Nuclear Fuel Recycling and Waste Management in Japan

NARUC Summer Meeting in Austin, Texas

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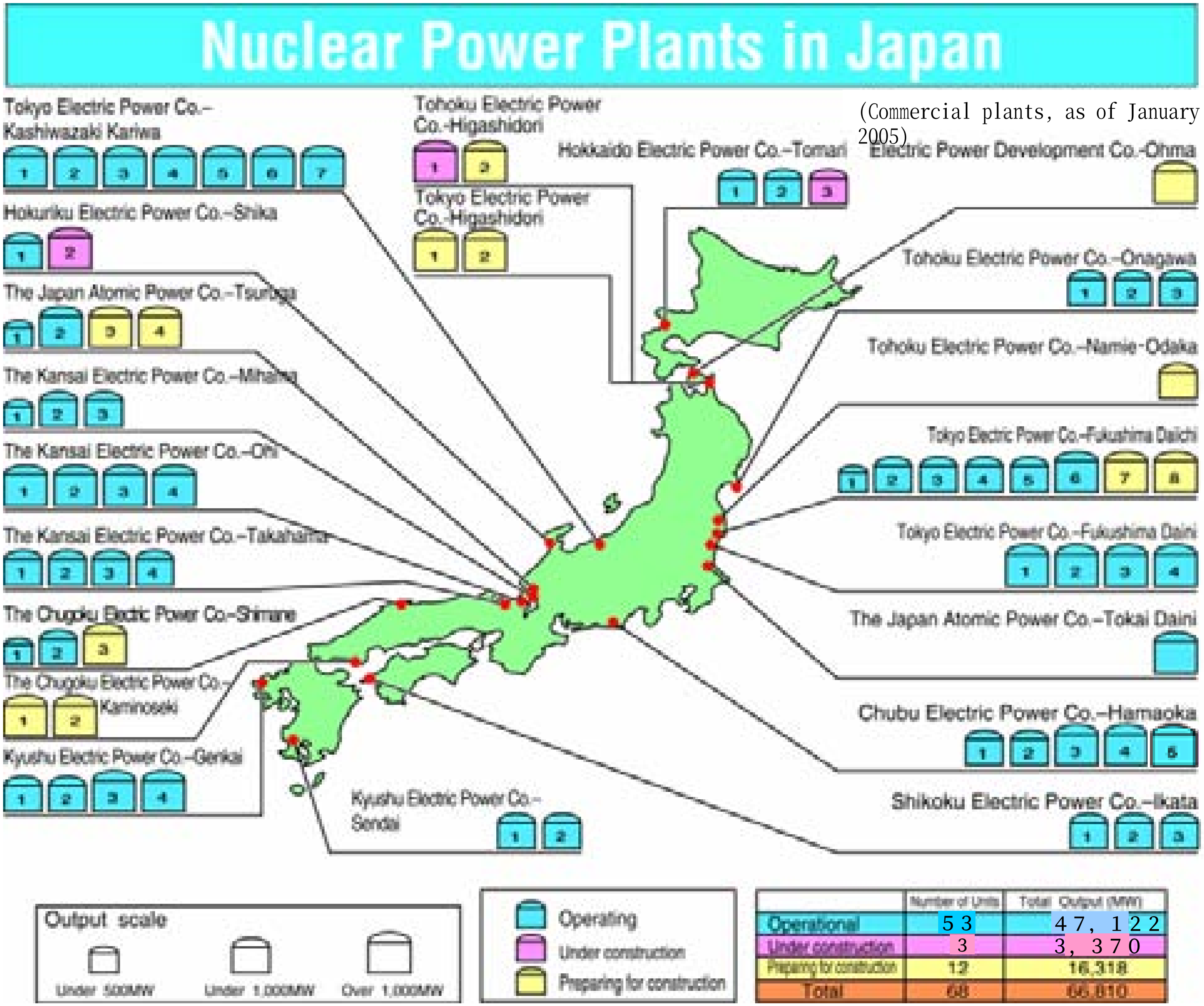
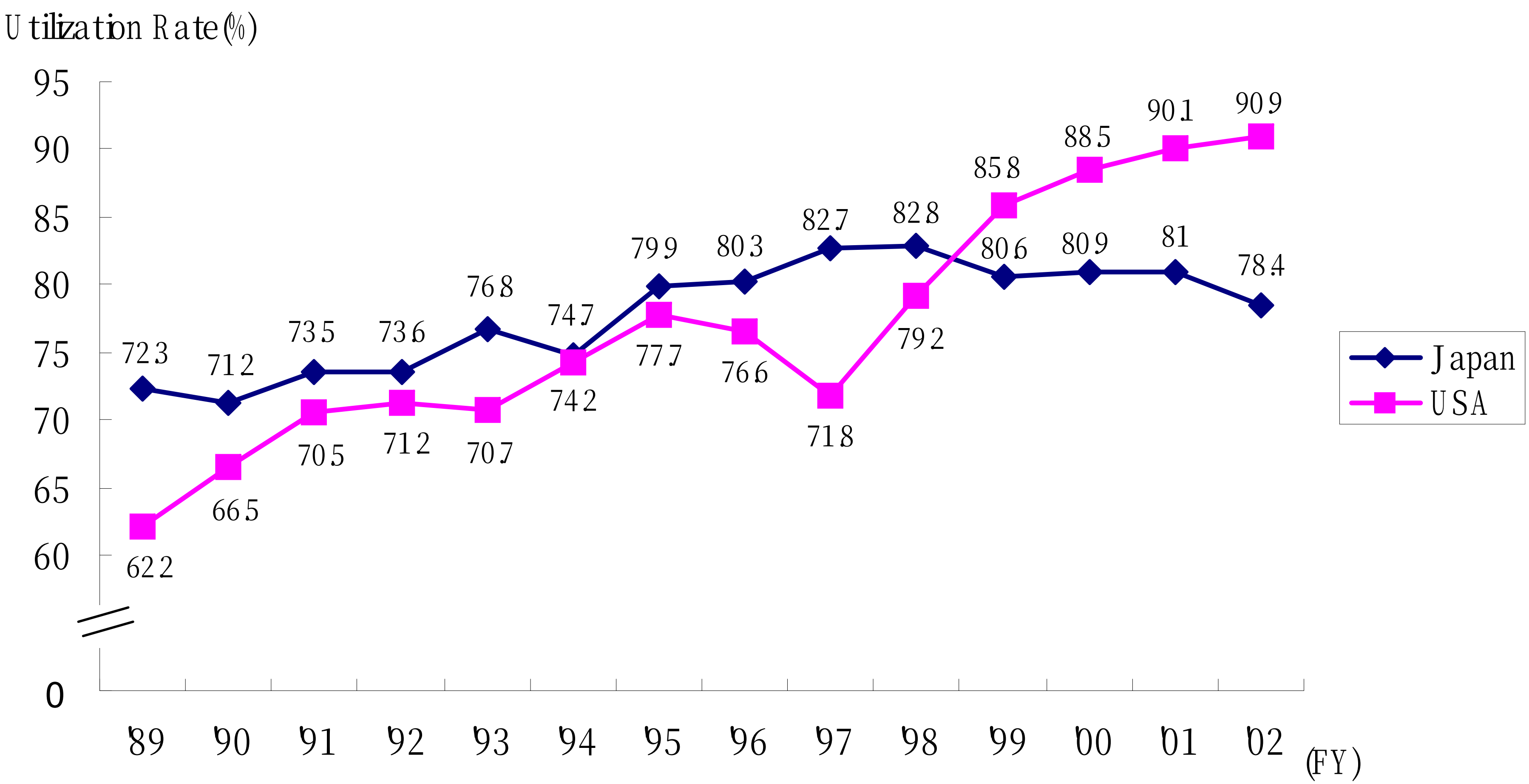
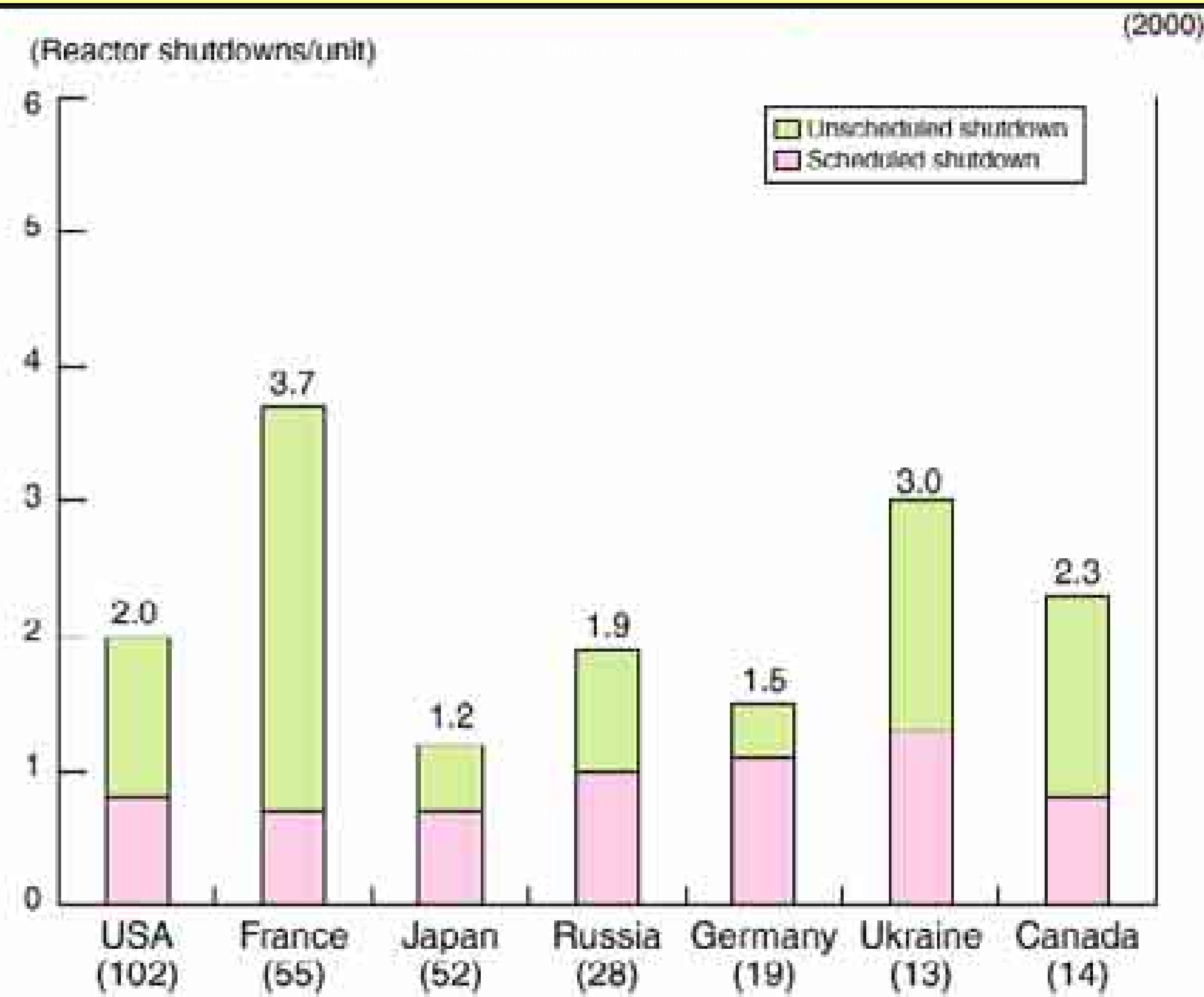

