Prospected Nuclear Energy System to 2030, 2050, and 2150 in Japan

Plenary Panel II: Prospect on the Projected Quantities of Nuclear Systems in the Future

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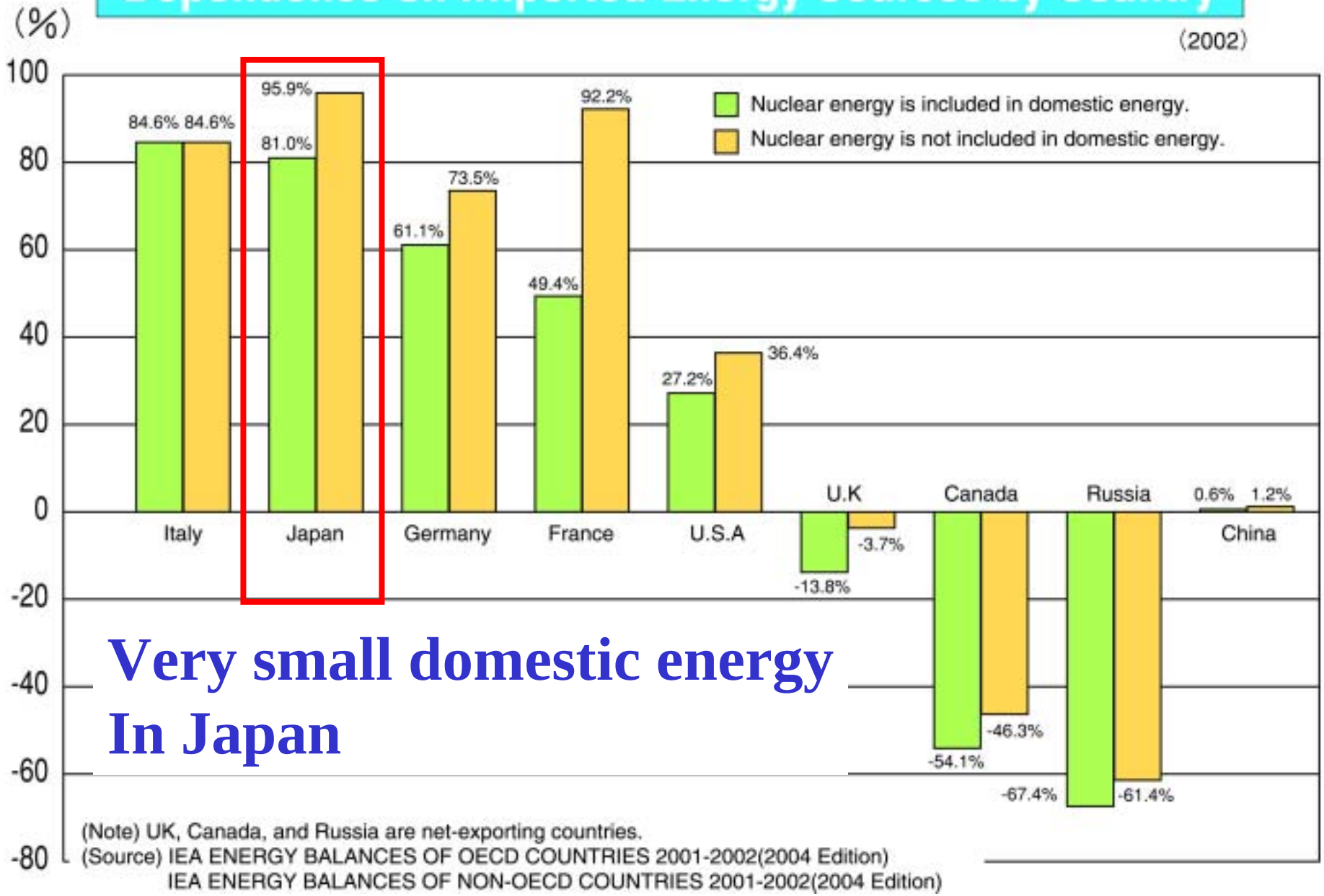
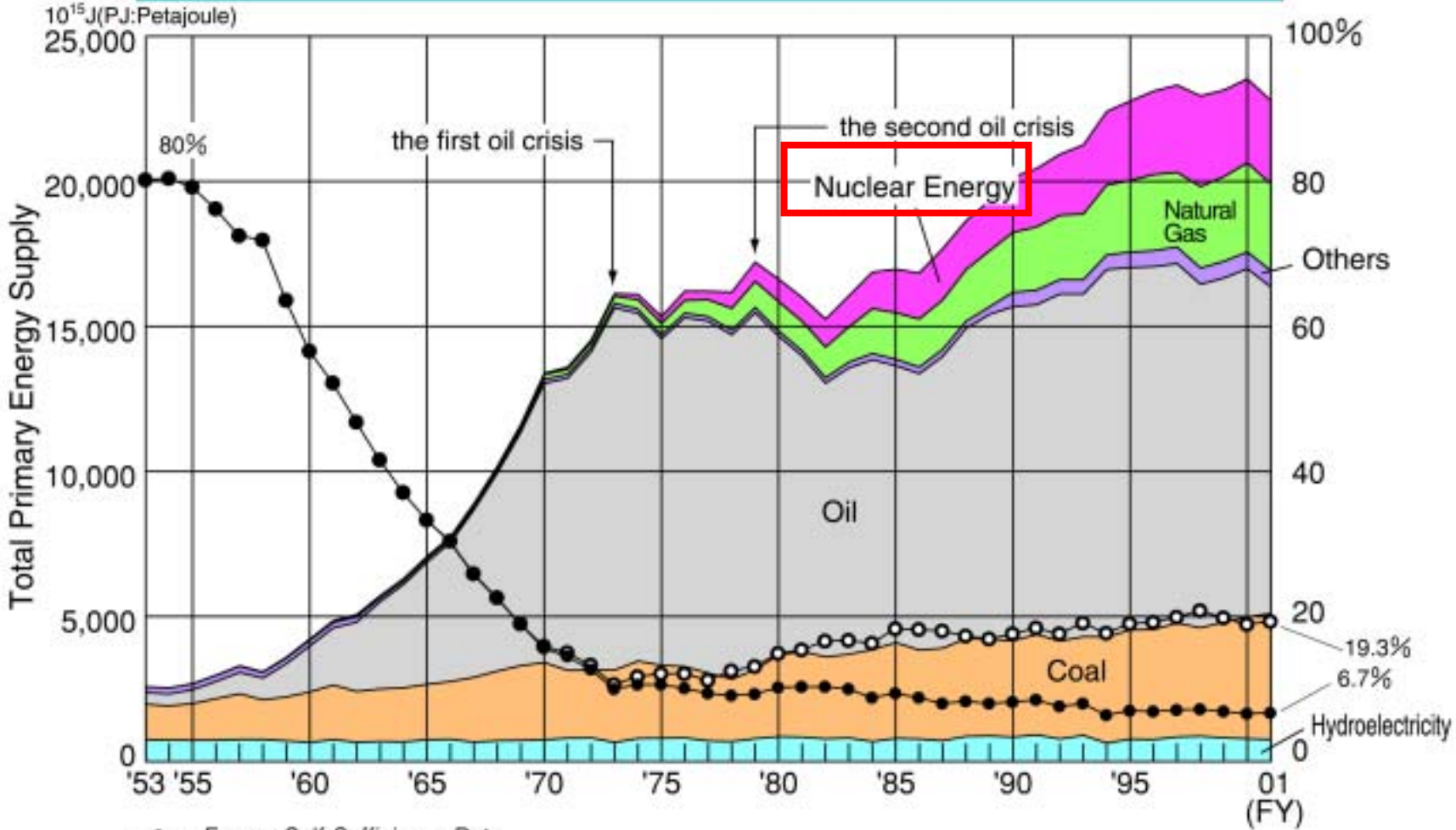
Dependence on Imported Energy Sources by Country



Very small domestic energy In Japan

(Note) UK, Canada, and Russia are net-exporting countries.
(Source) IEA ENERGY BALANCES OF OECD COUNTRIES 2001-2002(2004 Edition)
IEA ENERGY BALANCES OF NON-OECD COUNTRIES 2001-2002(2004 Edition)

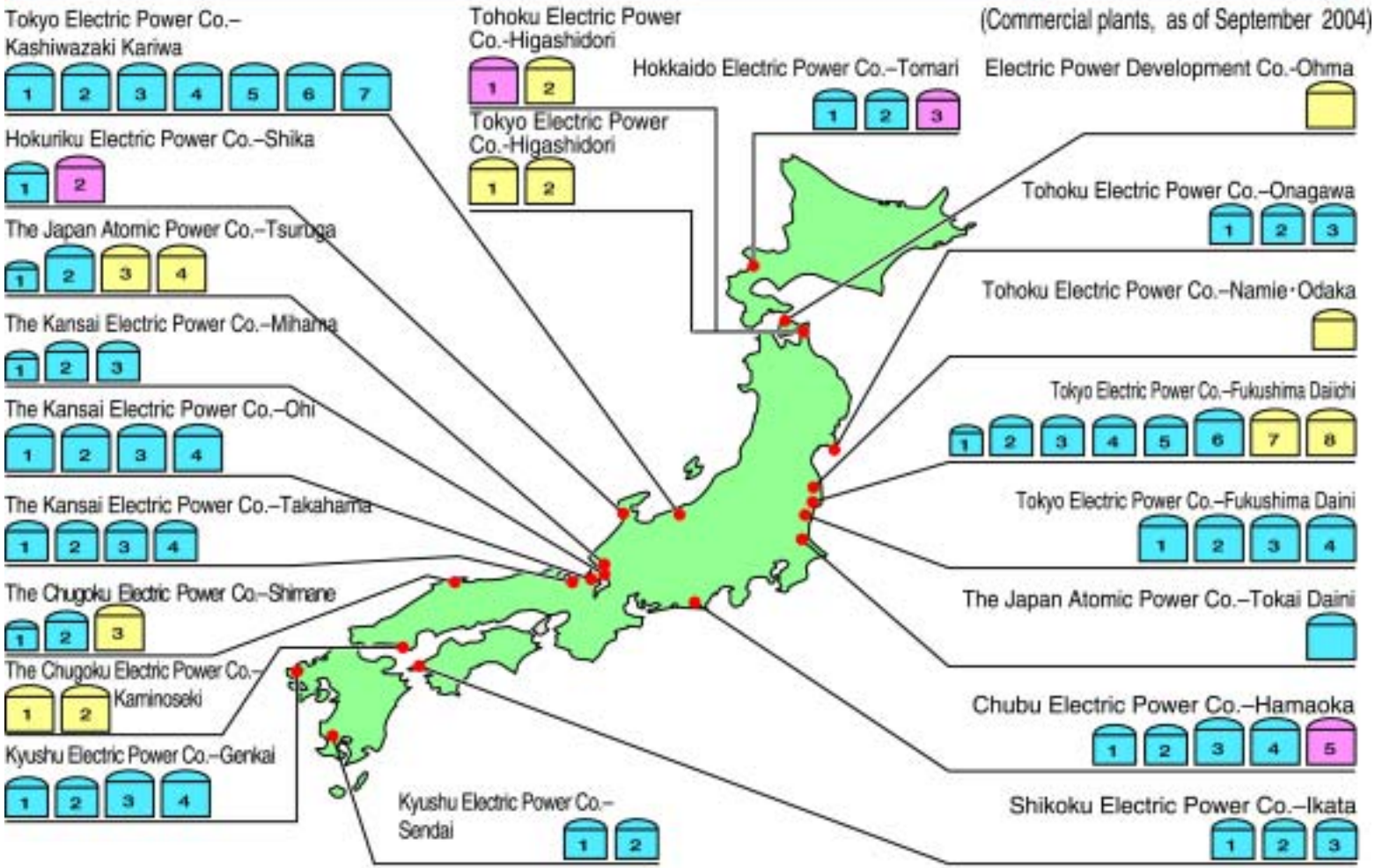
Historical Trend of Japan's Primary Energy Supply



(Note) One petajoule is equivalent to approximately 25,800,000 liters of crude oil in calorie.
(Source) Agency of Natural Resources and Energy

