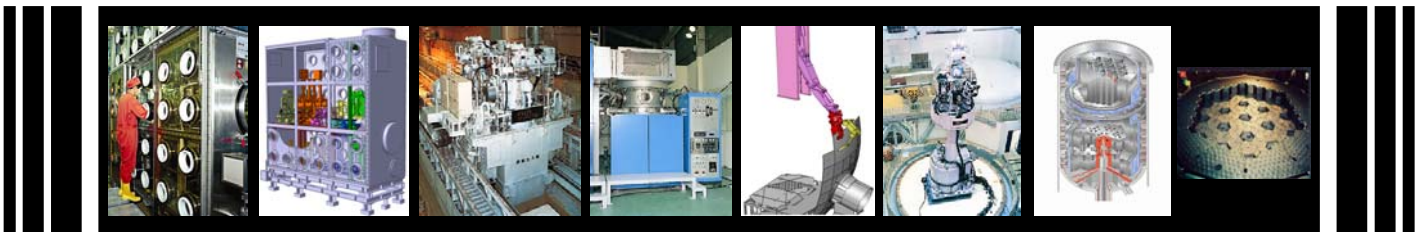


# Nuclear Technology of Fuji Electric





# 1. Main products and history in Nuclear field

Field		70's	80's	90's	00's
Commercial Reactor	Tokai Reactor		In-vessel maintenance equipment [Timeline bar]	Confirmatory test for remote dismantling of the reactor <b>Decommissioning</b> [Timeline bar]	
	HTGR		Helium Engineering Demonstration loop <b>HENDEL</b> [Timeline bar]	High Temperature Engineering Test Reactor <b>HTTR</b> [Timeline bar]	HTTR spent fuel storage facility [Timeline bar]
Advanced Reactor	FBR	<b>JOYO</b> [Timeline bar] <Fuel handling and storage>	<Fuel stuck, In core structure test section> <b>MONJU</b> [Timeline bar]	<Core internals, Fuel handling system> [Timeline bar]	Development of commercial reactor <GT-HTR, etc.> [Timeline bar]
	ATR	<b>FUGEN</b> [Timeline bar] <Fuel handling >	<Fuel handling, Engineering Safety Features, and etc.> [Timeline bar]	<b>JOYO Mk III</b> [Timeline bar] <Automatic control system for fuel handling system.>	
Nuclear Fuel Cycle (MOX fuel fabrication Reprocessing)				<b>MOX fuel fabrication facility</b> [Timeline bar] <Pellet inspection facility, Pellet storage and transport facility>	<b>Reprocessing plant at Rokkasyo</b> [Timeline bar]
Radioactive waste treatment plant		<b>JOYO</b> [Timeline bar]	<b>MONJU</b> [Timeline bar]	Renewal at <b>JOYO</b> [Timeline bar]	IC plasma spent resin volume reduction processing equipment [Timeline bar]
		<b>FUGEN</b> [Timeline bar]	Addition of facility at <b>FUGEN</b> [Timeline bar]		

# 2. Feature of FES' s Nuclear Technology

## Key Technology and FES' s experience

### 1. Remote-handling and Transfer Technology

- Fuel Handling and Storage System for Nuclear Plant
- Remote dismantle of the Nuclear Reactor
- MOX Fuel Fabrication Facility

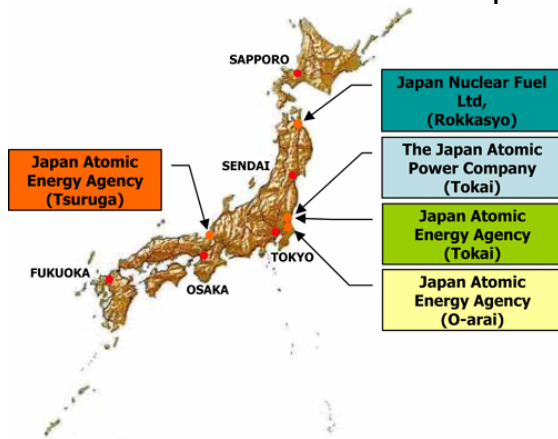
### 2. Radioactive Waste Treatment Technology

- Waste Treatment System for Nuclear Plant
- Reprocessing Waste Treatment
- Dismantling Waste Treatment

### 3. High Temperature Gas Cooled Reactor Technology

- HTTR (High Temperature Engineering Test Reactor)

<Map & Supplied System>



Customers	Reactor	Fuel Handling and Storage Facility	Radwaste Processing System	Other system
The Japan Atomic Power Company (Tokai)	○	○		○ (Decommissioning)
Japan Atomic Energy Agency (Tokai)				○ (J-PARC)
Japan Atomic Energy Agency (O-arai)	○ (HTTR)	○ (JOYO, HTTR)	○ (JOYO)	
Japan Atomic Energy Agency (Tsuruga)		○ (FUGEN, MONJU)	○ (FUGEN, MONJU)	
Japan Nuclear Fuel Ltd, (Rokkasyo)				○ (Transfer system etc)

J-PARC: The Japan Proton Accelerator Research Complex

Features of FES' s Fuel Handling and Storage System as the Remote Handling and Transfer Technology are follows.

<Feature>

(1) FES supplied the full set of the Fuel Handling and Storage System for the following new reactors in Japan.

