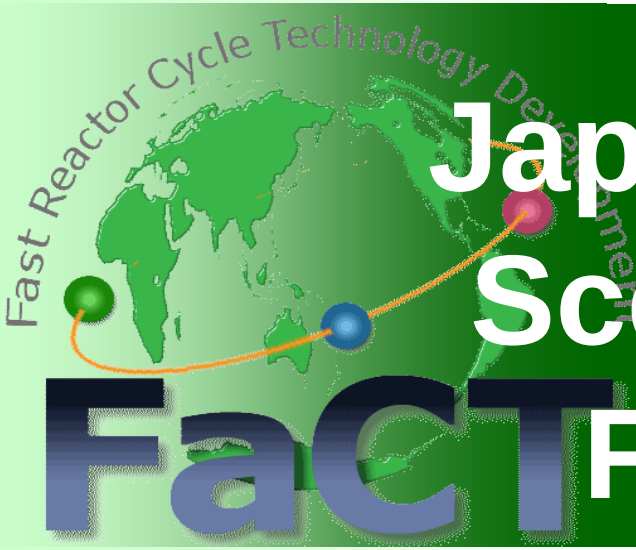



# Japanese FR Deployment Scenario Study after the Fukushima Accident

**Kiyoshi ONO**

**Hiroki SHIOTANI, Akira OHTAKI,**

**Kyoko MUKAIDA and Tomoyuki ABE**

**Japan Atomic Energy Agency**

**E-mail: ono.kiyoshi@jaea.go.jp**

# Schedule of political discussion for the energy and environment

**June**

**Presentation of three scenarios for future energy supply (June 29)**

- The Energy and Environmental Council provided three scenarios.

**July**

**National debate**

- Public hearing sessions (at 11 places nationwide)
- Solicitation of public comments

**September**

**Decide on *Innovative Strategy for Energy and the Environment (Council report, Sept. 14)***

- The Government will mobilize all possible policy resources to such a level as to even enable zero operation of nuclear power plants in the 2030's.

**Cabinet decision for a New Strategic Energy Plan of Japan (Sept. 19)**

**December**

***Change of government (Dec. 16)***

- Replacement from the Democratic Party to the Liberal Democratic Party
- Interruption of formulation of Framework for Nuclear Energy Policy

**January**

***Re-examination of Nuclear Energy Policy (Jan. 25)***

- New cabinet announced that **the previous administration's zero-nuclear policy should be reviewed** with a clean slate.

# New Energy Policy
# -The Energy & Environment Council Decision -

- **Energy and Environmental Council** provided **three scenarios** which can reduce dependence on nuclear energy as well as on fossil fuels and reduce $CO_2$ emissions based on the examination of **Fundamental Issues Subcommittee**, June 29, 2012.
- The share of the future nuclear power generation was anticipated.

## Electric power generation ratio of the three scenarios for 2030

Numerical values other than the current scenario are as of 2030.

| Scenarios | 0% Scenario | 15% Scenario | 20-25% Scenario | Current (2010) |
|---|---|---|---|---|
| Nuclear energy | 0 % | 15 % | 20-25 % | 26 % |
| Renewable energy | 35 % | 30 % | 25 -30 % | 10 % |
| Fossil fuel | 65 % | 55 % | 50 % | 63 % |
| $CO_2$ emission | - 23 % | - 23 % | - 25 % | - 0.3 % |
| Electric Power Generation | 1.1 trillion kWh at 2010<br>Approximately 1 trillion kWh at 2030 | | | |

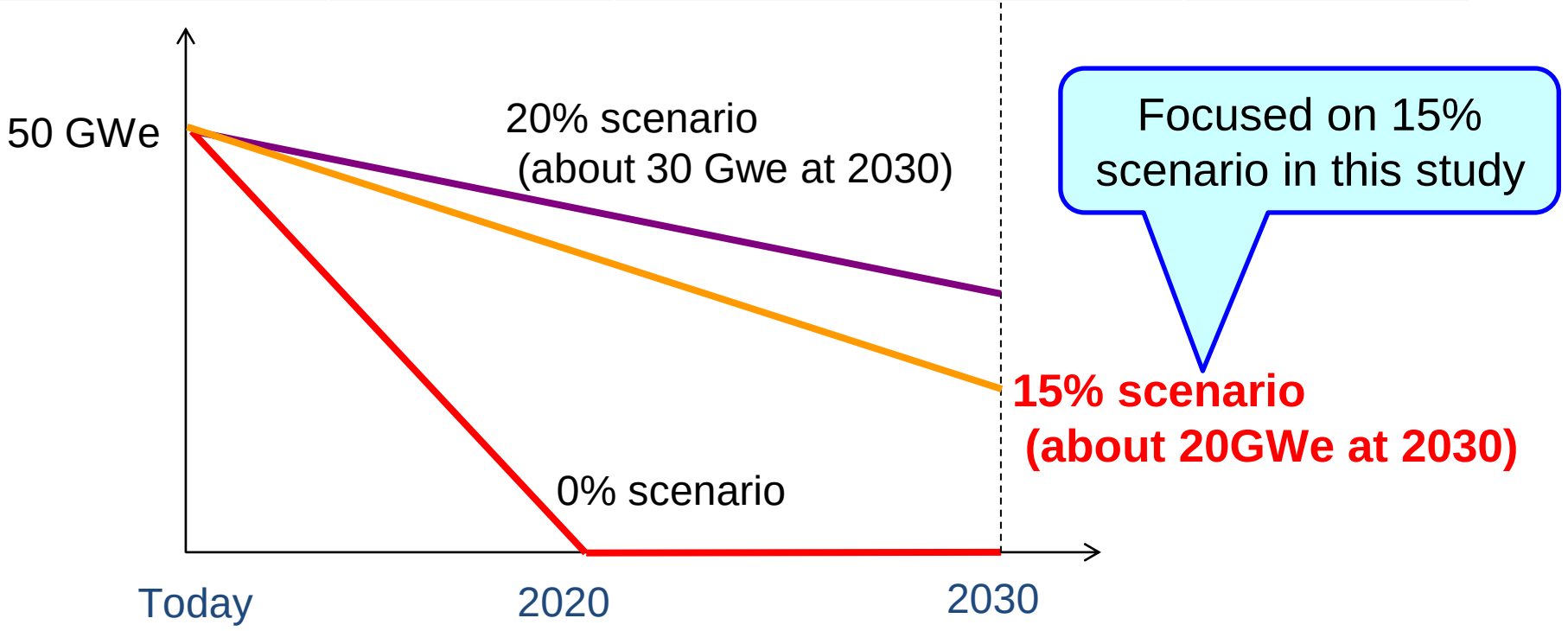
$CO_2$ emission are value of comparison with 1990.

