Nuclear Energy Strategy for Sustainable Growth:
Aiming at Green Innovation and Life Innovation

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The views expressed here are of the authors but not necessarily reflect the views of JAEC or Japanese government.

SUMMARY

- Japanese government is pursuing aggressive strategy to promote "green innovation" and "life innovation" and nuclear power is an essential part of such strategy
- Increasing share of nuclear power (~50% by 2030) with steady progress in nuclear fuel cycle is necessary to achieve that goal
- New social/economic environments should be established with enhanced public confidence
- Japanese government and industry should work more effectively for active contribution to global nuclear expansion while non-proliferation, security and safety must be secured
- For beyond 2020, Japan should develop robust social platform for sustainable R&D and human resource development

Administrative Organizations for Nuclear Energy Policy

Cabinet Office

Atomic Energy Commission (AEC)

- **Formulates the Framework of Nuclear Energy Policy**
- **Outlines the government budget for implementing nuclear energy policy**
- **Review the administrative judgments of other governmental agencies under 'the Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors'** **etc.**

Nuclear Safety Commission (NSC)

- Development of the intellectual infrastructure for ensuring nuclear safety
- Ensuring safety of nuclear facilities
- Nuclear disaster countermeasures
- Promoting dialog on nuclear safety with the general public etc.

Report

Basic policies & Principles

Related Governmental Organizations

Ministry of Foreign Affairs (MOFA)

- Diplomatic policies for peaceful use of Science and Nuclear energy
- Negotiation and cooperation with the foreign government, participation to the international organization for peaceful use of nuclear energy
- Preparation and enforcement for conclusion of nuclear international engagement

etc.

Ministry of Education, Sports, Culture, Science and Technology (MEXT)

- Nuclear policies on science and technology
- Nuclear development for the purpose of improving the level of science and technology
- Regulation on use of nuclear reactors for experiment and research, nuclear fuel resource and materials
- Prevention of radioactive hazards etc.

Ministry of Economy, Trade and Industry (METI)

Agency for Natural Resources and Energy

- Nuclear policies for energy use
- Development of nuclear engineering for energy use

Nuclear and Industrial Safety Agency (NISA)

- Regulation on project of nuclear refinement, processing, storage, reprocessing and disposal, and on nuclear power generation facilities etc.

Other related ministries

- Ministry of Internal Affairs and Communications
- Ministry of Health, Labor and Welfare
- Ministry of Agriculture, Forestry and Fisheries
- Ministry of Land, Infrastructure and Transport
- Ministry of the Environment

etc

Japan Atomic Energy Commission (JAEC)

○The Atomic Energy Basic Law

The full-scale conduct of research, development, and utilization of atomic energy in Japan began when the Atomic Energy Basic Law was enacted on December 19th, 1955. The Atomic Energy Basic Law provides that *the research, development, and utilization of atomic energy should be limited to peaceful purposes only*. Based on this law, Japan Atomic Energy Commission was established on January 1st, 1956, with the purpose of systematically carrying out national policy measures under democratic administration of atomic energy operations.

○The Role of Japan Atomic Energy Commission

The Japan Atomic Energy Commission is set up in the Cabinet Office and has five commissioners. Its mission is *to conduct planning, deliberations, and decision-making regarding basic policy for research, development, and utilization of nuclear energy, including the formulation of the Framework for Nuclear Energy Policy*. When the JAEC deems it necessary as a part of its assigned mandate, *JAEC can recommend and demand reports of the head of relevant administrative organization through the Prime Minister*.

Members： 5 (appointed by the Prime Minister with the consent of the House of Representatives and House of Councilors)

Chairman
Dr. Shunsuke KONDO

Vice Chairman
Dr. Tatsujiro SUZUKI

Commissioner
Ms. Etsuko AKIBA

Commissioner
Dr. Mie OBA

Commissioner
Mr. Akira OMOTO

JAEC's Report on Strategy for Growth

- JAEC released a report in May, 2010, to identify role of nuclear energy for "green innovation" and "life innovation"
- The key messages are: "*strengthening capability to meet global challenge*" and "*enhancing citizens' confidence in nuclear energy technologies*"
- 5 recommendations:1～4 by 2020, 5:beyond 2020
  1. Increase share of nuclear power
  2. Promote radiation-related industry
  3. Develop social and economic environments to meet domestic challenge
  4. Develop measures to meet increasing global needs
  5. Develop long term social platform for sustainable growth

Nuclear Energy Strategy for Growth

～"enhancing public confidence" & "strengthening capability to meet global challenge"～

Green Innovation

Increase Nuclear Power's Share

- Achieve World Best Performance, Promote Replacement
- Enhance measures for aging, seismic safety, quality assurance
- Clarify responsibility of local/central gov't
- Promote nuclear fuel cycle including expansion of spent fuel storage capacity

Life Innovation

Promote Medical Application of Radiation

- Human resource development, and cost down of high quality medical equipment/facilities

International Approach

Meet Global Needs

- Maintain and enhance 3S (safety, safeguards, security) measures
- Promote bi-lateral nuclear cooperation
- Coordinate domestic activities to meet various needs of new nuclear power countries
- Utilize financial mechanism, and promote mechanism to cover nuclear liability

Local Development

Vitalize Local Economy Through Nuclear Science

- Promote institutional mechanism for wider usage of advanced facilities such as SPring-8 and J-PARC
- Enhance capability of existing facilities and promote further R&D

- *Promote radiation related industry for both medical and industrial application, using financial mechanism such as ODA*

Make radiation-related industry as a "strategic industry"

Develop social and economic environment to meet new challenge

Improve citizen's scientific literacy
Innovation in Information Disclosure

Reform safety regulatory structure for improved public confidence

Enhance networking of experts among public/private sectors

Secure Better Employment

Assist local programs for effective utilization of nuclear related facilities to secure better local employment

Economic visualization of CO_2 merits

Platform for sustainable growth

Human Resource

Development of human resource for international development through internationalization of education system

Science/Technology

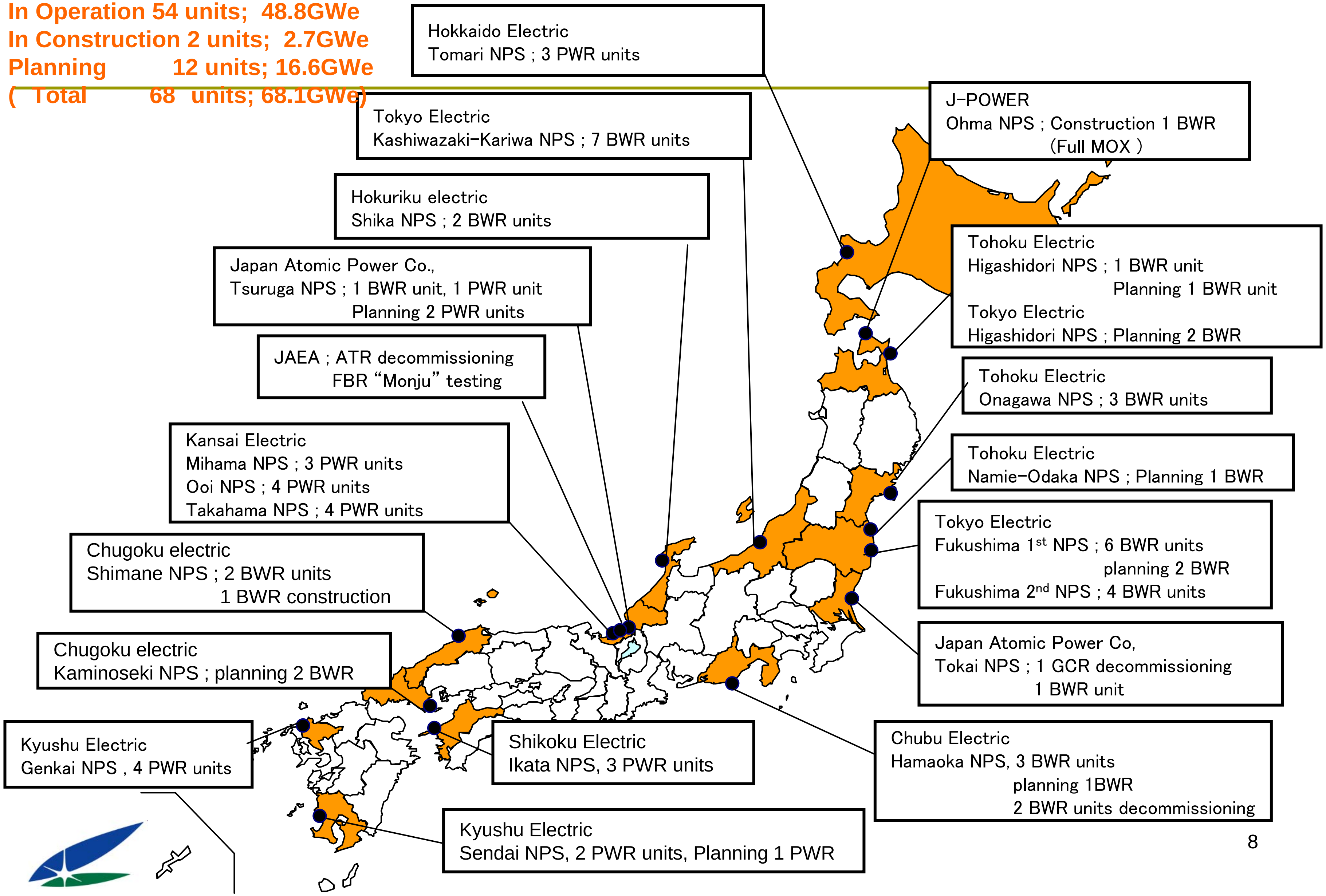
World best R&D activities and networking (FR cycle, HTGR, Nuclear Fusion, etc.)