Nuclear Power Plants in Japan
(Commercial plants, as of January 2005)
Tokyo Electric Power Co.–Kashiwazaki Kariwa
Hokuriku Electric Power Co.–Shika
The Japan Atomic Power Co.–Tsuruga
The Kansai Electric Power Co.–Mihama
The Kansai Electric Power Co.–Ohi
The Kansai Electric Power Co.–Takahama
The Chugoku Electric Power Co.–Shimane
The Chugoku Electric Power Co.–Kaminoseki
Kyushu Electric Power Co.–Genkai
Kyushu Electric Power Co.–Sendai
Tohoku Electric Power Co.-Higashidori
Tokyo Electric Power Co.-Higashidori
Hokkaido Electric Power Co.–Tomari
Electric Power Development Co.-Ohma
Tohoku Electric Power Co.–Onagawa
Tohoku Electric Power Co.–Namie-Odaka
Tokyo Electric Power Co.–Fukushima Daiichi
Tokyo Electric Power Co.–Fukushima Daini
The Japan Atomic Power Co.–Tokai Daini
Chubu Electric Power Co.–Hamaoka
Shikoku Electric Power Co.–Ikata
Output scale
Under 500MW
Under 1,000MW
Over 1,000MW
Operating
Under construction
Preparing for construction
Number of Units
Total Output (MW)
Operational 53 47,122
Under construction 3 3,370
Preparing for construction 12 16,318
Total 68 66,810

Load Factors of Nuclear Power Plants



Source：JNES

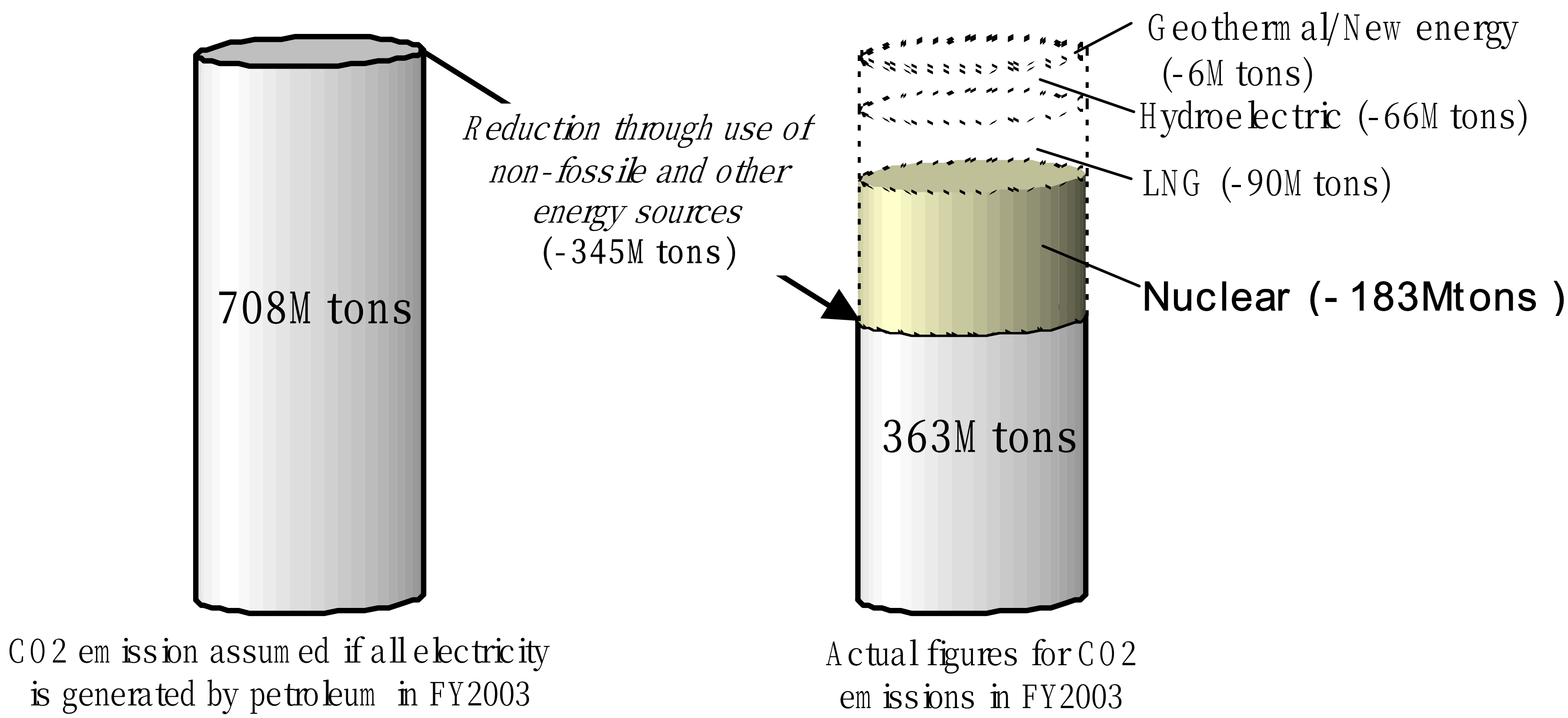
Reactor Shutdowns in Major Counties



(Note) Parentheses indicate number of units.
(Source) Agency of Natural Resources and Energy web site

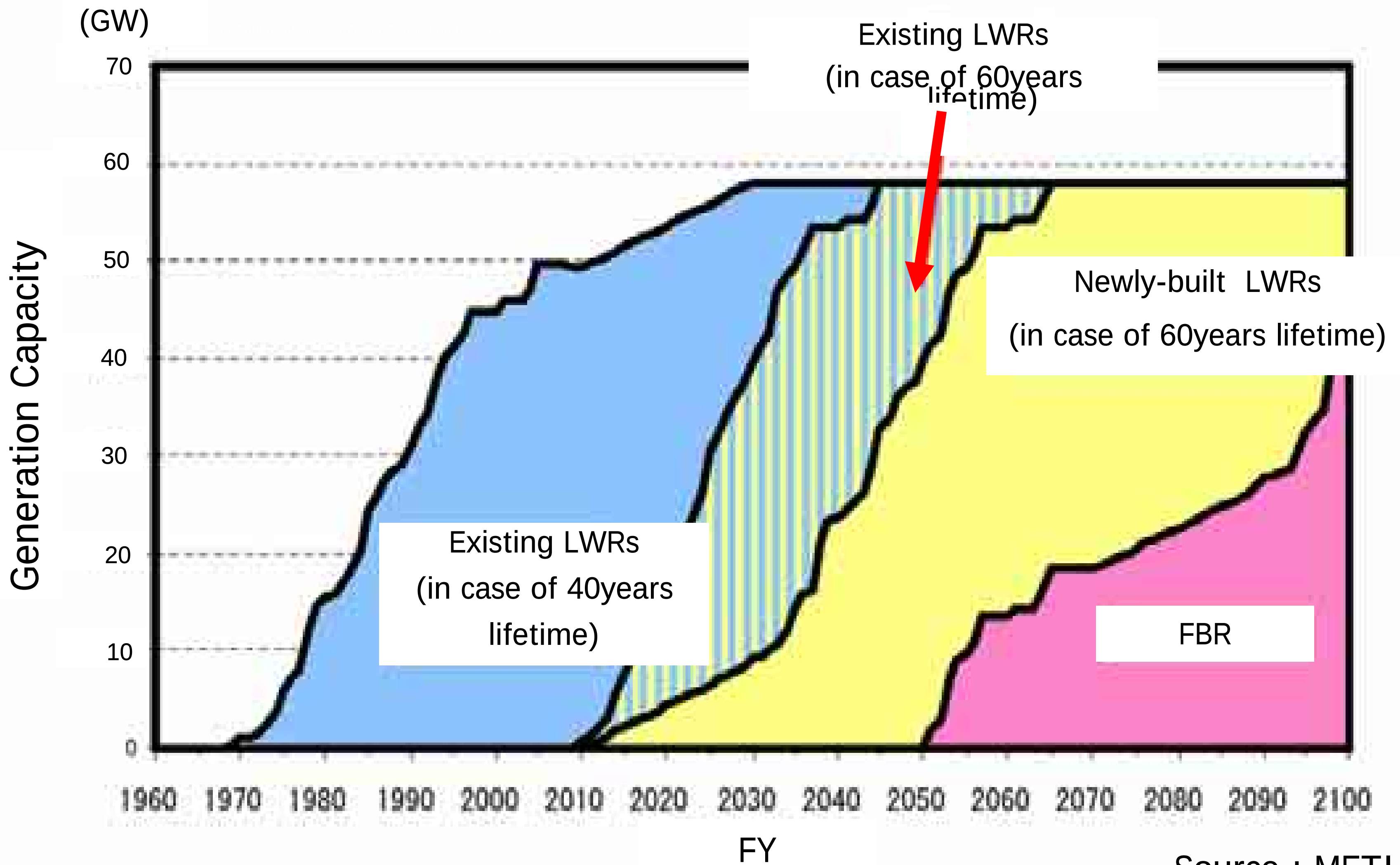
CO2 Emissions and Reduction in Japan (FY 2003)

- The reduction in CO2 emissions is calculated at 345 million tons of CO2, which is close to the same level as the actual figures for FY 2003.
- The use of nuclear energy results in a net reduction 183 million tons of CO2.