# Nuclear Fuel Cycle Policy
## -Options for Spent Fuels-

- **Option 1: Full reprocessing policy (Current Policy)**
  - All spent fuels are reprocessed and the recovered uranium and plutonium are reused.
  - **Commercialization of fast breeder reactors (FBR) or fast reactors (FR) is necessary.**
- **Option 2: Dual policy of reprocessing and direct disposal**
  - Both reprocessing and direct disposal of spent fuels are kept as options.
  - **FBRs/FRs is an option to prepare for future uncertainty.**
- **Option 3: Full direct disposal policy**
  - All spent fuels are disposed after adequate storage period.
  - **FBRs/FRs is not an option.**

# Nuclear Fuel Cycle Policy
## -Anticipated Ratio of Nuclear Power Generation-

| Scenario | 0% Scenario | 15% Scenario | 20% Scenario | Previous Scenario |
|---|---|---|---|---|
| Share of nuclear energy at 2030 | 0 % | 15 % | 20 % | 30-40% |
| Nuclear fuel cycle policy | Full direct disposal | Dual policy of reprocessing and direct disposal | | Full reprocessing |



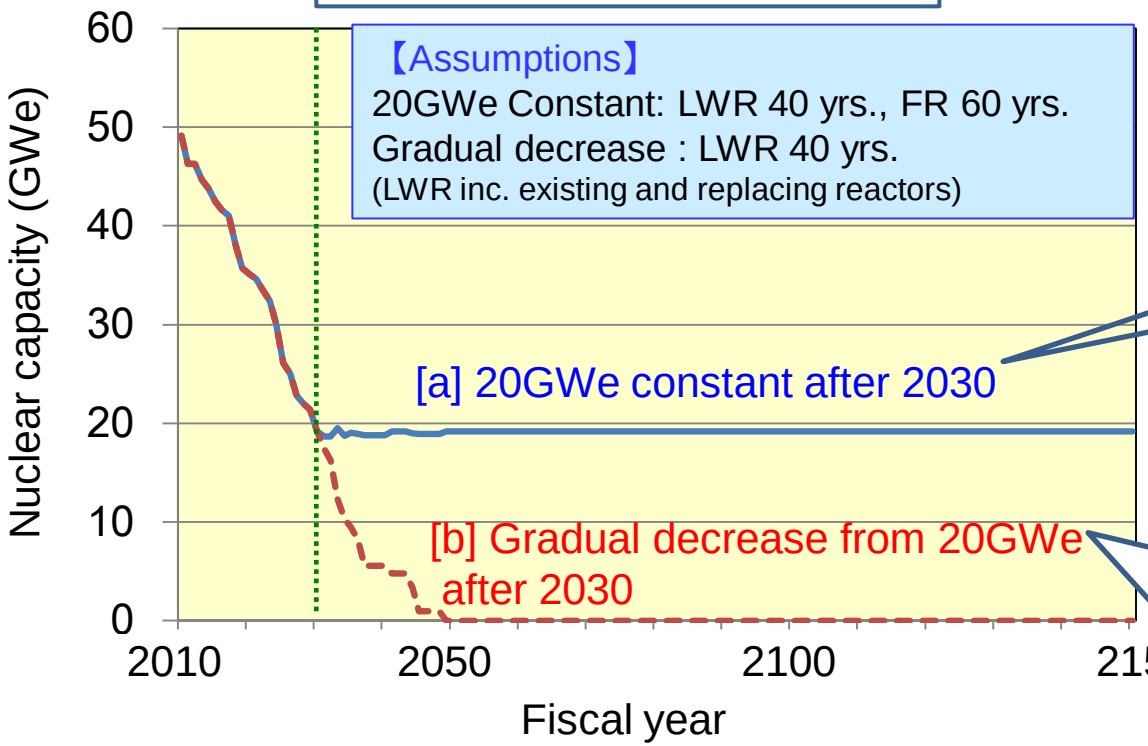
# Long-Term FR Deployment Scenario in Japan
## -Nuclear Capacity and Evaluation Case-

- Future nuclear capacities were assumed based on the energy policy debate by the Government.

