Trends in International Nuclear Markets and Impending Issues for Japan

Nuclear Renaissance and the U.S.-Japan Alliance:
Finding New Markets and Preventing Proliferation

The Brookings Institution, Center for Northeast Asian Policy Studies
Hokkaido University, Slavic Research Center

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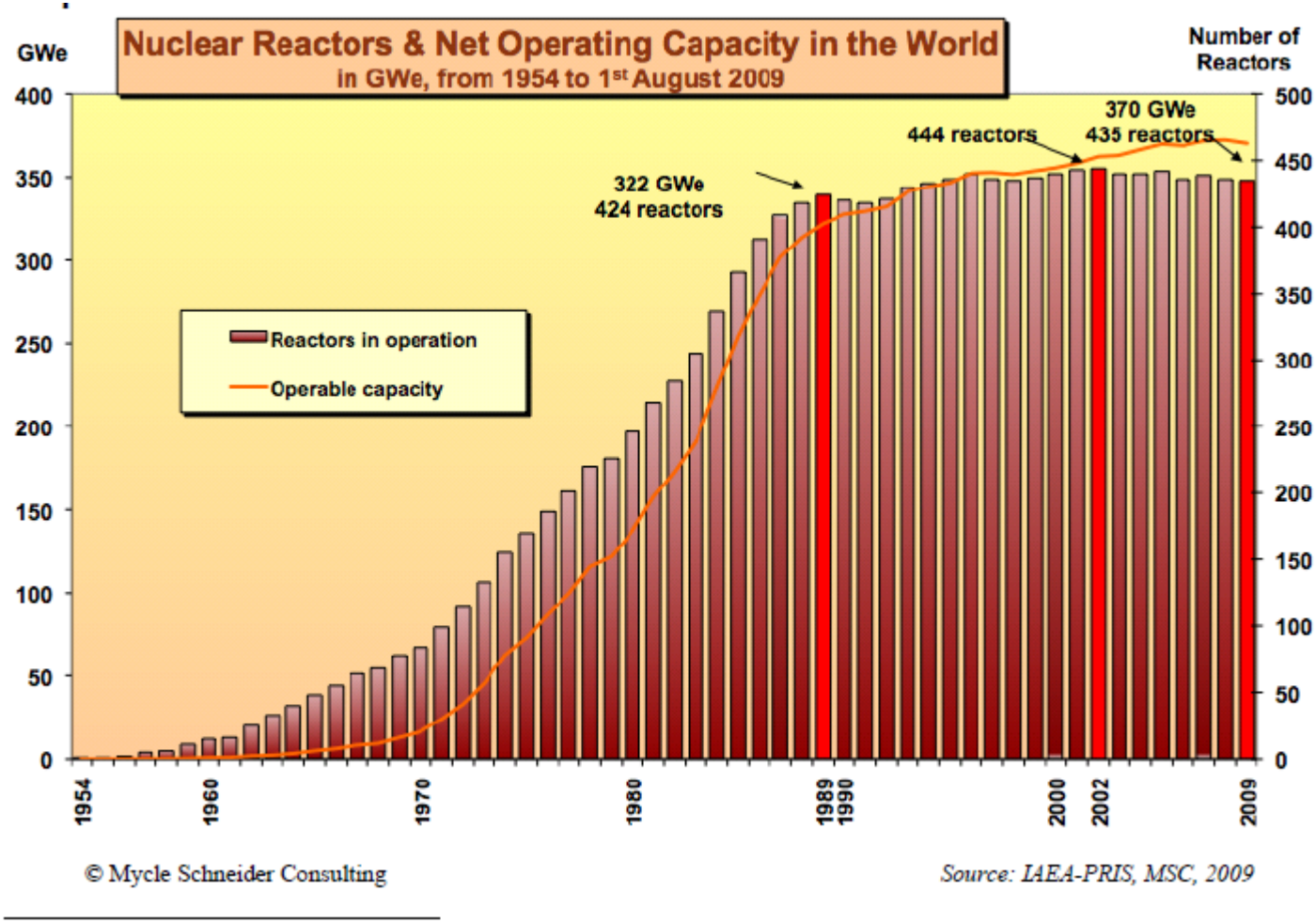
Current Status of Global Nuclear Energy