Source : the Federation of Electric Power Companies in Japan

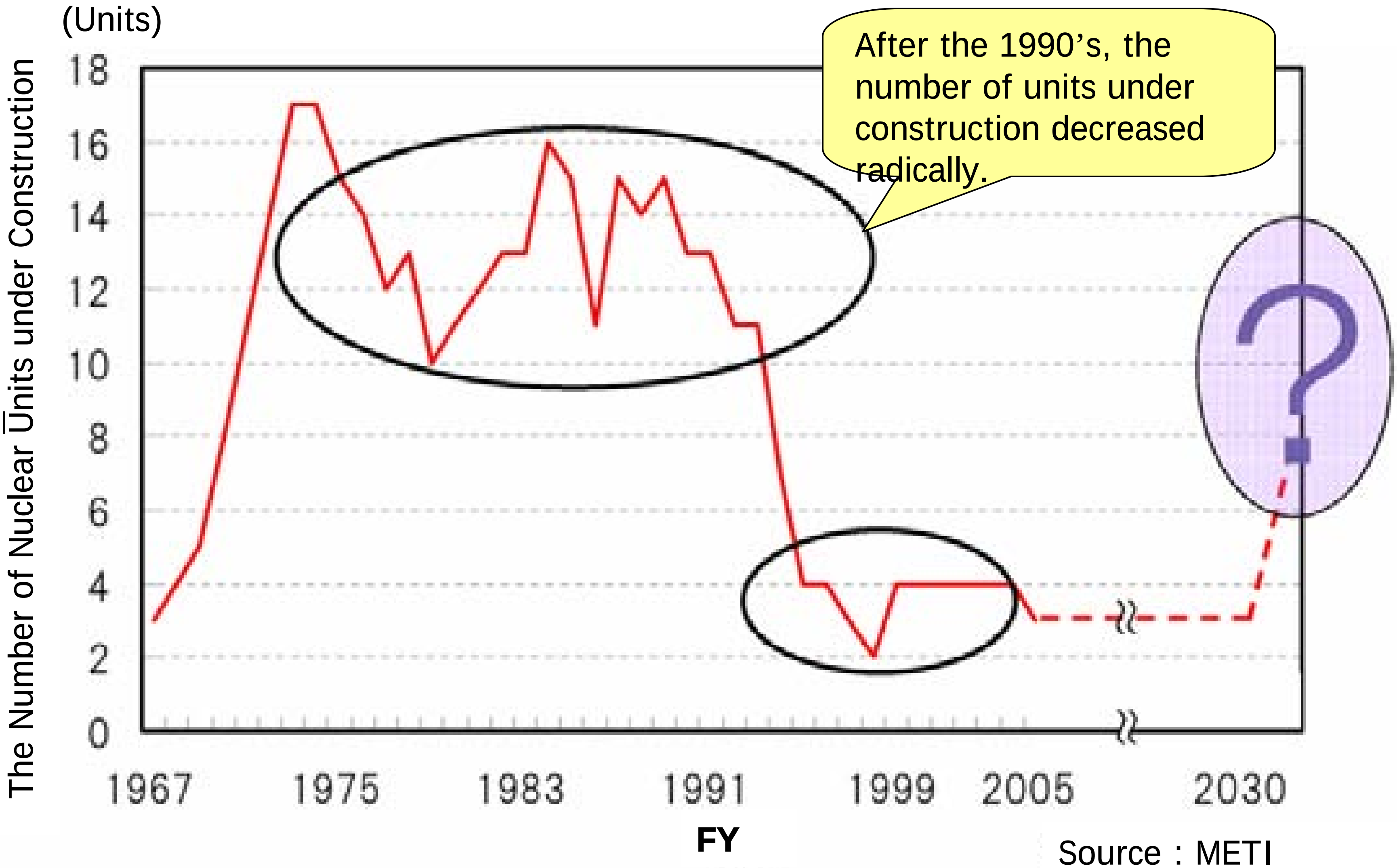
Long-term Outlook of Nuclear Power Generation In Japan



Source：METI

(*) Generation Capacity by nuclear in Japan is assumed to be constant at 58GW.

The Number of Nuclear Units under Construction in Japan



Source : METI

Nuclear Fuel Recycling Policy

Atomic Energy Long-Term Plan of Japan

- Atomic Energy Commission (AEC) of Japan renews the Atomic Energy Long-Term Plan every five years or so.
- New Nuclear Policy Planning Council of AEC, started in June, 2004, will formulate a new Long-Term Plan (LTP) by the end of this year.
- This Council consists of members with diverse interests, and include an industry representative, a scientist, a sociologist, an economist, a lawyer, a diplomat, an editorialist, a labor union representative and a consumer representative.
- On November 12, 2004, the Council published the Interim Report on Nuclear Fuel-Cycle Policy.
- Drafting of the final report started in early July.

Nuclear Fuel Cycle Policy Formulation

Four scenarios for the handling of spent nuclear fuel:

Scn-1 : Reprocess all

Scn-2 : Partial Reprocessing

Up to 32,000tU : reprocess

Beyond 32,000tU : dispose

Scn-3 : Direct disposal of all

(Not operate RRP)

Scn-4 : No decision will be made

for several decades

×

Synthetic Evaluation

Ten Perspectives ;

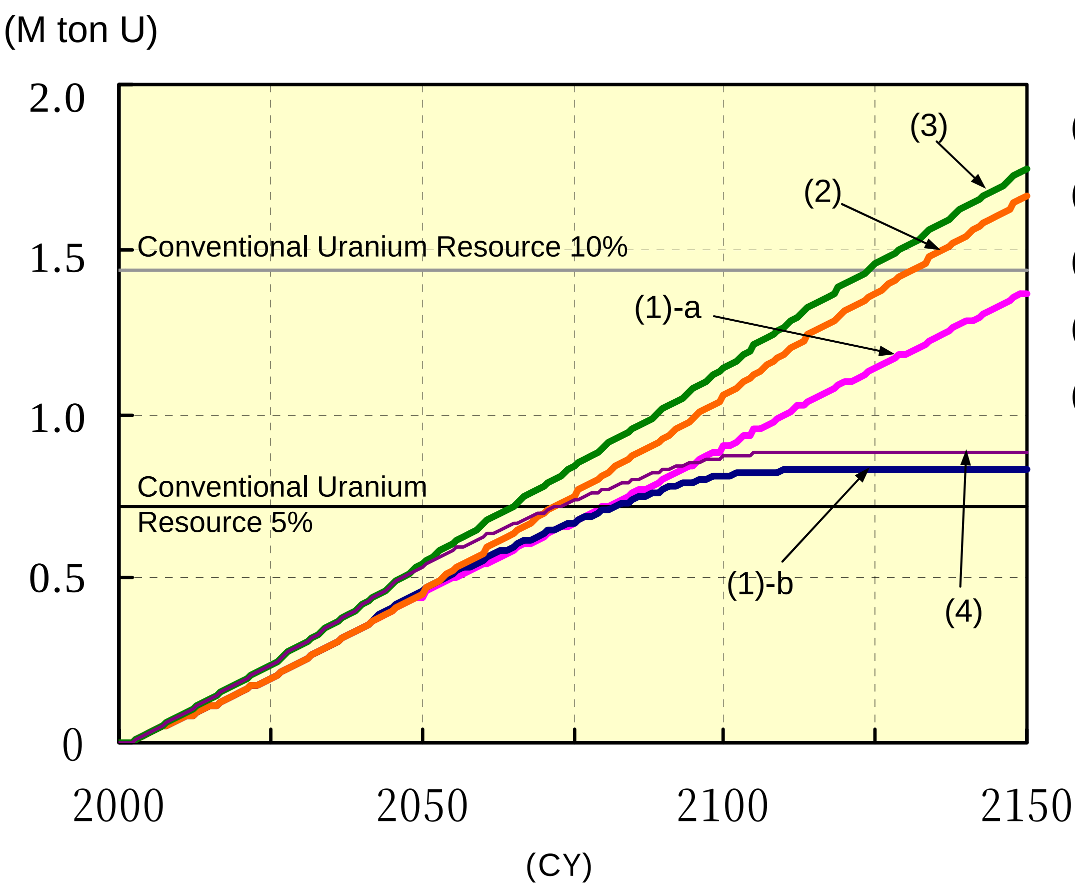
(1) Safety
(2) Energy security
(3) Environmental compatibility
(4) Economics
(5) Nuclear Non-proliferation Compliance
/
/
(10) Reference to international trends

Result

The basic nuclear fuel-cycle policy of Japan is to reprocess all spent nuclear fuel and to use effectively the recovered plutonium and uranium. (Scenario 1)

Energy Security

- LWR-MOX-fuel utilization will conserve uranium by 10 - 20% (approximately 13% in the case of plutonium use; approximately 26% if recovered uranium is used).
- Implementing the FBR nuclear fuel cycle in the future could secure nuclear fuel resources on a semi-permanent basis.