Nuclear Power Plants in Japan

(Commercial plants, as of September 2004)



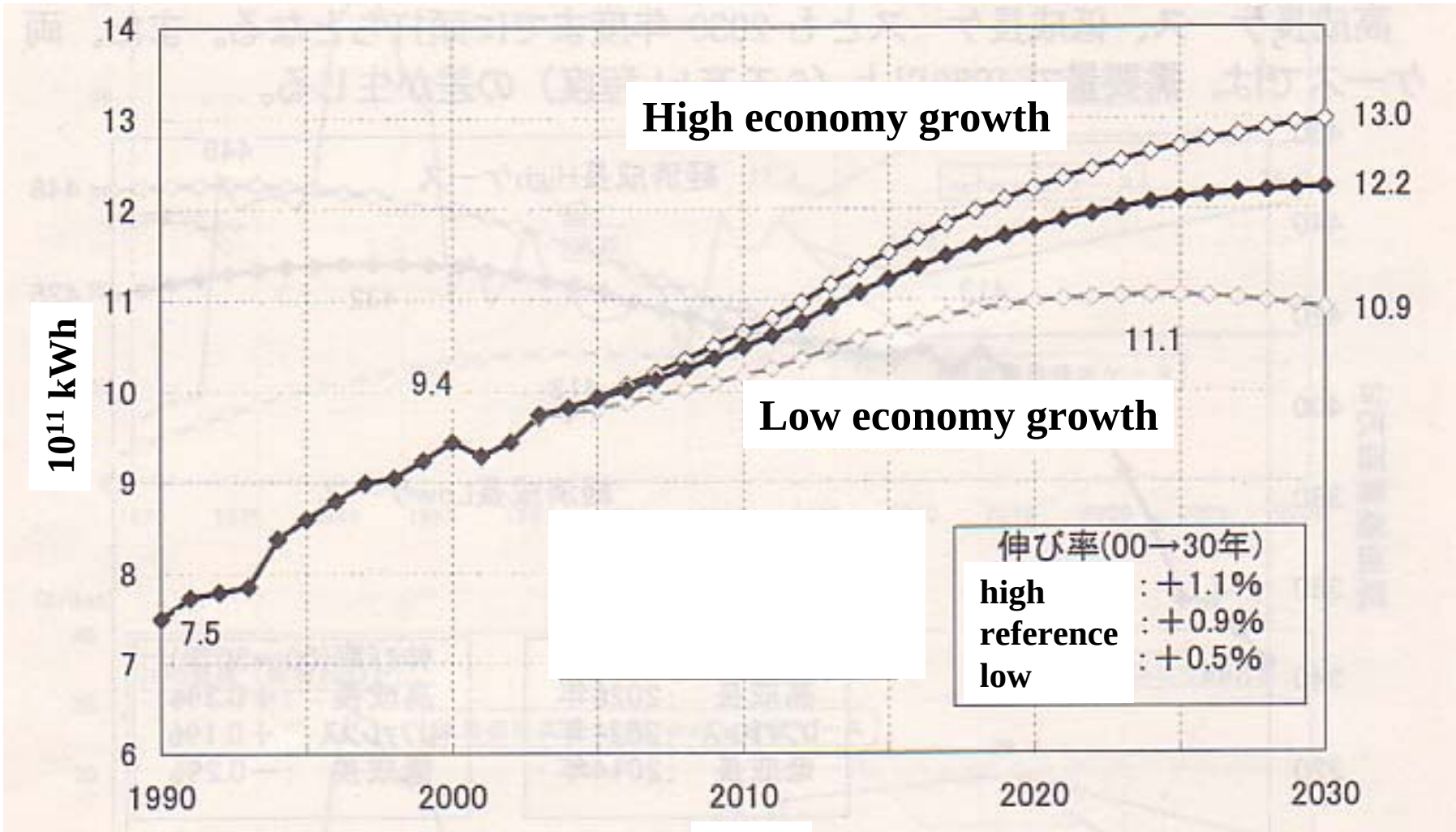
Output scale

Under 500MW | Under 1,000MW | Over 1,000MW

Operating
Under construction
Preparing for construction

	Number of Units	Total Output (MW)
Operational	52	45,742
Under construction	4	4,570
Preparing for construction	12	16,318
Total	68	66,810

Forecast of Electricity Production in 2030 by Ministry of Economy, Trade and Industry (METI) (2005)



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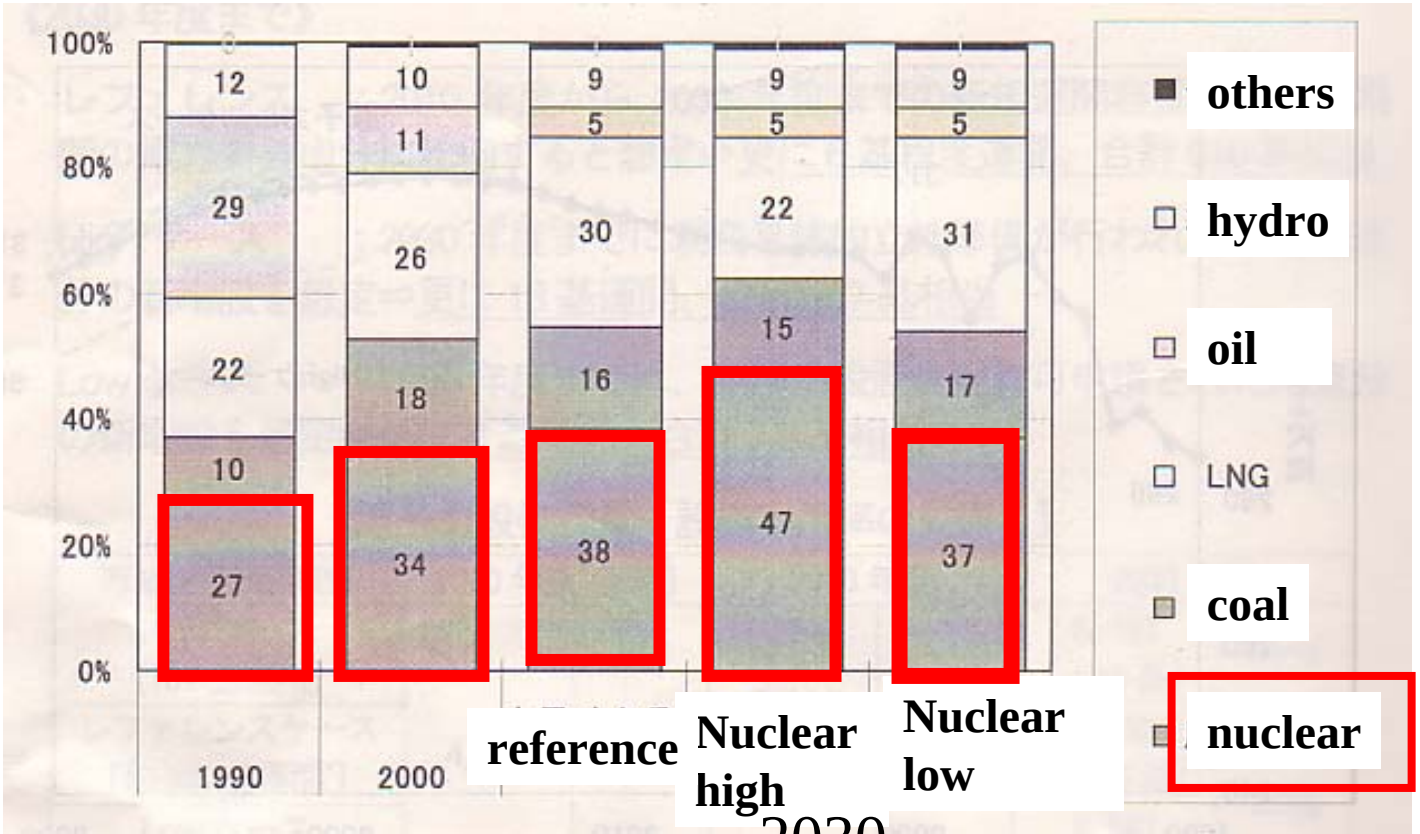
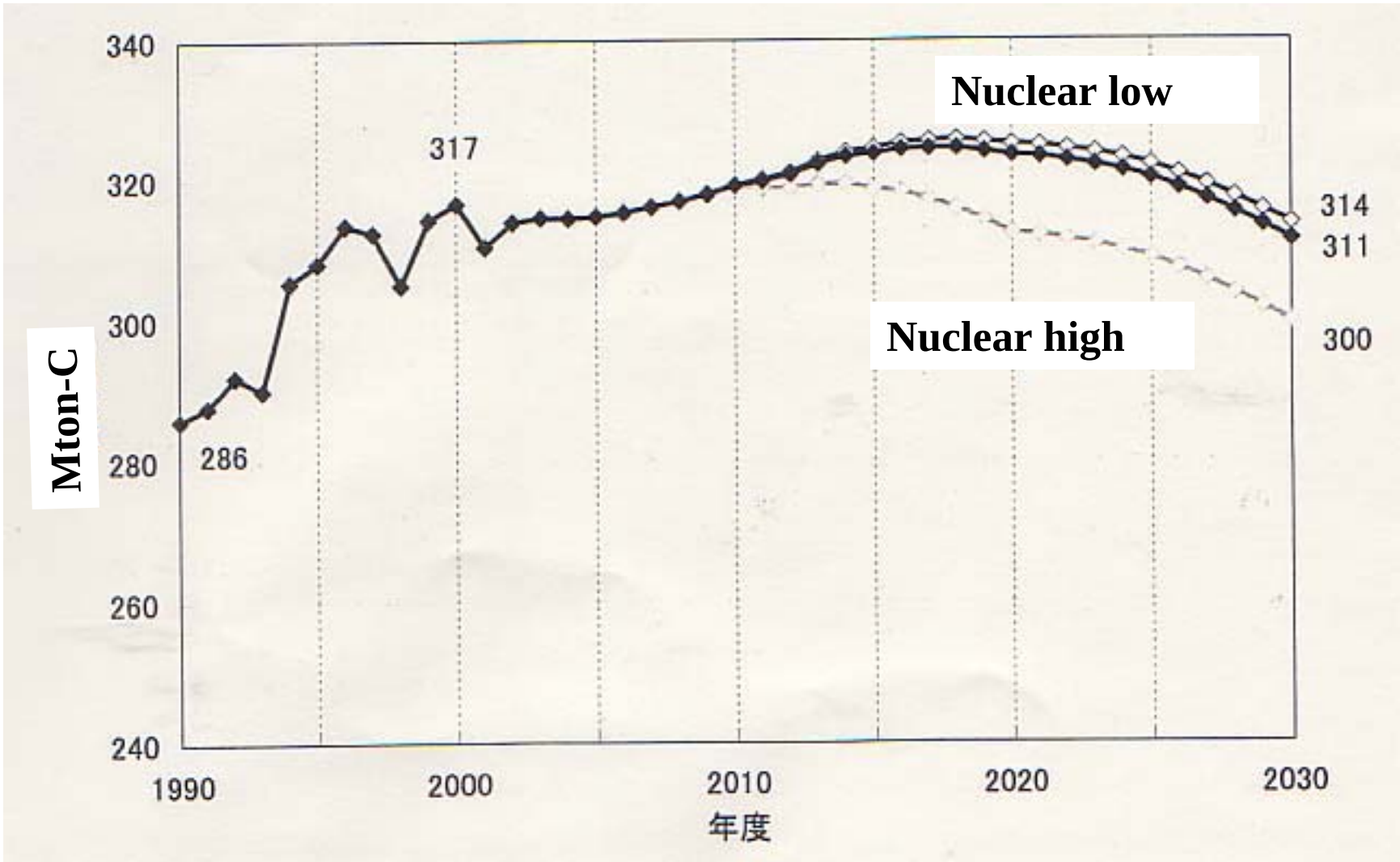


Capacity/availability	2000	2010	2030
High	44.9GW 82%	50.1GW 85% NPP +3	68.0GW 90% (+13)
Reference			58.0GW 85% (+6)
Low			56.0GW 85% (+4)

Forecast of Carbon Release in 2030 by METI (2005)