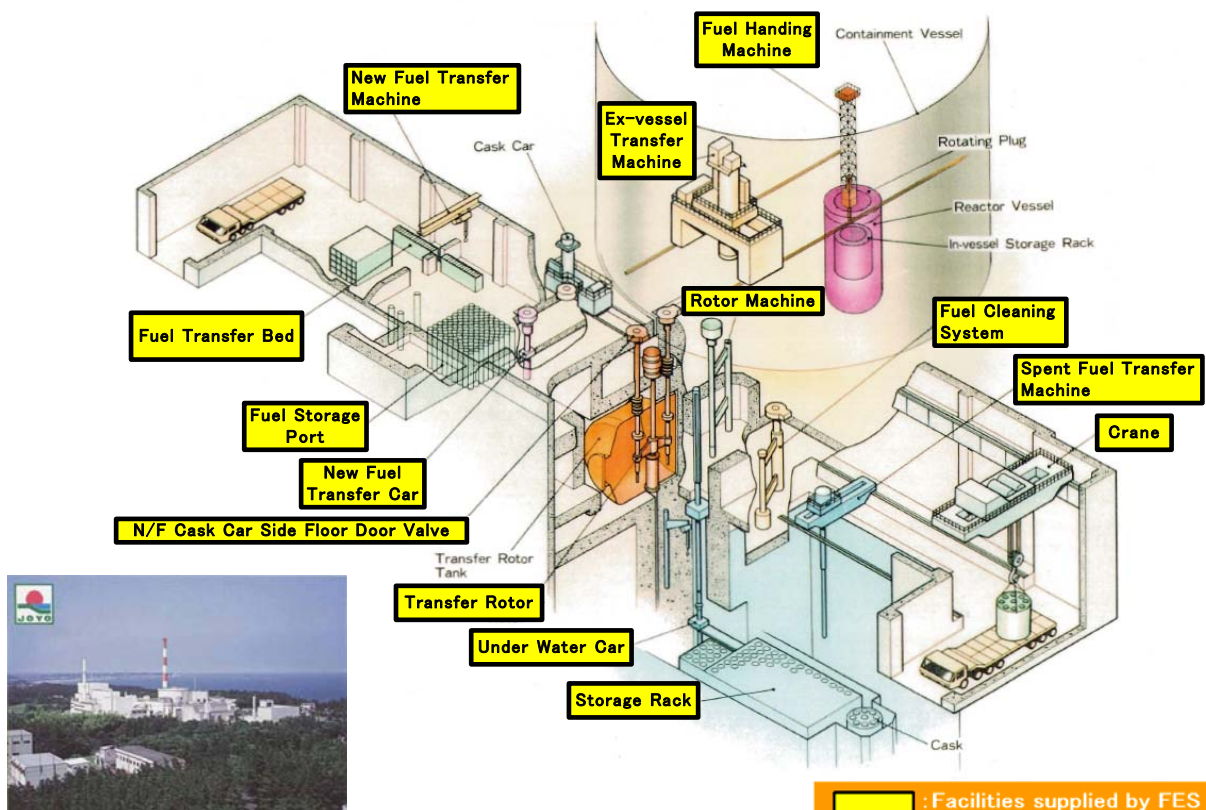
- \* "JOYO" : The Experimental Fast Breeder Reactor
- \* "MONJU" : The Prototype Fast Breeder Reactor
- \* "FUGEN" : The Prototype Advanced Thermal Reactor
- \* "HTTR" : The High Temperature Engineering Test Reactor

(2) The fuel handling and storage system for these plants are realized to the fully automatic operation for remote handling rather than that of LWR.

(3) Spent fuel transfer and storage technology in the water pool such as FBR "JOYO", FBR "MONJU", and ATR "FUGEN", is directly applicable to the LWR plant.

The following shows our experience with fuel handling and storage systems in Japan.

Reactor dismantling and MOX fuel manufacturing facility are also shown as an other experience of our remote-handling and transportation technology.



# 4.1 'Joyo' Fuel Handling and Storage System



Fuel Handling Machine



Spent Fuel Storage Facility



Ex-vessel Transfer Machine

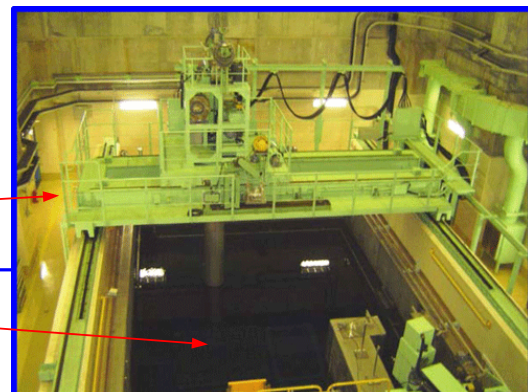
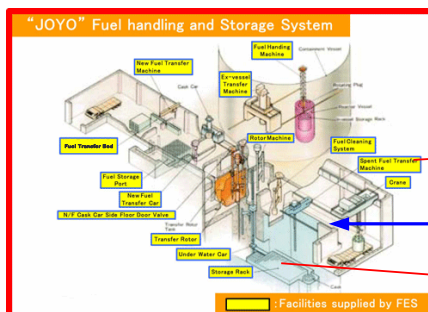
- Customer : JAEA
- Output power : 100MWh
- Main products :
  - Fuel handling and storage system
  - Spent fuel storage facility
  - Radiation monitoring system
  - Electrical power supply system
  - General purpose maintenance facilities
  - Radioactive waste treatment system
  - Instrument and plant control system

# 4.2 'Joyo' Spent Fuel Storage Facility

**\* Spent fuel handling and storage technology is directly applicable to the LWR plant.**

<Feature>

- The number and direction of fuel assembly which is underwater can be checked and dealt with by ITV.
- Fuel transfer can be remotely-operated from the outside of a radiation controlled area.



