Japan's Nuclear Power Program -Trends and Issues-

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Tatsujiro Suzuki
Senior Research Scientist
Central Research Institute of Electric Power Company (CRIEPI)
The University of Tokyo

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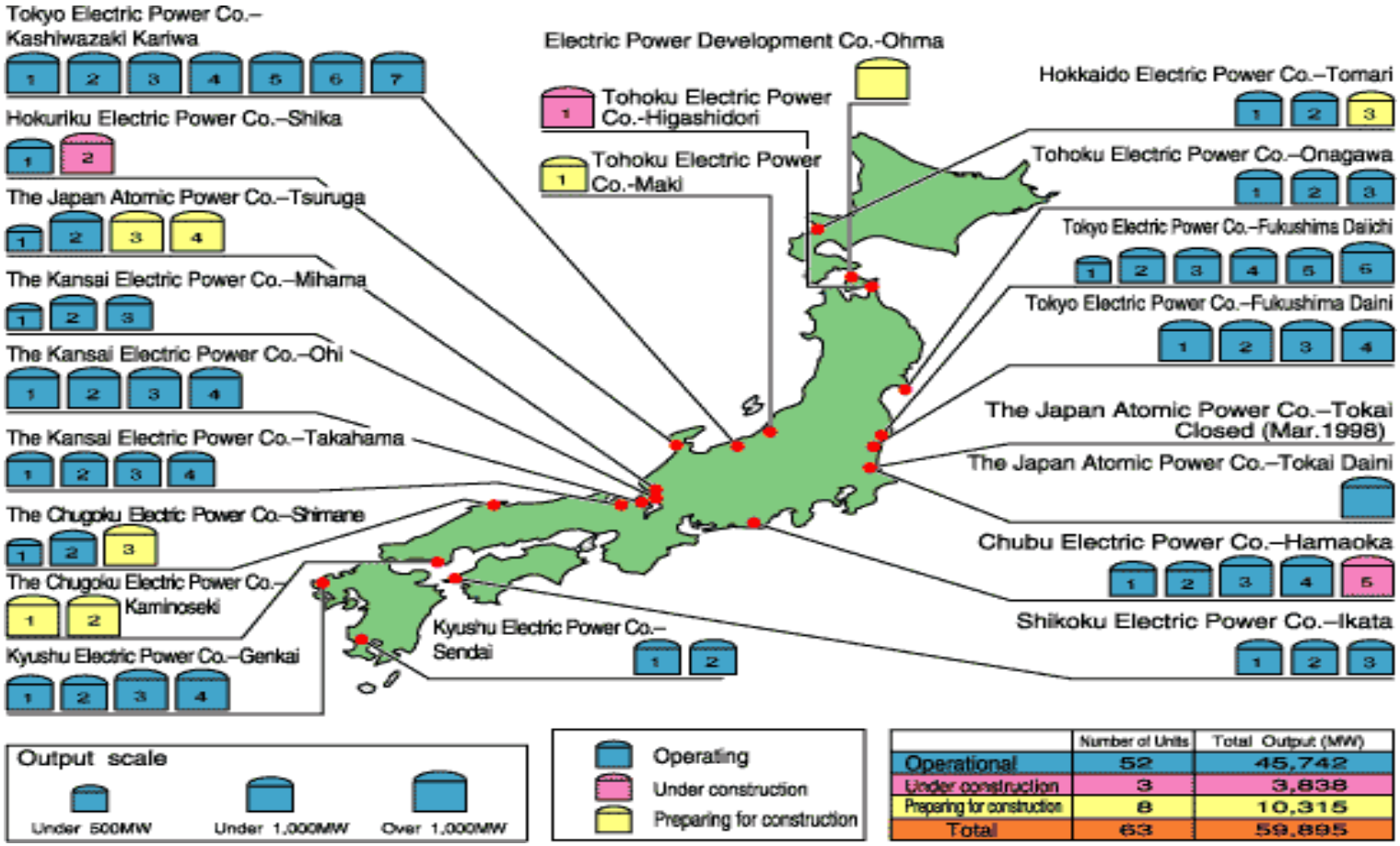
Overview of Japan's Nuclear Power Programs and Policies

- Total of 52 nuclear power plants (45.7 GWe) are now providing roughly 1/3 of total electricity generation in Japan.
- Nuclear power is expected to maintain its share (30~40%) until 2030, for both energy security and environmental reasons.