→ Two scenarios were assumed. First, the nuclear capacity remains constant at 20GWe after 2030. Second, it gradually reduces to zero after 2030.

→ Three cases regarding nuclear fuel cycle were set up.

Long-term nuclear capacity




Evaluation case

[a] 20GWe constant after 2030 case
- Full Reprocessing
- Direct Disposal

[b] Gradual decrease from 20 GWe after 2030 case
- Full Reprocessing
- (Partial Reprocessing)
- Direct Disposal

# Long-Term FR Deployment Scenario in Japan
## -Main Assumptions (1/2)-

**Assumptions for FRs**

| | Item | Condition |
|---|---|---|
| Reactor | Deployment year | Demo. reactor: 2025, Comm. reactor: 2050 |
| | Average burn-up | Demo. reactor: 60 (initial) ~ 150 GWd/t<br>Comm. reactor: 150 GWd/t |
| | Breeding (Conversion) ratio | Demo. reactor: 1.1<br>Comm. reactor: 1.1(early phase) ~ 1.03<br>Burner reactor: 0.6 |
| | Capacity per unit | Demo. reactor: 750MWe<br>Comm. reactor & burner reactor: 1,500MWe |
| | Lifetime/Load Factor | 60 years / 80% |
| Fuel fab. | Commercial Facility | Starts before the FR deployment, 100t/y or 200t/y (according to the demand), MA upper limit: 5% |
| Repro-cessing | Commercial Facility | Starts after the FR deployment, 100t/y or 200t/y (according to the demand), MA recovery considered |

# Long-Term FR Deployment Scenario in Japan
## -Main Assumptions (2/2)-

## Assumptions for LWRs

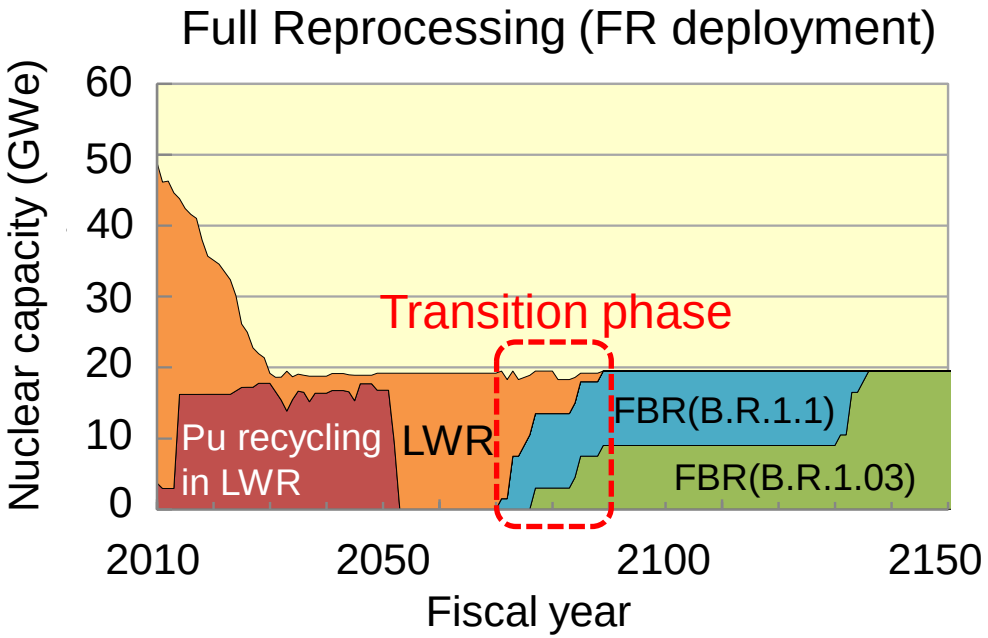
| | Item | Condition |
|---|---|---|
| Reactor | Average burn-up | 45 (before 2030) ~ 60GWd/t |
| | Lifetime/Load Factor | 40 years / 80% |
| Repro-cessing | Future facilities after the Rokkasho plant | Starts after the closure of the Rokkasho plant<br>Possible for reprocessing of MOX and high burn-up fuels, MA recovery |