**Spent Fuel Storage Facility**

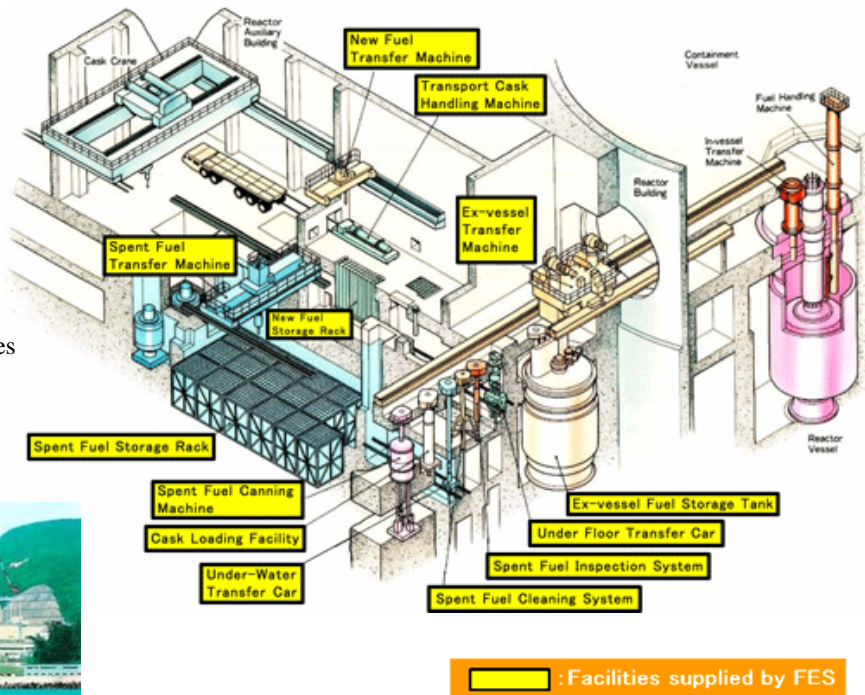
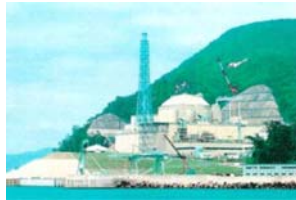
<Main Specification>

◆ Water cooling Pond	W 7.2m X L 9.5m X D 11m
• Retained water	640m <sup>3</sup>
• Lining	SUS304
◆ Fuel transfer machine	Handling load capacity 350kg
◆ Water cooling purification system	Circulation pump 5.1kW * 2 sets
◆ ITV for check	Underwater camera * 3 sets

# 5. Prototype Fast Breeder Reactor 'MONJU'

- \* FES supplied the full set of fuel handling and storage system for 'MONJU'
- \* Spent fuel handling and storage technology is directly applicable to the LWR plant.

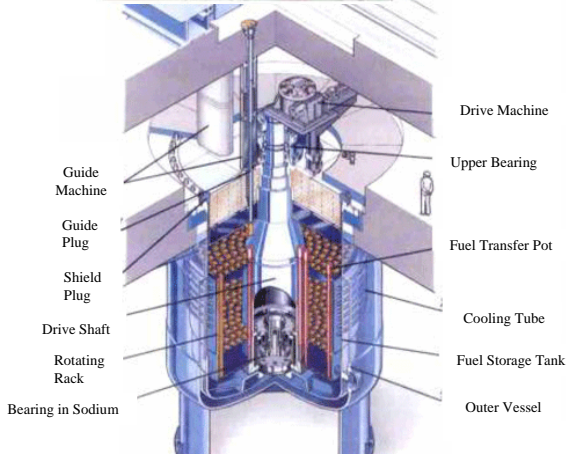
- Customer: JAEA
- Thermal Power: 280MW
- Main Facilities Supplied by FES
  - Fuel handling and storage system
  - Radioactive waste treatment system
  - General purpose maintenance facilities
  - Radiation monitoring system
  - Instrument and plant control system



## 5.1 'MONJU' Fuel Handling and Storage System

- \* Fuel handling and storage of "MONJU" can be fully operated automatically for remote handling.

### Ex-vessel Transfer Machine



Ex-vessel Fuel Storage Tank

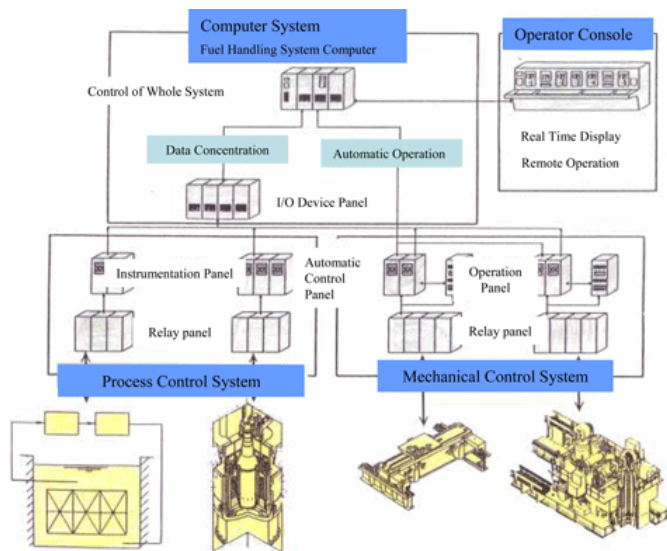


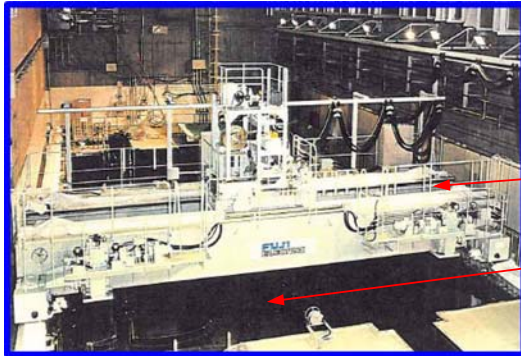
Diagram of Control System for Fuel Handling Facilities