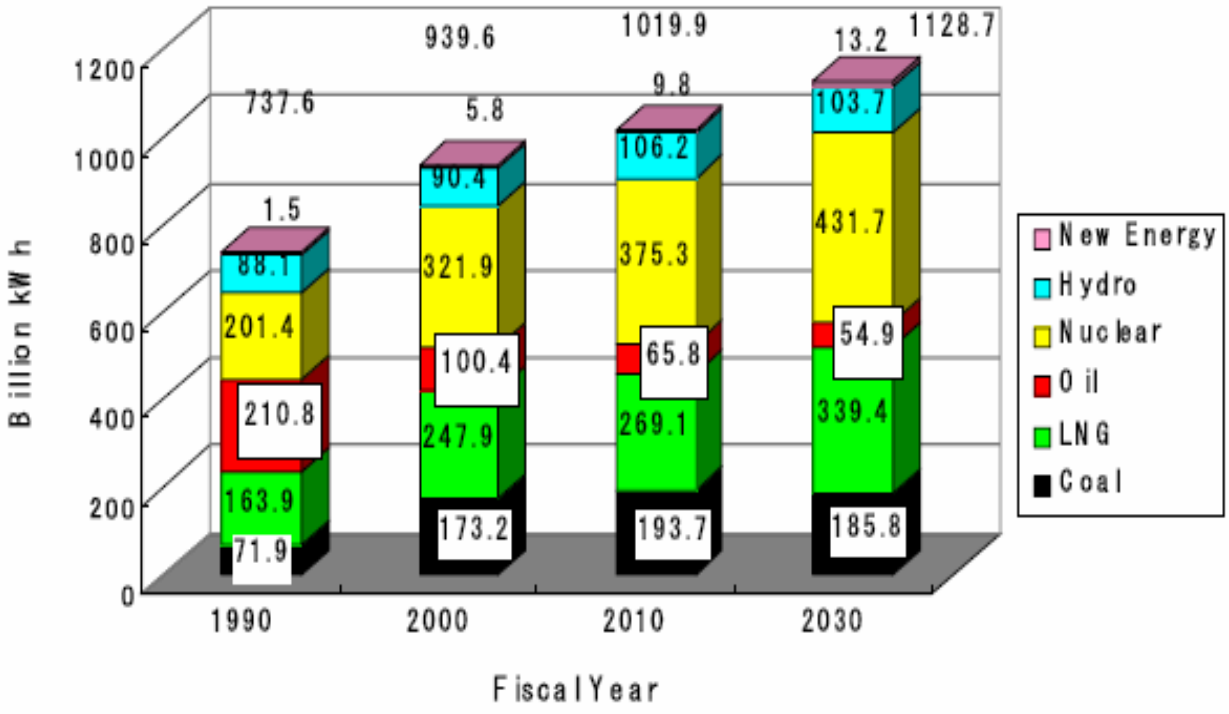
Nuclear Power Plants in Japan



Source: Federation of Electric Power Companies, http://www.fepc.or.jp/english/nuclear_power/generation/plants.html, April 2005