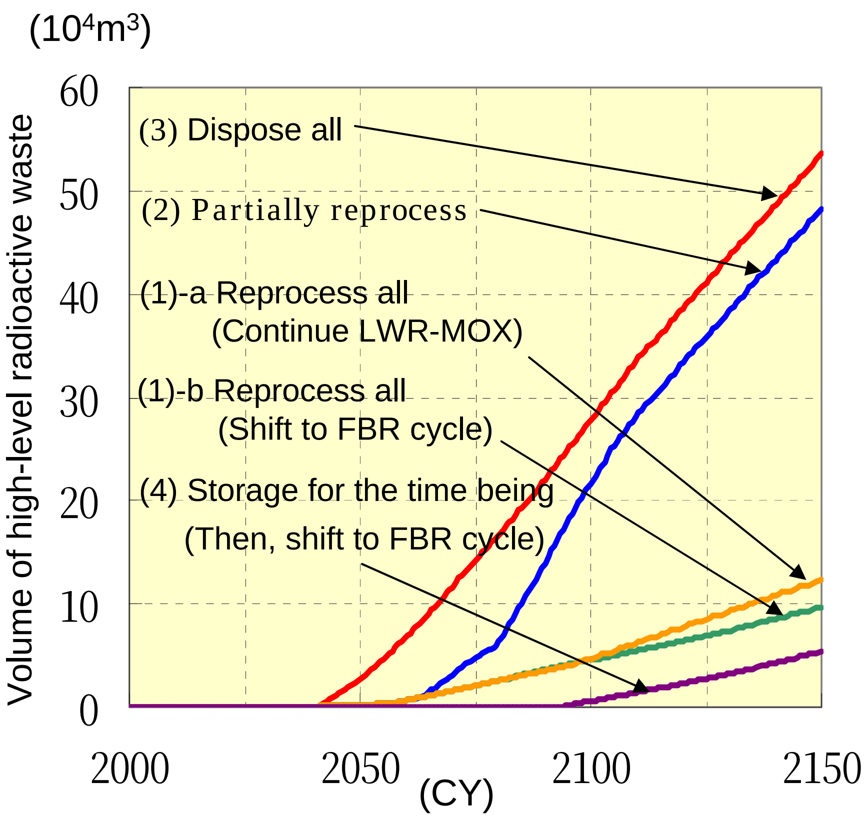


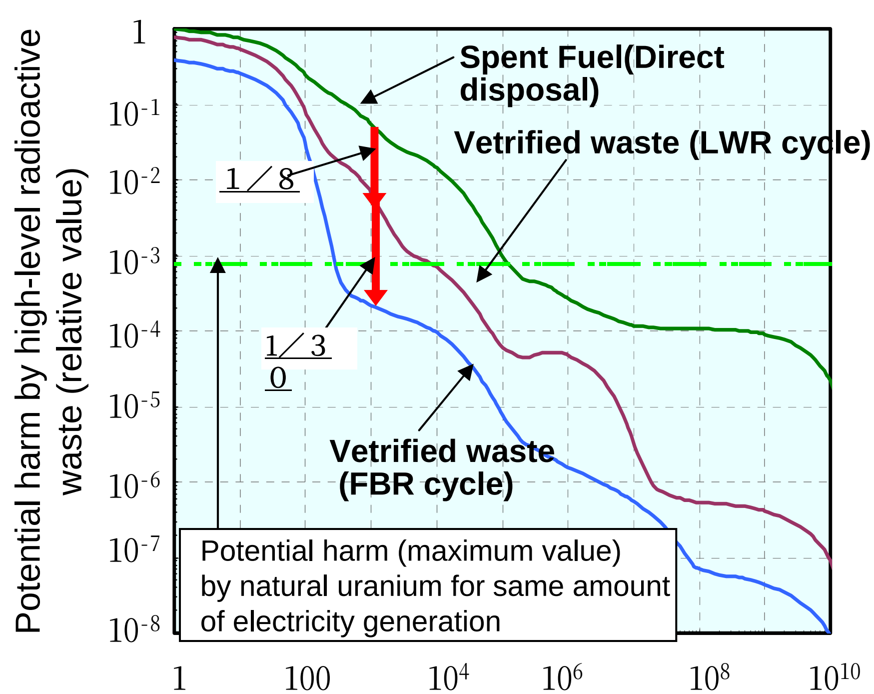
(1)-a : Reprocess all (Continue LWR-MOX)
(1)-b : Reprocess all (Shift to FBR cycle)
(2) : Partially reprocess
(3) : Dispose all
(4) : Storage for the time being (Then, shift to FBR cycle)

(Note) Conventional Uranium Resource : 14.4MtonU
(Source : OECD/NEA-IAEA, Uranium 2003 – Resources, Production and Demand)

Environmental Compatibility

- In direct disposal (Scn-3), the volume of high-level radioactive waste (spent fuel) produced is much larger than reprocessing (Scn-1).
- Also, in Scn-3, the potential harm due to radiation caused by the high-level radioactive waste (spent fuel) after 1,000 years is approximately eight times higher than reprocessing (Scn-1).





(Source) New Nuclear Policy Planning Council (7 Oct. 2004)

Economics

Nuclear fuel-cycle costs are calculated for the amount of power to be generated over a 59-year period (FY2002-2060).

⇒ Total power to be generated is approx. 25 Tri- kWh (= approx.70,000 tU nuclear spent fuel)

(discount rate = 2%) (Yen/ kWh)

	Scenario1 Repcocessing of all spent nuclear fuel	Scenario2 Partial reprocessing	Scenario3 Direct disposal of all spent fuel	Scenario4 Storage for the time being
Nuclear power generation costs	5.2	5.0 - 5.1	4.5 - 4.7	4.7 - 4.8
Nuclear fuel-cycle costs	1.6	1.4 - 1.5	0.9 - 1.1	1.1 - 1.2
(Front end)	(0.63)	(0.63)	(0.61)	(0.61)
(Back end)	(0.93)	(0.77 - 0.85)	(0.32 - 0.46)	(0.49 - 0.55)
Costs of policy changes (*)			0.9 - 1.5	
(Costs relating to the RRP)			(0.2)	
(Costs relating to alternative thermal power)			(0.7 - 1.3)	
(Reference value) Nuclear power generation costs + costs of policy changes	5.2	5.0 - 5.1	5.4 - 6.2	5.6 - 6.3

(*) There are various issues that may result from policy changes, such as potential harm to the relationship of trust with the region in which facilities are located. The figures presented here are the result of calculations of those factors that can be quantified based on a specific hypothesis.

Nuclear Non-Proliferation Compliance

The Atomic Energy Basic law of Japan allows only peaceful nuclear activities.

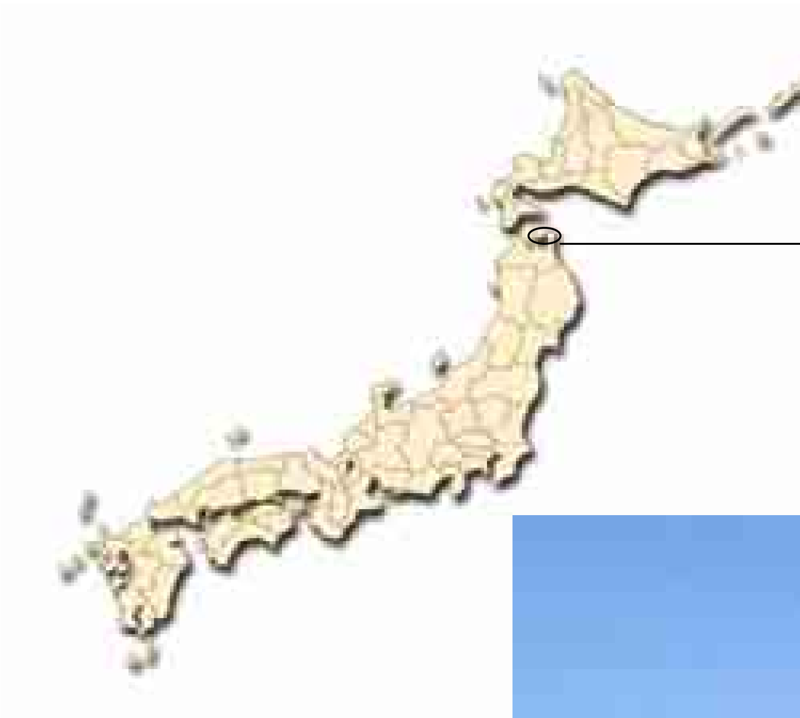
Japan ratified the NPT at the earliest stage of its history and has committed to accepting the full scope safeguards system of IAEA.

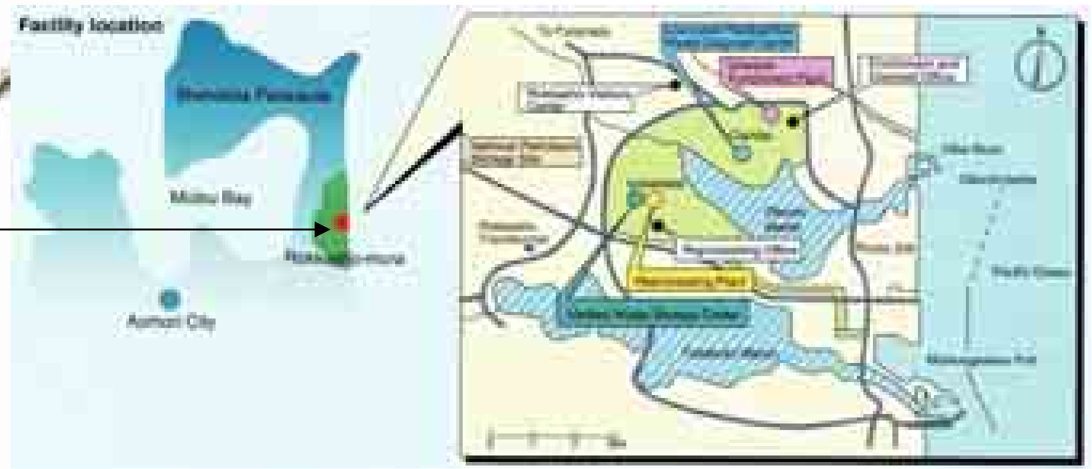
From the earliest stages of design and construction of the reprocessing plant, Japan invited IAEA/U.S. specialists to augment the safeguard features into the buildings and equipments.

Full time resident inspectors of IAEA stay at the plant and they operate independent chemical analysis systems and monitor the containment and surveillance systems.

Result: No big differences in proliferation risk among scenarios if Japan keeps full scope safeguards by IAEA and continues current management of nuclear materials.