## 5.2 'MONJU' Spent Fuel Storage Facility

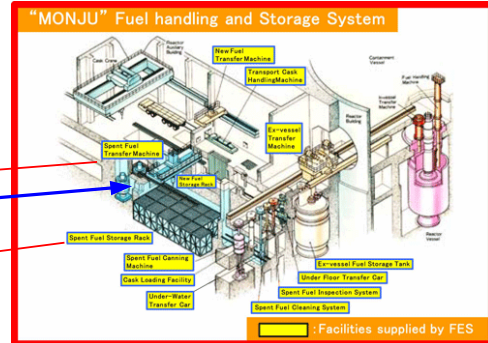
\* Spent fuel handling and storage technology in a water pool is directly applicable to the LWR plant.

<Feature>

- The fuel which exists underwater can be dealt with.
- Fuel transfer can be remotely-operated from the outside of a radiation controlled area.



Spent Fuel Storage Facility

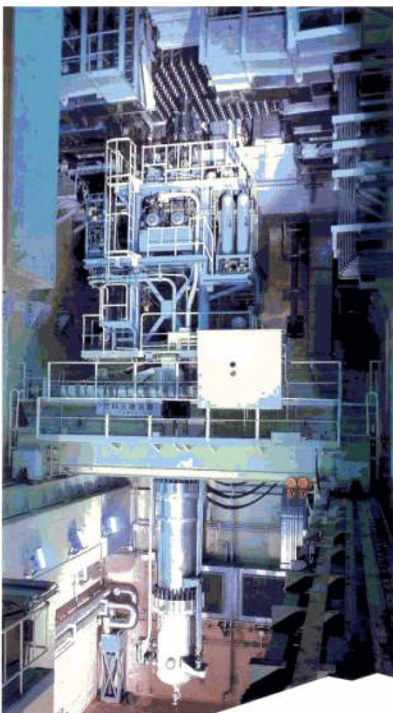


<Main Specification>

◆ Fuel transfer machine	Handling load capacity 475kg
◆ Water cooling Pond	W 11.5m X L 23m X D 14m
◆ Lining	SUS304

## 6. Advanced Thermal Reactor 'FUGEN'

\* FES supplied the full set of fuel handling and storage system for ATR 'FUGEN'

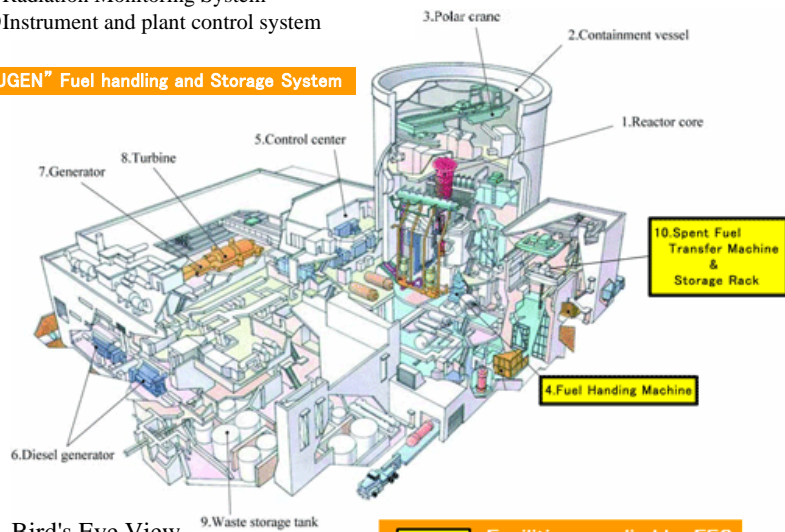


Fuel Handling Machine

- Customer: JAEA
- Electric Power: 165MW
- Main Facilities Supplied by FES
  - Fuel handling and storage system
  - Radioactive waste treatment system
  - Engineered safety protection system
  - Reactor Seal Plug
  - Radiation Monitoring System
  - Instrument and plant control system



"FUGEN" Fuel handling and Storage System



Bird's Eye View

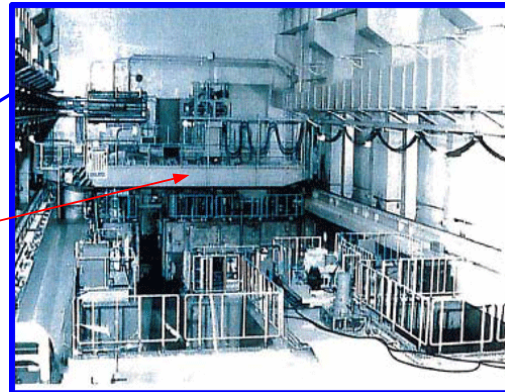
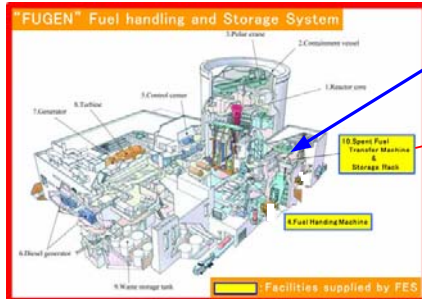
Legend: Facilities supplied by FES

## 6.1 'FUGEN' Spent Fuel Transfer Machine

\* Spent fuel handling and storage technology is directly applicable to the LWR plant.