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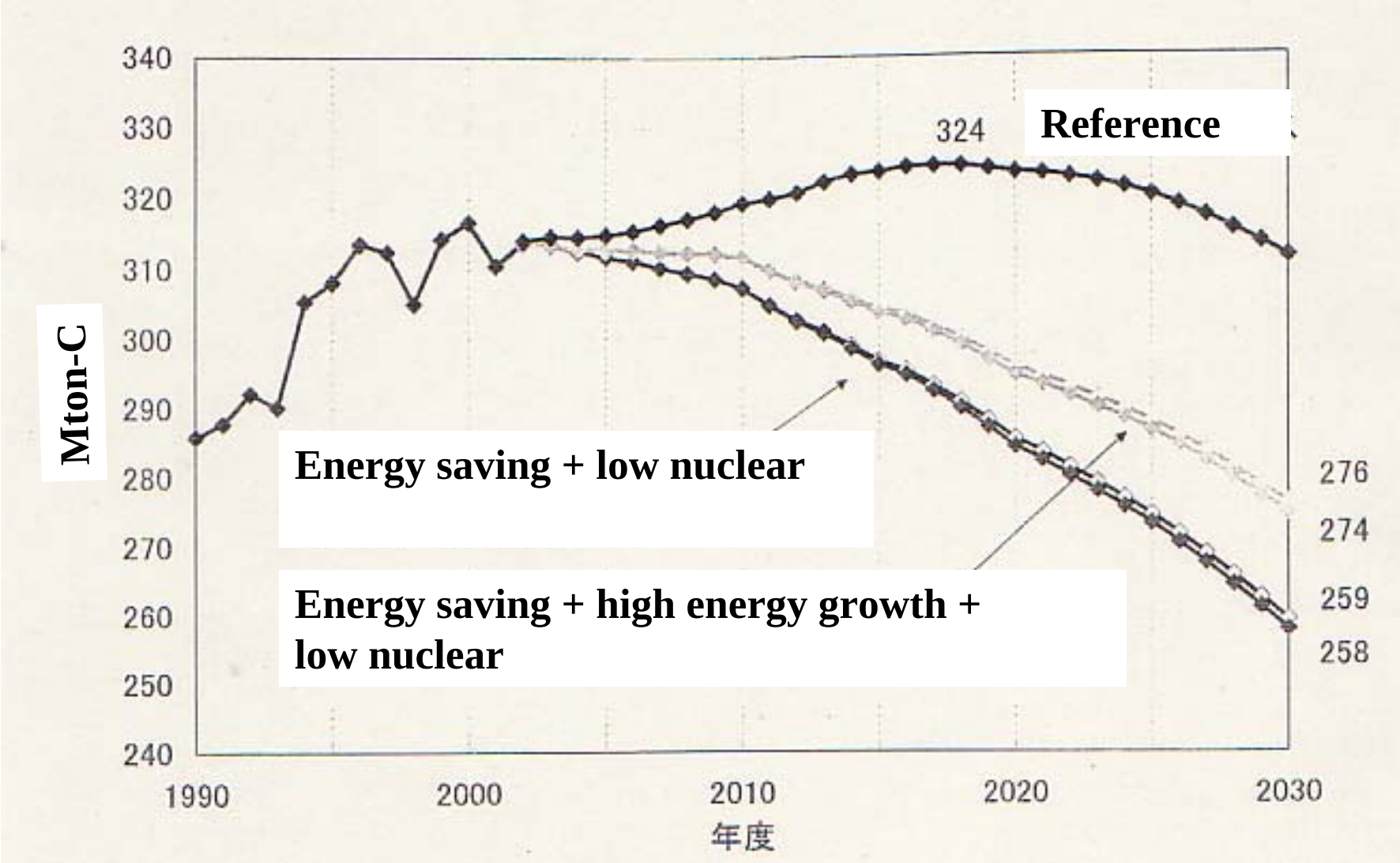
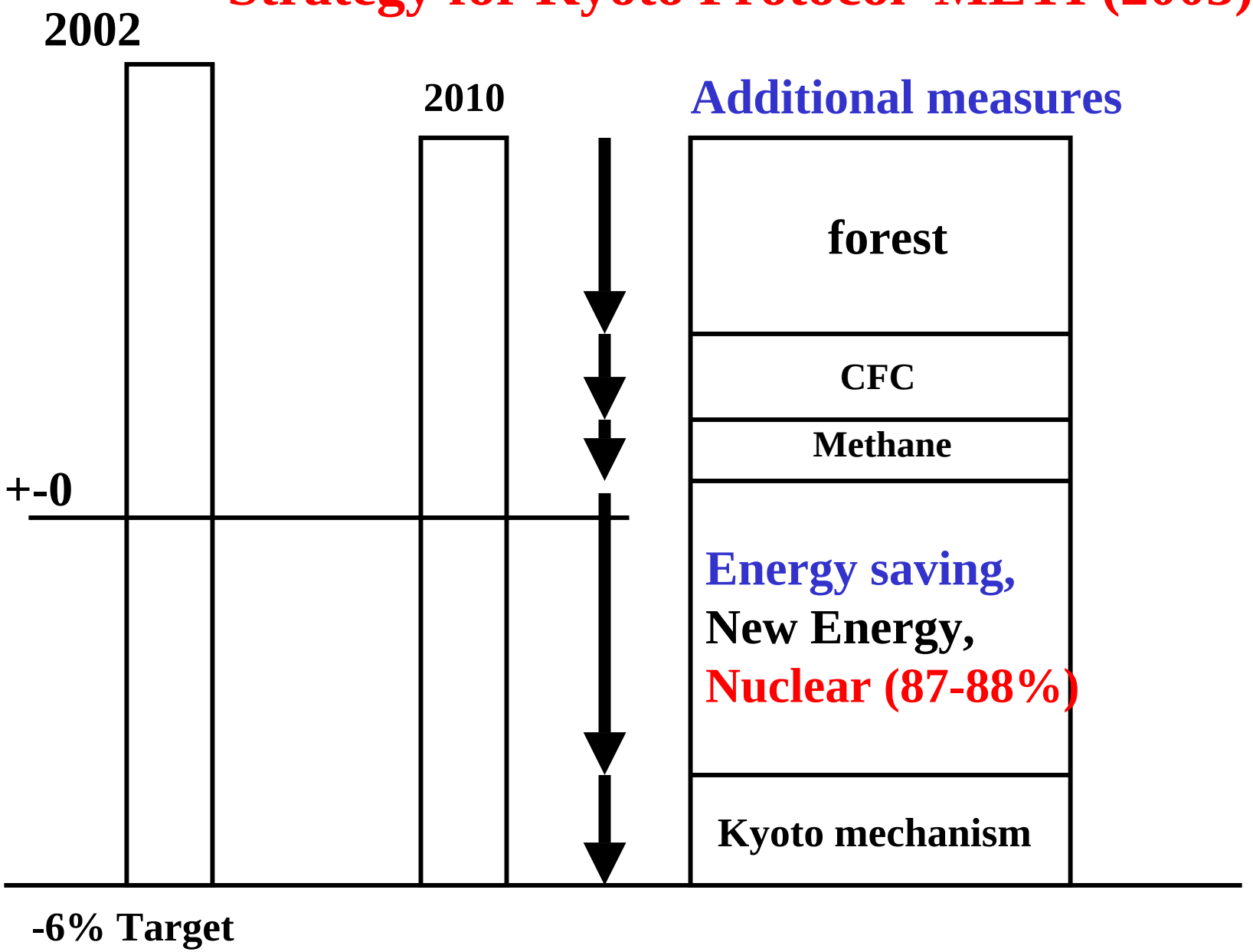
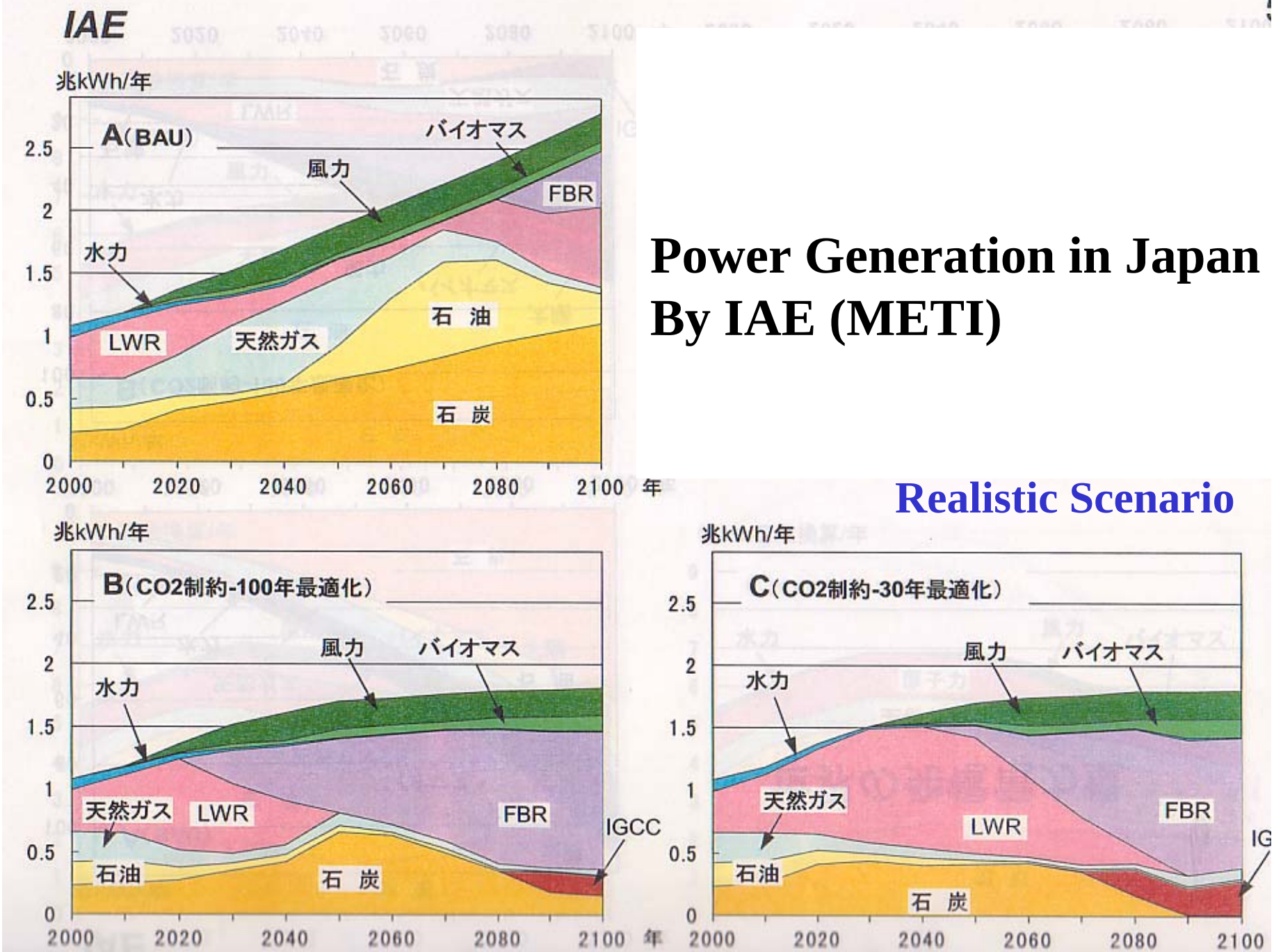


Strategy for Kyoto Protocol METI (2005)



