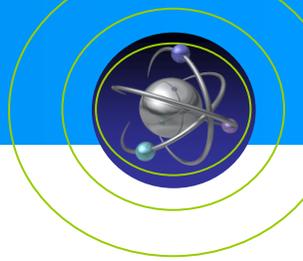
Hook handling for lifting



Part disassembly and extraction



PRIDE Facility Brief Overview

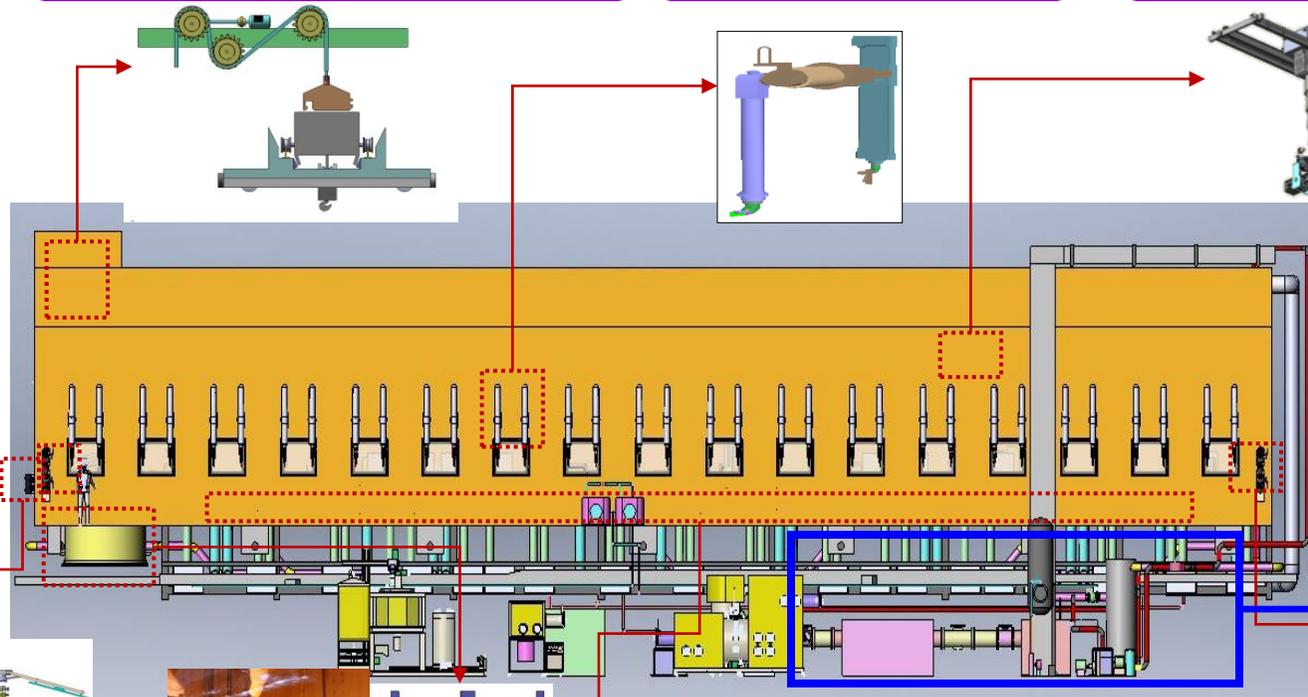


Main Cell Operation Equipments(side view)