<Feature>

- Fuel is transferred to the spent fuel rack in the pool by the spent fuel transfer machine.
- Fuel handling machine can be operated remotely and automatically from the central control room.



Spent Fuel Transfer Machine

<Main Specification>

◆ Run Span	3.3m
◆ Lifting height	20m
◆ Lifting load	600kg
◆ Driving unit	Wire drive system
◆ Gripper	Solenoid opening and shutting type
◆ Main material	Stainless steel

## 7. Gas cooled reactor 'Tokai Power Station'

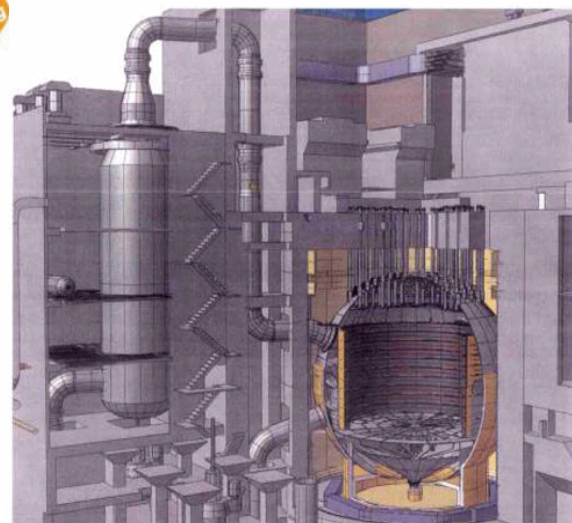
\* FES engaged in the construction of the Tokai No1 nuclear plant, the first commercial nuclear plant in Japan. At present FES is studying the reactor dismantling method for Tokai No1 using one of our key technology.



Full view of Tokai Power Station

- Customer: The Japan Atomic Power Company
- Output: 166MWe

Start operation: July 1966 Stop operation: March 1998



Reactor vessel, internals and primary cooling system  
( Drawing by 3D CAD for dismantling simulation )



## 8. MOX Fuel Manufacturing Facility (1/2)

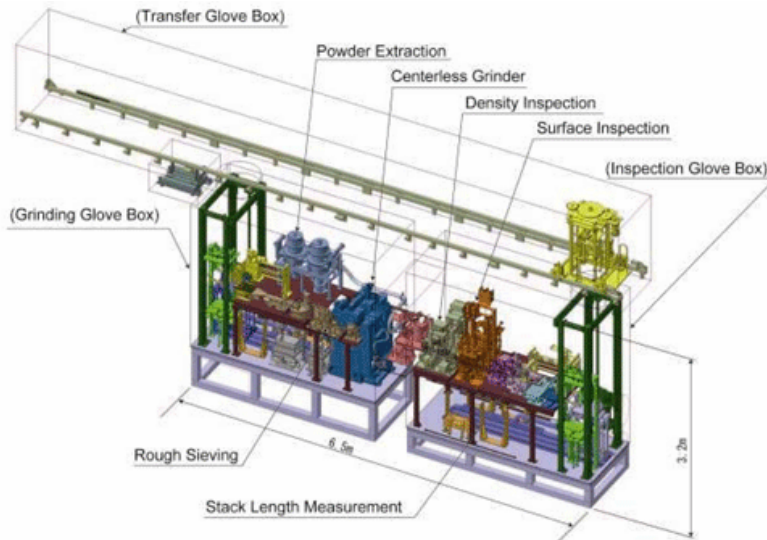
**\* MOX fuel manufacturing facility is another example of FES's remote handling and transfer technology.**

● Main Equipment Supplied by Fuji Electric Systems

- Pellet Grinding and Inspection Equipment
  - Pellet size and density inspection system
  - Density measuring Device
  - Equipment to Inspect the Grinded Pellet
  - Grinding machine
  - Pellet surface inspection equipment
- Inspection Machine of Fuel Assembly
- Automatic Storage Facility of Uranium

● Features

- Simplification of the system by the function integration
- High Speed Processing
- Minimum hold up
- Improved maintainability
- Remote & Automation



Photograph of Glove Box (Pellet Inspection Equipment) Presented by JAEA

## 8. MOX Fuel Manufacturing Facility (2/2)

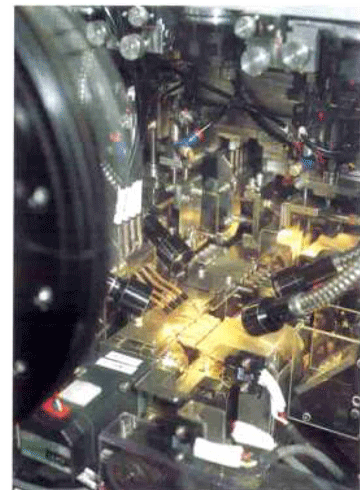
● Grinding Machine

- Major Spec.
  - Method: Dry type center-less grinding method
  - Function: Grinding of the pellet periphery



● Pellet surface inspection equipment

- Major Spec.
  - Method: 3 ITV camera imaging
  - Spec.: Equipment check the surface of both end and the body of pellets



● Pellet size and density inspection system

- Major Spec.
  - Method: Size measurement by laser instrument  
Weight measurement by electromagnetic balance type
  - Function: Quality check by measurement of size and weight of the pellet and computing density



Features of FES's radioactive waste treatment system are follows.