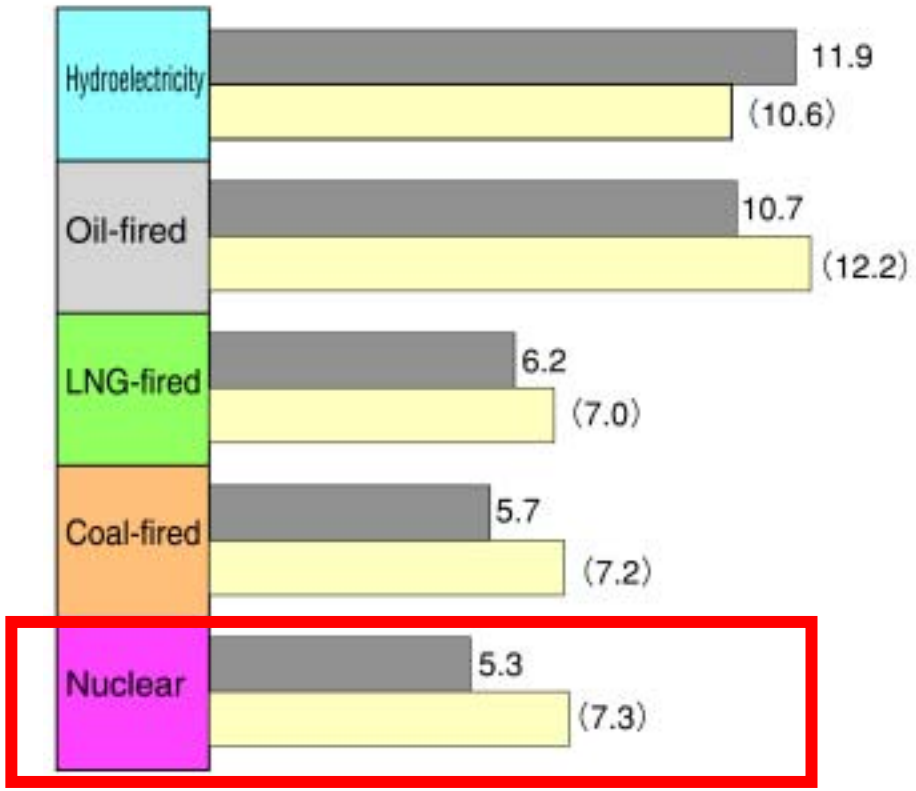
Power Generation in Japan By IAE (METI)

Realistic Scenario



METI (2004)

Generation Costs per kWh (sending end)



＜Premises of trial calculation＞

Power source	Operation period	Utilization rate	Output per unit
Hydroelectricity	40 yrs	45%	15MW
Oil-fired	40 yrs	80%	400MW
LNG-fired	40 yrs	80%	1,500MW
Coal-fired	40 yrs	80%	900MW
Nuclear	40 yrs	80%	1,300MW

- Based on the assumption that a plant started operation in FY2002
- Exchange rate (avg. in FY2002) 121.98 yen/$
- Fuel prices (avg. in FY2002)
  Oil: 27.41$/bbl
  Coal: 35.5$/t
  LNG: 28,090 yen/t
- Fuel cost increase in oil, coal, & LNG IEA, "World Energy Outlook"

Breakdowns of nuclear fuel cycle costs

Nuclear fuel cycle expenses	1.47yen/kWh
Front-end	0.66yen/kWh
Back-end	0.81yen/kWh
Reprocessing of spent fuel (fuel transports included)	0.50yen/kWh
Intermediate storage of spent fuel (fuel transports included)	0.04yen/kWh
HLW storage, transports, disposal	0.15yen/kWh
TRU processing, storage, disposal	0.09yen/kWh
Decommissioning of reprocessing facillities	0.03yen/kWh

Upper — Generation cost when operating period set at 40 years.
- Discount rate set at 3%

Lower — Generation cost when operating period set at valid service life for each power source.
(Hydroelectricity 40 years, Oil-fired 15 years, LNG-fired 15 years, Coal-fired 15 years, Nuclear 16 years).
- Discount rate set at 2%

COE by Nuclear is comparable with LNG-fired and Coal-fired

Discussion on Nuclear Fuel Policy in Japan (2004) for "Framework of Nuclear Energy Policy" by AEC (2005)

Scenarios for the spent fuel handling

Scenario-1 : Reprocess all spent fuel

Scenario-2 : Partial Reprocessing up to 32,000tU (Rokkasyo R. P. Capacity) disposal beyond 32,000tU

Scenario- 3: Direct disposal of all SF

Scenario- 4: No decision will be made for several decades

Evaluation points

(1) Safety
(2) Energy Security
(3) Environmental Compatibility
(4) Economics
(5) Non-proliferation Compliance
(6) Engineering Feasibility
(7) Public Acceptance
(8) Flexibility
(9) Policy Change Issues
(10) International Trends

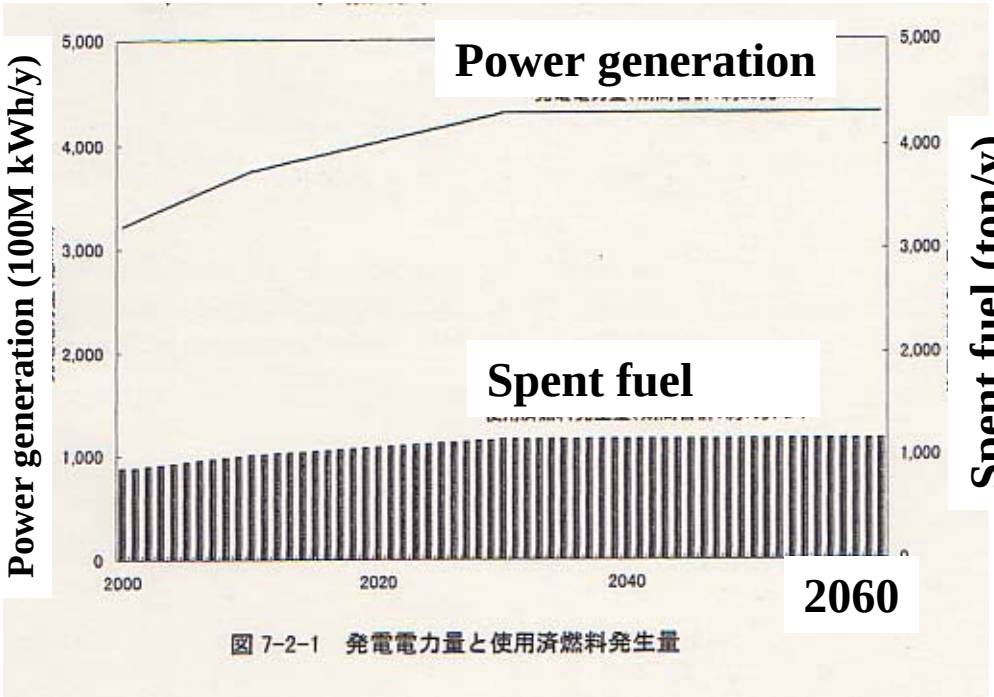


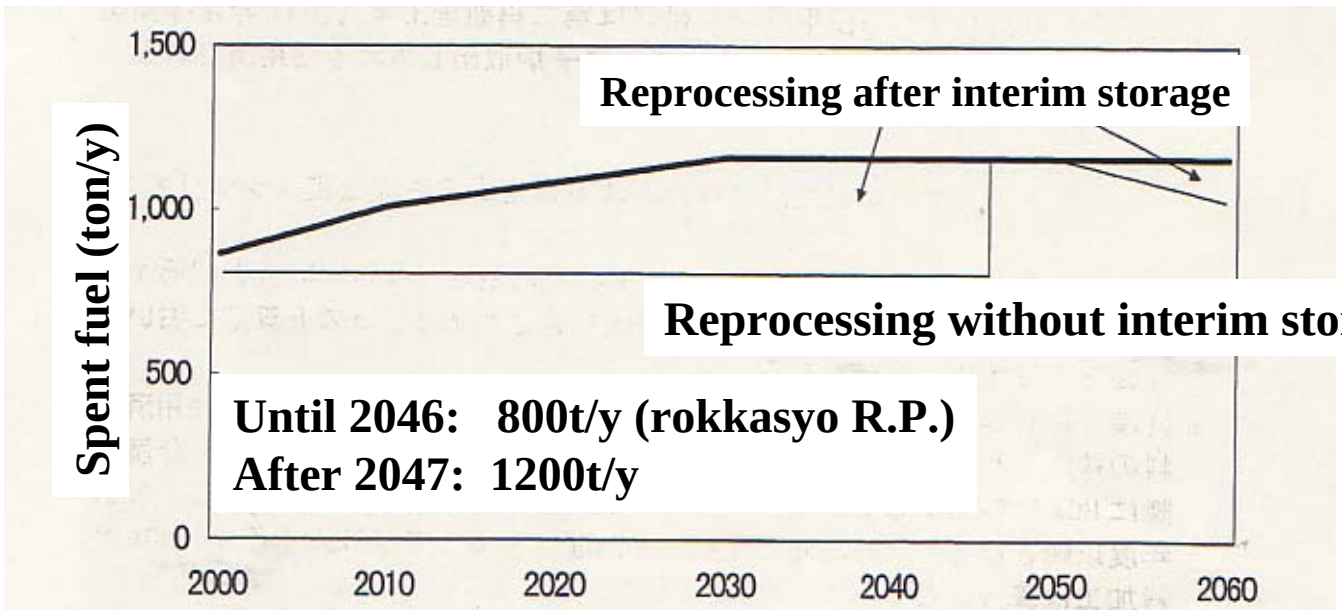
図 7-2-1　発電電力量と使用済燃料発生量

COE calculation

-Fuel cycle cost for Nuclear Power Generation from 2002 to 2060

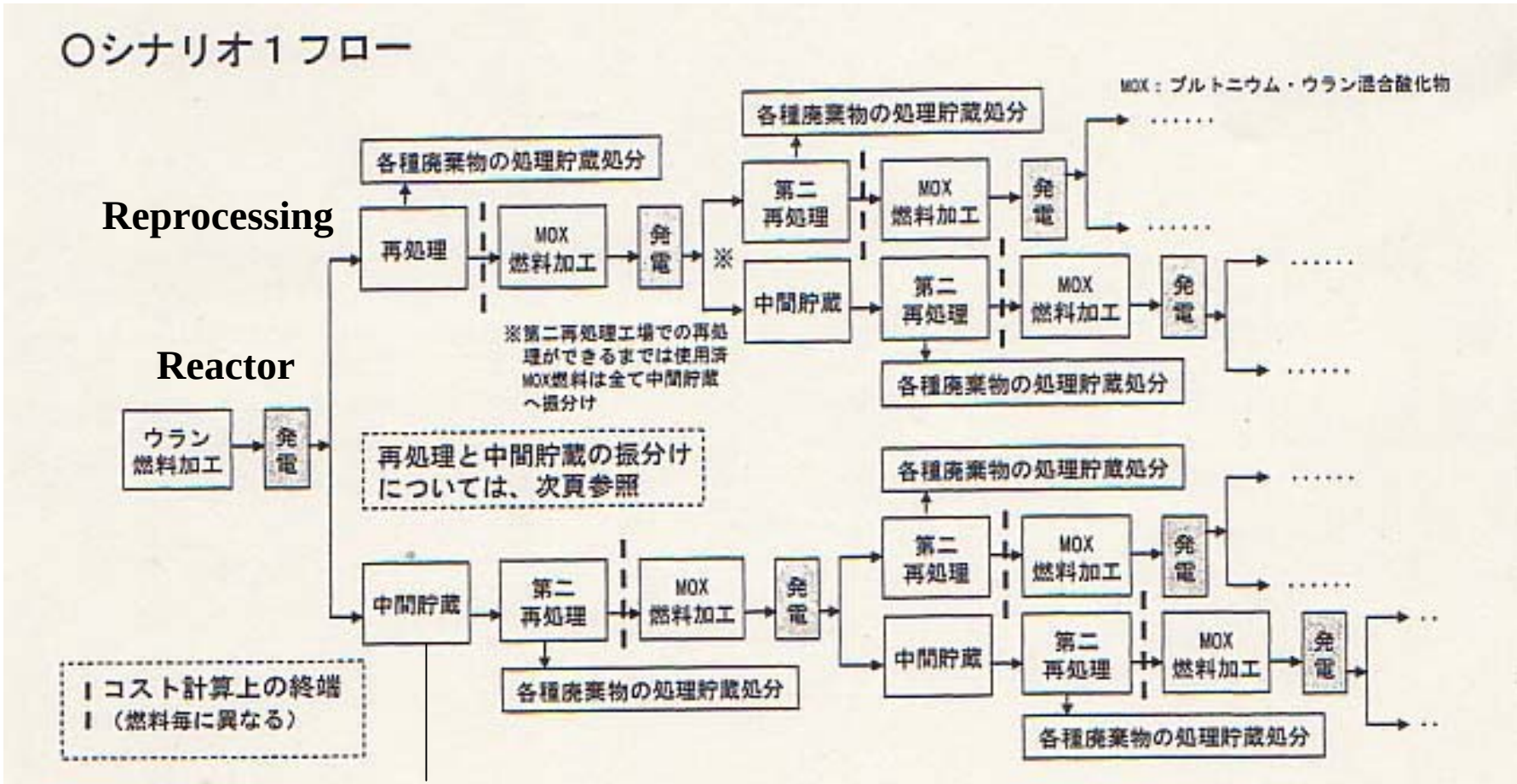
-45,000MWD/t

-Thermal efficiency 34.5%



Scenario 1

Detailed Calculation Scheme for Scenario 1



Economic Comparison (Yen/kWh)

Items	Sce. 1 Repr. All	Sce. 2 Partial Repr.	Sce. 3 Direct Disposal	Sce. 4 Storage
COE	~5.2	5.0-5.1	4.5-4.7	4.7-4.8
Fuel cycle	1.6	1.4-1.5	0.9-1.1	1.1-1.2
Front end	0.63	0.63	0.61	0.61
Backend	0.93	0.77-0.85	0.32-0.46	0.49-0.55
Cost by Policy Change	-	-	0.9-1.5 Decom. RPP ~ 0.2 fossile plant 0.7-1.3	
COE + Pol. Ch.	~ 5.2	5.0-5.1	5.4-6.2	5.6-6.3

Conclusion on Nuclear Fuel Policy (AEC) (2004)

Overall consideration is important: energy security, economics, recycle society, flexibility for future uncertainty.