Long Term Energy Outlook to 2030

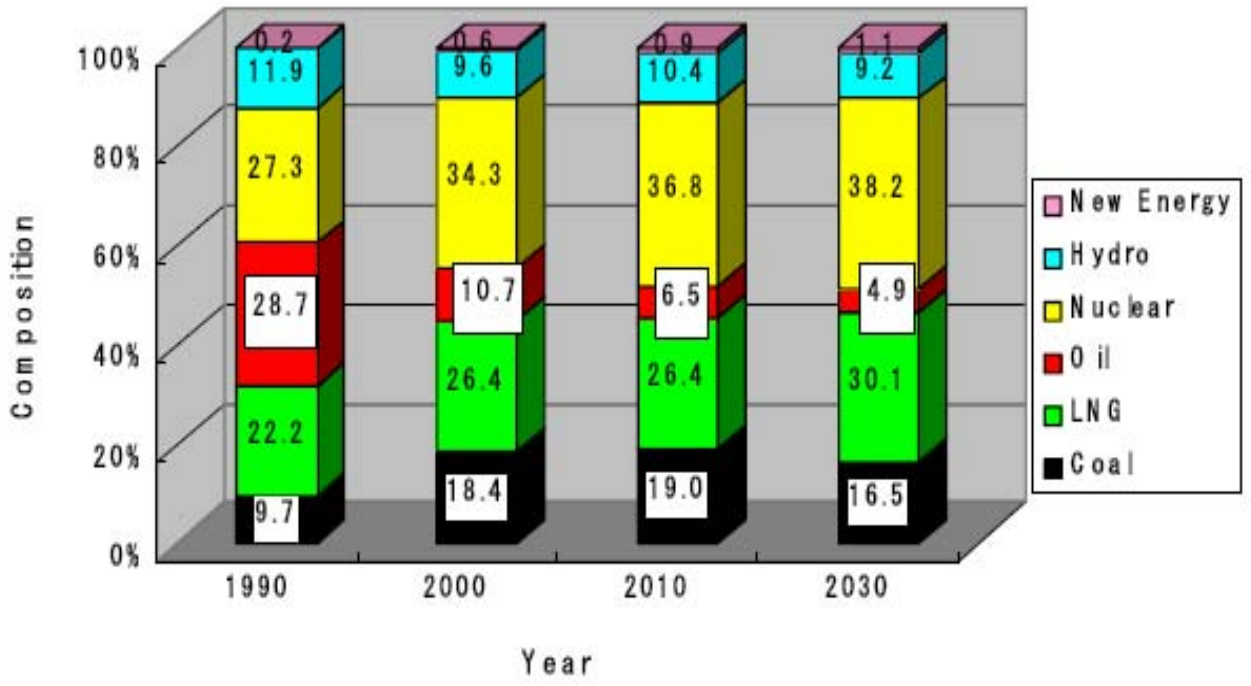
FIG. 3: Outlook on Japan's electricity generation output (for electric utilities, basis kWh) by source up to FY 2030 (Base Case)



Source: K. Fujime, December 2004.

Long Term Energy Outlook to 2030

FIG. 4: Outlook on Japan's electricity source composition (for electric utilities, basis kWh) up to FY 2030 (Base Case)



Source: K. Fujime, December 2004.

Nuclear Power in Japan in 2030
- METI's Long Term Outlook-
June 2004

Current: 52 units (45.7GWe)

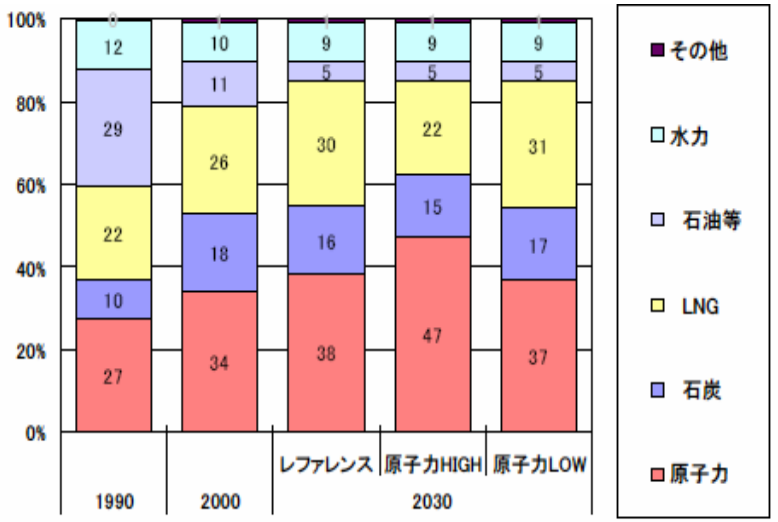
High Case: +17 units(67.95 GWe)
Reference: +10 units (57.98 GWe)
Low Case: + 8 units (55.97 GWe)

Current share: 34%
High Case: 47%
Reference: 38%
Low Case: 37%

【原子力設備容量 設備利用率の見通し】

万kW／利用率(%)	2000年度[実績]		2010年度		2030年度	
High ケース [17基運開]	4,492	82%	5,014 [+4基]	85%	6,795 [+13基]	90%
レファレンスケース [約10基運開]					5,798 [+約6基]	85%
Low ケース [8基運開]					5,597 [+4基]	