### <Feature>

(1) FES supplied the radioactive waste treatment system for the following new reactors.

- \* The Prototype FBR "MONJU" (Gaseous and Liquid Waste Treatment System)
- \* The Experimental FBR "JOYO" (Liquid Waste Treatment System) etc.

(2) The performance of these facility is superior to that required in LWR plant.

(3) FES is developing the spent resin volume reduction stabilization process equipment.

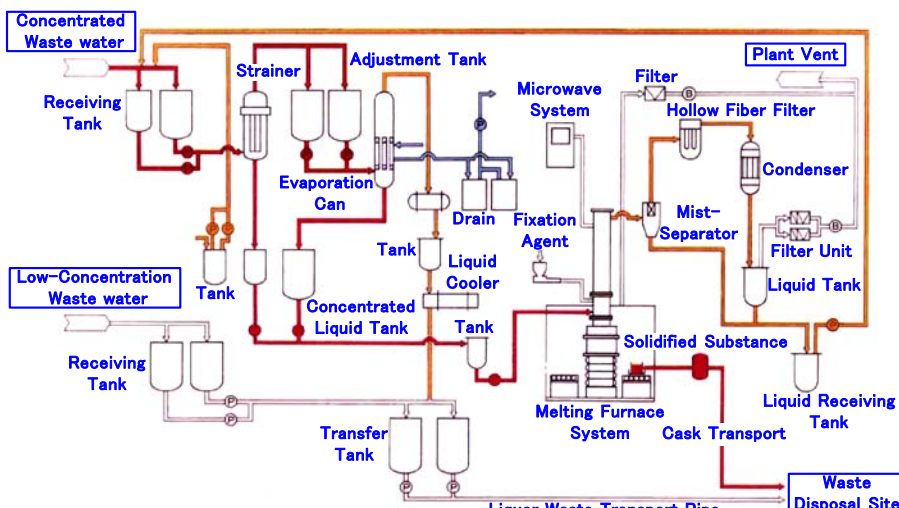
(4) FES can supply radioactive waste treatment system and / or equipment in response to the users' requirement.

The following shows our experience with radioactive waste treatment systems in Japan.

### Liquid Waste Treatment System for "JOYO"

#### ●Major Components

- Receiver tank
- Evaporation & Condensation equipment
- Glassification equipment using microwave
- Concentration conditioning tank
- Concentrated solution tank
- Control system



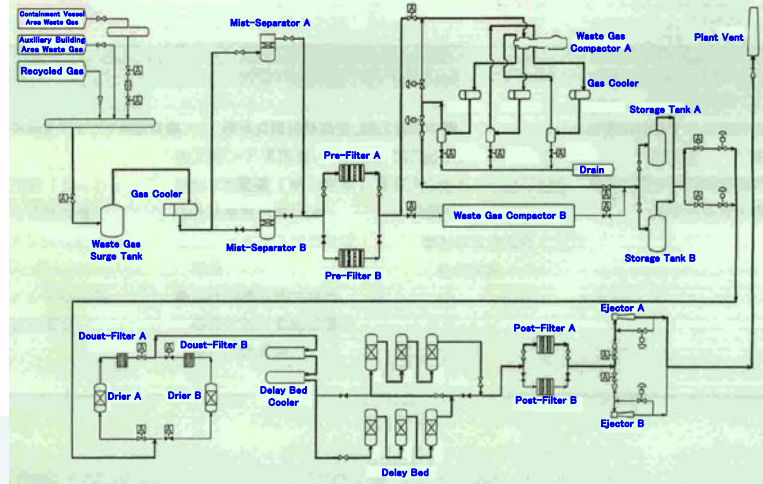
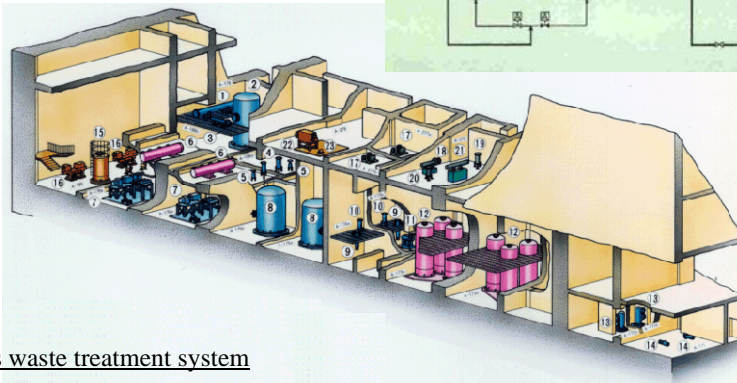
Microwave glassificator

Liquid waste treatment process

### Gaseous Waste Treatment System for "MONJU"

- Major Spec.
- Processing Capacity
  - Peak processing : 70Nm<sup>3</sup>/h
  - Continuous processing : 10Nm<sup>3</sup>/h
- Noble gas hold up time
  - Xe : over 30 days
  - Kr : over 40h

1. Waste Gas acceptance vessel
2. Waste Gas Surge Tank
3. Gas Cooler
4. Mist-Separator
5. Drain Pot
6. Pre-Filter
7. Waste Gas Compactor
8. Storage Tank
9. Drier
10. Dust-Filter
11. Delay Bed Cooler
12. Delay Bed
13. Post-Filter
14. Ejector
15. Tank
16. Chiller Unit
17. Gas Blower
18. Gas Heater
19. Mist-Separator
20. Gas Drier
21. Gas Cooler
22. Sampling Box
22. Sampling Pump