The basic nuclear fuel cycle policy of Japan is to reprocess all spent fuels and to use the recovered plutonium and uranium efficiently.

Projected Quantities of Nuclear Systems in the Future evaluated by AEC (2004)

(1) Until 2050

To evaluate middle term by comparing with current reprocessing scenario

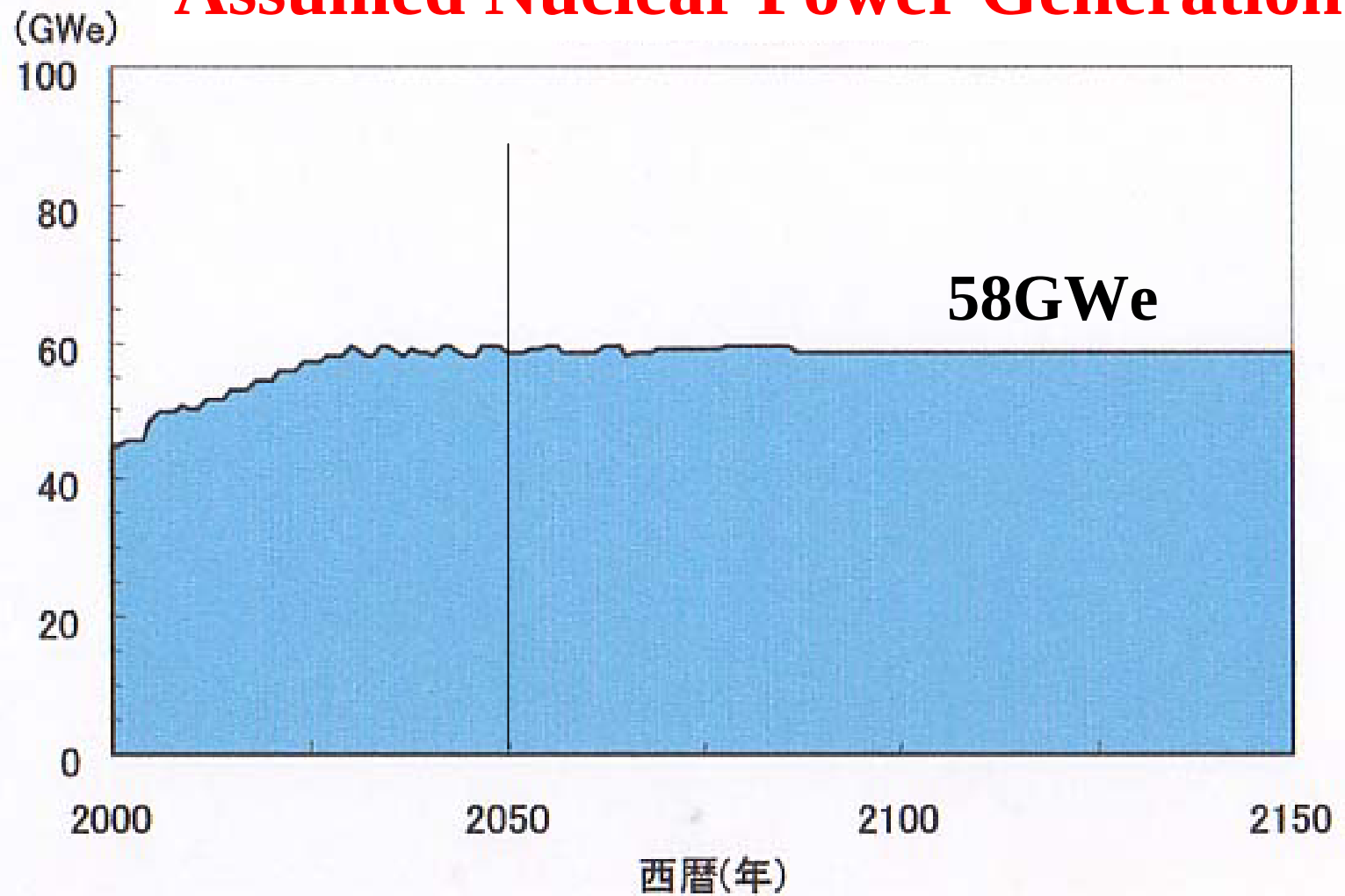
(2) Until 2150

To evaluate long term by comparing FBR scenario with other scenarios

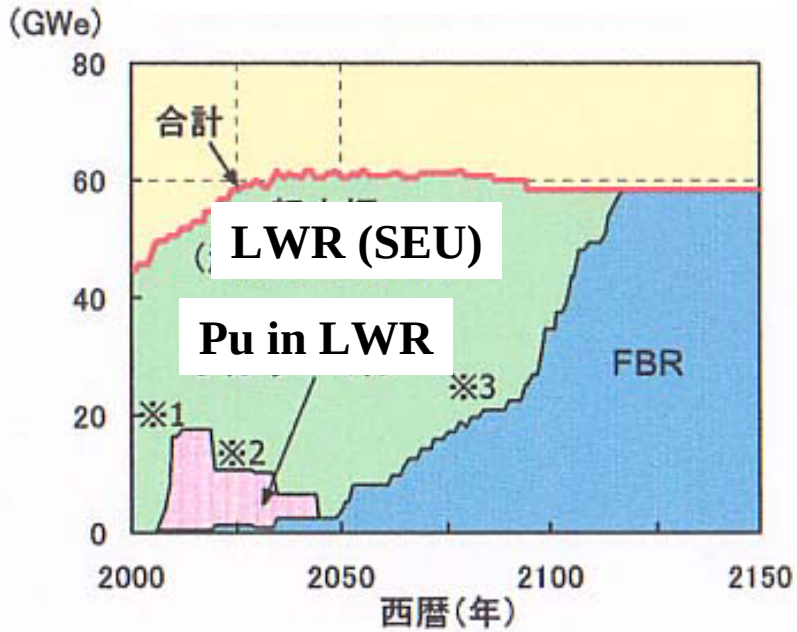
Scenarios

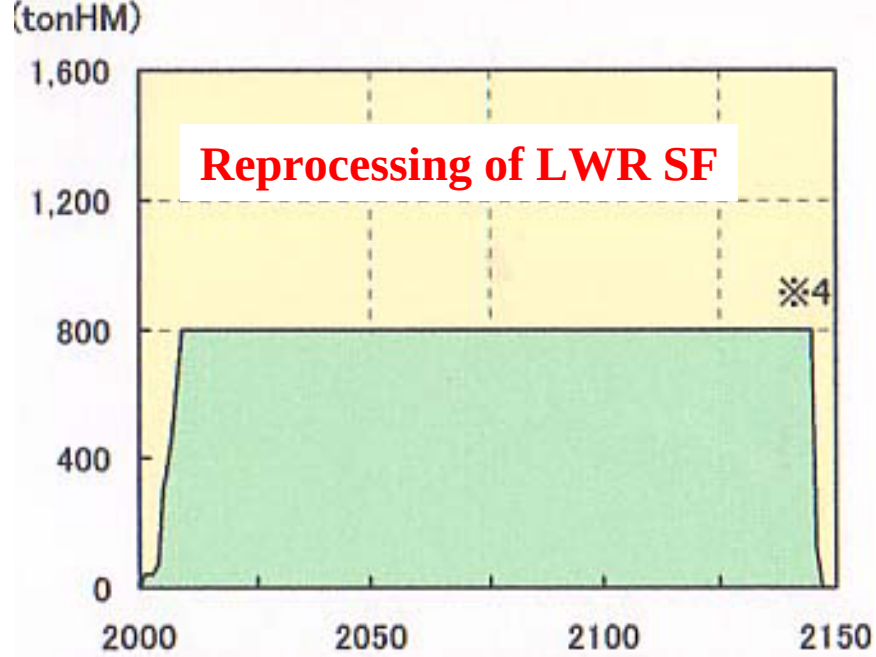
1. **Reprocessing all (FBR after 2050, cont.MOX in LWR)**
2. **Partial Reprocessing (Rokkasyo R. P. only, + DD)**
3. **Direct disposal**
4. **Storage until 2050, then decide**