*1基136万kWとして基数換算



Source: METI's Advisory Committee on Energy, June 2004

Liberalization of Electricity Market in Japan

- Japanese electricity market is gradually being liberalized after 1995.
- 1995 IPP* was introduced
  - Independent Power Producer
- 2000. 3~ : >2,000 kWe market (~25%)
- 2004. 3~ : > 500 kWe market (~40%)
- 2005. 3~ : > 50 kWe market (~63%)
- 2007 Full market liberalization will be discussed

Nuclear power is believed to be still competitive in Japan

	¥/kWH	¥/kWh
dicount rate	1%	3%
UO2 Fuel	0.53	0.59
MOX Fuel	0.09	0.07
sub total	0.62	0.66
Reprocessing	0.61	0.5
HLW storage/disposal	0.16	0.15
TRU storage/disposal	0.12	0.09
Decomm. (reprocessing)	0.08	0.03
SF storage	0.05	0.04
total	1.64	1.47
Total Generation Cost	5.0	5.3
LNG	5.9	6.2
Coal	5.2	5.7

Assumptions: Capacity factor (80%), 40 year life time average cost

Source: METI Subcommittee on Electric Utilities (2004)

Importance of Back-End of Fuel Cycle Cost

Nuclear Power Generation Cost Breakdown in Japan

	yen/kWh	%
Capital Cost	2.3	39.0
O&M	1.9	32.2
Fuel Cycle	1.7	28.8
Uranium, Conv	0.17	2.9
Enrichment	0.27	4.6
Fabrication	0.29	4.9
Reprocessing	0.63	10.7
Interim Storage	0.03	0.5
Final Disposal	0.25	4.2
Total	5.9	100.0

Source: METI, Advisory Council on Energy, Nuclear Energy Subcommittee, 1999
Note: Average cost over 40 year life. 80% capacity factor.

Back-End of Fuel Cycle

Spent Fuel Management Issues

- Legal Constraints
  - Reactor and Radioactive Material regulation requires reactor operators to specify “final disposal method” of spent fuel
  - “reprocessing” is the only method for utilities since JAEC’s LTP does not allow direct disposal
  - Amendment made in 1998 to allow “interim storage” (outside reactor and reprocessing sites)
- Law for HLW Disposal (1999)
  - Law defines HLW as “vitrified waste from reprocessing” (spent fuel is not included as HLW and cannot be disposed by Nuclear Waste Management Organization [NUMO])

Back-End of Fuel Cycle
Spent Fuel Management Issues

- Physical and Political constraints
  - Utilities promised reactor site communities to remove SF to reprocessing facility
  - Physical storage capacity has been limited by political opposition to:
    - Expansion of storage capacity on site
    - Acceptance of SF from other reactors/sites
  - Spent fuel handling tax is being raised at reactor sites

SF Storage Capacity for TEPCO

	In stoarge (tons, as of the end of FY)					storage capacity			
Site	1998	1999	2000	2001	2002	exisiting	expanded	core res.	years
Fukushima#1	5208	5956	6528	7100	7420	15,558	16010	3356	4.7
Fukushima#2	6384	6964	7328	7001	6967	10940	10940	3056	0.9
Kashiwazaki-Kariha	6285	7509	8480	9328	9680	19810	22536	5564	3.9
Total	17877	20429	22336	23429	24067	46308	49486	11976	3.4
	Source: Tokyo Electric Power Co., http://www.tepco.co.jp/nu/programs/fuelstoc-j.html								

Overview of Rokkasho Project
(as of 2003. 9)

	LLW disposal	Enrichment	HLW Storage	Reprocessing
Size	~1 million drums* to 3 mill drums	Started with 150 ton SWU/y to 1500 ton SWU/y	1,440 canisters to 2,880 can.	800 ton/y (SF pool of 3,000 tons)
Status	143,755 drums (1992)	1050 ton SWU/y (1992)	760 canisters (1995)	U testing (2004) Hot testing (’05)
Construction Cost	\160 bill	\250 bill	\80 bill	\2,140 billion

*200 litter each

Source: http://www.fepc.or.jp/menu/cycle/cycle1.html

Status of Rokkasho Reprocessing Plant

Site of Rokkasho

Overview of Construction Site

Liberalization and Back-end of Fuel cycle

- Feb. 2003: Subcommittee of Electric Utilities (METI Adv. Council on Energy and Resources) recommended that "appropriate measures should be taken in order to promote nuclear power and its back-end of fuel cycle.."
  - Subcommittee established a study group to study economics of nuclear power and back-end of fuel cycle