- At the April of 2009, **436** nuclear power plants in operation in with a total net installed capacity of **370.2 GW(e) .**
- ~**80%** of its capacity is in OECD countries
- **5** units(3.9GW) in long term shutdown (2006)
- **45** units(40 GW) under construction, 25 of which is in Asia(2008)
- Supply **~16%** of global electricity generation

Source: International Atomic Energy Agency.(2009) and Mycle Schneider, Steve Thomas, Antony Froggatt and Doug Koplow, “The World Nuclear Industry Status Report 2009," August 2009.



Source: Mycle Schneider et.al "The World Nuclear Industry Status Report 2009," August 2009.
http://www.bmu.de/files/english/pdf/application/pdf/welt_statusbericht_atomindustrie_0908_en_bf.pdf

OECD/IEA's nuclear power growth estimate up to 2030: 416GW~519GW

Region	Nuclear Capacity [GW]			Share of nuclear in electricity generation		
	2005	2030 Reference Scenario	2030 Alternative Policy	2005	2030 Reference Scenario	2030 Alternative Policy
OECD	**308**	**296**	**362**	**22%**	**16%**	**22%**
OECD North America	112	128	144	18%	15%	18%
OECD Europe	131	74	110	28%	12%	20%
OECD Pacific	65	94	108	25%	32%	41%
Transition economies	**40**	**54**	**64**	**17%**	**18%**	**23%**
Developing countries	**19**	**66**	**93**	**2%**	**3%**	**5%**
China	6	31	50	2%	3%	6%
India	3	19	25	2%	6%	9%
Other Asia	5	10	10	4%	3%	4%
Latin America	3	4	6	2%	2%	3%
Middle East and Africa	2	3	3	1%	1%	1%
World	**368**	**416**	**519**	**15%**	**10%**	**14%**

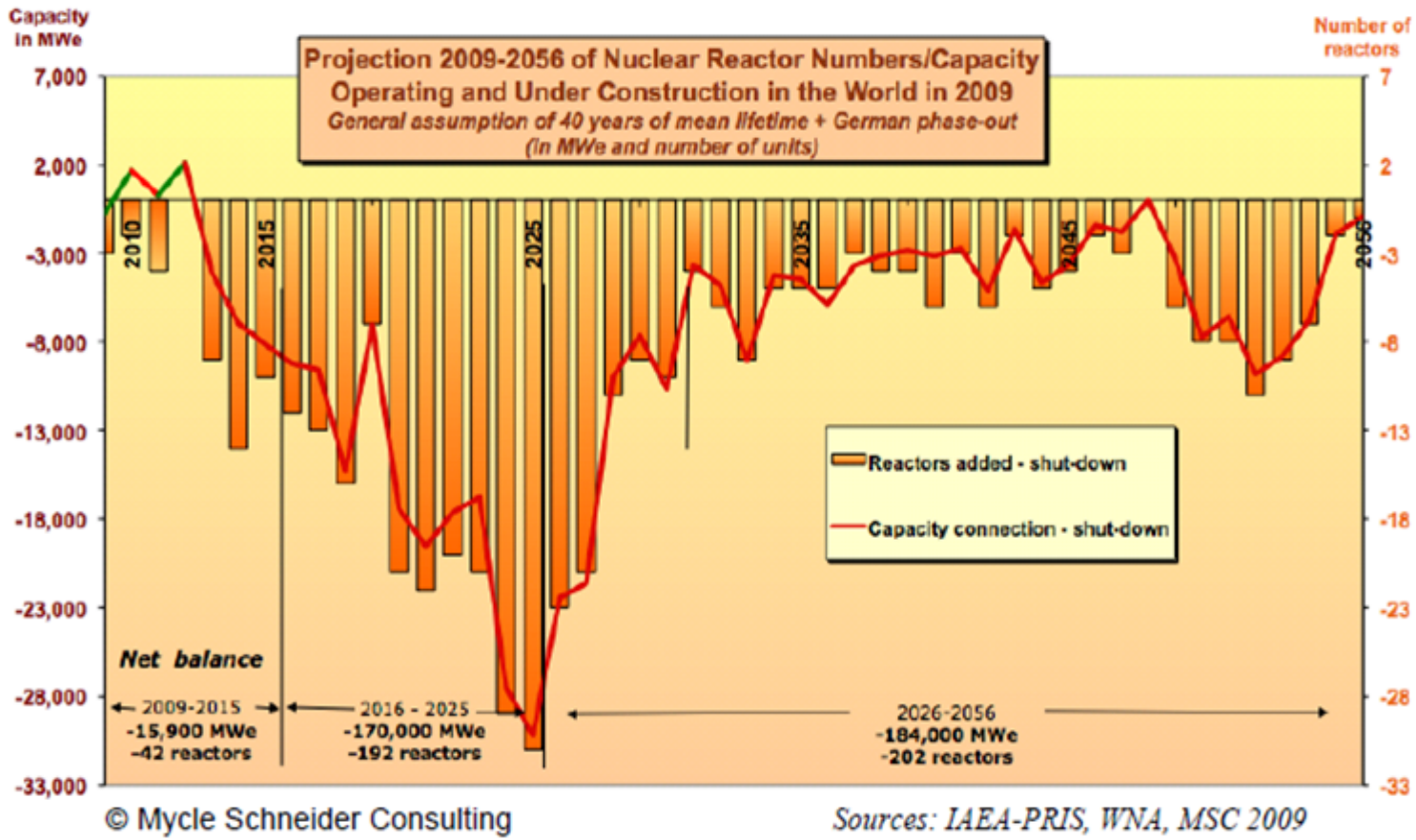
Table 7.2. International Energy Agency (IEA) nuclear capacity projections for 2030.[313]