Rec. 1: Increase share of nuclear power for green innovation

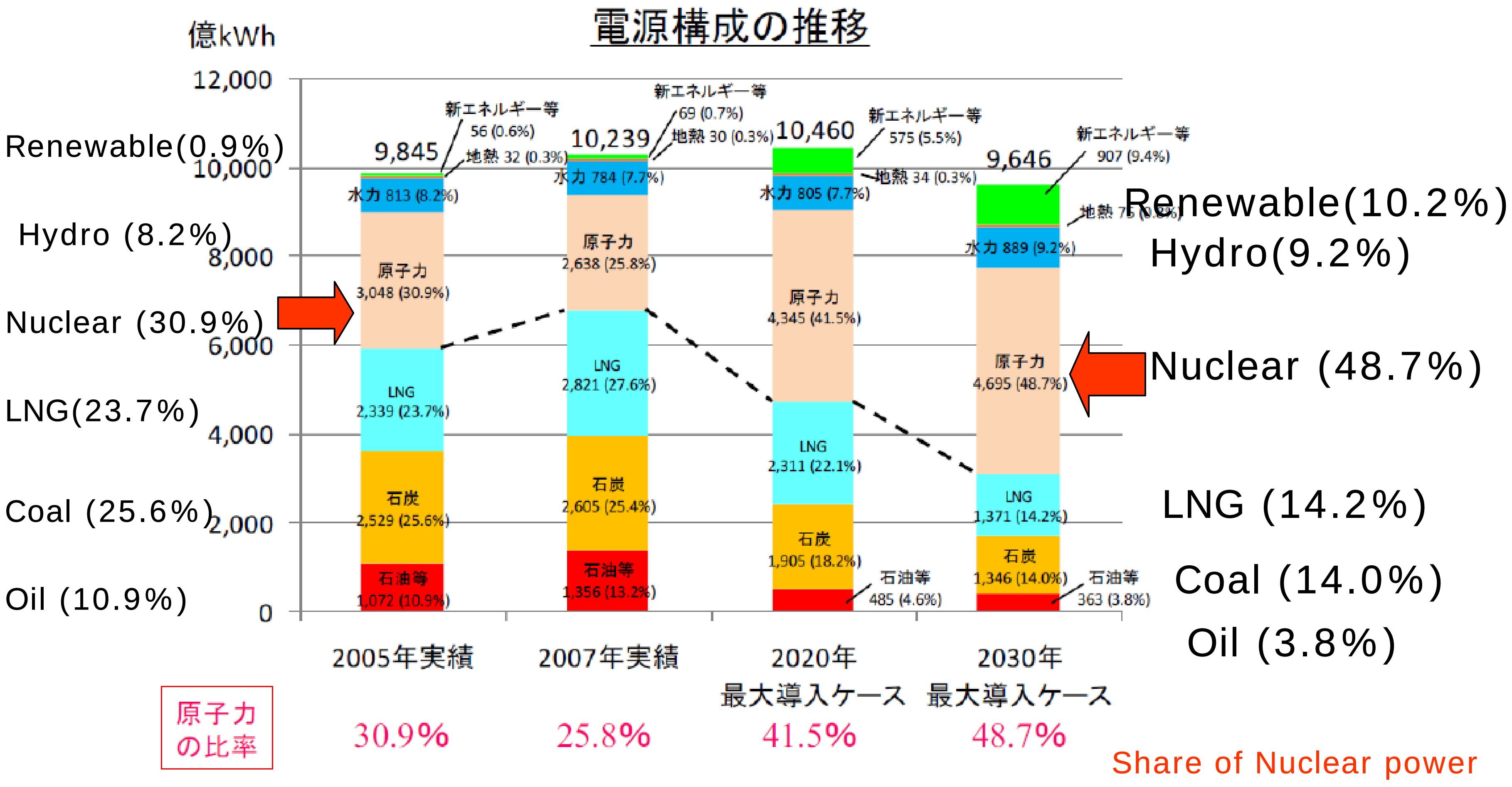
- Improve performance of existing nuclear power plants
  - Aim at world-best class (~90%) from current level (~60%)
  - Shorten inspection and shutdown periods
- Improve environment for building additional nuclear power plants
  - Shorten lead time
  - Reduce capital cost
- Steady Progress in nuclear fuel cycle
  - Secure spent fuel storage capacity
  - Make progress in HLW disposal siting process

Nuclear Power Plants in Japan （as of March 2010)

Commercial Plants
In Operation 54 units; 48.8GWe
In Construction 2 units; 2.7GWe
Planning 12 units; 16.6GWe
(Total 68 units; 68.1GWe)



Goal of Power Production Mix in 2030

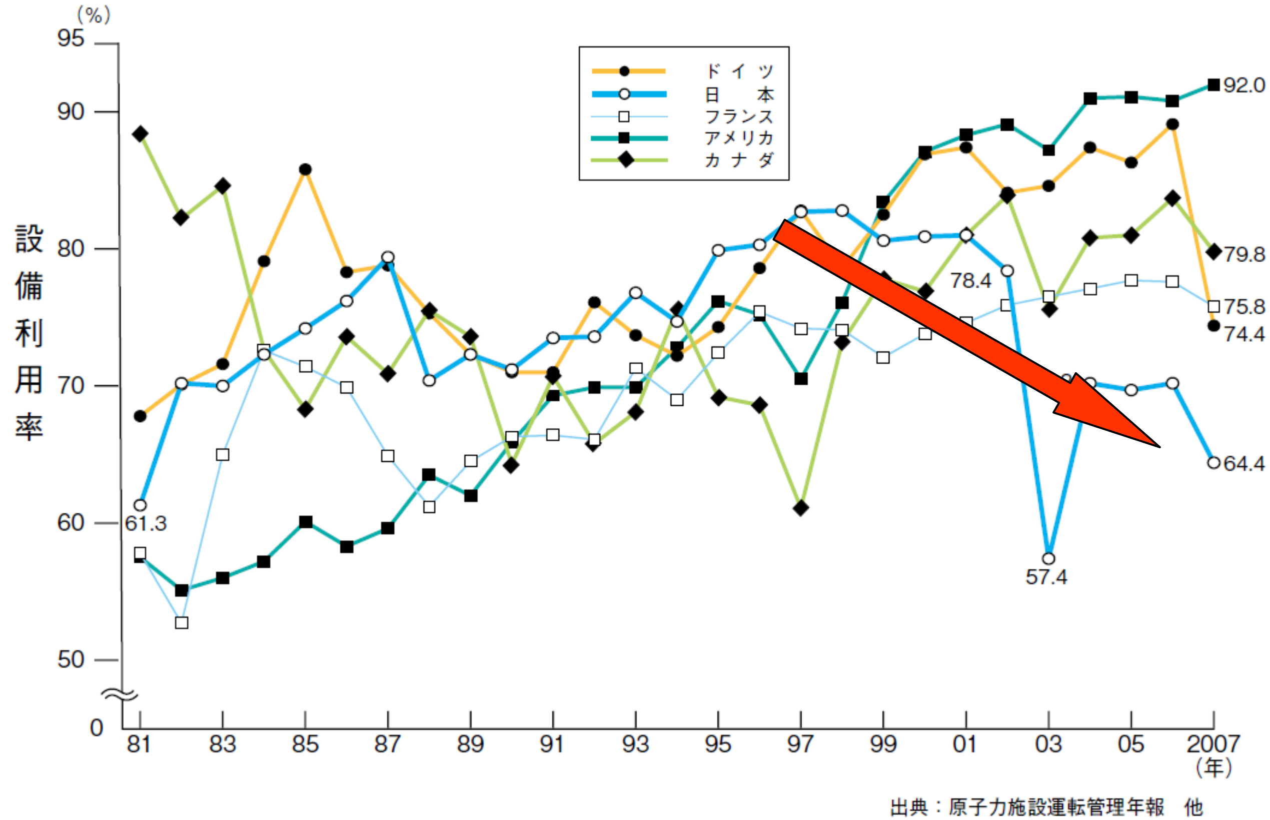


Source: Institute of Energy Economics, March 2010

Goal of New Energy Basic Plan(2010)

- Achieve 30% GHG reduction from 1990 level by 2030
- Build 9 new nuclear plants and improve capacity factor from current 60% to 85% by 2020
- Build at least 14 reactors more and achieve 90% of capacity factor by 2030
- Share of non-carbon energy in electric power generation should reach ~70%
  - Nuclear ~50%, renewable/hydro ~20%

Capacity Factor of Nuclear Power Plants (1985-2007)



USA 92.0%

Canada 79.8

France 75.8

Germany 74.4

Japan 64.4

Source: METI

Low Capacity Factors caused primarily caused by earthquakes (FY2008)

Best 10	%	Worst 10	%
Genkai#1	101.8	Kashi/Kariha#1	0
Onagawa#2	99.4	Kashi/Kariha#2	0
Genkai#4	99.1	Kashi/Kariha#3	0
Shimane#1	96.4	Kashi/Kariha#4	0
Hamaoka#3	95.4	Kashi/Kariha#5	0
Fukushima1#6	95.2	Kashi/Kariha#6	0
Fukushima2#4	93.4	Kashi/Kariha#7	0
Fukushima1#4	90.5	Shika#1 *1	0
Fukushima2#1	89.1	Onagawa#1 *2	0.5
Hamaoka#4	87.4	Tsuruga#2 *3	23.1

*1: Operation not allowed by local government due to hiding the criticality accident
*2: Repairing the recirculation pipe by SCC cracks
*3: Repairing the hot-leg nozzles of SG by SCC cracks

Source: METI and JAEC

Best 20 nuclear plants in the world :6 out of 20 are Japanese (2009)