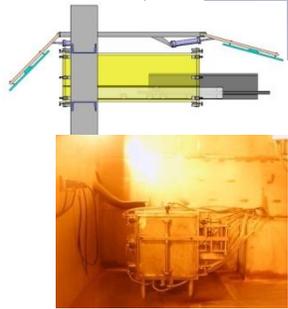
Argon Cell Crane & Trolley Hoist

Master-Slave Manipulator

Dual Arm Servo Manipulator



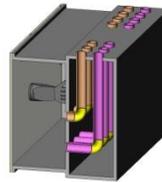
Argon cooling and circulation systems



Small Transfer Lock System



Large Transfer Lock System



Feed-throughs



Gravity tube



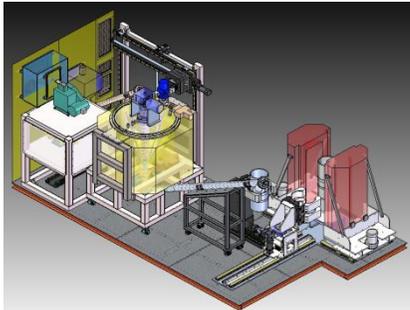
V. PRIDE 시설



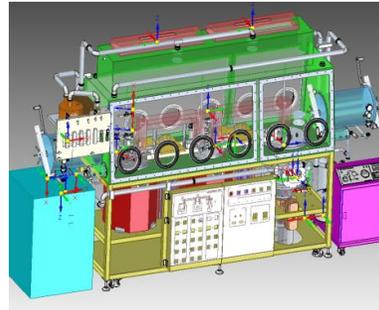
2 nd Floor



1 st Floor



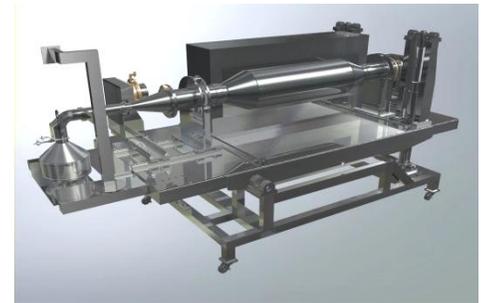
Waste solidif.



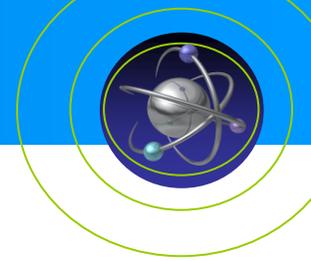
U-Chlorinator



Ingot casting furnace



pretreatment



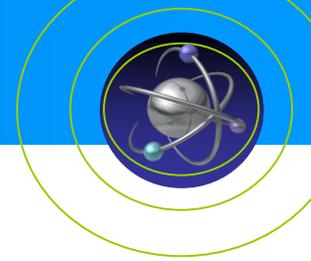
◆ Current Status

- Installation argon cell structure of PRIDE : '11.07 ~ '11.12
- Installation cell operation and remote equipments : '11.10 ~ '12.02
- Installation of BDSM : ~ '12.03
- Installation argon system and HVAC : '11.10 ~ '12. 02
- Manufacturing process apparatus and installation on PRIDE : ~ '12.05
- PRIDE construction is completed : '12.07

◆ Schedule

- PRIDE start-up test in progress : '12.08 ~
- PRIDE operation and utility systems operational and functional performance test : '12.08 ~ '13.02
- BDSM operational and functional performance test : '12.08 ~ '13.02
- Process equipment's operational and functional test : '12.08 ~ '13.02
- Process equipment remote handling test : '12.08 ~ '13.02
- Process equipment's salt test : '13.03 ~

PRIDE Program

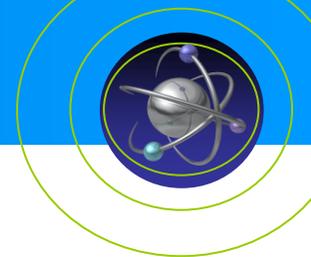


◆ Program

2012	2013	2014	2015	2016	2017	2018	2019	2020
Blank est								
	Salt test							
		U test						
			Surrogate mat'l test					
					Long-term integral test			

◆ achievements

- ✓ Utility Operation experience
- ✓ Equipment design improvement
- ✓ Material Measurement – online offline monitoring
- ✓ Material Flow Check
- ✓ Applicability of the other concepts
- ✓ Personnel Training



Thank you for your attention

Clean Energy! Clean Korea!