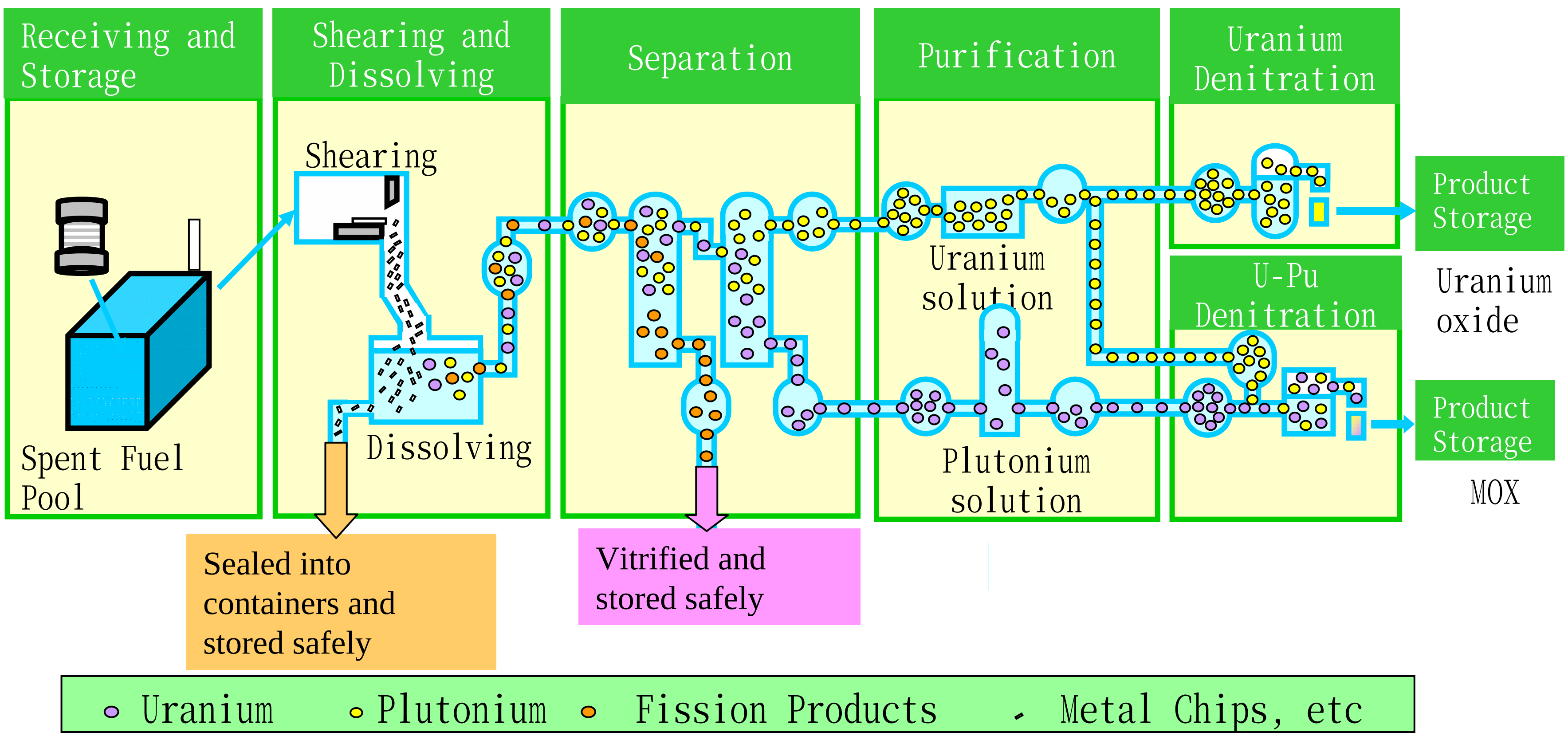
JNFL Reprocessing Plant



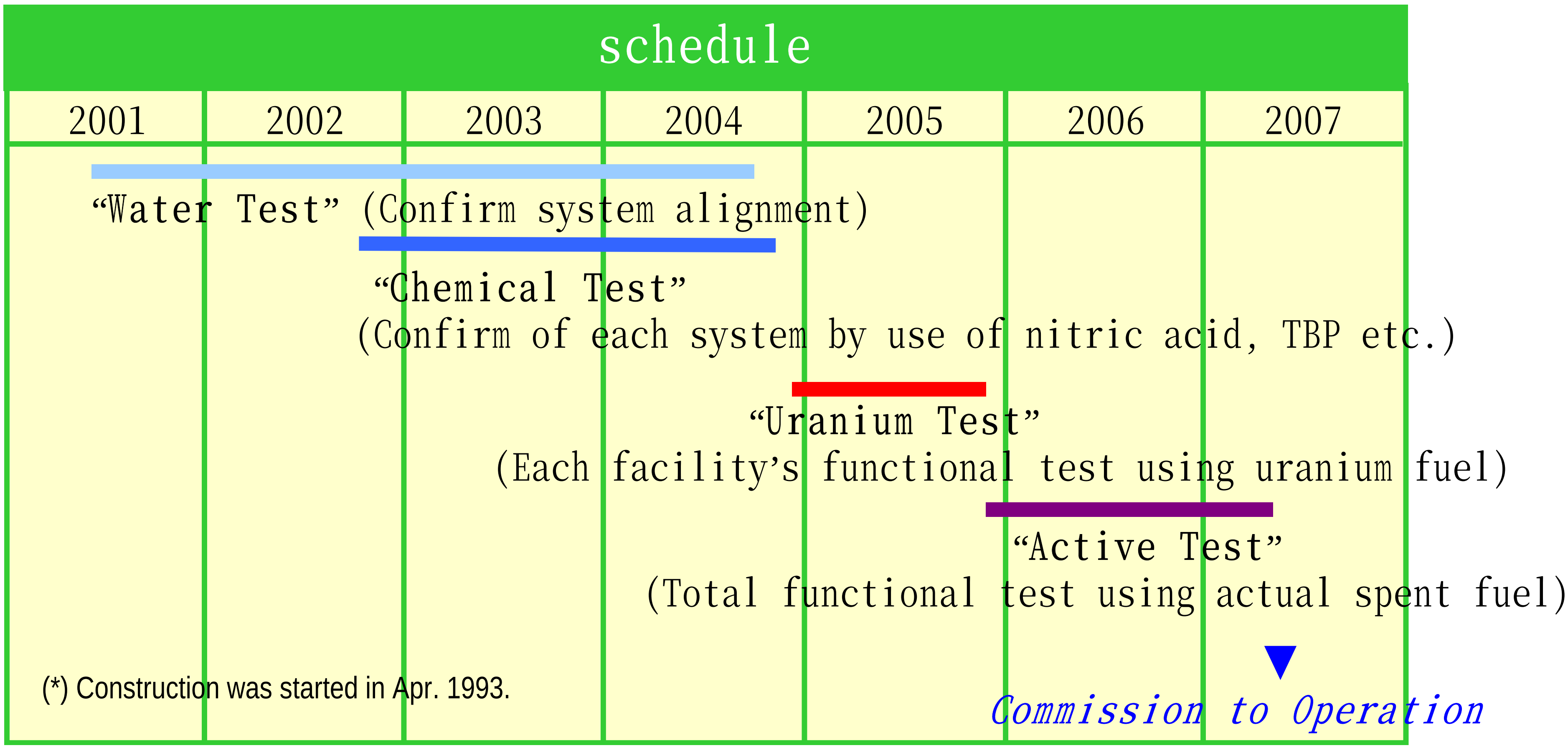


Rokkasho Reprocessing Plant

Plant Capacity	Reprocessing	800 tU/year
	Spent Fuel Storage	3,000 tU
	MOX powder storage	60t（U+Pu）
Construction Cost	Approx. $19.9 billion (\2.19 trillion) ($1=\110)	

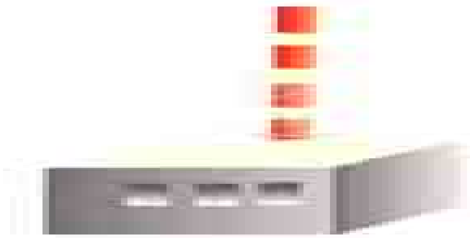


Master Plan of Test Operation



Total Scheme of Pu Balance in Japan

Rokkasho Reprocessing Plant (800t/year）



4.8tPuf/year

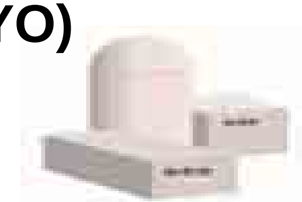
Overseas Reprocessing (UK, France)

Total appr.30tPuf

1/3MOX(LWR) : 15-17units
(0.3-0.4tPuf/unit/year)
Full MOX(ABWR) : 1units
(1.1tPuf/unit/year)

5-8tPuf/year

FBR Research Reactor (MONJU, JOYO)



A few hundreds kg Puf/year

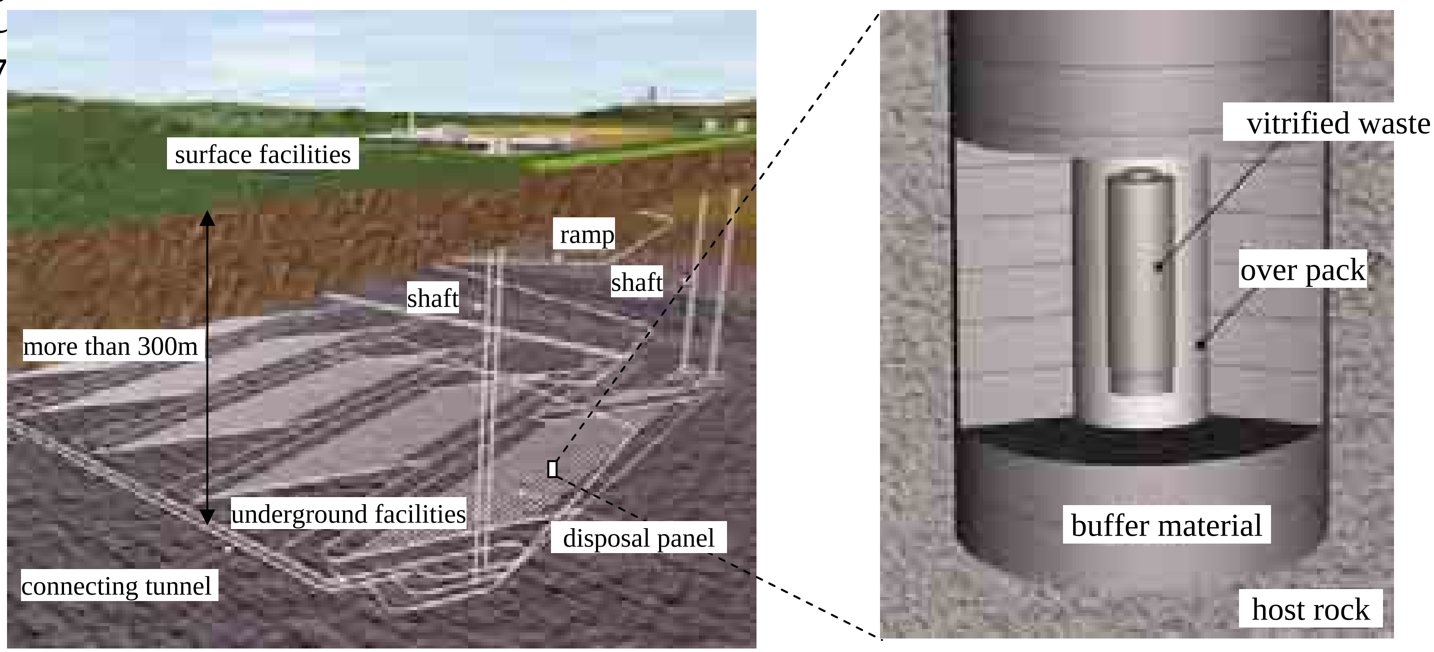
Nuclear Waste Management in Japan

High-Level Radioactive Waste Disposal

■Time scheme to Final Disposal

2000. 6	The Law was enacted.
2000.10	Nuclear Waste Management Organization of Japan (NUMO) was established.
2001. 1	Funding of the disposal cost started.
2002.12	Invitation of candidate areas for preliminary investigation.
2008～ 2012	Selection of areas for detailed investigation
2023～ 2027	Selection of the site for repository construction
Around 2025	Design, licensing and construction
2033～ 2037	Operation