Source: International Panel on Fissile Materials (IPFM), "Global Fissile Material Report 2007", p.84. (original data from International Energy Agency, "World Energy Outlook 2006," p. 362)

Global Nuclear Capacity Projection

Need for Replacement Orders

Graph 7: The 40-Year Lifetime Projection



Source: Mycle Schneider et.al "The World Nuclear Industry Status Report 2009," August 2009. http://www.bmu.de/files/english/pdf/application/pdf/welt_statusbericht_atomindustrie_0908_en_bf.pdf

Global Nuclear Power Scenario to meet Climate Change Challenge (MIT, 2003)

Global Growth Scenario

REGION	PROJECTED 2050 GWe CAPACITY	NUCLEAR ELECTRICITY MARKET SHARE 2000	2050
Total World	**1,000**	**17%**	**19%**
Developed world	625	23%	29%
U.S.	300		
Europe & Canada	210		
Developed East Asia	115		
FSU	50	16%	23%
Developing world	325	2%	11%
China, India, Pakistan	200		
Indonesia, Brazil, Mexico	75		
Other developing countries	50		

Projected capacity comes from the global electricity demand scenario in Appendix 2, which entails growth in global electricity consumption from 13.6 to 38.7 trillion kWhrs from 2000 to 2050 (2.1% annual growth). The market share in 2050 is predicated on 85% capacity factor for nuclear power reactors. Note that China, India, and Pakistan are nuclear weapons capable states. Other developing countries includes as leading contributors Iran, South Africa, Egypt, Thailand, Philippines, and Vietnam.