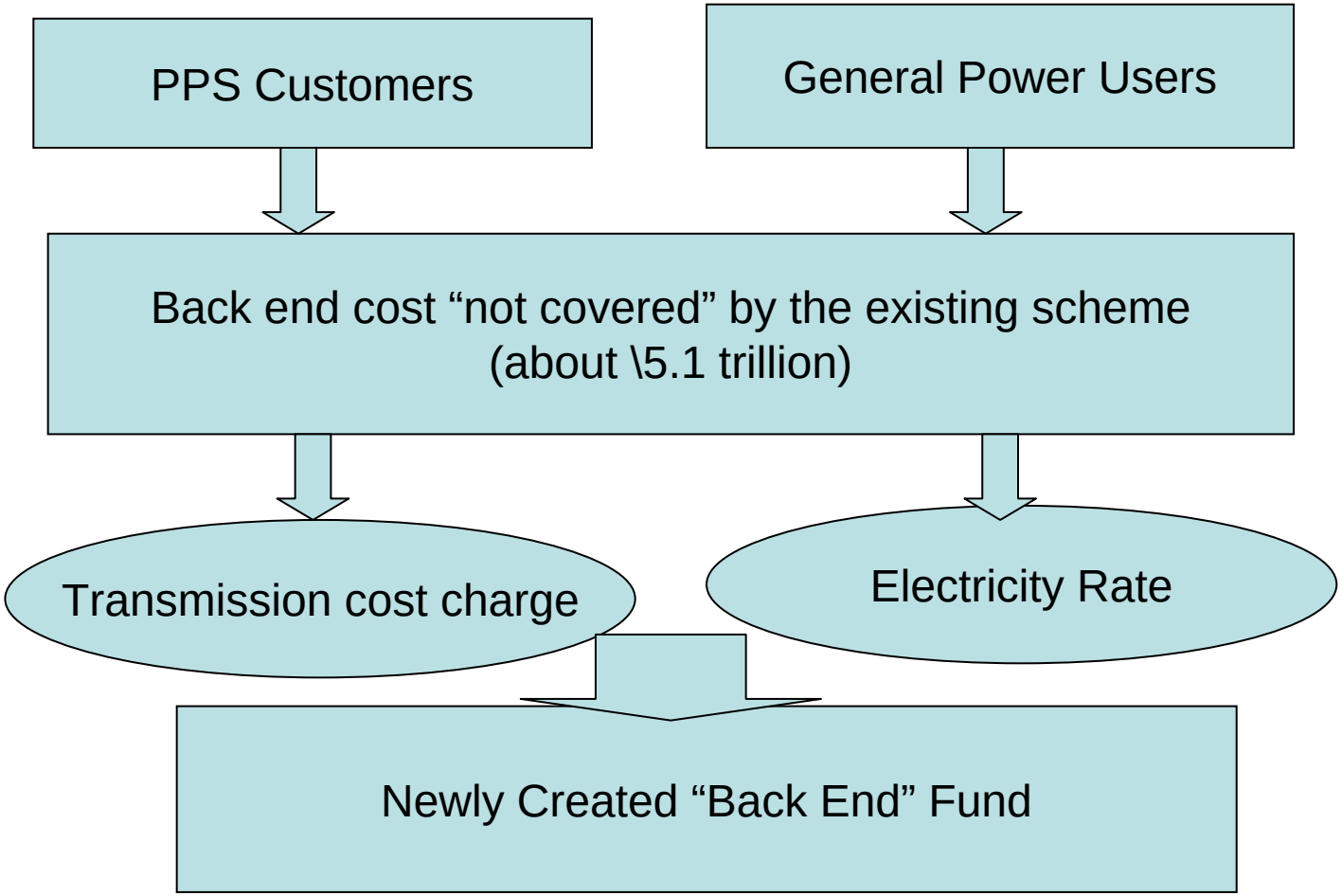
Liberalization and Back-end of Fuel cycle

- Subcommittee concluded:
  - Nuclear power is competitive compared with other power sources (~\5.3/kWh vs \5.7/kWh for coal)
  - Out of \18.8 trillion, “uncovered cost” under the current rate system should be collected from all power producers
    - Total of about \5.1 trillion will be additionally charged with the customer