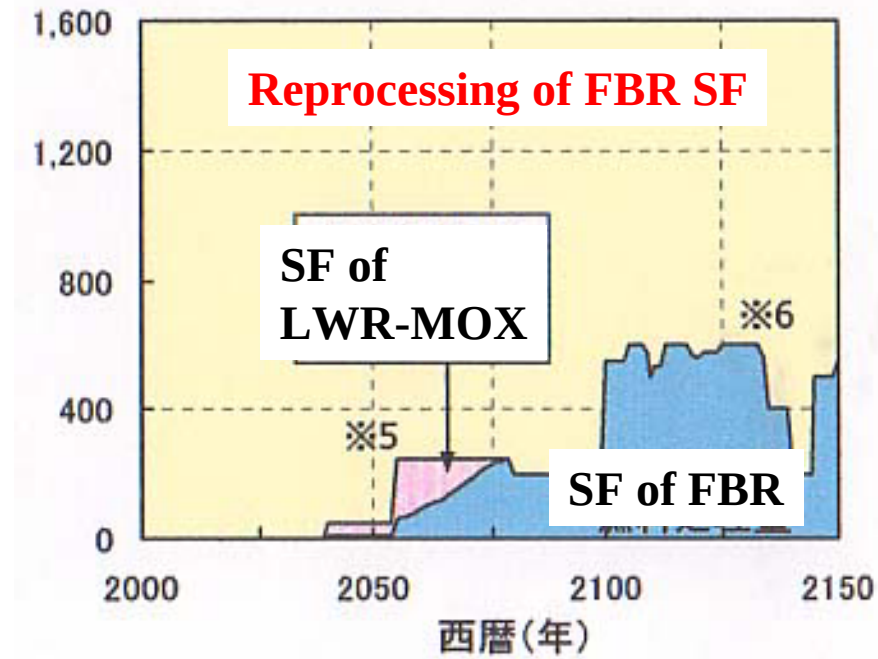
Assumed Nuclear Power Generation



Nuclear Power Generation

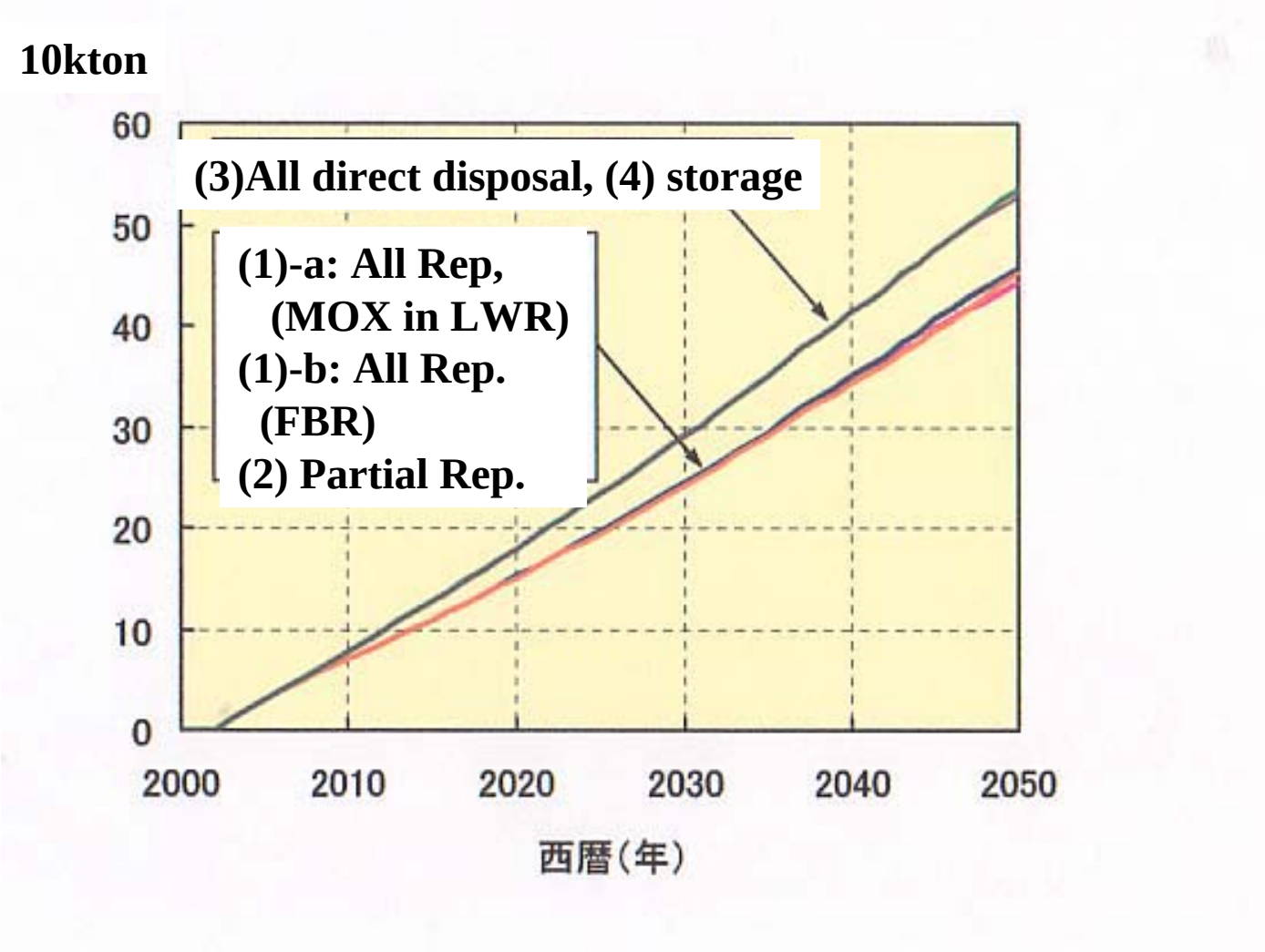






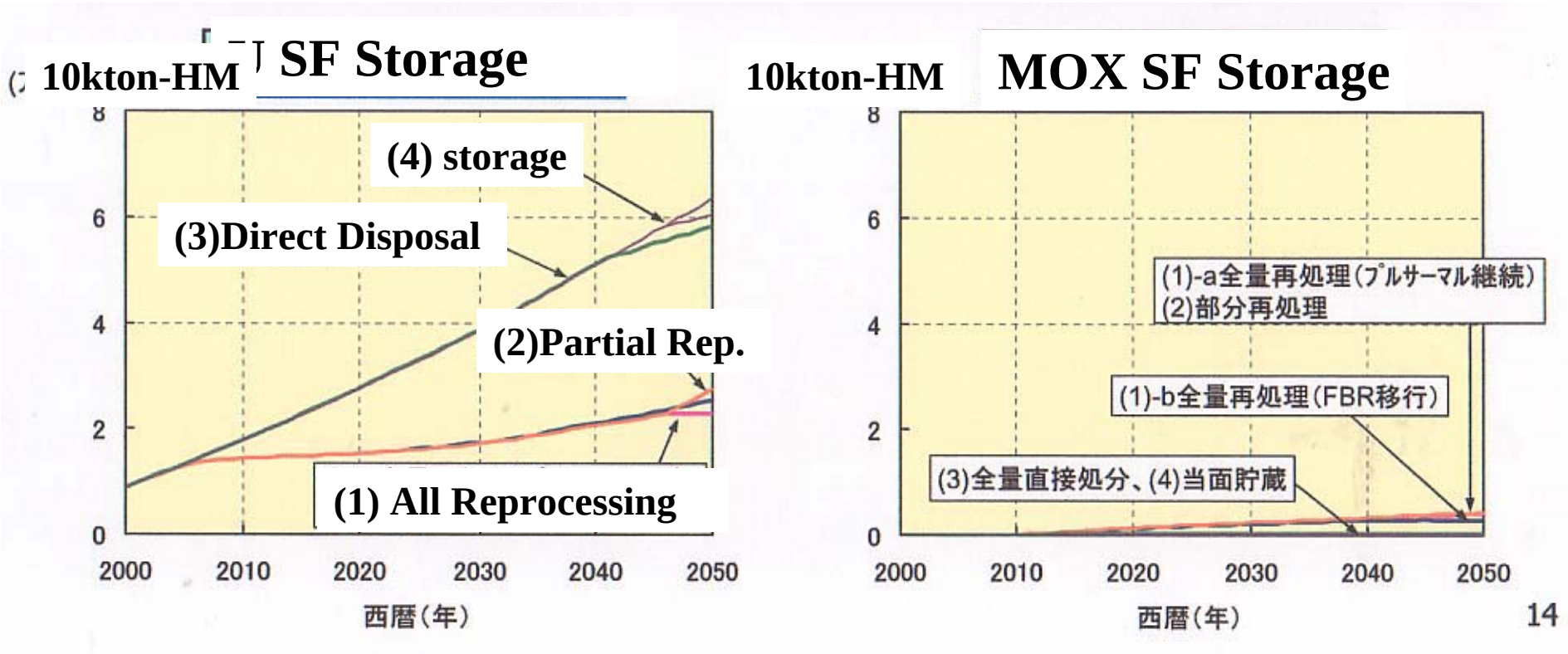
Scenario 1
Reprocessing All
(shift to FBR)

Required Uranium till 2050



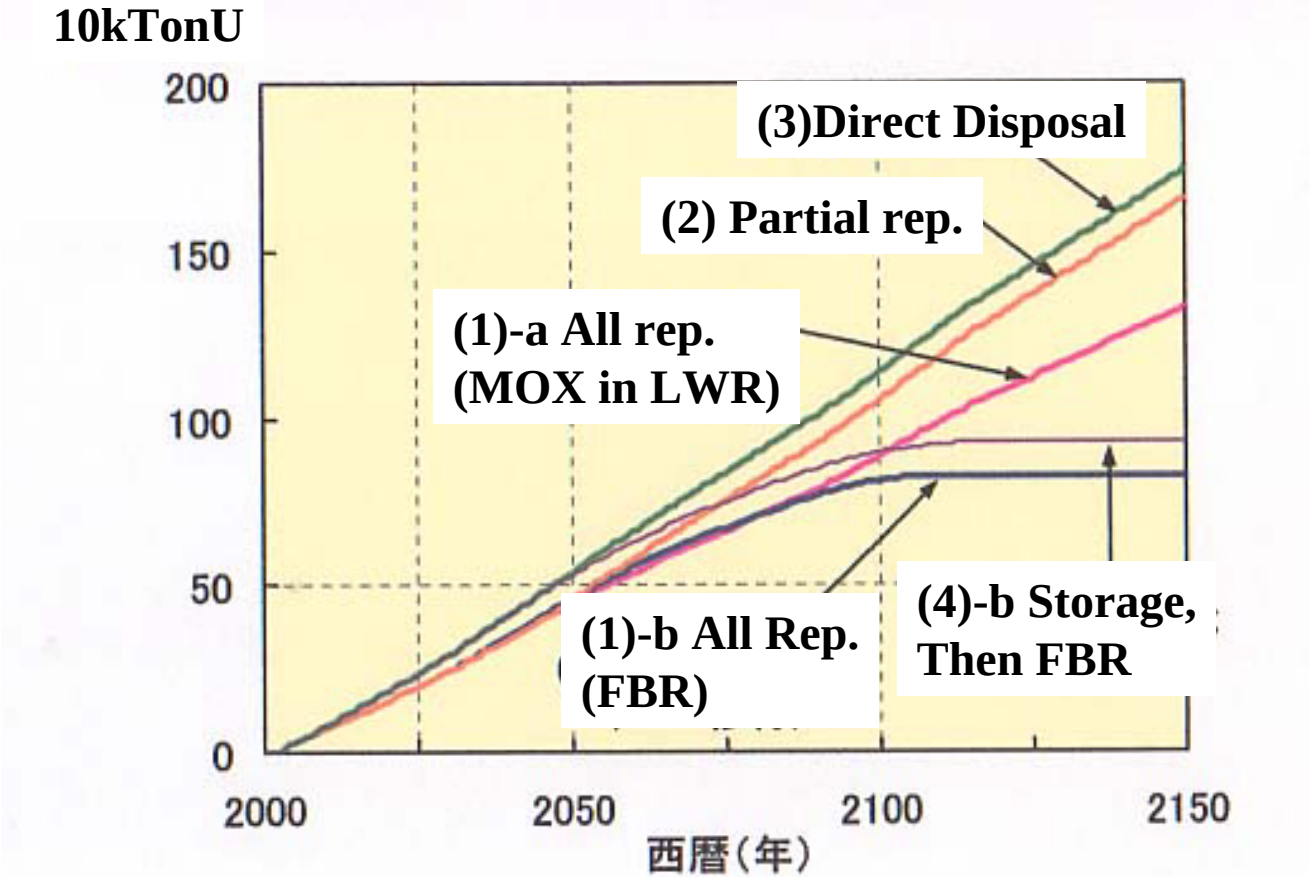
10-20% lower in reprocessing scenario

Spent Fuel Storage



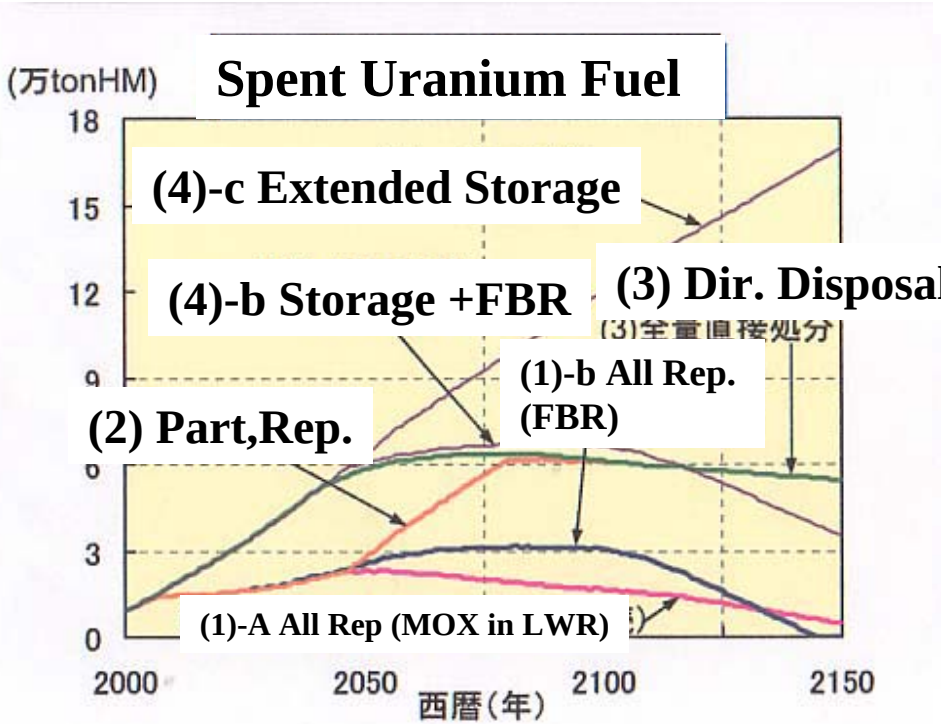
Many intermediate storage facilities required in (3) direct disposal and (4) storage until 2050