No	Country	Plamt	Utility	Type	Vendor	MW	2009		2007-2009	
							Power Generated MWh	Capacity Factor %	Power Generated MWh	Capacity Factor %
1	**Japan**	**Sendai#1**	**Kyushu**	**PWR**	**MHI**	**890**	**8,186,427**	**104.99**	**6,724,957**	**86.18**
2	U.S.	San Onofre-3	SCE et al	PWR	CE	1,127	10,283,101	104.16	8,842,962	89.51
3	U.S.	Comanche Peak-1	Luminant Power	PWR	West	1,215	11,022,673	103.56	9,994,115	93.81
4	U.S.	Susquehanna-1	PPL Susquehanna	BWR	GE	1,202	10,875,525	103.29	10,029,543	95.17
5	**Japan**	**Takahama#4**	**Kansai**	**PWR**	**MHI**	**870**	**7,848,689**	**102.97**	**6,340,566**	**83.12**
6	**Japan**	**Ikata#3**	**Shikoku**	**PWR**	**MHI**	**890**	**8,026,654**	**102.94**	**7,274,782**	**93.22**
7	U.S.	FitzPatrick	Entergy	BWR	GE	849	7,650,216	102.86	7,243,376	97.31
8	U.S.	St. Lucie-1	FloridaP&L	PWR	CE	872	7,845,120	102.7	7,148,400	93.5
9	U.S.	Millstone-3	Dominion Energy et al	PWR	West	1,206	10,840,563	102.61	9,718,972	91.92
10	**Japan**	**Tomari#1**	**Hokkaido**	**PWR**	**MHI**	**579**	**5,198,597**	**102.48**	**4,218,953**	**83.11**
11	U.S.	Limerick-1	Exelon	BWR	GE	1,163	10,377,108	101.86	10,145,936	99.5
12	Lithuania	Ignalina-2	Lietuvos Energija	RBMK	MAE	1,300	11,598,200	101.83	10,459,700	91.76
13	**Japan**	**Oi#4**	**Kansai**	**PWR**	**MHI**	**1,180**	**10,498,543**	**101.55**	**8,916,095**	**86.18**
14	South Korea	Yonggwang-2	KHNP	PWR	West	978	8,674,891	101.24	7,899,387	92.11
15	U.S.	Byron-2	Exelon	PWR	West	1,210	10,690,001	100.85	10,063,757	94.86
16	South Korea	Yonggwang-3	KHNP	PWR	KHIC-CE	1,039	9,174,997	100.79	8,521,338	93.53
17	U.S.	Calvert Cliffs-1	Constellation	PWR	CE	890	7,857,418	100.78	7,771,094	99.59
18	**Japan**	**Fukushima2 #3**	**TEPCO**	**BWR**	**Toshiba**	**1,100**	**9,702,910**	**100.68**	**7,841,887**	**81.31**
19	U.S.	Vermont Yankee	Entergy	BWR	GE	635	5,594,248	100.57	5,215,741	93.68
20	South Korea	Ulchin-2	KHNP	PWR	Framatome	984	8,665,788	100.52	8,013,341	92.87

Source: Nucleonics Week

Japan needs to reduce inspection periods

	Operation Periods (Months)*		Regular Inspection Periods (Months)**	
	Japan	US	Japan	US
1990	12.4	14.2	4.6	3.1
1995	13.1	15.5	3.2	2.1
2000	13.5	17.5	2.9	1.4
2005	12.4	18.9	4.2	1.3

* Japan: Average operation periods between regular inspections
** Japan: Average regular inspection periods excluding those beyond 800 days,
US: Average refueling periods
Source: METI

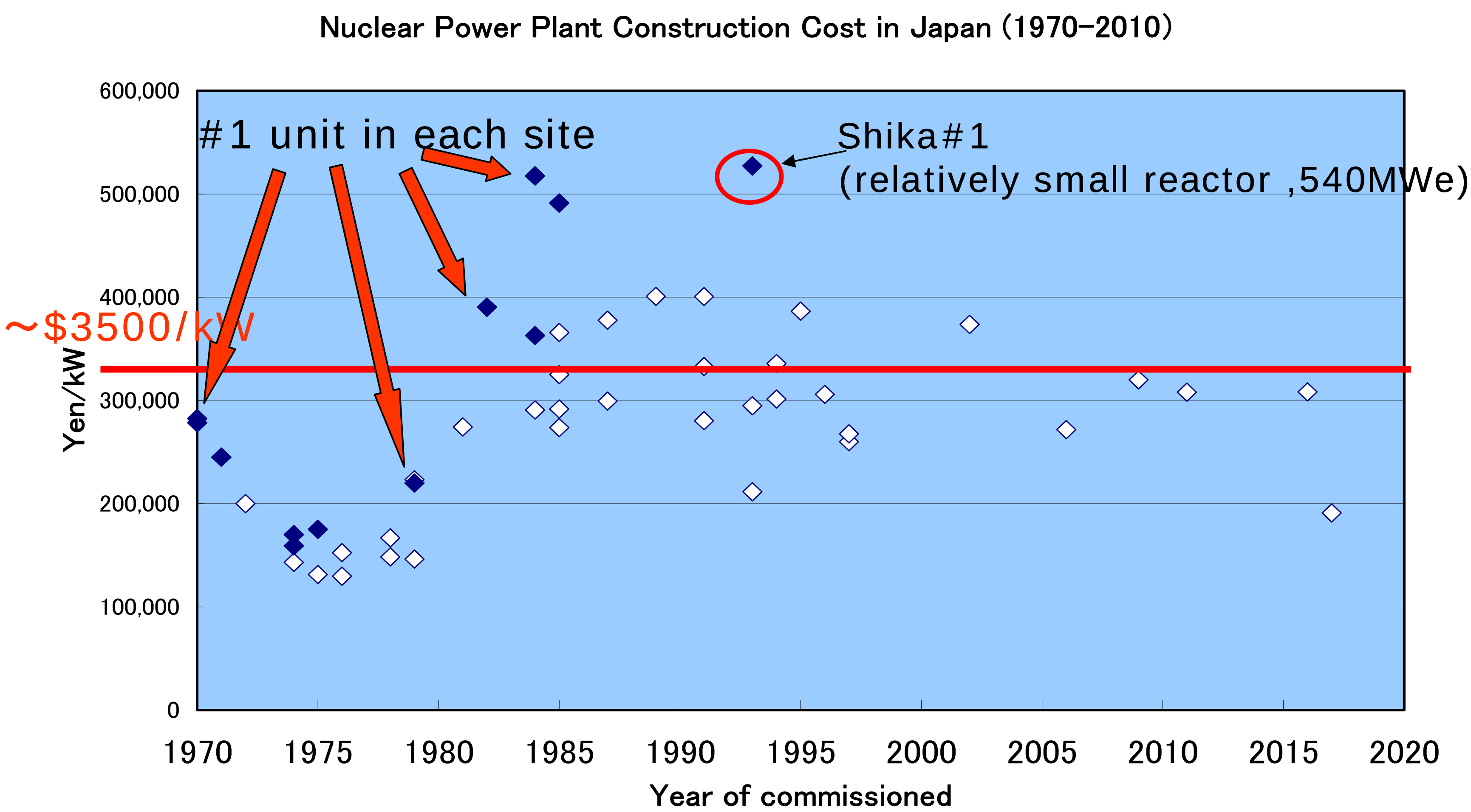
Low frequency, but longer unplanned shutdown period for Japan

	No. of Units	Frequency of Unplanned shutdown (event/reactor･year	Average Shutdown Periods (Days)
Japan	55	0.55	37.2
USA	103	1.50	5.1

For Japan: Between 2007~2008
For US: Between 2004~2005

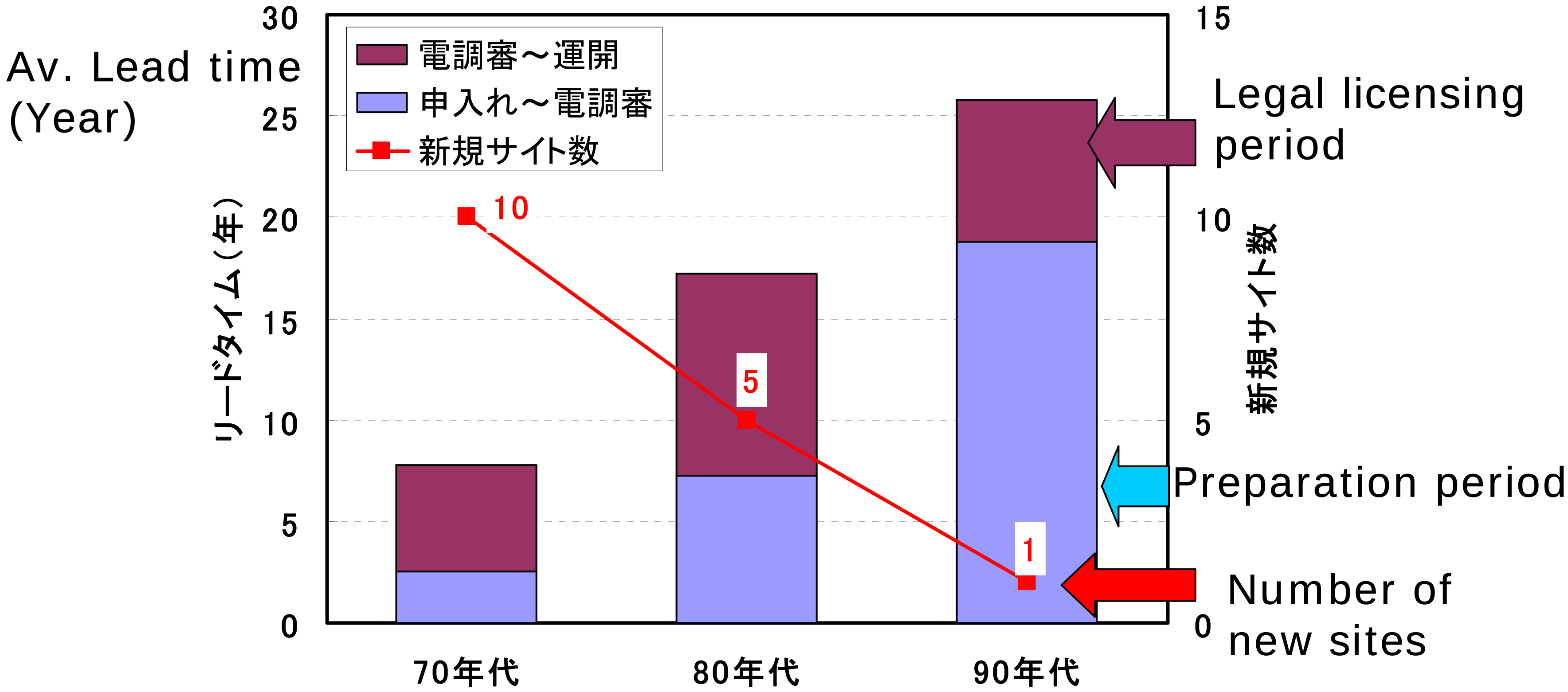
Source: Japan Atomic Energy Commission (2010)