Category	Items	\ 10 bill
Reprocessing	Rokkasho (800tx 40 yrs) Decommissoning (\155)	1100
HLW Storage	From Europe	30
LLW Storage	From Europe	57
HLW transportation		19
HLW disposal	Only vitrified waste	255
TRU disposal		81
SF transportation		92
SF storage	Up to 34000 tons	101
MOX fuel fabrication		119
U. Enrich. Back end		24
Total		1,880

Report of Study Group on Cost Estimate for Nuclear Fuel Cycle (METI, 2004)

Cost Sharing Scheme (draft)



Source: Denki Shimbun, May 12, 2004

Direct Disposal vs. Recycling

- June 2004: JAEC has started the LTP process, suggesting that it will compare “recycling” vs. “direct disposal”
- It was found that government and utilities conducted internal cost comparison studies in 1994 (METI, utilities), 1998 (METI).
- METI subcommittee on Electric Utilities published its conclusion of “back-end” measures, despite the fact that debate was still underway at JAEC’s LTP process.

Results of Internal Studies (METI, FEPCO) on Recycling vs Direct Disposal

discount rate	5%(¥/kWh)	0%(¥/kWh)
direct disposal	1.23	1.35
recycling (int'l price)	1.59	1.91
recycing (domestic price)	2.3	2.9
recycling (weighted ave.)	1.91	2.35

METI "cost estimate of nuclear fuel cycle" Feb. 4, 1994. (published on July 5, 2005)

Fixed reprocessing (Rokkasho+storage)	All reprocessing (Rokkasho+oversea)	Direct disposal
1.347 ¥/kWh	1.418 ¥/kWh	0.991 ¥/kWh

Case study on Fuel Cycle Cost, Federation of Electric Power Companies, 1994, (published on July 7, 2004)

Debate at JAEC's LTP
- Recycling vs Direct Disposal - (1)

- JAEC established technical-subcommittee on economic comparison of fuel cycle options.
- Four scenarios until 2060
  1. Reprocessing all spent fuels (Rokkasho+2nd Plant)
  2. Reprocessing at Rokkasho, and direct disposal
  3. Direct disposal of all spent fuels
  4. Interim storage of all spent fuels (decisions to reprocess or direct disposal will be deferred)

Debate at JAEC's LTP
- Economic Comparison (\/kWh, 2% DR) - (2)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
U Fuel	0.57	0.57	0.61	0.61
MOX fuel	0.07	0.05	-	0.01
Reprocessing	0.63	0.42	-	0.06
HLW Storage/trans/ disposal	0.16	0.10	-	0.06
TRU Disposal	0.11	0.07	-	0.03
Interim Storage	0.04	0.06	0.14	0.13
SF direct disposal	-	0.12~0.21	0.19~0.32	0.09~0.16
Total fuel cycle cost	1.6	1.4~1.5	0.9~1.1	1,1~1.2
Total Power gen. Cost	5.2	5.0~5.1	4.5~4.7	4.7~4.8

Debate at JAEC's LTP - Recycling vs Direct Disposal - (3)

- For scenarios 3 and 4 (which include cancellation of Rokkasho), JAEC estimated "costs associated with policy change"
  - Spent fuel will be returned to NPP sites
  - NPPs will be shut down as storage pools run out of space
  - New Fossil Power Plants will be built
  - Cost increase due to above changes will occur

Debate at JAEC's LTP
- Recycling vs Direct Disposal - (4)

(¥/kWh)	Secnario1	Scenario 2	Scenario 3	Scenario 4
Power Gen. Cost	5.2	5.0~5.1	4.5~4.7	4.7~4.8
Cost due to Policy Change	-	-	0.9~1.5	0.9~1.5
Total Cost	5.2	5.0~5.1	5.4~6.2	5.6~6.3

Debate at JAEC's LTP - Recycling vs Direct Disposal - (5)

- JAEC LTP committee decided that maintaining "all reprocessing/recycling policy" is appropriate
- 2nd reprocessing plant will be needed after 2040, and FBR should follow.
- It is not clear whether JAEC will include R&D on direct disposal as a future option.

Conclusions

- Nuclear power is expected to maintain its current share (~30%) until 2030.
- But under the liberalized electricity market, nuclear power may face tough competition.
- Back-end of fuel cycle will be a key factor in determining future viability of nuclear power in Japan.
  - Nuclear power may lose its competitiveness
  - Politics of spent fuel/waste management will be a major issue to be overcome.