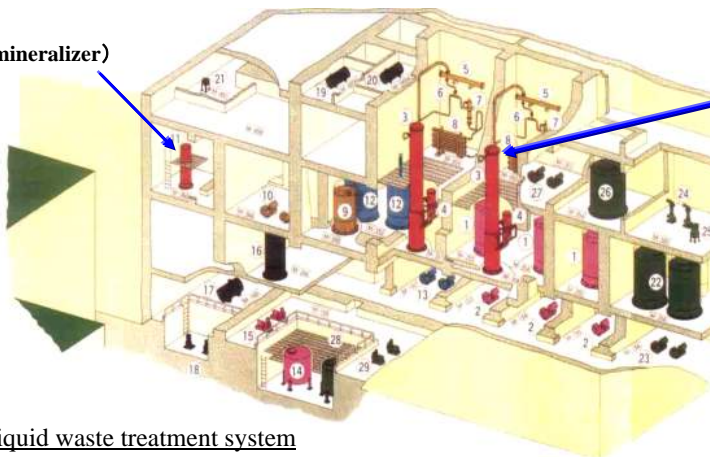


Gaseous waste treatment system

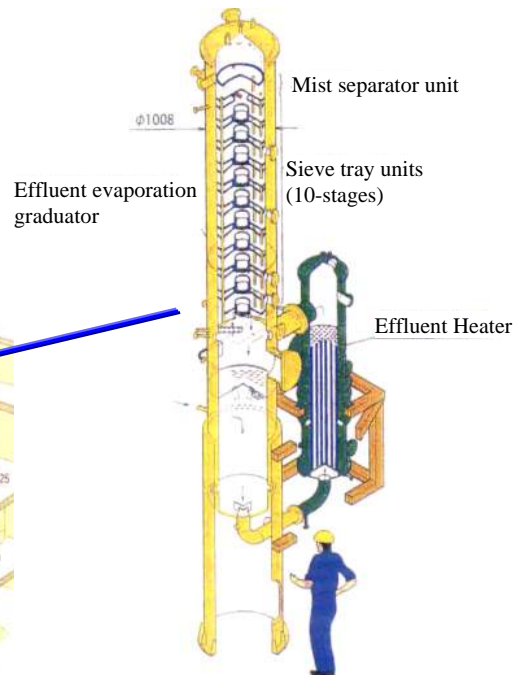
### Liquid Waste Treatment System for "MONJU"

- Major Spec.
- Treatment Capacity : 2m<sup>3</sup>/h
- Major equipment
  - Natural circulation type evaporator for liquid waste
  - Demineralizer
  - Transfer pump

(Demineralizer)



Liquid waste treatment system



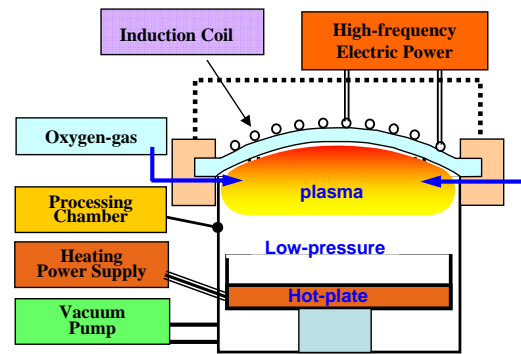
Natural Circulation type Evaporator

## <IC plasma spent resin volume reduction stabilization process equipment>

### Advantage

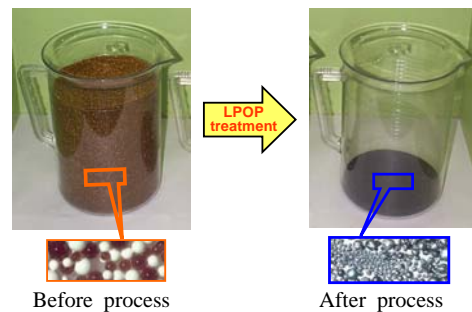
- High volume reduction
- Small size unit type system
- Cost reduction for final disposal
- Lower environmental impact
- The residuum is easy to mix cement
- Module type system
- Stabilization process

Item	Specification
Volume reduction method	Inductively coupled plasma Low pressure oxygen  Plasma: 0.15 - 0.73psi (10 - 50hPa) Temperature: 750 - 1290°F (400 - 700°C) Low carry-over (<math>10^{-4}</math> as Co)
Dealing material	Spent Resin, Charcoal
Capacity	13.2gal (50wet-liter) / day·unit 353ft <sup>3</sup> (10m <sup>3</sup> ) / year
Volume reduction	More than 95% (1/20 of volume reduction)



Conceptual Diagram of the LPOP System (using ICP)