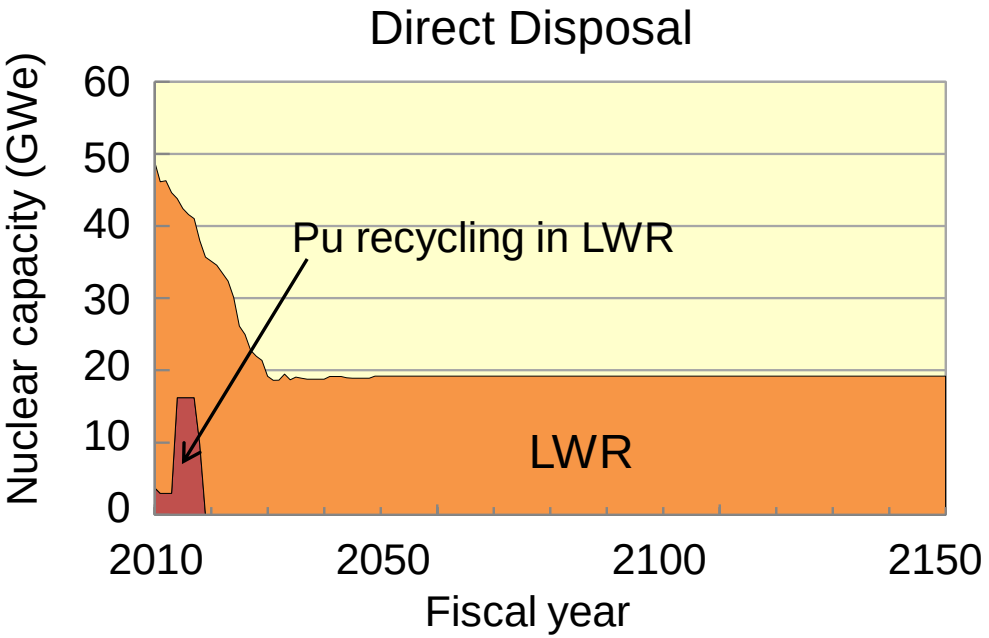
## Assumptions for wastes

| | Item | Condition |
|---|---|---|
| Spent fuel storage | Storage period | Recycle case: less than 40 years before reprocessing |
| | | Direct disposal case: 48 years before disposal |
| Geolo-gical re-pository | Deployment year | Vitrified waste: 2037 (upright position in hard rock) |
| | | Spent fuel: 2047 (upright position in hard rock) |

# Results on 20GWe constant case (1/4)
# -Breakdown of Nuclear Capacity-

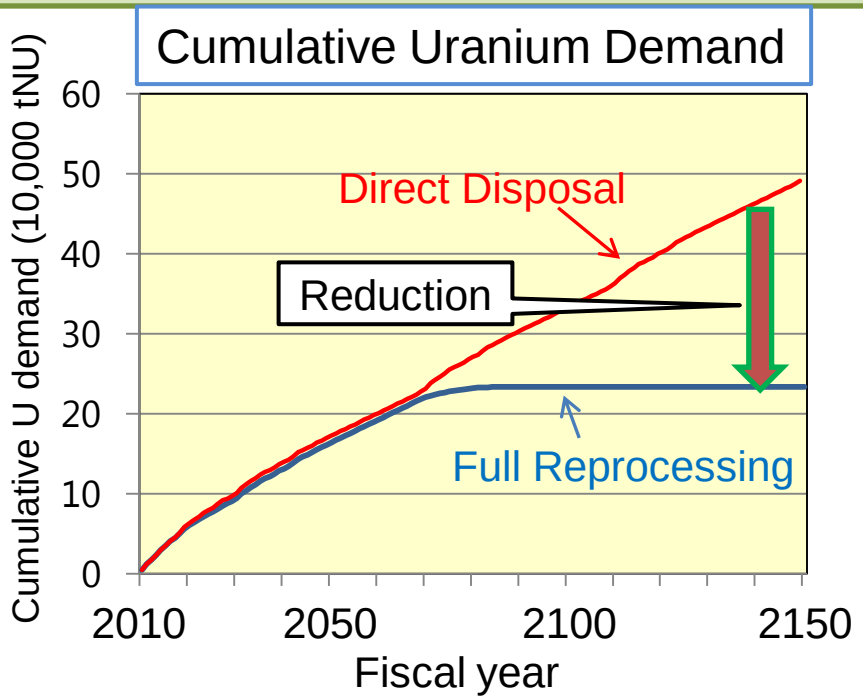
- “Full Reprocessing” case : Pu recycling in LWRs will be implemented over 40 years by using Pu recovered from overseas and Rokkasho plants. All LWRs will be replaced by FRs within about 20 years after 2070.
- “Direct Disposal” case : Pu recycling in LWRs will be implemented over 10 years by using Pu mainly recovered from overseas reprocessing plants.