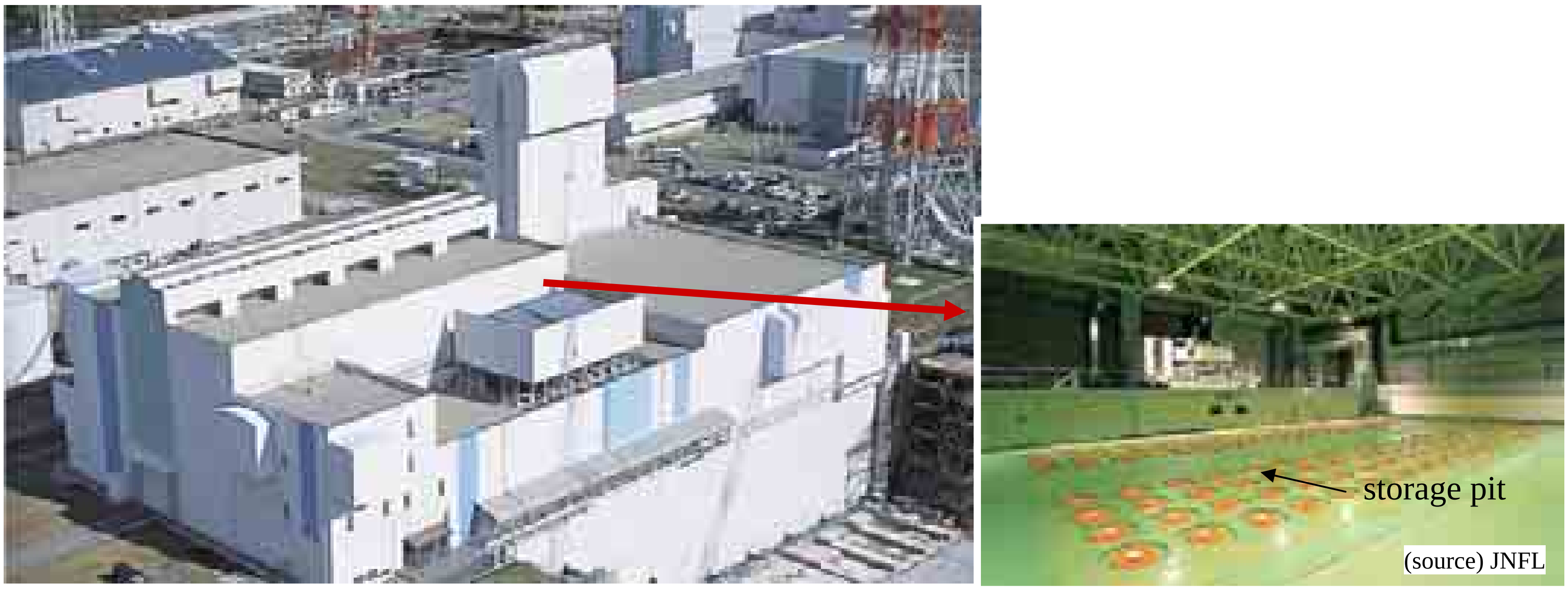
■Conceptual diagram of high-level radioactive waste disposal site (example)



(source) NUMO

The Interim Storage of Vitrified HLW from reprocessing in Europe

- ◯ From UK (BNFL) and France (COGEMA), a total of 2,200 canisters will be returned.
- ◯ These will be stored at JNFL for about 30-50 years for cooling before final disposal.



Vitrified Waste Storage Center (JNFL)

Low-Level Radioactive Waste Disposal

■ Waste comes from nuclear power plants operation

〇The Low-level Radioactive Waste Disposal Center of JNFL, started operations in December 1992.

〇The site can accommodate 600,000m^3 (3,000,000 drums) of LLW (the ultimate capacity).

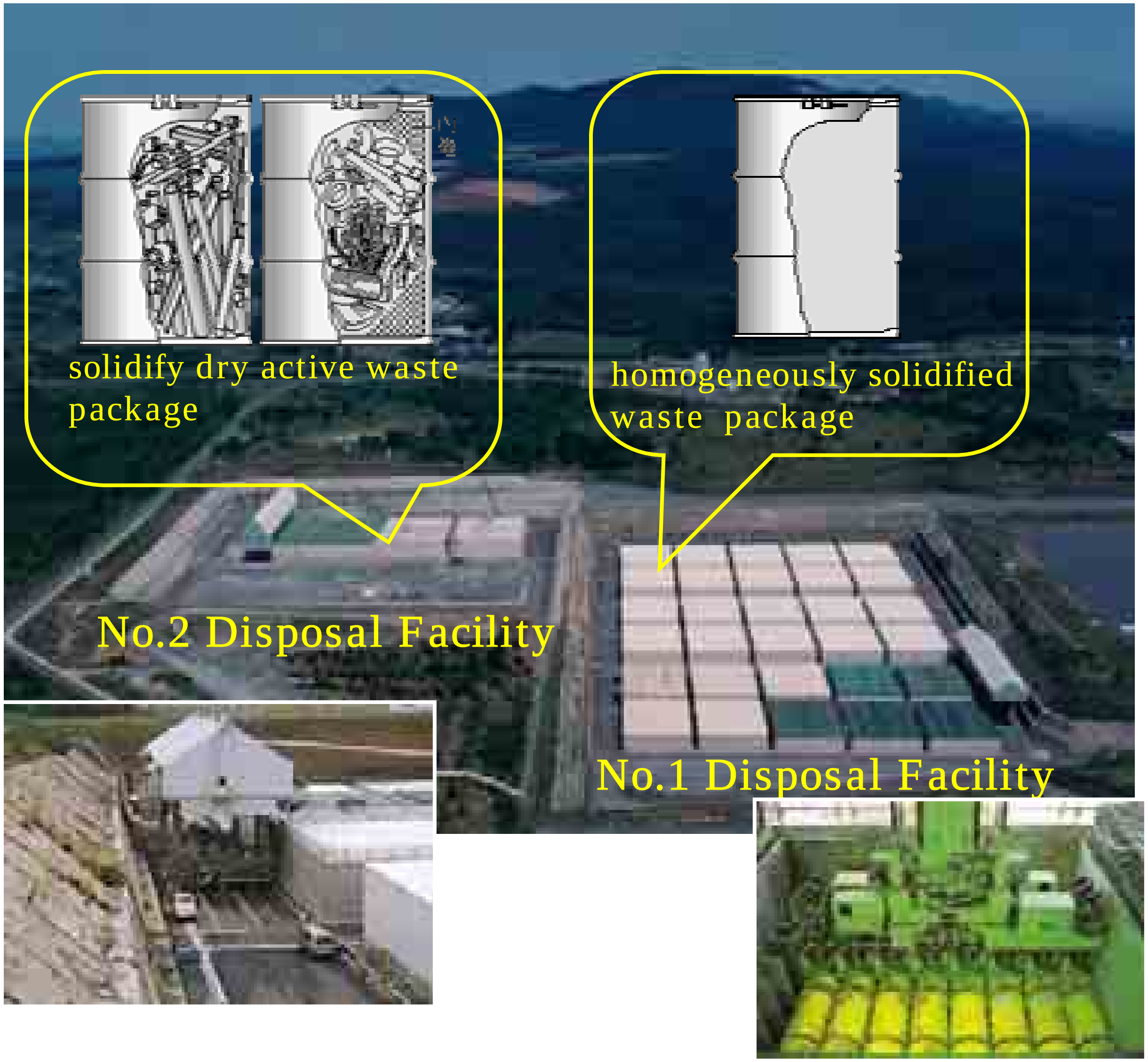
〇Two facilities are licensed for a capacity of 200,000 drums each. (One drum has 200 liter size)

〇At the end of May, 2005,

No.1 Disposal Facility ：135.899 drums disposed
（ homogeneous waste package ）

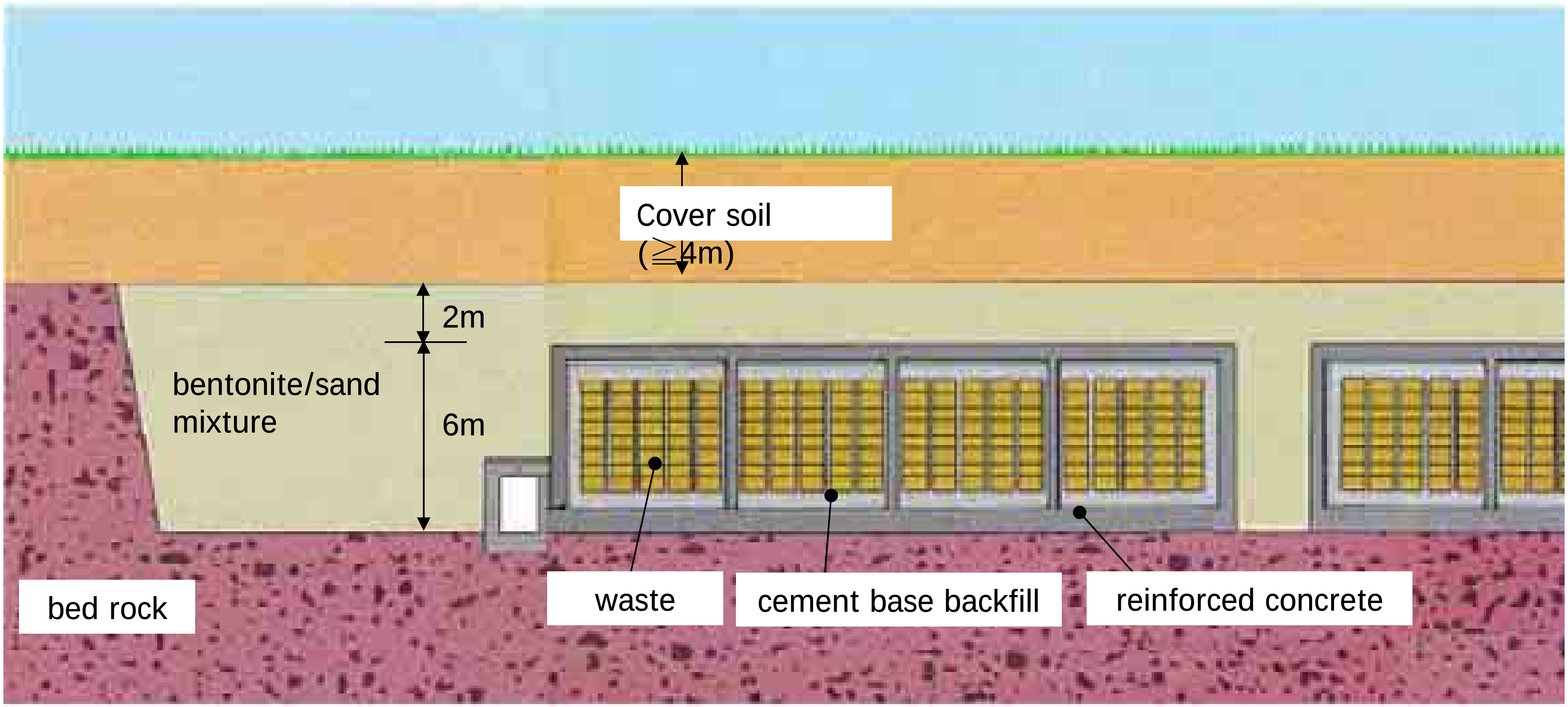
No.2 Disposal Facility : 38,698 drums disposed
（ non-homogeneous waste package ）

Low-level Radioactive Waste Disposal Center (JNFL)