Nuclear Power Plant Capital Cost Trends in Japan ('70-2010)



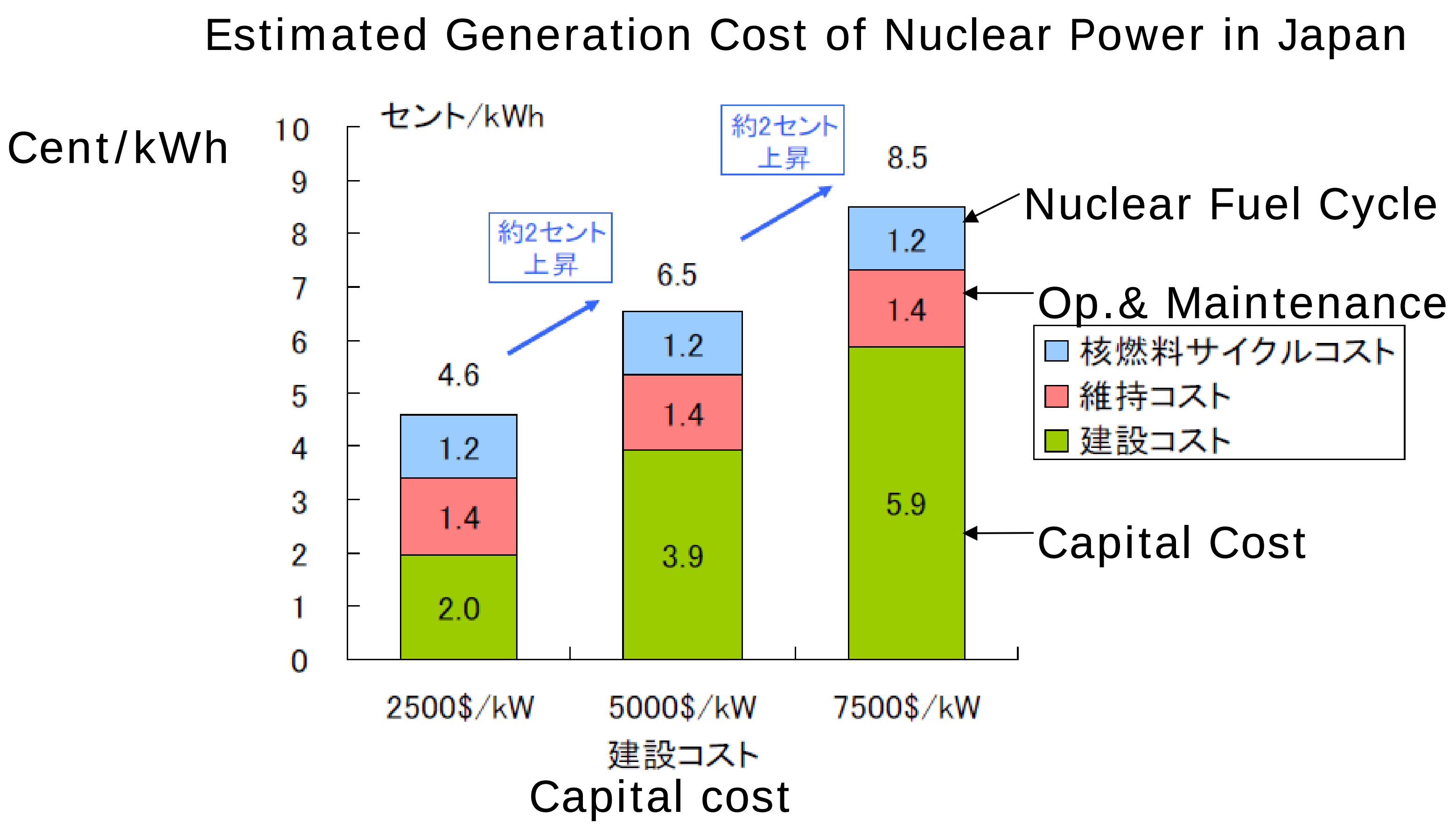
Source: JAEC based on the data published by utilities and local governments

Lead time for finding new construction site needs to be shortened



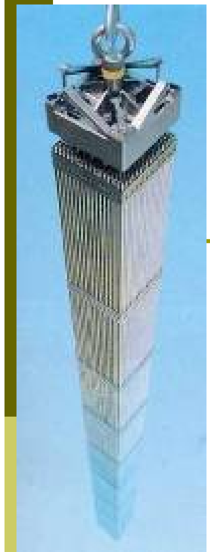
Source: S. Muto, Tokyo Electric Power Co., April 2010

Economics of Nuclear Power: Capital cost is key



Source: Institute of Energy Economics, March 2010

Three types of spent fuel storage capacity



At-reactor storage

Storage capacity: 19,420 tU/17 sites

On-site dry cask storage is not allowed by local governments (Fukushima-1 & Tokai-2 was allowed).

Rokkasho reprocessing plant

Storage capacity:**3,000tU**

(storage **2,834 tU** as of March 2010)

Construction cost: ¥2.14Trillion

Mutsu Interim storage site

Dry Cask storage type

Capacity : totally 5,000 tU

1st 3,000 tU, add 2,000tU in future

Operation: July 2012

(Status : Permitted)

Construction cost: ¥0.1Trillion

(including dry casks)

Amount of Spent Fuel at Each Site [tU]

(As of the end of September 2009)

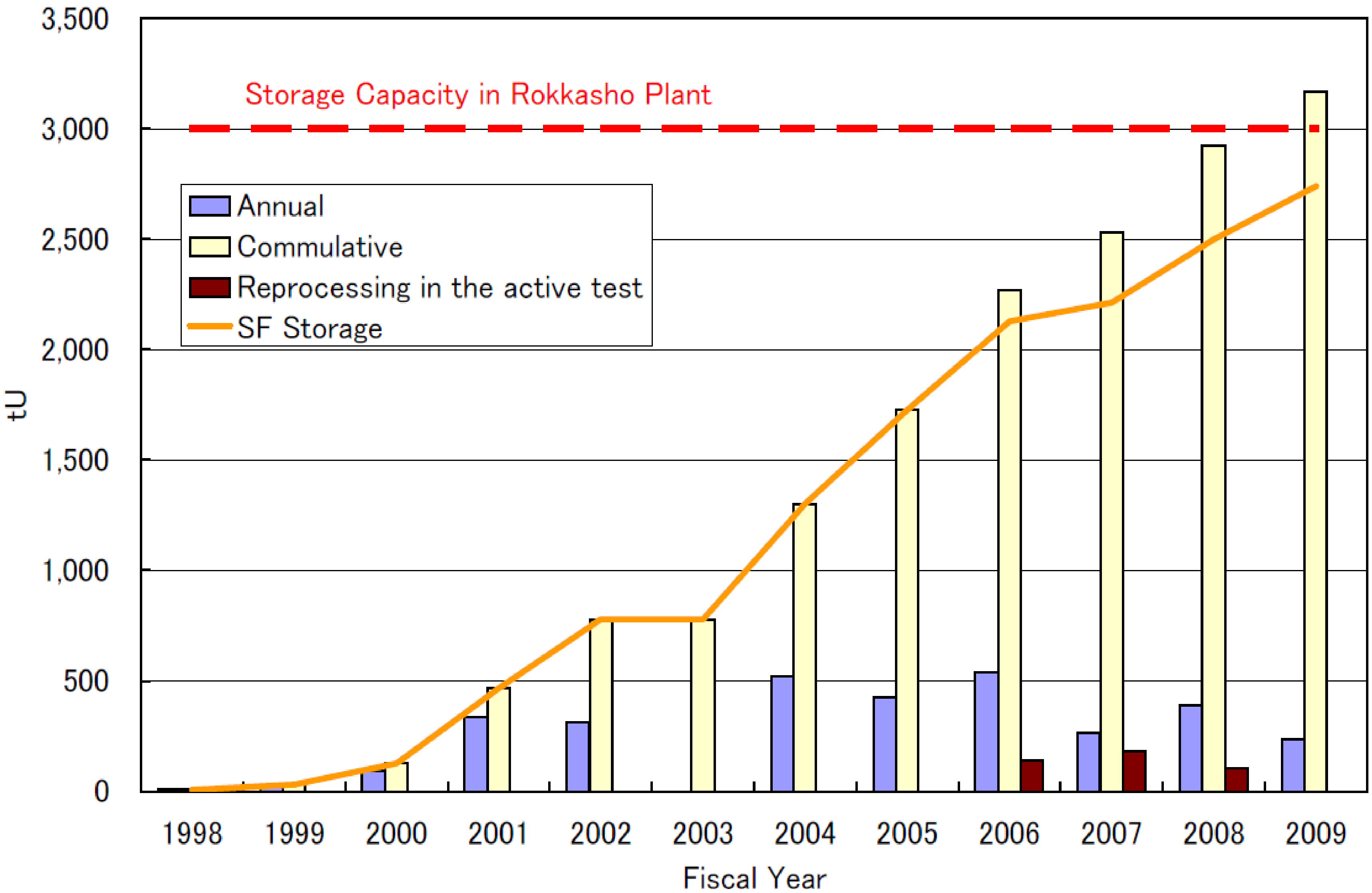
Utilities	Plants		Number of unit	1 Full Core	Annual discharge	Amount of spent fuel	Effective storage capacity
Hokkaido	Tomari	PWR	2	100	30	340	420
Tohoku	Onagawa	BWR	3	260	60	360	790
	Higashidori	BWR	1	130	30	30	230
Tokyo	Fukushima I	BWR	6	580	140	1,720	2,100
	Fukushima II	BWR	4	520	120	1,030	1,360
	Kashiwazaki -Kariwa	BWR	7	960	240	2,140	2,910
Chubu	Hamaoka	BWR	3	410	100	1,080	1,740
Hokuriku	Sika	BWR	2	210	50	110	690
Kansai	Mihama	PWR	3	160	50	320	620
	Takahama	PWR	4	290	100	1,120	1,630
	Ooi	PWR	4	360	110	1,250	1,900
Chugoku	Shimane	BWR	2	170	40	370	600
Shikoku	Ikata	PWR	3	170	60	540	930
Kyusyu	Genkai	PWR	4	270	100	740	1,060
	Sendai	PWR	2	140	50	810	1,140
JAPC	Tsuruga	BWR/ PWR	2	140	40	540	860
	Tokai-II	BWR	1	130	30	350	440
Total			**53**	**5,000**	**1,340**	**12,840**	**19,420**