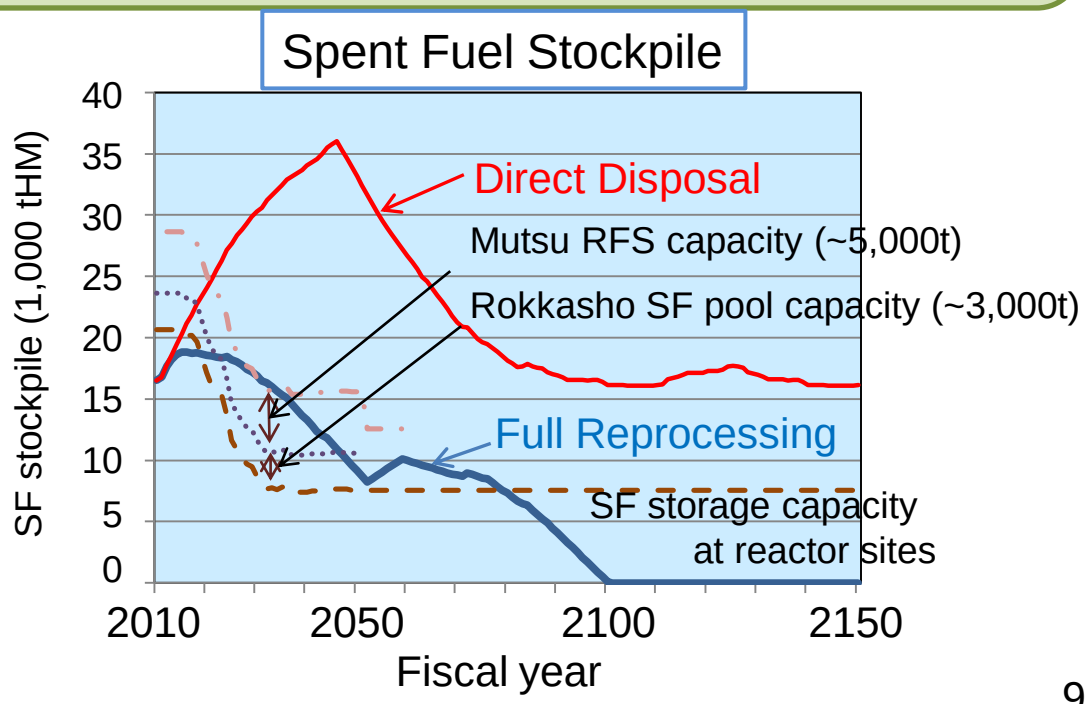


# Results on 20GWe constant case (2/4)
# -Cumulative Uranium Demand and Spent Fuel Stockpile-

- Full reprocessing make it possible to reduce natural U demand drastically after FR deployment and fully independent from foreign natural U in around 2090. It will be reduced to half of “Direct disposal” at 2150.
- SF stockpile in “Full Reprocessing” case remains at 10,000-20,000t until around 2060. Additional capacity will be needed until 2080.
- SF stockpile in “Direct disposal” case will be reached up to 35,000t before 2050 and become constant at about 17,000t after 2080. Additional capacity of 10,000-20,000t will be needed.



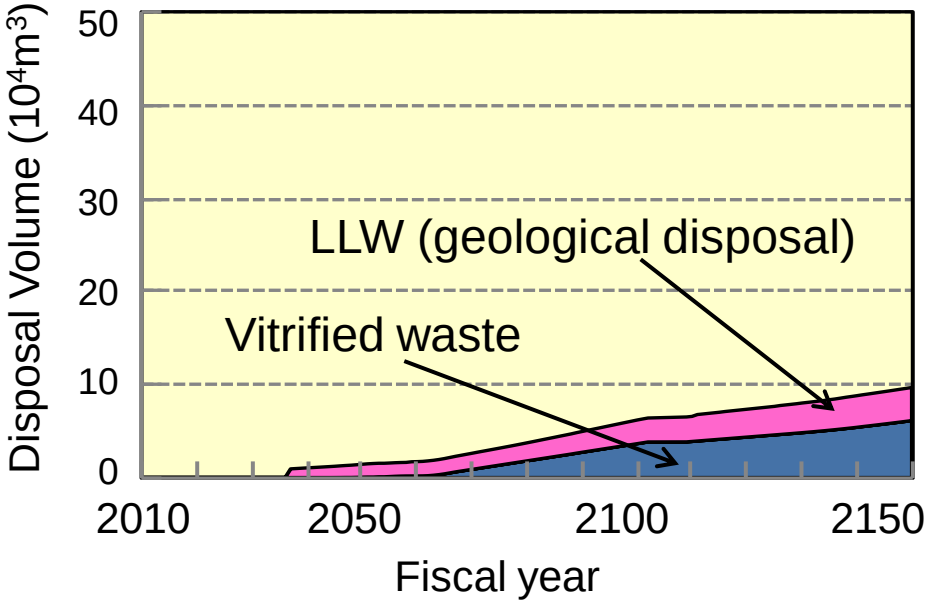




Note: Each SF occupancy of 5 out of 17 reactor sites in Japan exceeds 70% (Sept. 2011)

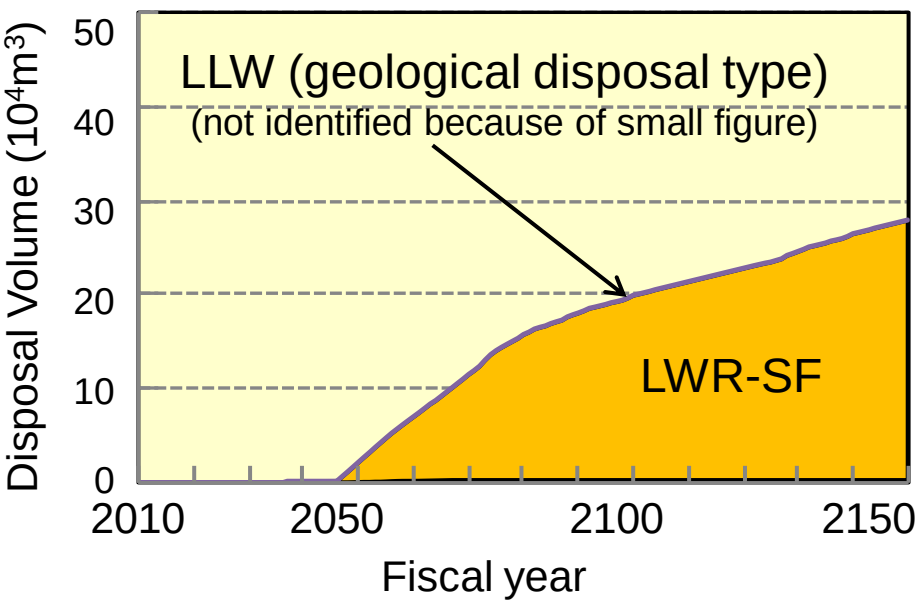
# Results on 20GWe constant case (3/4)
# - Radioactive Wastes-