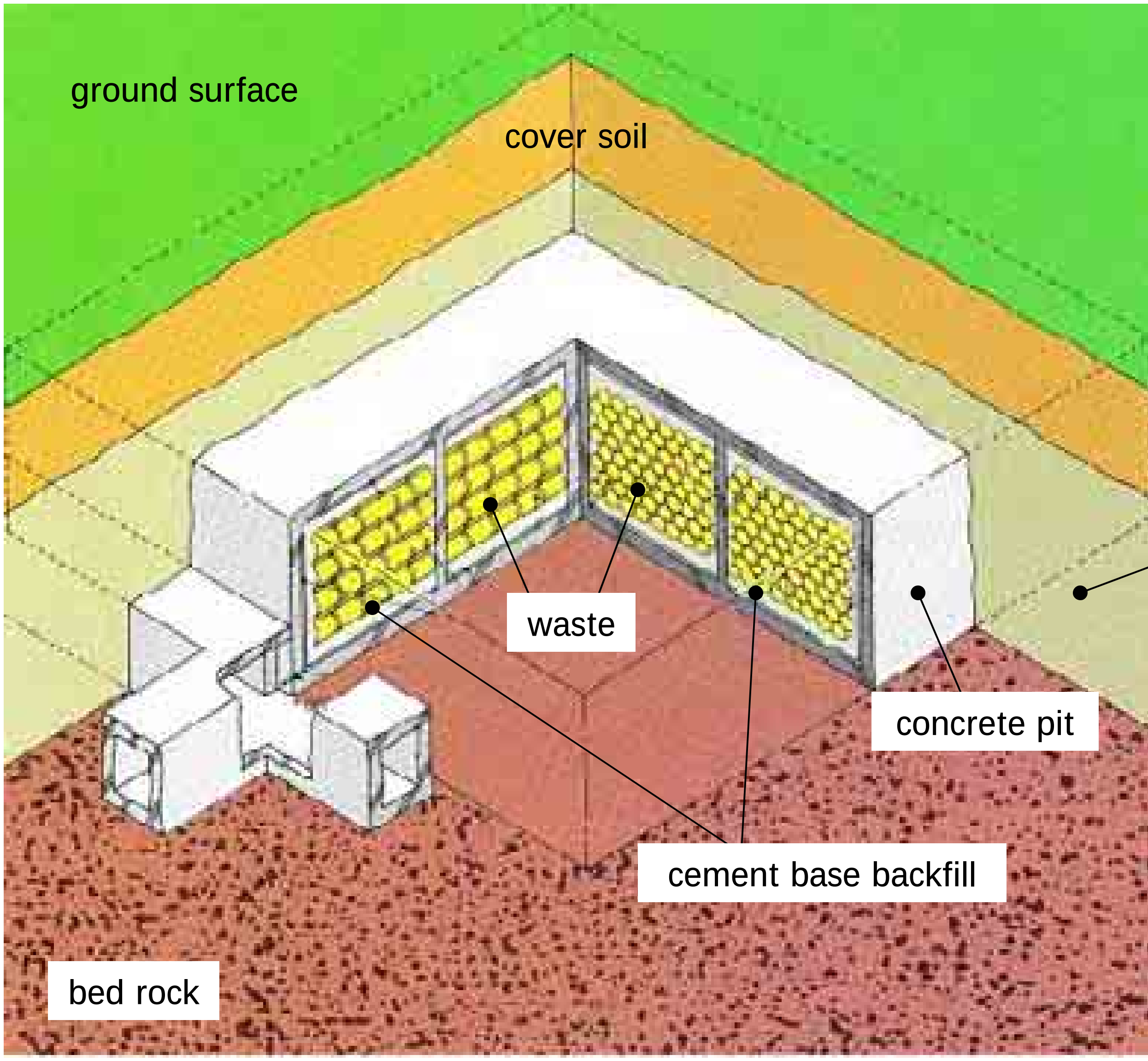


(source) JNFL

A Cross Section of a LLW Facility



A Cutaway View of a LLW Facility



■ Waste with relatively high levels of radioactivity (Level-1 waste)
：Disposal at around 50-100 meter depth

〇The geological survey started in Nov. 2002.

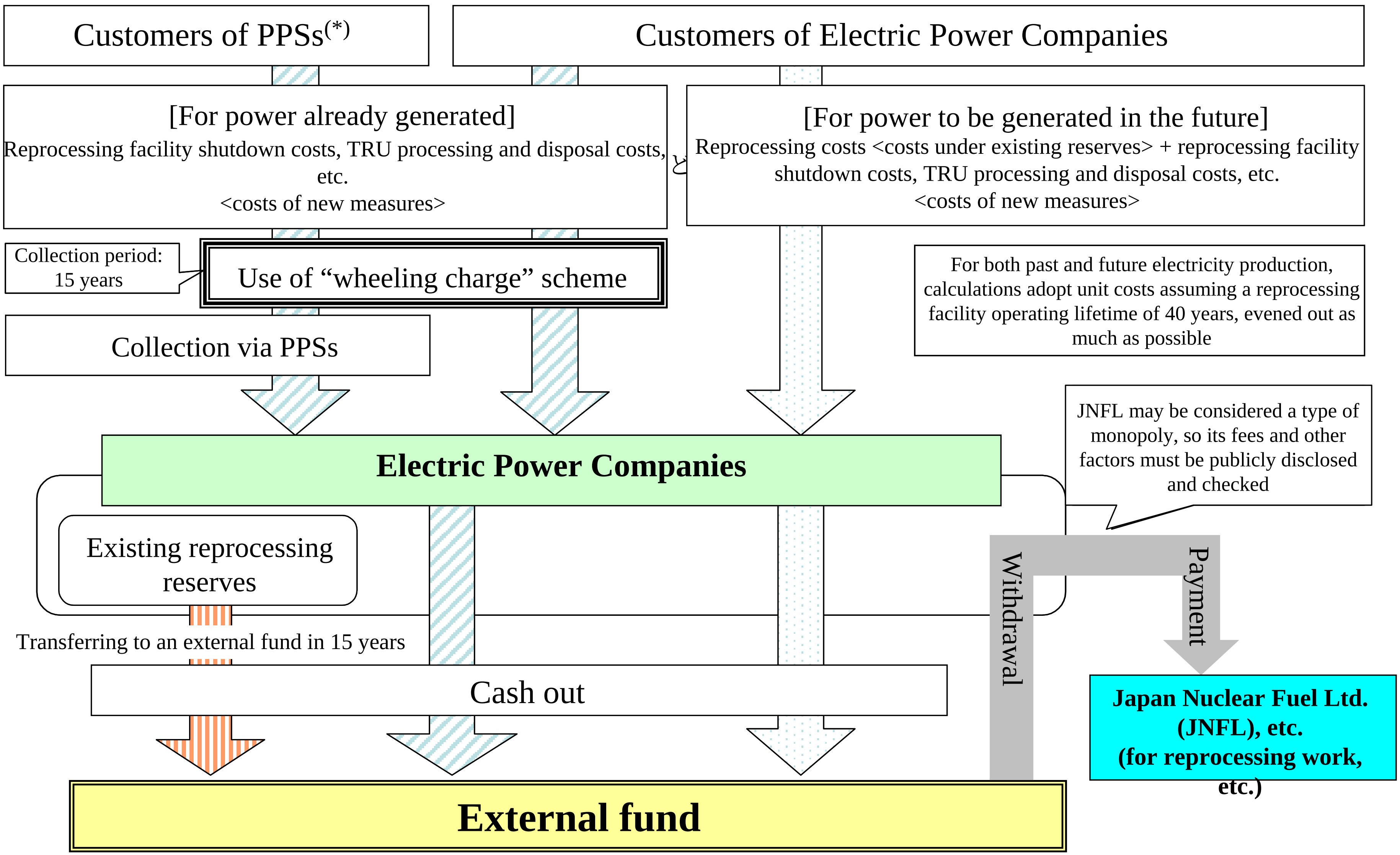
The End

Thank you very much for your attention.

Summary of Evaluation of Basic Scenarios for Each Perspective

Perspectives	Summary of Evaluation
Safety	Practically no difference among scenarios
Energy Security	10-20% uranium saving for LWR fuel recycle scenario Fuel is secure semi-permanently for FBR fuel recycle scenario.
Environmental Compatibility	Recycling is in line with the philosophy of sustainable society. I.e. Recover resources and reduce wastes
Economics	Direct disposal of all of the spent fuel is cheaper than "reprocess all" scenario by 0.5-0.7yen/kWh.
Nuclear Non-Proliferation Compliance	No big differences among scenarios if Japan keeps full scope safeguards by IAEA and continues current management of nuclear materials.
Technical Readiness	Direct disposal is studied far behind technically compared with reprocessing. R&D would be necessary for direct disposal of spent fuel in future, just for a case.
Acceptability (Difficulty of new sites)	Interim storage of spent fuel (scenario#3 and #4) requires a site of 4,000-ton capacity in every five years up to 2050. Can people trust that all fuel would be taken out at the end of storage?
Elasticity for Future Option (Flexibility)	Direct disposal has the least flexibility for future option. To continue technical innovation around a reprocessing option will make it possible to accommodate possible changing circumstances in future.
Impact Assessment from Policy Change	Local government and people would upset, because they have supported the national policy by accepting the reprocessing facility. Large investment has been made by industry and economic loss would be serious if reprocessing would be given up. Replacing nuclear with fossil power would cause the higher energy cost.
Reference to International Trends	The Council learned that each country has its own reason to choose a scenario.

Diagram of Financial Scheme for Back-end Costs



*PPSs (Power Producers and Suppliers): Alternative suppliers, New market entrants

Estimated costs for back-end operations

	Expense ($1=\110)	
	(billion Yen)	(billion US$)
reprocessing (decommissioning of reprocessing plant*)	11,000 (1,550)	100 (14)
returned high level radioactive	300	3
returned TRU	560	5
high level radioactive waste transportation	190	2
high level radioactive waste disposal	2,550	23
TRU waste formation disposal	810	7
spent fuel transportation	920	8
spent fuel intermediate storage	1,010	9
MOX fuel fabrication	1,190	11
back-end of uranium enrichment plant	240	2
total	18,800	171