Source:MIT Interdisciplinary Study, “The Future of Nuclear Power,” 2003. http://web.mit.edu/nuclearpower/

Expectations and Realities (IAEA Projections)

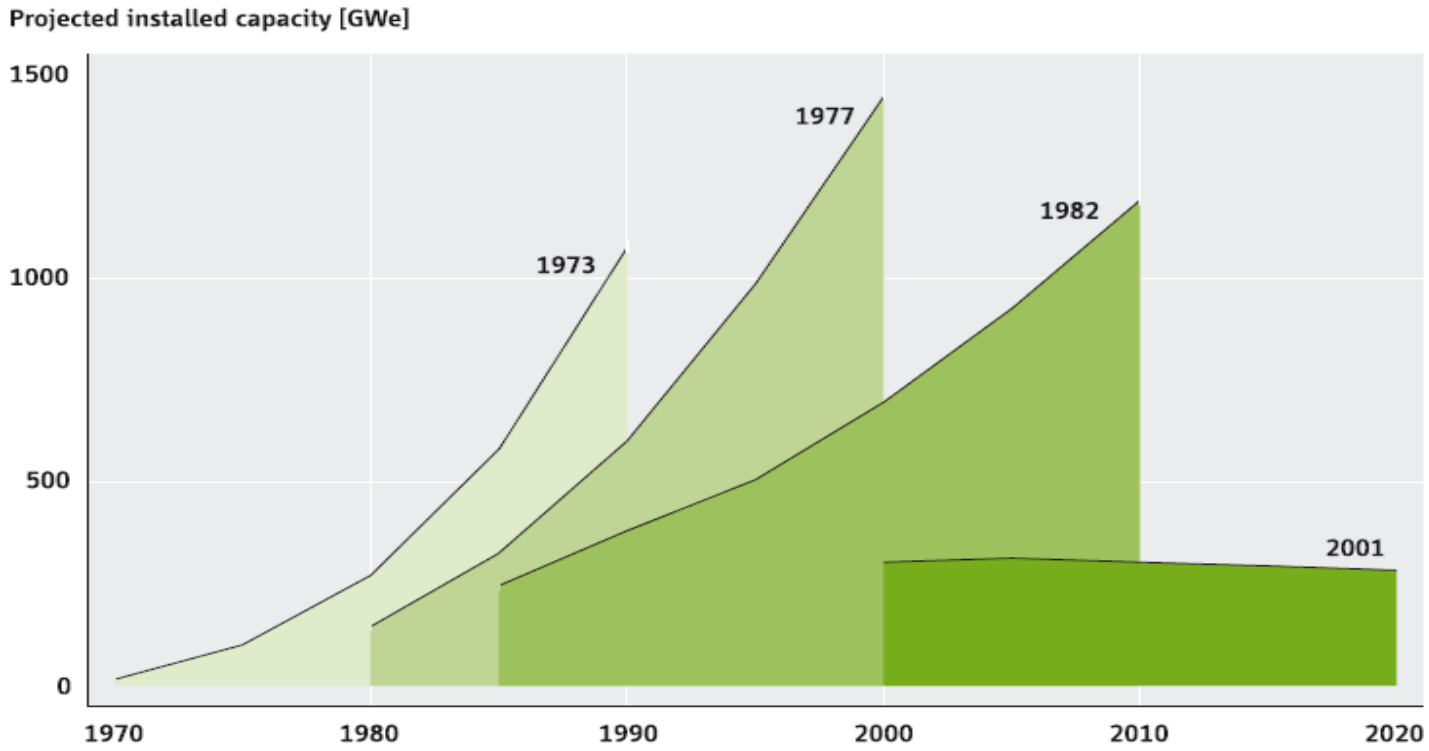


Figure 7.2. IAEA forecasts made in 1973, 1977, 1982, and 2001 for nuclear capacity growth in OECD countries.[316]

Source: International Panel on Fissile Material (IPFM), "Global Fissile Material Report 2007," http://www.fissilematerials.org/ipfm/site_down/gfmr07.pdf

Challenges and Issues for Japan

- Changes in Global Nuclear Industry Structure and Competitive Market
- Nuclear Diplomacy
- Spent fuel management