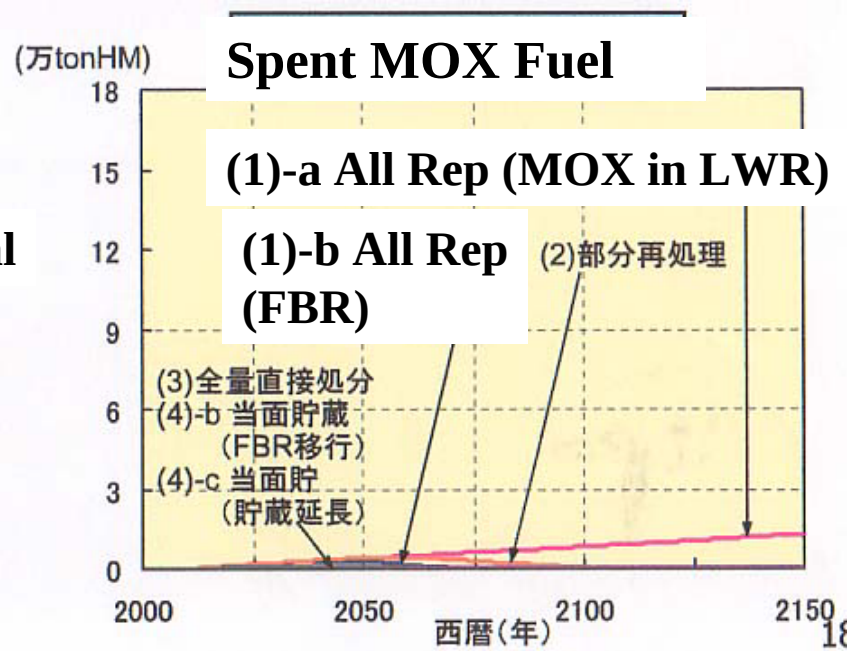
Natural Uranium Required until 2150



Required uranium amounts saturate in the cases of (1)-b all reprocessing (FBR) and (4)-b storage then FBR

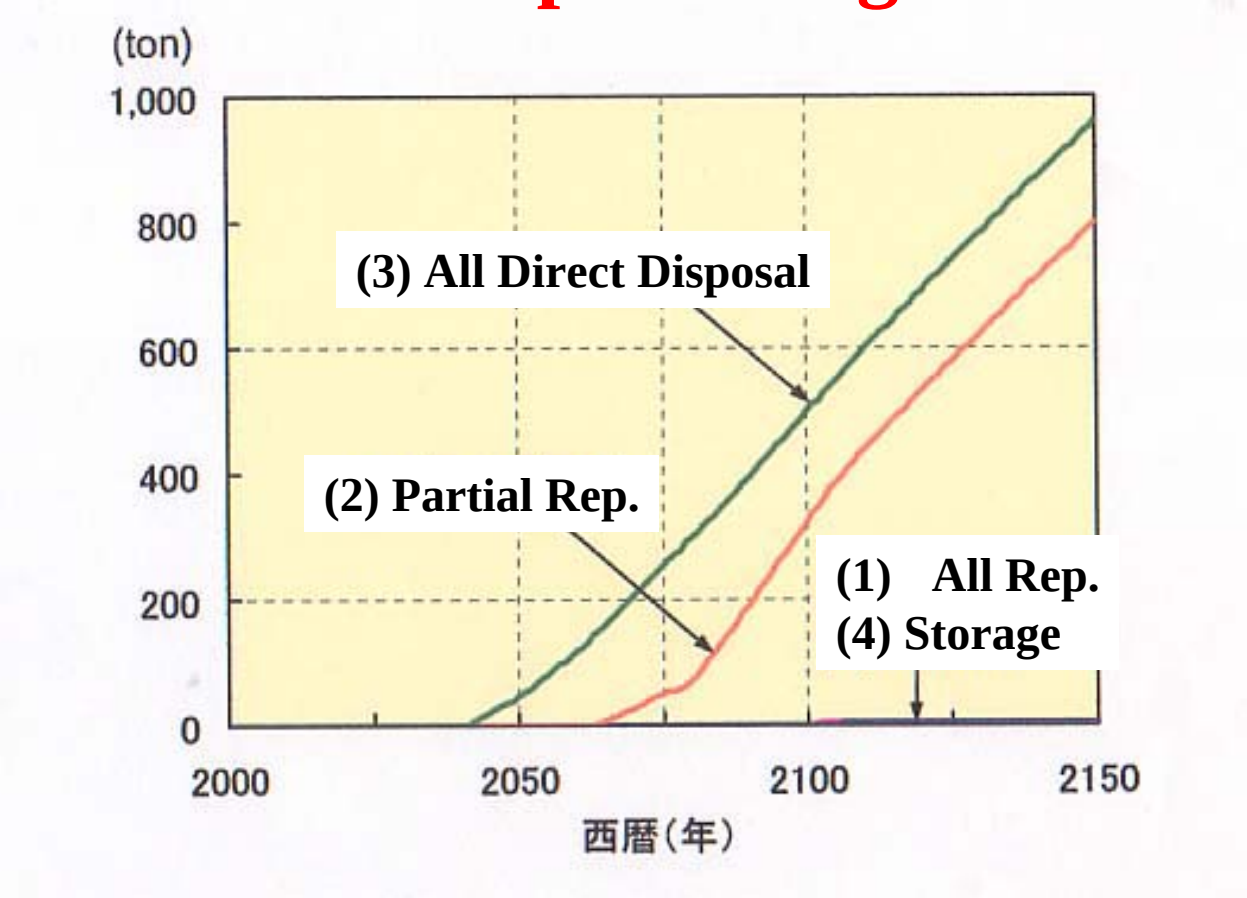
Spent Fuel Storage till 2150





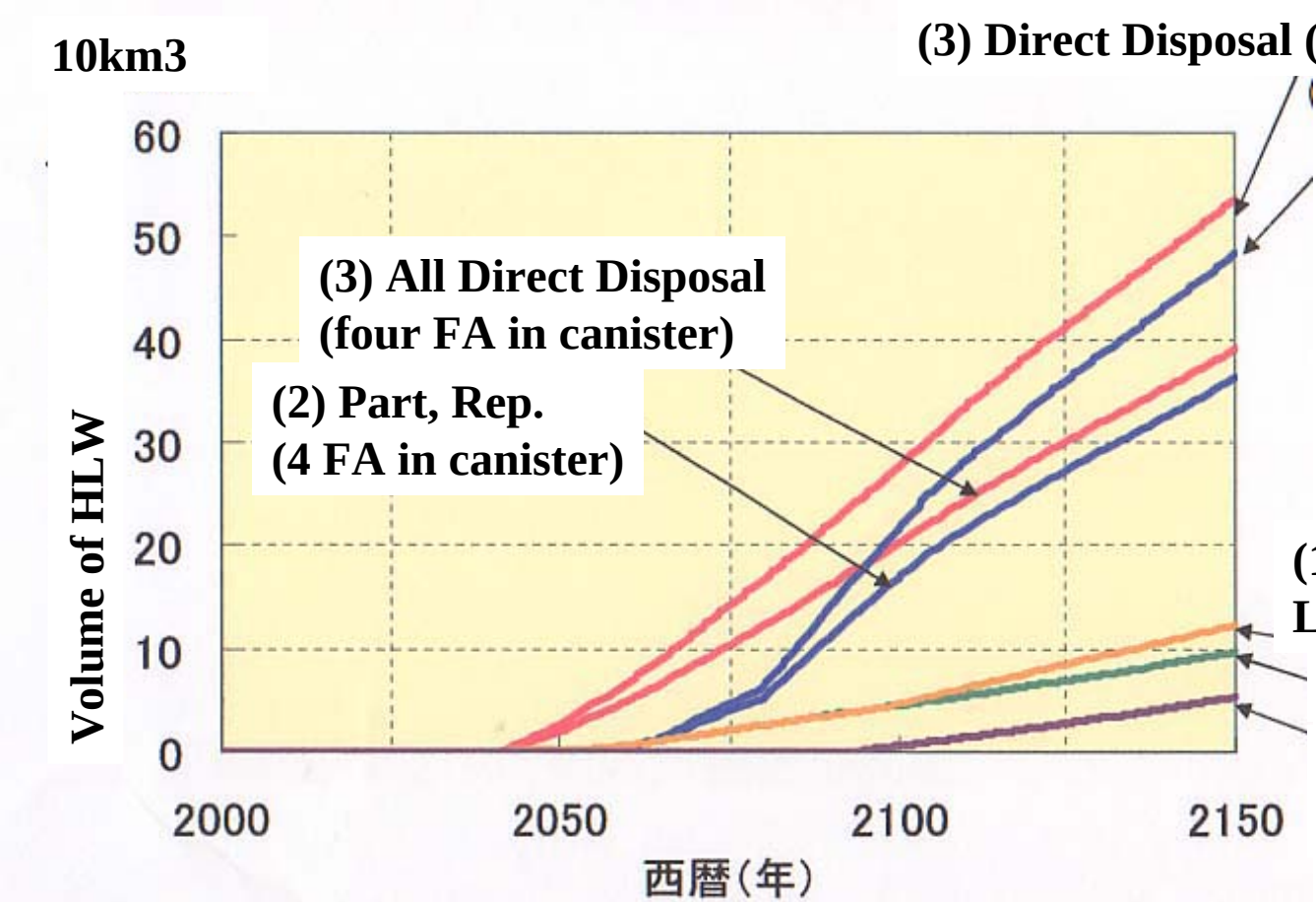
Many Interim Storage Facilities in Extended Storage, Direct Disposal