- In “Full Reprocessing” case, low-level radioactive waste (LLW) volume will be increased due to the deployment of reprocessing facilities, whereas high-level radioactive waste (HLW) volume will be decreased. Total volume will be reduced to less than half of “Direct disposal” case.
- In “Direct disposal” case, the amount of SF will be continuously increased.

Full Reprocessing (FR deployment)

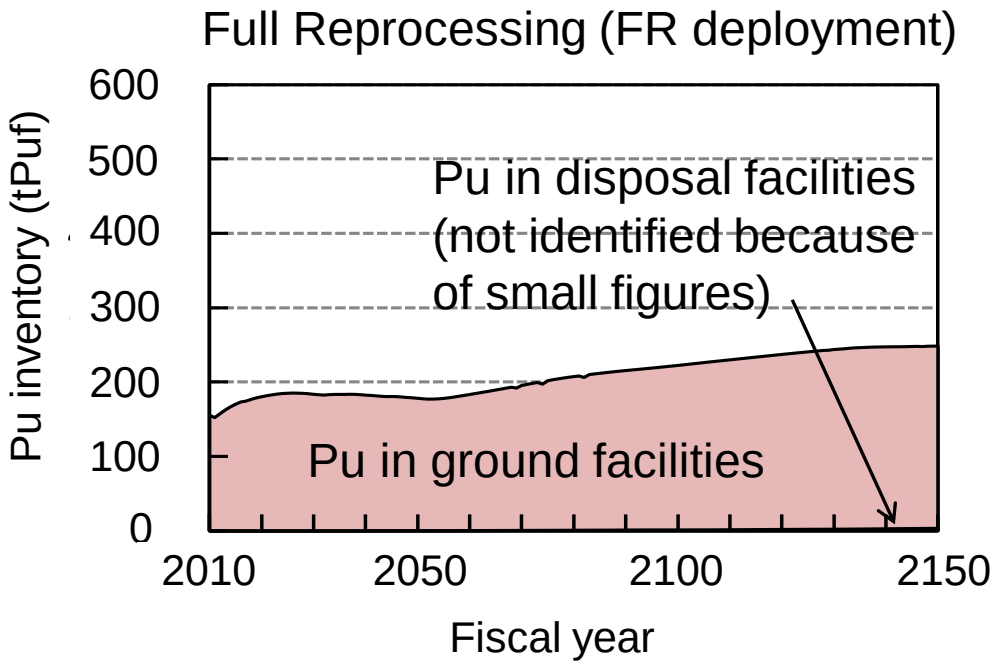


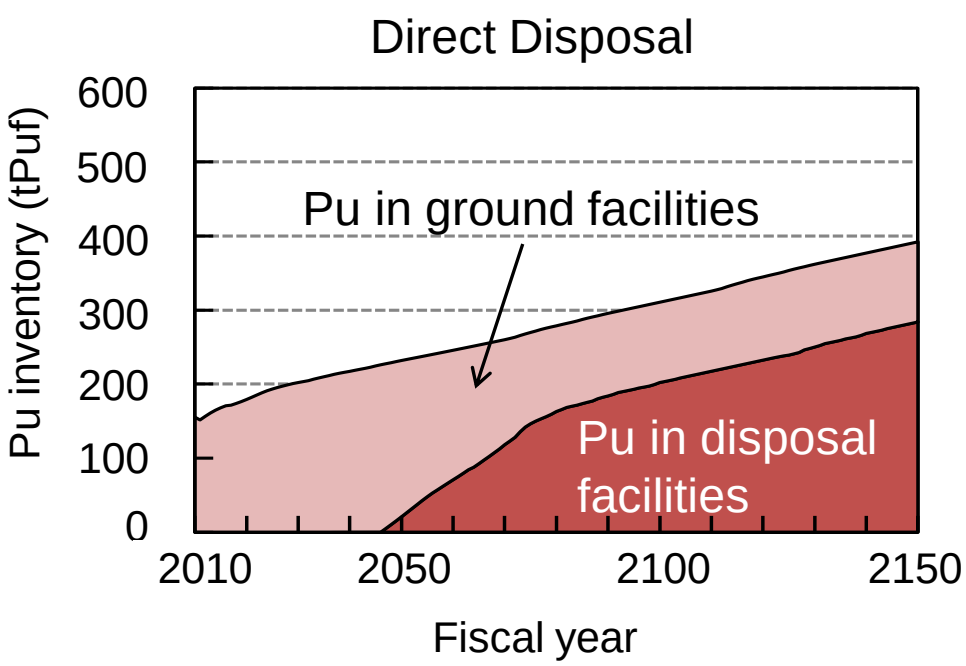

Direct Disposal



# Results on 20GWe constant case (4/4) -Plutonium Inventory-

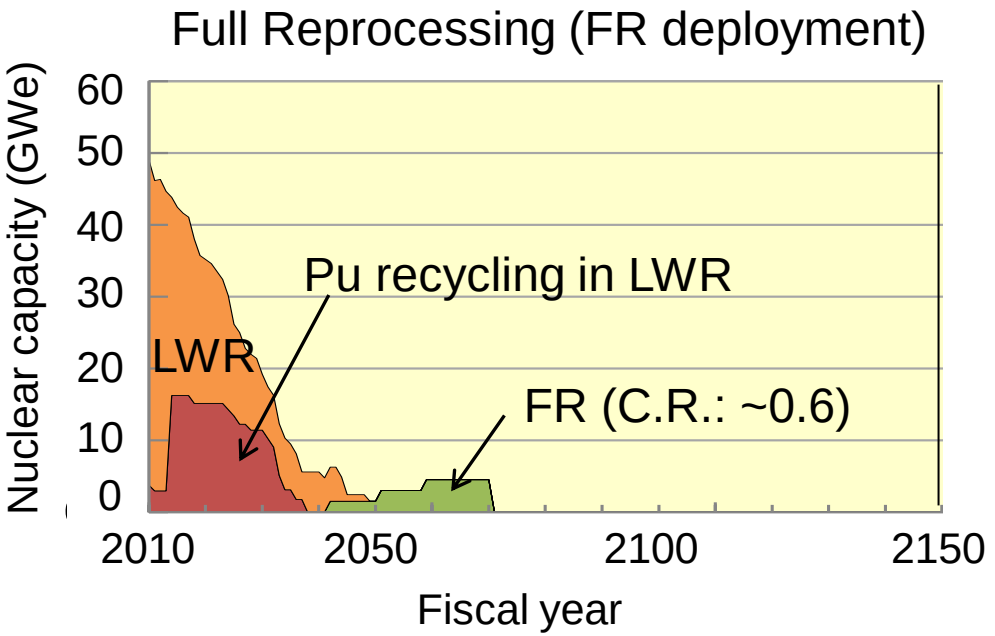
- “Full Reprocessing” case enables to lower Pu inventory in the whole fuel cycle facilities by FR deployment following the Pu recycling in LWR.
- “Direct disposal” case leaves large amount of Pu within the SF in storage facility for cooling in the near-term and in geological repositories in the long-term.