Effective storage capacity = Storage capacity - (1 Full core + Annual discharge)

Status of Japan's Nuclear Fuel Cycle Programs

- Rokkasho reprocessing plant
  - Due to difficulties of vitrification process, the plant will not operate at least until October 2012.
  - Securing spent fuel storage is urgent task for some utilities
- MOX recycling program
  - Kyushu, Shikoku and Tokyo have started loading MOX fuels. Chubu and Kansai will soon start loading MOX fuels.
  - J-MOX plant will start operation in March 2016.

Transportation Volume to Rokkasho Reprocessing Plant SF Pool



Revised Schedule for Rokkasho as of 2010/09/10 (cf. as of 10/03/31)

(ton U)	FY2010	2011	2012
Spent fuel Received	94(94)	80(80)	20(20)
Reprocessed spent fuel	0(80)	0(320)	80(480)
Spent fuel in storage	2834(2755)	2914(2515)	2854(2055)

Source: Japan Nuclear Fuel Ltd., September 10, 2010

Securing Spent Fuel Storage capacity is critically important

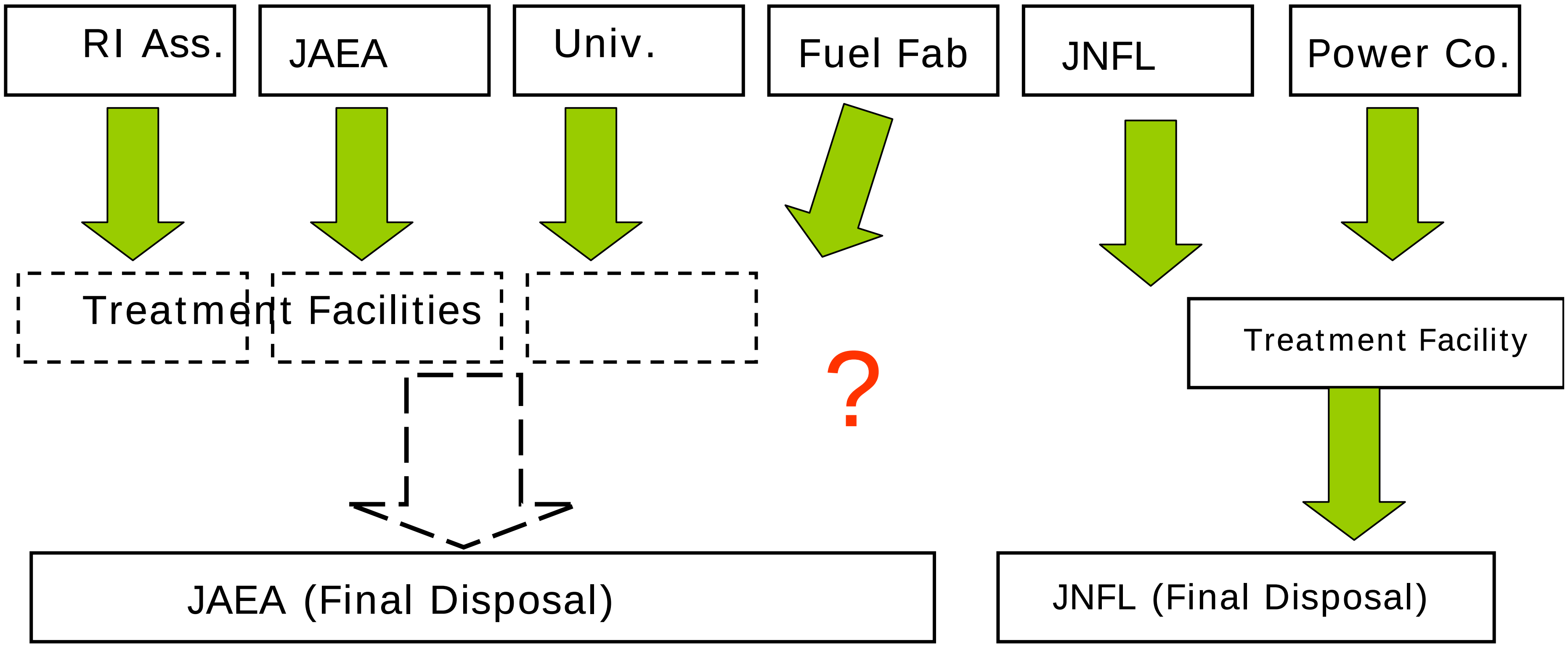
- Recommendation (p. 11)

"...It is important to secure spent fuel storage capacity both on site and offsite, until spent fuel will be reprocessed, assuming that reprocessing operation may not go smoothly as expected..."

Radioactive Waste Management in Japan: Steady progress, but complicated

- Low Level Waste (LLW) from commercial power plants → Japan Nuclear Fuel Ltd's（JNFL's) Rokkasho disposal facility
- LLW from Hospitals/Universities/other facilities → JAEA will dispose
- TRU waste from oversea reprocessing → will be stored at JNFL's Rokkasho facility
- HLW from reprocessing → stored at JNFL's Rokkasho facility, will be disposed by Nuclear Waste Management Organization (NUMO)

LLW management: Not confirmed yet



Geological Disposal of HLW: History

2000: Law on Specified Radioactive Waste (HLW) passed: Nuclear Waste Management Organization (NUMO) was established.

2002: Voluntary siting process started. JAEA(JNC at that time) started the construction of two underground research laboratories, aiming at improving the reliability of disposal technology.

2007: Toyocho (Kochi) applied for preliminary survey, but withdrew later due to public opposition (Mayor recalled)

2007: METI changes its voluntary process to include government's initiative

2008: The HLW Law amended to include TRU waste

2008: JAEC policy review committee recommended to ask for third party's opinion

Geologic Disposal of HLW: JAEA's R&D Efforts

OBJECTIVE:

- To develop technical basis for disposal project and for safety regulations

ACTIVITIES:

- Demonstrate engineering technology and safety assessment methods
- Develop integrated methods for characterizing the deep geological environment
- Develop knowledge basis for promoting geological disposal activities

Geologic Disposal of HLW: Public Opinion (NIMBY syndrome?)

- 2009 public opinion poll:
  - Our generation should decide the site without delay: agree (51.9%): agree on balance (30.3%).
  - How do you think when your or your neighboring municipality plan to accept a HLW repository: affirmative (3.2%): affirmative on balance (12.9%); negative on balance (34.3%); negative (45.3%).