Plutonium in Disposed High Level Waste



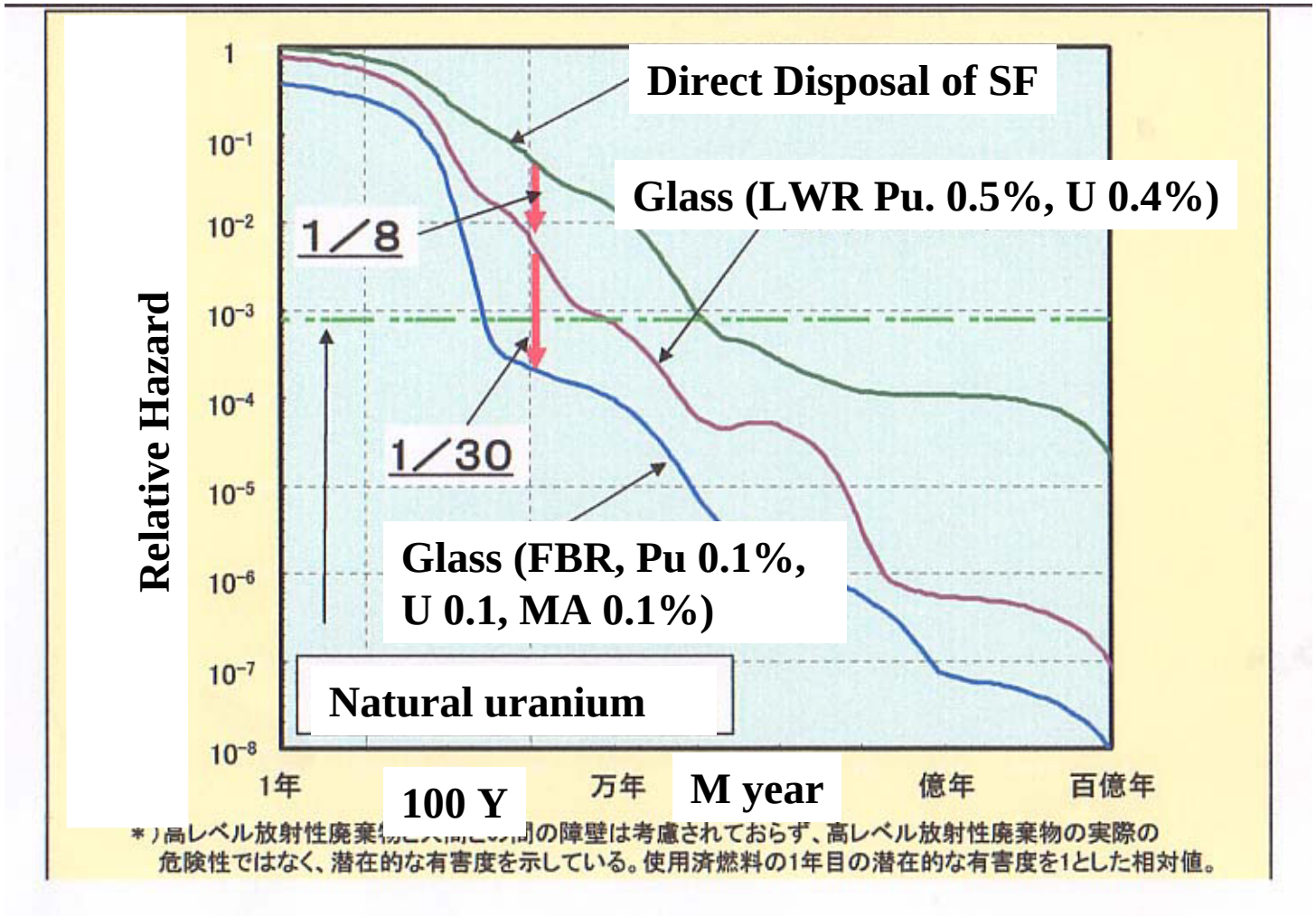
800-900 Tons of Plutonium in HLW at 2150 for (2) Partial Disposal and (3) Direct Disposal Scenarios

Volume of Disposed High Level Waste



Small HLW Volume in Reprocessing Scenario and Storage + FBR Scenario

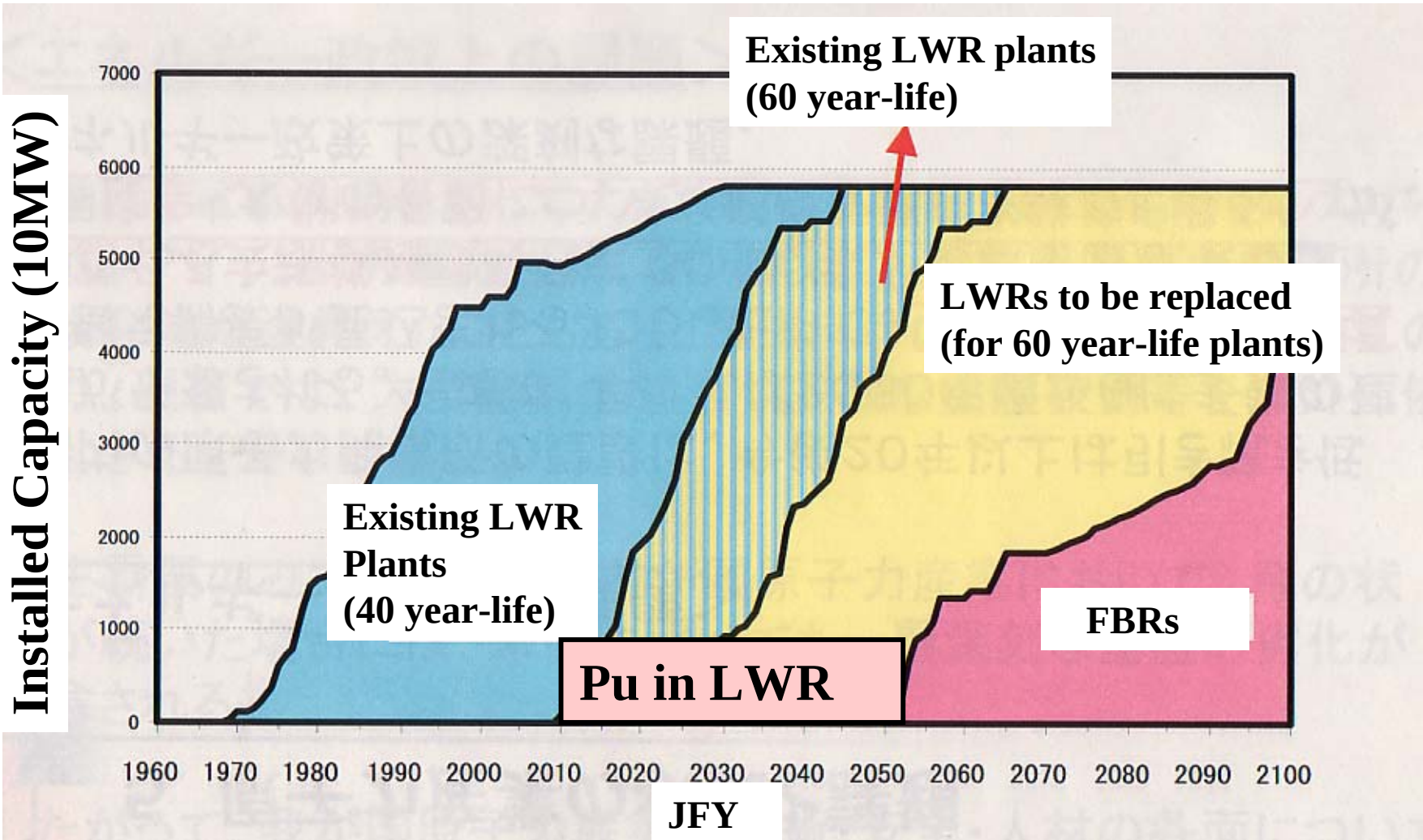
Relative Hazard in High Level Waste



Direct disposal contains U, Pu, FP

A visual image of nuclear power generation capacity and its comparison in this century

(The installed capacity is assumed to saturate at 58GW for illustrative purpose)

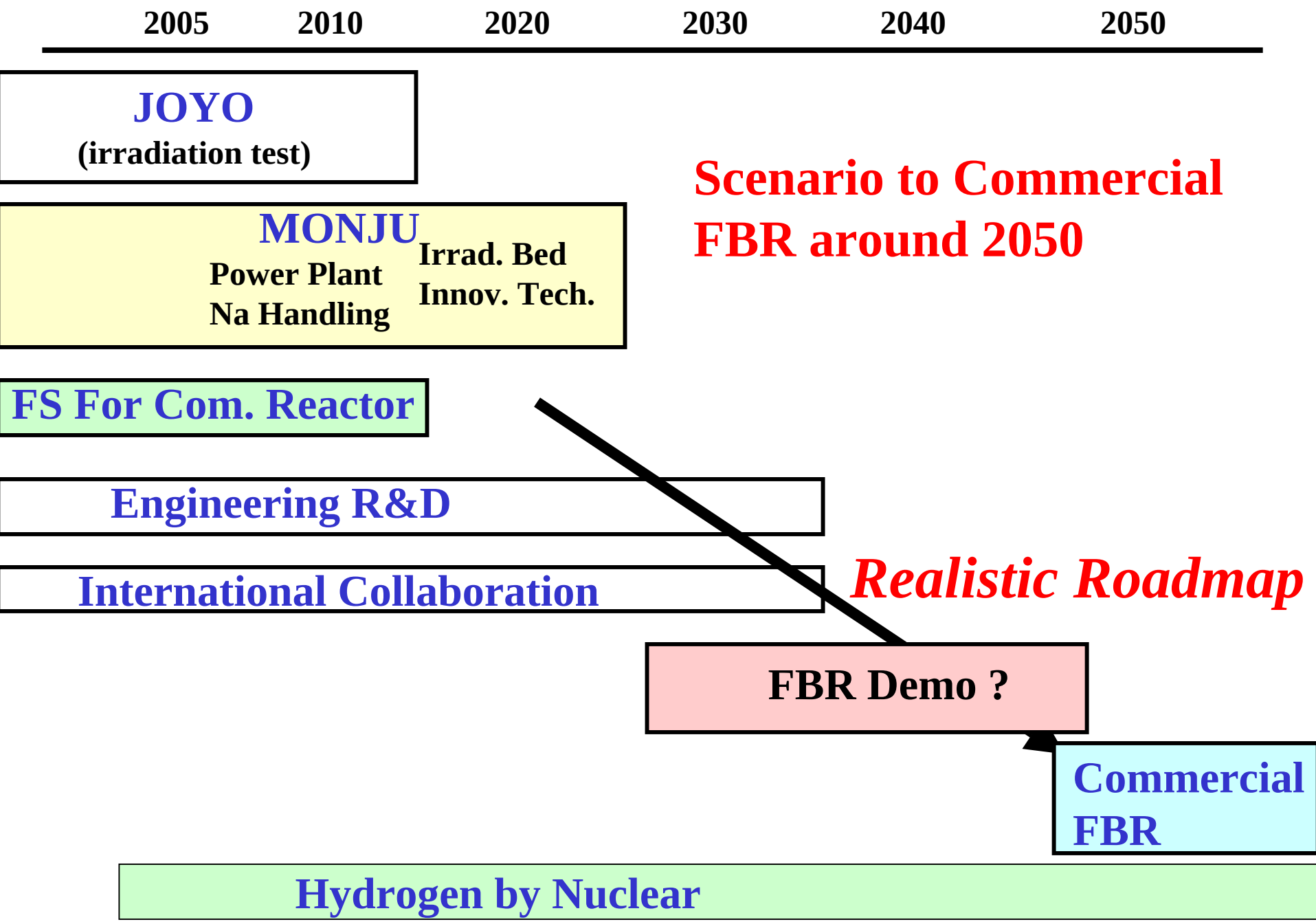


In Framework of Nuclear Energy Policy, AEC (2005)

-Share of nuclear power in electricity generation after the year 2030 similar to greater than the current level of 30-40 %

-Develop fast reactors and advanced fuel cycle technologies, aiming at their commercial introduction at around 2050

-Start discussion about second commercial reprocessing plant at around 2010


2005
2010
2020
2030
2040
2050
JOYO
(irradiation test)
MONJU
Power Plant
Na Handling
Irrad. Bed
Innov. Tech.
Scenario to Commercial FBR around 2050
FS For Com. Reactor
Engineering R&D
International Collaboration
Realistic Roadmap
FBR Demo ?
Commercial FBR
Hydrogen by Nuclear

FBR R&D (will be discussed at MEXT and METI)

-At 2005-2006, Review of the Second Phase Report of FS.
(Main concepts, R&D plan to 2015, R&D subjects after 2015)

-FS objective: Final report at around 2015 to show appropriate FBR system and R&D plan to this.

Roadmap construction toward commercial FBR

-By including Academic Societies (ex.RRTD/AESJ) and Research Institutes

Partitioning and Transmutation (P&T)

- P&T technology has been promoted under the OMEGA program in Japan.
  - Homogeneous recycling of MA in FBR was mainly studied by JNC and CRIEPI
    - Demonstration at MONJU is planned
  - Dedicated transmutation by ADS was mainly studied by JAERI
    - Basic experiments at J-PARC are planned
- Both concepts will be explored in the new organization JAEA.
- Benefit of P&T technology on the waste management is being discussed.

Hydrogen Production by Nuclear Energy

- IS Process is being developed in JAERI.
- HTTR is being operated in JAERI.
  —Coupling of IS Process with HTTR is planned.
- Hydrogen production by FBR is also studied in JNC
- JAEA will play a leading role in this region.
- Pilot Plant in 2010?

Conclusions

1. **Forecast of 2030 by METI**

2. **The basic nuclear fuel cycle policy of Japan is to reprocess all spent fuels and to use the recovered plutonium and uranium efficiently**

3. **Projected Nuclear Quantities till 2050 and 2150 by AEC**

4. **Realistic R&D plan for commercial FBR**