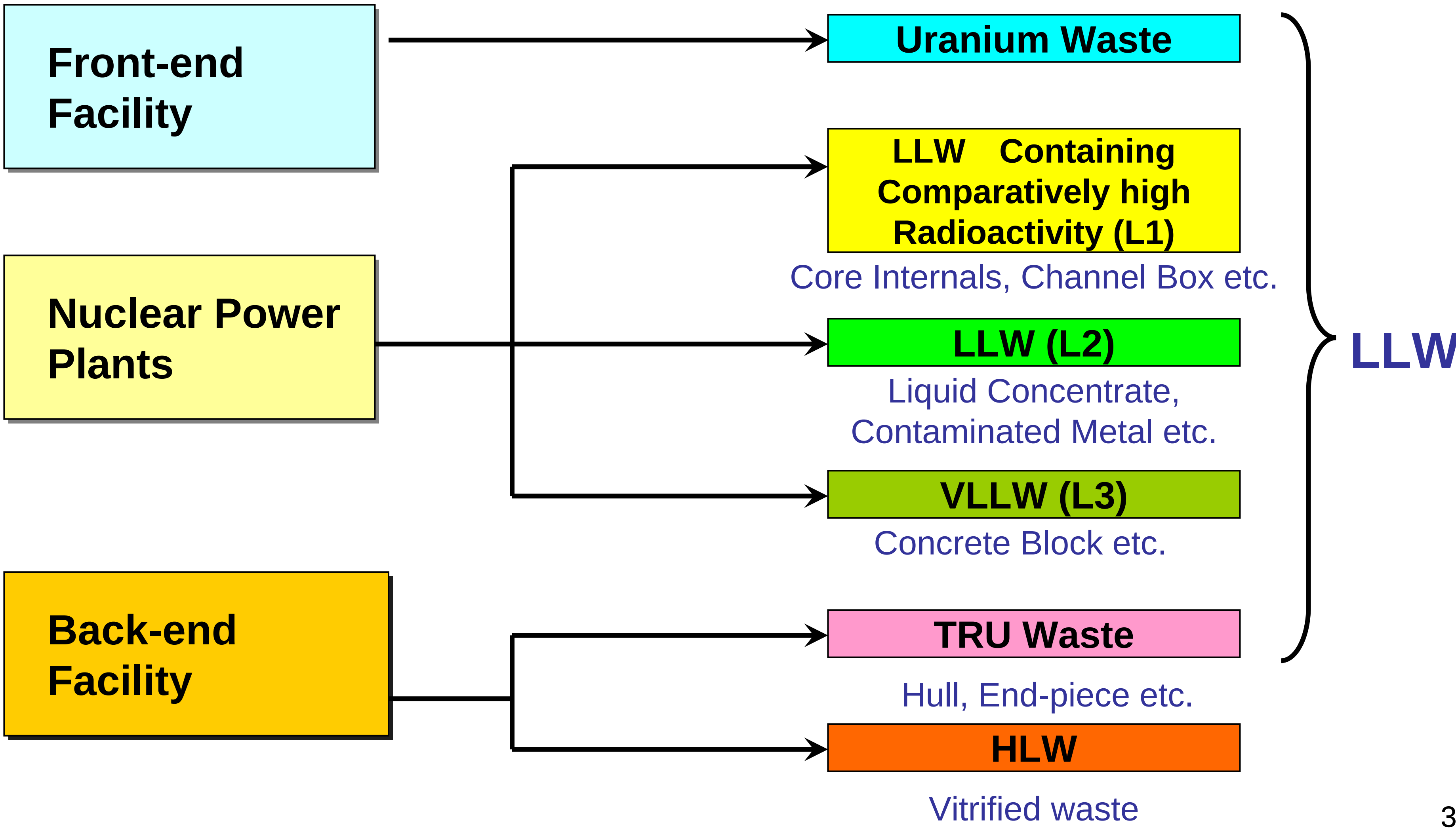
Source: Based on the document of the government's sub-panel to study regulations and measures (2004/3/18)
*Cost for decommissioning of reprocessing plant are not reserved.

Back-end Cost Burden-Sharing Concept

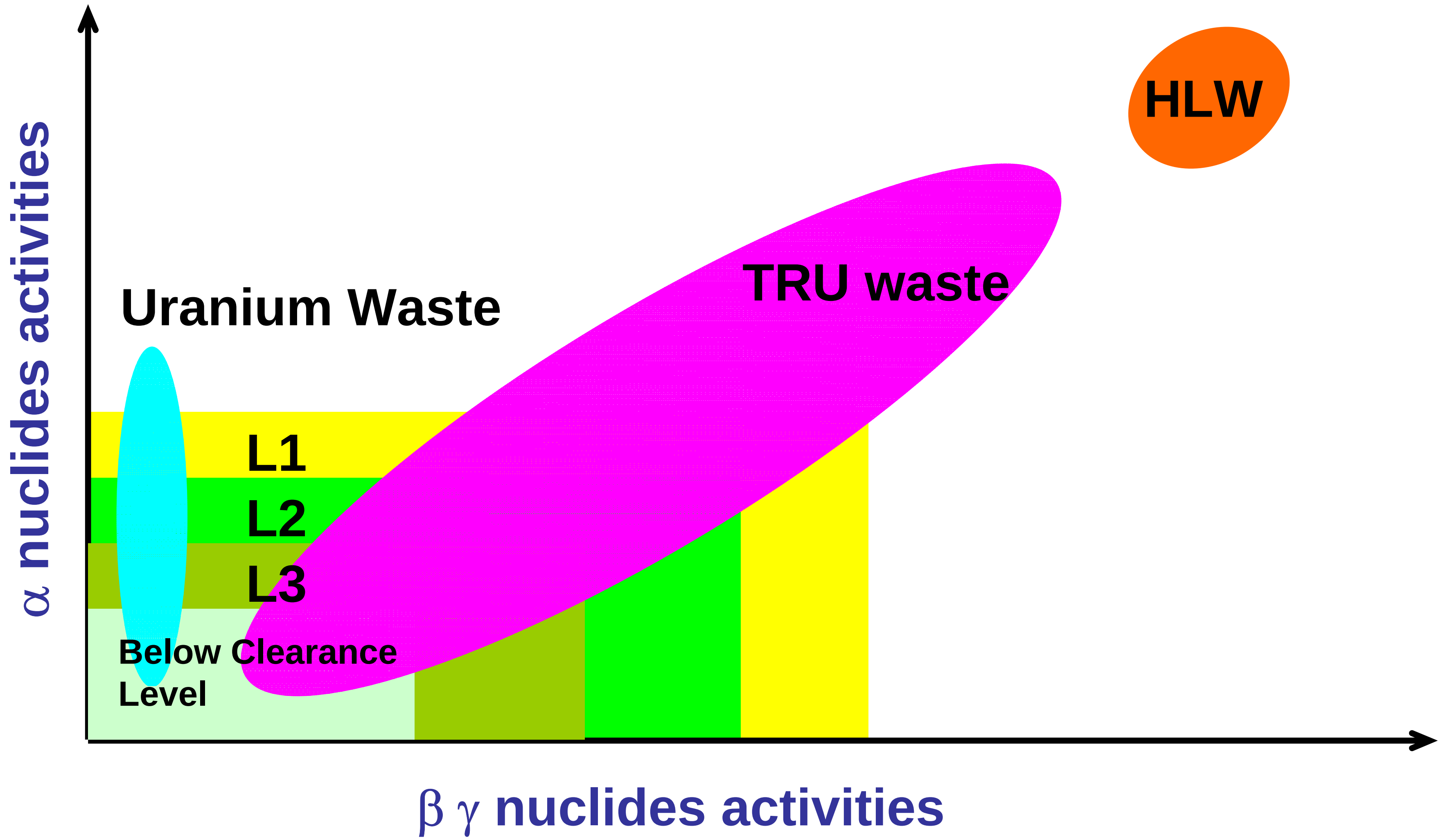
	For power already generated (equivalent to 14,000 tons of spent fuel)	For power to be generated in the future (equivalent to 18,000 tons of spent fuel)
Completed under existing system measures (reserves and contributions)	Portion of reprocessing operating costs, and high-level radioactive waste disposal costs \10.1 trillion *Collected by electric power companies from customers*	
Preparation of new reserves	Reprocessing facility shutdown measures; processing, storage and disposal of waste products from operations \5.1 trillion	
	For power already generated \2.7 trillion *Collection from all customers, including former customers*	For power to be generated in the future \2.4 trillion *To be collected by electric power companies from customers*
Items external to the new system measures (no reserves)	Intermediate storage of spent fuel, MOX fuel fabrication, international transportation fees for waste products that are reprocessed overseas and returned \3.6 trillion *To be collected by electric power companies from customers*	
Total	\18.8 trillion	

Waste Management Scheme in Japan

Category of Radioactive Wastes



Characteristics of Radioactive Wastes



Amount of Radioactive Waste in Japan

Classification			Amount of Domestic Storage (the end of 2003F.Y.)	Total Amount (Estimated)
HLW		Domestic	130 Canisters	41,000 Canisters
HLW		Returned from France and England	892 Canisters	2,200Canisters
LLW	Arising from Rectors		640,000 Drums ($128,000m^3$)	2,750,000 Drums ($550,000m^3$)
LLW	TRU Waste	Domestic	130,000 Drums ($25,000m^3$)	650,000 Drums ($130,000m^3$)
LLW	TRU Waste	Returned from France and England	0 Drums	63,000 Drums ($13,000m^3$)
LLW	Uranium Waste		140,000 Drums ($27,000m^3$)	430,000 Drums ($85,000m^3$)
LLW	RI Waste etc.		240,000 Drums ($49,000m^3$)	350,000 Drums ($70,000m^3$)

(Source) New Nuclear Policy Planning Council (10 Feb. 2005)

Status of Regulation Developments for Radioactive Waste

<table>
<tr><th colspan="3" rowspan="2">Classification</th><th>Atomic Energy Commission</th><th colspan="4">Nuclear Safety Commission</th><th>Nuclear and Industrial Safety Agency (METI)</th></tr>
<tr><th>Basic Policy for Disposal</th><th colspan="2">Direction for Safety Regulation</th><th>Radionuclide Limits for Disposal</th><th>Method of Safety Examination</th><th>Establishment of Regulatory Law and Provision</th></tr>
<tr><td colspan="3">HLW</td><td>May. 1998</td><td>Nov. 2000</td><td rowspan="8">Common Important item (Jun. 2004)</td><td></td><td></td><td></td></tr>
<tr><td rowspan="7">LLW</td><td rowspan="4">Arising from Reactors</td><td>L1</td><td>Oct. 1998</td><td>Sep. 2000</td><td>Sep. 2000</td><td></td><td>Dec. 2000</td></tr>
<tr><td>L2</td><td rowspan="3">Aug. 1984</td><td rowspan="3">Oct. 1985</td><td>Feb. 1987, Jun. 1992</td><td>Mar. 1988</td><td>Mar. 1987 – Feb. 1993</td></tr>
<tr><td>L3(Concrete etc.)</td><td>Jun.1992</td><td>Jan. 1993</td><td>Sep. 1992 – Feb. 1993</td></tr>
<tr><td>L3(Metal etc.)</td><td>Sep. 2000</td><td></td><td>Dec. 2000</td></tr>
<tr><td colspan="2">TRU Waste</td><td>Mar. 2000</td><td>Jun. 2000～</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Uranium Waste</td><td>Dec. 2000</td><td>Apr. 2001～</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">RI Waste etc.</td><td>Jun. 1998</td><td>Jun. 1998～</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Clearance Level</td><td>Aug. 1984</td><td colspan="3">Oct. 2004</td><td></td><td>May 2005</td></tr>
</table>

: Already studied (or established)
: Under studying
: Almost studied (or established)
: No discussion is made.

(Source) New Nuclear Policy Planning Council (10 Feb. 2005)