JAEC Seeks Advice from Science Council of Japan on HLW (2010)

- Policy Assessment report (review of JAEC's Framework for Nuclear Energy Policy[2005]) on Waste Management (2008)
  - "…JAEC needs to explore new ways …for better public confidence through seeking advices from independent & third parties …"
- JAEC has decided to seek advice from the Science Council of Japan (September 2010)
  - "…*JAEC decided to seek independent advice from third party*…on ways to provide information to the public, not only on technical facts but also social aspects of science & technology…"

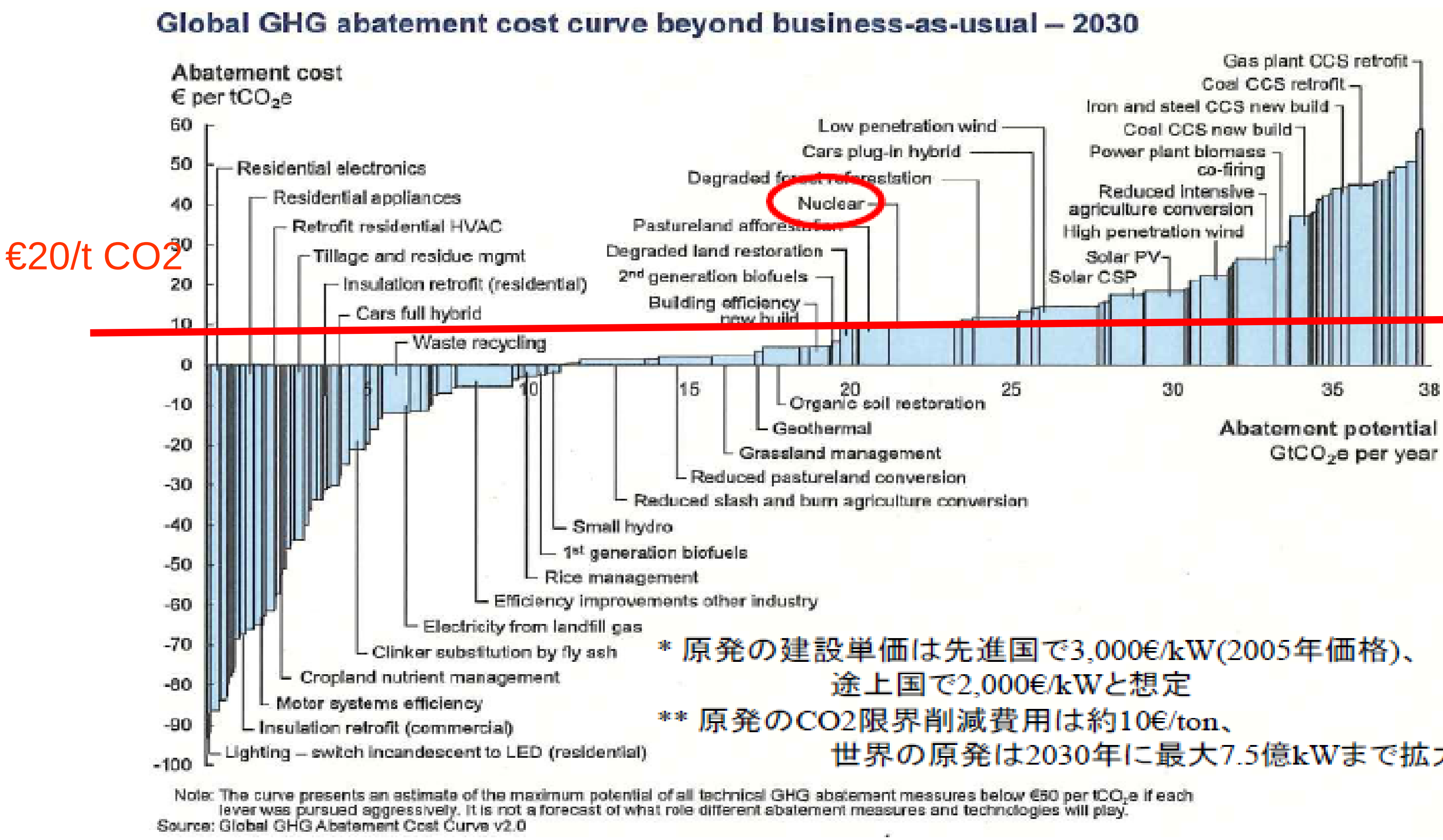
Rec. 3 Develop social and economic environment (1)

- *Initiate new data/information disclosure approach for better public access and policy making*
  - Use advanced information/internet technologies for easier access
  - Improve quality of policy debate and decision making
  - Use new approaches, including objective assessment of social implications of technological development ("Technology Assessment")

Rec. 3 Develop social and economic environment (2)

- “Visualization” of CO2 merits of nuclear power
  - Nuclear power is excluded from Kyoto Mechanism (such as CDM/JI) for CO2 credit
  - It will be most effective if “price” (economic merit) of CO2 reduction is attached to nuclear power as well as other non-carbon sources
  - Japan should introduce such economic measures and seek international agreement on such measures

McKinsey's GHG reduction cost curve (2009)

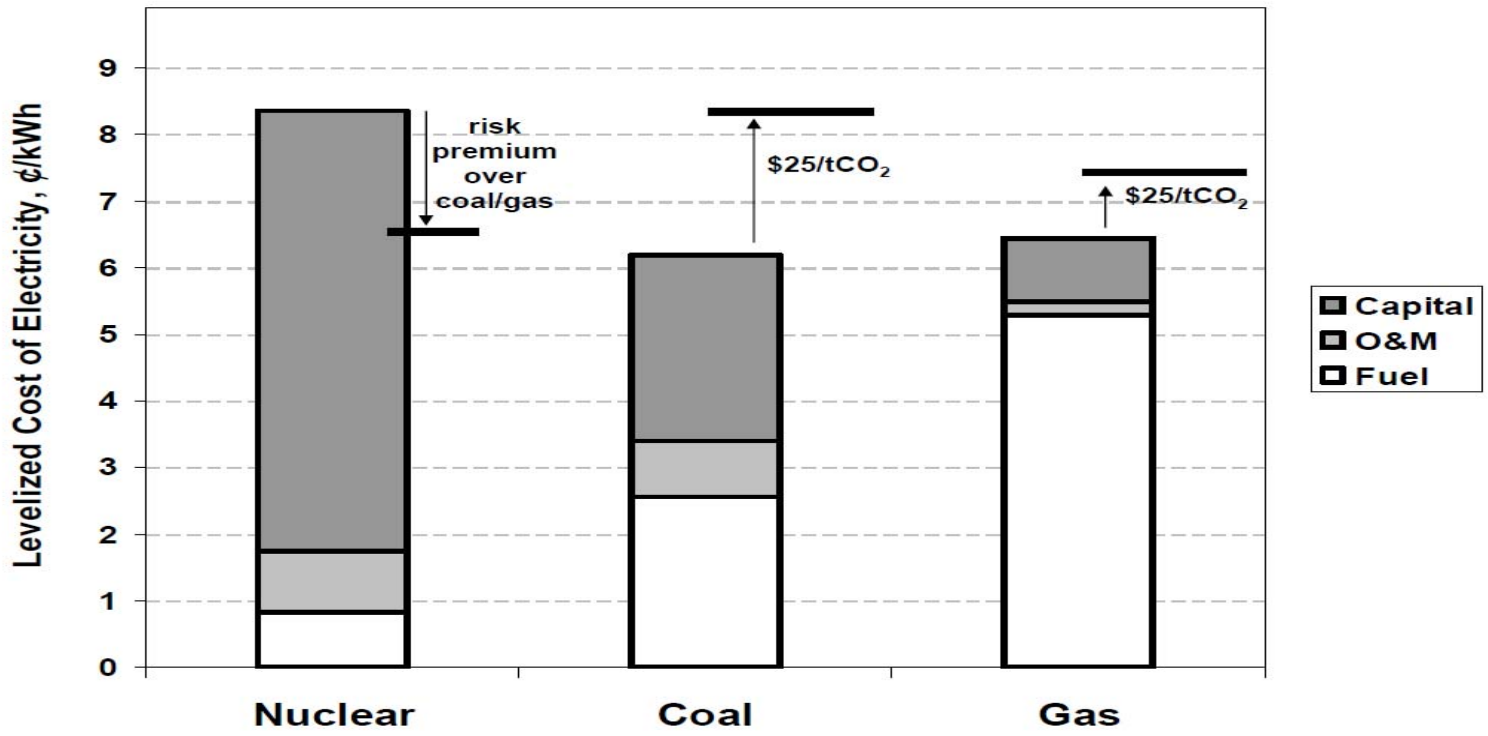


* 原発の建設単価は先進国で3,000€/kW(2005年価格)、
途上国で2,000€/kWと想定

** 原発のCO2限界削減費用は約10€/ton、
世界の原発は2030年に最大7.5億kWまで拡大すると想定

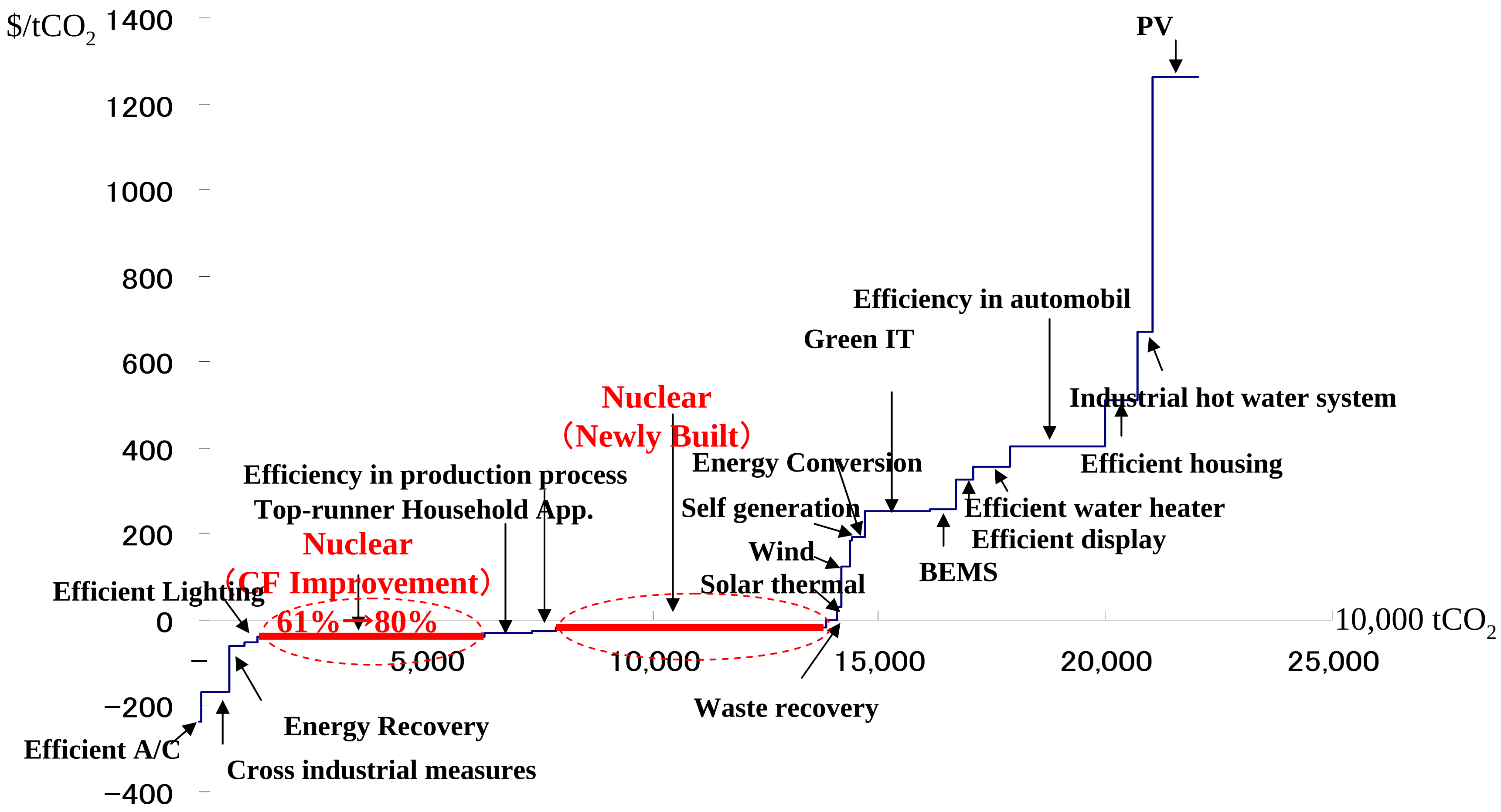
Nuclear power can be competitive with carbon price in the US