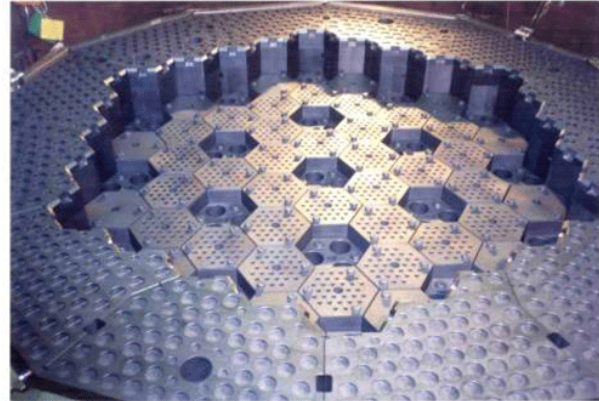
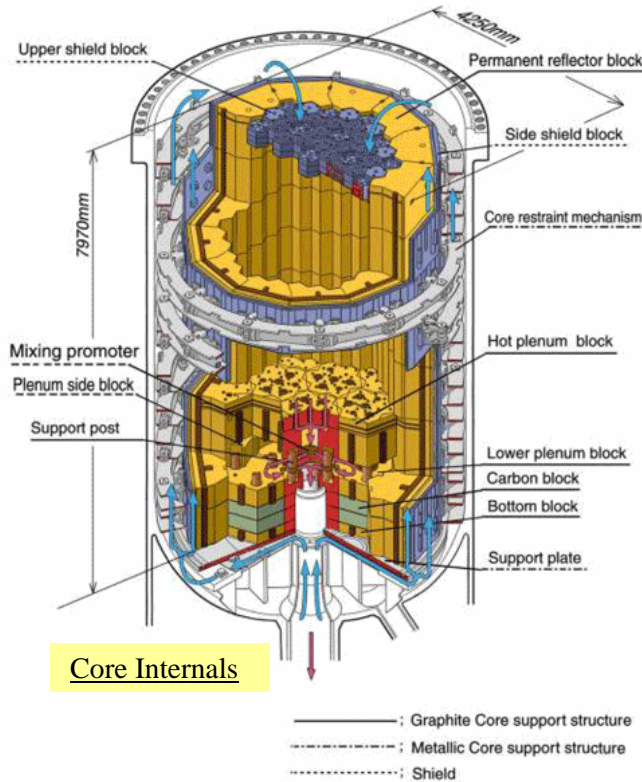
\*ICP (Inductively Coupled Plasma)



### <Feature>

- FES supplied the reactor internals for HTTR (High Temperature Engineering Test Reactor), the first HTGR in Japan.
- FES supported the JAEA's nuclear / thermo hydraulic design and safety analysis for HTTR.
- FES also supplied the full set of fuel handling and storage system for HTTR. HTTR fuel is handled in helium atmosphere and fuel handling machine is operated automatically for remote handling.

## 10.1 High Temperature Engineering Test Reactor 'HTTR'



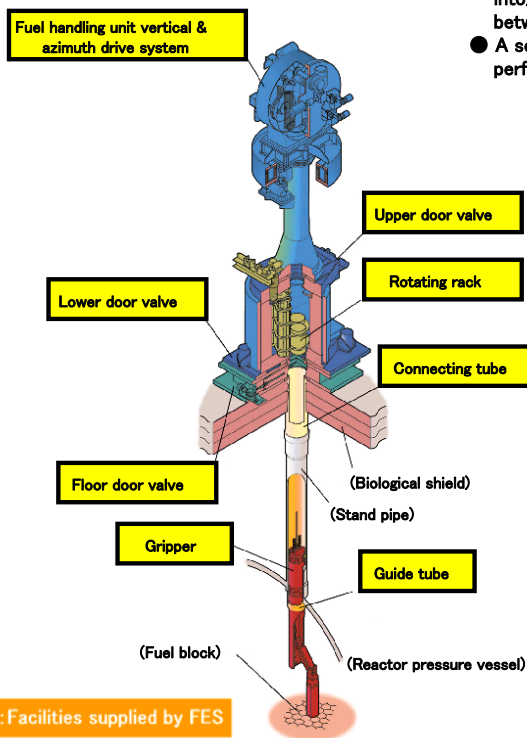
Reactor internals ( top view, outer dimension 4.25m)

- Customer: Japan Atomic Energy Agency (JAEA)
- Output Power: 30MWth
- Outlet coolant temperature : 850°C / 950°C
- Main products: Reactor internal structures, Fuel handling & storage system
- Core design, Safety analysis: in cooperation with JAEA

## 10.2 'HTTR' Fuel Handling Machine

<Feature>

- Fuel handling machine is used for charging/discharging of fuel blocks into/out of nuclear reactor and is used for transfer of fuel blocks between spent fuel storage facilities and fresh fuel storage facilities.
- A series of refueling operations and positioning to the fuel block is performed remotely and automatically.



Fuel Handling Machine



Fuel Handling Machine (Gripper)

<Main Specification>

◆ Design pressure	98kPa
◆ Design temperature	100 °C
◆ Dimensions	H 11m
◆ Weight	150ton
◆ Inside atmosphere	Helium gas
◆ Handling load capacity	200kg

- We operate
  - ISO 9001 (certification for quality management system)
  - & ISO 14001 (certification for environmental management system).



- Currently **ASME NQA-1 QA** program is under development.

- Fuji Electric FA Europe GmbH
- Fuji Electric Device Technology Europe GmbH
- Fuji Electric (Shenzhen) Co., Ltd.
- Hong Kong Fujidenki Co., Ltd.
- Fuji Electric (Asia) Co., Ltd.
- Fuji Electric Device Technology Hong Kong Co., Limited
- Atai Fuji Electric Co., Ltd.
- Fuji Electric Dalian Co., Ltd.
- Fuji Electric Motor (Dalian) Co., Ltd.
- Fuji DE Drives (Wuxi) Co., Ltd.
- Shanghai Fuji Electric Switchgear Co., Ltd.
- Fuji Electric (Shanghai) Co., Ltd.
- Fuji Electric Taiwan Co., Ltd.
- Fuji Electric FA Taiwan Co., Ltd.
- Fuji Electric Singapore Private Ltd.
- Fuji Electric FA Singapore Pte., Ltd.
- Fuji Electric (Malaysia) Sdn. Bhd.
- Fuji Electric Philippines, Inc.
- **Fuji Electric Corp of America (Fremont, CA and NJ)**

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November, 2010

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