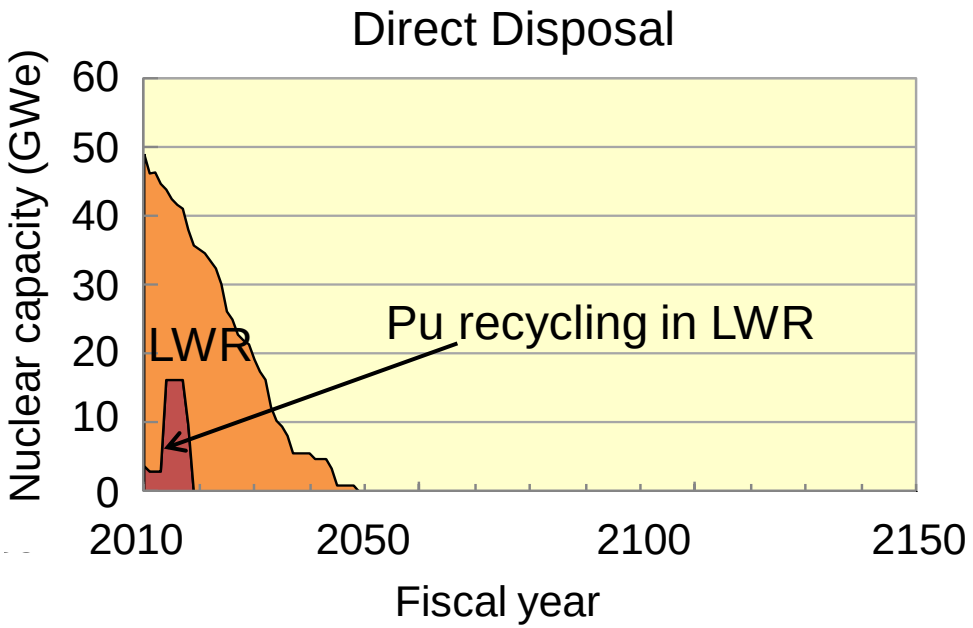


# Results on gradual decrease after 2030 case (1/2) -Nuclear Capacities-

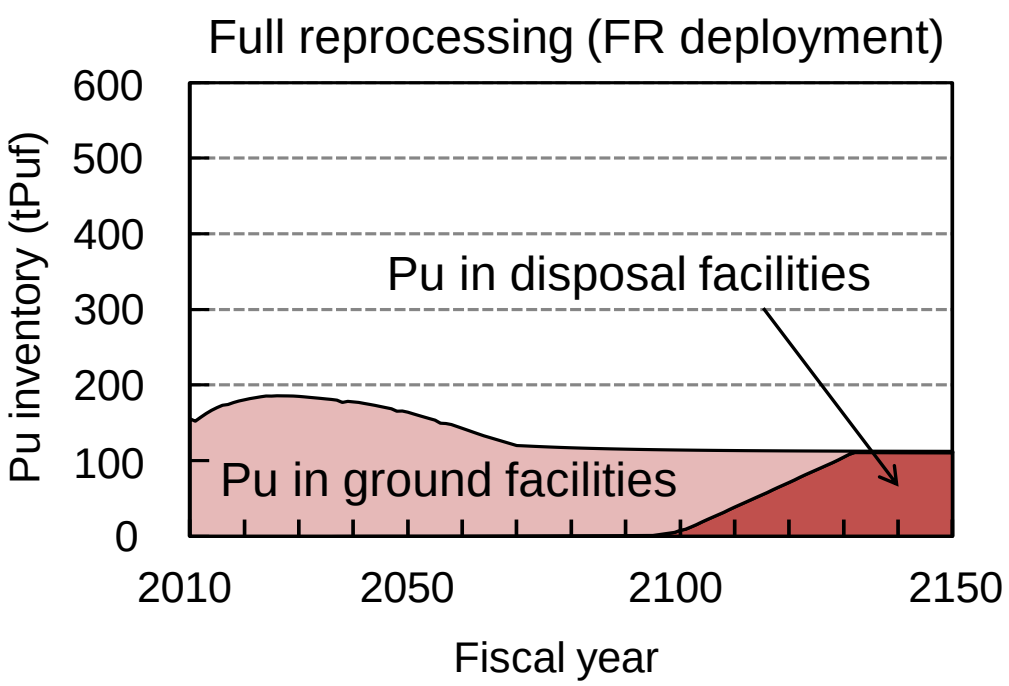
- In “Full Reprocessing” case, FR will be introduced up to about 5 GWe after the implementation of Pu recycling in LWR, in order to pursuit reduction of radioactive wastes.
- In “Direct disposal” case, Pu recycling in LWRs will be implemented for over 10 years by using Pu mainly recovered from overseas reprocessing plants.

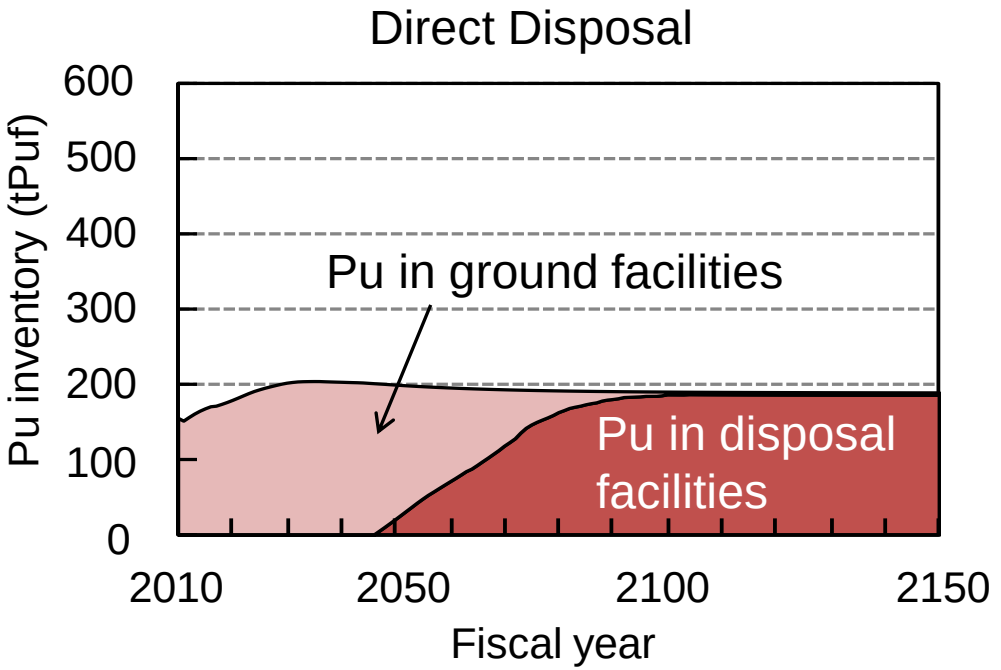


# Results on Gradual decrease after 2030 case (2/2) -Plutonium Inventory-

- “Full Reprocessing” case enables to lower the Pu inventory in the whole fuel cycle facilities to the half of “Direct disposal” case.
- “Direct disposal” case leaves 200t Pu within the SF in ground facilities and/or disposal site.
- Furthermore, in “Full Reprocessing” case, the total volume of HLWs and LLWs decreases to about the half of “Direct disposal” case.



# Conclusion

- The results revealed a need for the implementation of reprocessing and development of FR from the view point of reducing waste, etc. in the medium to long term.

- JAEA's contribution to international cooperation and standardization focusing on the enhancement of safety and reduction of the radioactive waste burden will be increasingly important in current situation.

- JAEA intend to continue to build and propose FR deployment scenarios and identify their characteristics.

***Thank you for your attention!***