Figure 1: Summary Results for the Levelized Cost of Electricity from Alternative Sources



Source: Yangbo Du and John E. Parsons, "Update on the cost of Nuclear Power," May 2009, MIT-CEEPR 090-004, http://web.mit.edu/nuclearpower/pdf/nuclearpower-update2009.pdf

CO2 Cost Curve in Japan by 2020：Nuclear Power is competitive



Source: Institute of Energy Economics, April 2010

Rec. 4 Take New International Approach to meet global demand

- Enhance international efforts to secure 3S (non-proliferation/safeguards, security and safety) with IAEA and other network
- Promote bi-lateral cooperation agreements through strategic planning
- Enhance "coordinating function" among various actors for effective export activities in order to meet various market needs
  - Nuclear industry will establish a new dedicated company for this purpose
- Develop effective financing scheme to reduce financial risk of nuclear power development

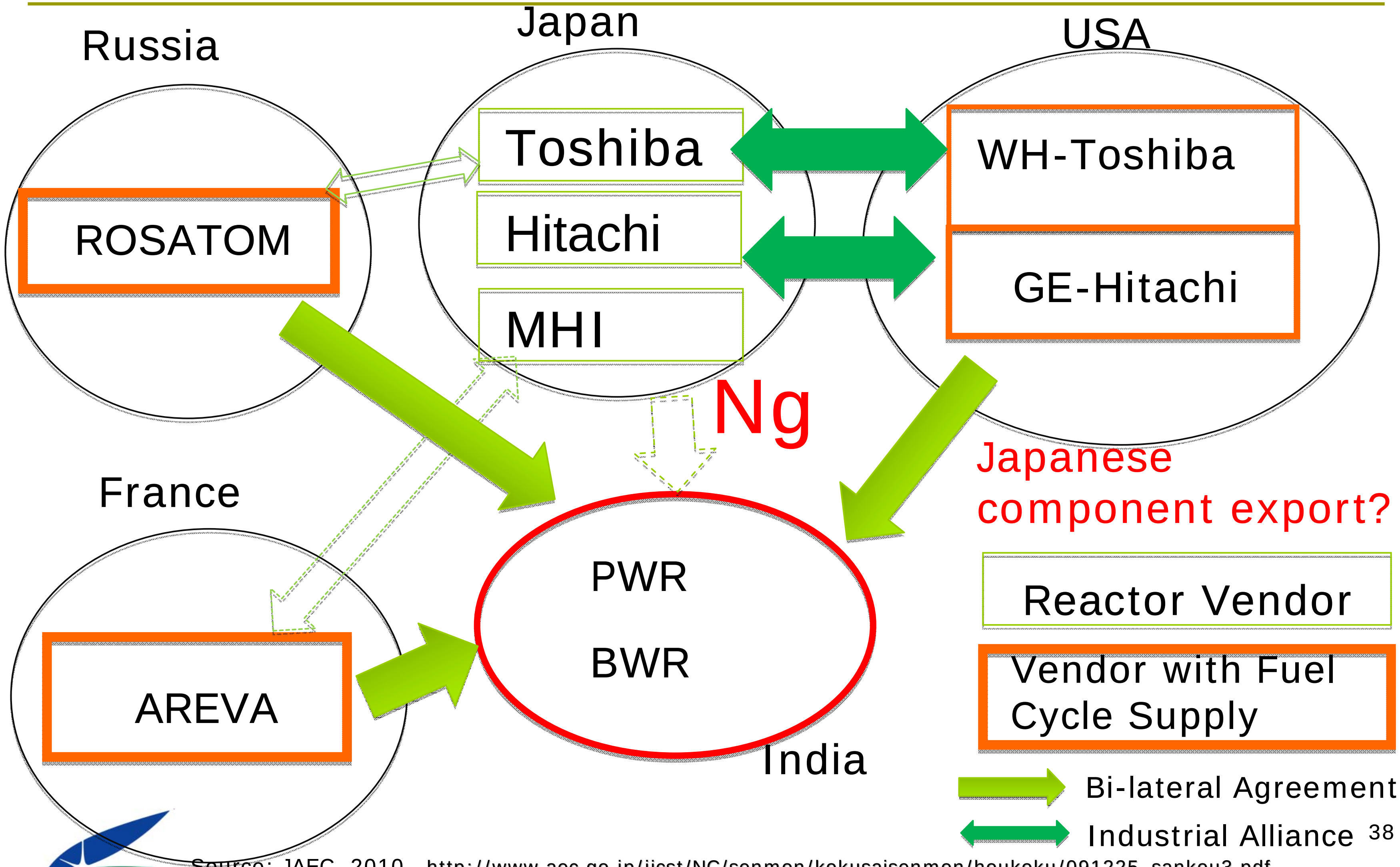
Bi-lateral Cooperation Agreements: Japan is catching up

		USA	France	Russia	UK	Canada	ROK	China	Japan
Ru	Russia	○	◎						○
	Vietnam	Ng	○	○			○	○	Ng.
	Brazil	◎	◎	○		○	○	◎	
	Jordan	Ng.	○	○	○	○	○	○	○
	Turkey	◎	○	○		○	○		
	Indonesia	◎	◎	○		○	○		
	Egypt	◎	◎	○		○	○	○	
	Khazakhstan	◎	○	◎		Ng	○		○
	UAE	◎	○				◎		Ng
	India	◎	◎	○	Ng	Ng	Ng		Ng
	Arzentine	○	○	○		○	○	○	
	S.Africa	○		○				○	Ng

◎:ratified ○:signed Ng: in negotiation

Source: METI, MOFA and updated by JAEC

Bi-lateral Cooperation with India



Source; JAEC, 2010, http://www.aec.go.jp/jicst/NC/senmon/kokusaisenmon/houkoku/091225_sankou3.pdf

NSG Decision to treat India as exception

- In 2008, the NSG decided that nuclear exports to India are allowed as an exemption based on the "commitments and actions" that India has taken voluntarily;
  - a) separate civilian nuclear facilities and a safeguards agreement with the IAEA on such facilities,
  - b) a commitment to sign and adhere to an Additional Protocol with respect to India's civil nuclear facilities,
  - c) refraining from transfer of enrichment and reprocessing technologies to states that do not have them,
  - d) continuing its unilateral moratorium on nuclear testing and its readiness to work with others toward the conclusion of a multilateral Fissile Material Cutoff Treaty.
- the Japanese government decided to join this decision at the last moment after thorough consideration of all factors.
  - At the NSG meeting, then, the Japanese government clarified its position that if India stopped its unilateral moratorium on nuclear testing, the NSG should discontinue its treatment of India as an exemption and that all NSG members should stop their respective nuclear cooperation with India under such occasion.

JAEC issued a statement on negotiation with India (June 29, 2010)

- "...JAEC believes that the government should make sure that the following conditions are met.."
  - India has implemented its "commitments and actions"

- "*Moreover, reflecting Japanese citizens' strong desire for abolishment of nuclear weapons, both countries must have the strong intention to make steady progress in nuclear disarmament creatively and realistically through collaboration with international community*"

Source: JAEC, "Statement on Initiation of Bilateral Negotiations For Japan-India Cooperation Agreement on Peaceful Use of Nuclear Energy," June 29, 2010

http://www.aec.go.jp/jicst/NC/about/kettei/seimei/100629_e.pdf

Bi-lateral Cooperation with Jordan : A possible new approach?

- Sept. 10, 2010: Japan-Jordan Cooperation Agreement signed
  - 10th agreement for Japan (US, UK, Canada, France, Australia, *China*, Euratom, *Russia*, *Kazakhstan, Jordan*) *italic: Japan as a supplier*
- Art. 2,#3: No transfer of enrichment and reprocessing technologies from Japan
- Art. 9: No enrichment and reprocessing within the territory of Jordan
  - *"Nuclear material transferred pursuant to this Agreement and material recovered or produced as a by-product shall not be enriched or reprocessed within the jurisdiction of the Hashemite Kingdom of Jordan"*

Source: http://www.mofa.go.jp/mofaj/gaiko/treaty/pdfs/shomei_61_e.pdf

Rec. 5 Promote Platform for sustainable growth

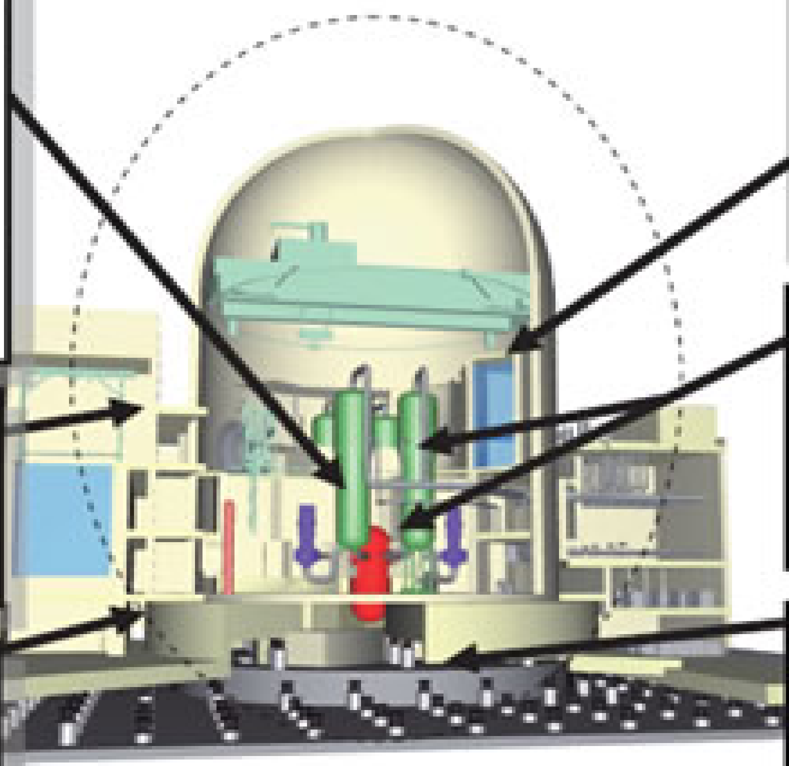
- Promote most advanced R&D activities, including FBR/Fuel Cycle, and develop international network for sustainable R&D infrastructure
  - *Pursue portfolio management* (short-mid term and long-term, diversified technology options including HTGR, Fusion, Thorium, and other innovative nuclear technologies)
- Promote internationalization of human resource development
  - Develop educational infrastructure to *create world-class human resources* to meet increasing global activities

Mid-term R&D Activities: Next Generation LWRs

(1) Significant decrease of spent fuel discharge and highly improved availability by innovative fuels with uranium enrichment above 5%.

(2) Significant shortening of construction period by innovative construction techniques.

(3) Improvement of both plant availability and safety by innovative digital man-machine interface technologies.



(4) Simultaneous realization of higher plant safety and economy by harmonizing passive and active safety systems.

(5) 80 years plant lifetime and significant reduction of worker's exposure by new materials and innovative coolant chemistry control.

(6) Standardization of plant design independent of site conditions by seismic isolation technologies.

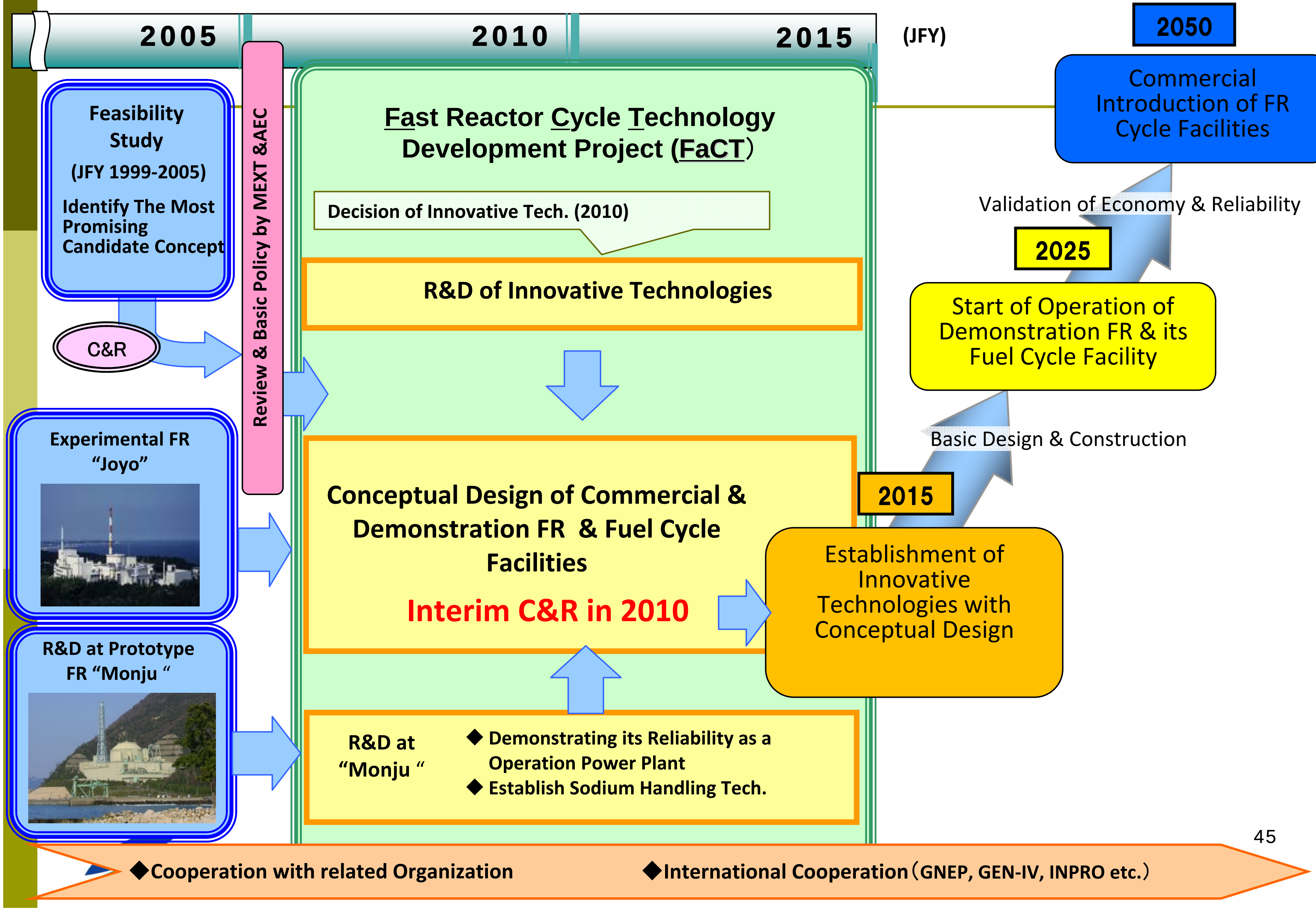
Source: The Institute of Applied Energy HP

1. Technologies shown in the above figure were identified as promising and their development has been promoted.
2. The results of the development will be reviewed in this year and the roadmap for introducing selected technologies will be determined soon.

Summary of Next Generation LWR project

- Target year for commercialization: 2030
  - To meet replacement of majority of Japanese nuclear power plants
- Major Goals
  - Construction cost: ~$1600/kW (1760 MWe)
  - Burnup: ~70 GWD/ton
  - Construction period: <30 months
  - Plant lifetime: 80 years
  - Capacity Factor: 97%
- Total R&D cost: ~$700 million (¥55 bill)
  - Shared by the government and private sectors (~50% each)

FR Cycle Development Program in JAPAN



R&D of Fast Reactor & Its Fuel Cycle Technology: Issues

- Technological Issues:
  - ✓ Acceptance of positive coolant void coefficient in safety design of sodium cooled large fast core reactors: to assure that core melt is non-energetic and or that its occurrence probability is extremely low.
  - ✓ Development of both reprocessing technology to recover mixed plutonium and minor actinides (MAs) from used fuel and fuel fabrication technology to fabricate U-Pu-MA fuel, taking into consideration the high radioactivity and high heat generation rate of actinides in the processes.
  - ✓ Introduction of integrated components to reduce volume and length of piping is worth pursuing or not.
- Programmatic Issues:
  - ✓ Appropriateness of selected requirement: is it necessary and feasible to pursue international harmonization of standards for safety, proliferation resistance and physical protection
  - ✓ How to accelerate technology demonstration: international coordination of national/regional activities.

R&D Portfolio for Pursuing Sustainable Nuclear Energy Technology

- **Basic and generic R&D**: for sustaining expertise in nuclear science and engineering, including material science, earthquake engineering, advanced modeling and simulation, advanced safeguards technology, etc.
- **Short and medium term R&D**: for assuring safe, reliable and efficient operation of LWR and its fuel cycle, and commercializing advanced LWRs with reduced capital cost, robustness in maintaining safety and reliability and improved human consciousness.
- **Long-term R&D**: for developing fourth generation nuclear energy technology, focusing on the fast reactor and its fuel cycle, hydrogen generation and fusion energy

SUMMARY

- Japanese government is pursuing aggressive strategy to promote “green innovation” and “life innovation” and nuclear power is an essential part of such strategy
- Increasing share of nuclear power (~50% by 2030) with steady progress in nuclear fuel cycle is necessary to achieve that goal
- New social/economic environments should be established with enhanced public confidence
- Japanese government and industry should work more effectively for active contribution to global nuclear expansion while non-proliferation, security and safety must be secured
- For beyond 2020, Japan should develop robust social platform for sustainable R&D and human resource development