Japanese Nuclear Industry Description by Reactor Type

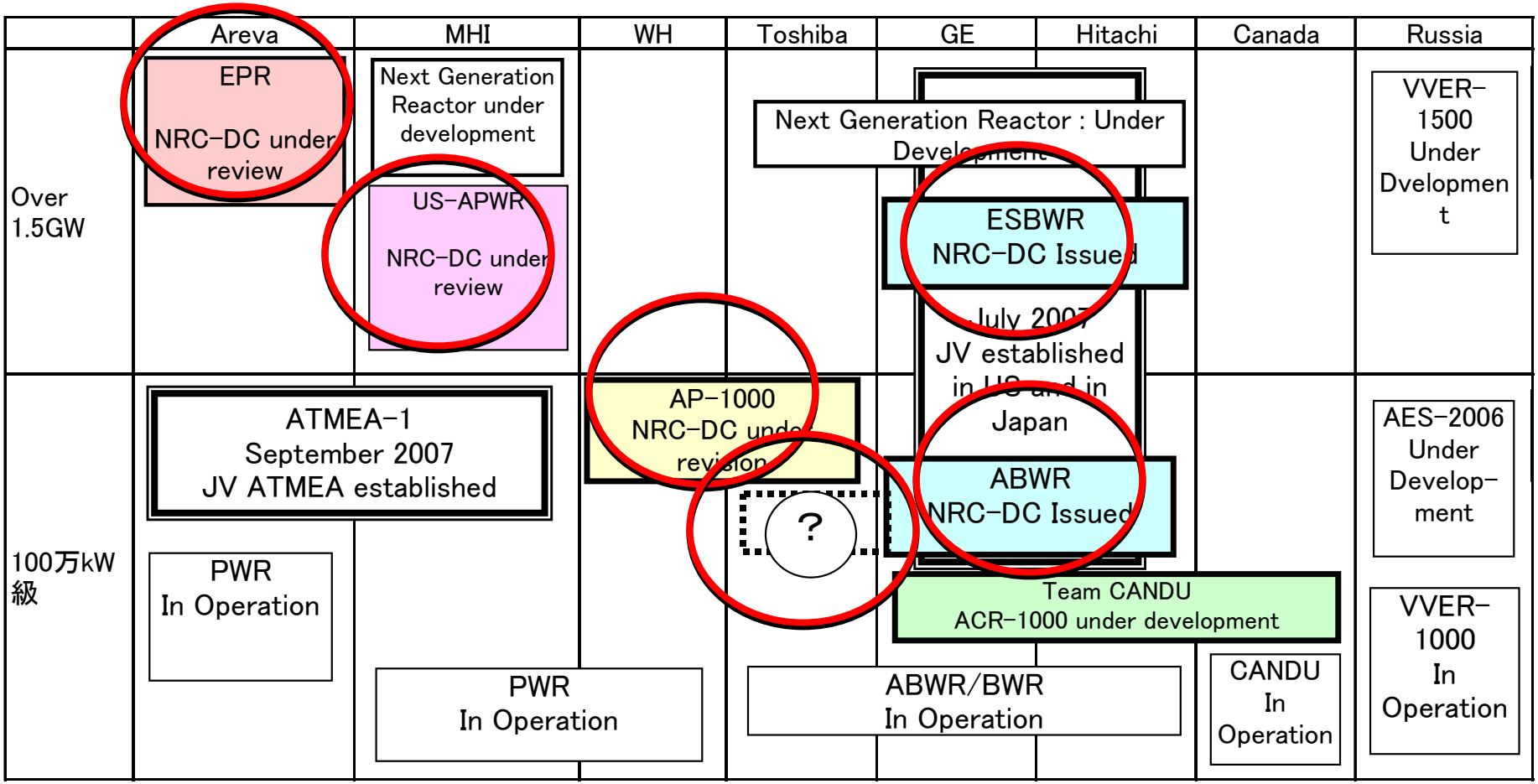
- PWR is a dominant reactor type (>80%) in global market, while PWR/BWR share roughly 50% each in Japan

	BWR Group	PWR Group
Plant Maker	GE, Toshiba, Hitachi	Westinghouse, Mitsubishi
Electric Power Utilities	Tokyo(17), Tohoku(4), Hokuriku(2), Chubu(5), Chugoku(2), JAPC(2), J-Power	Kansai(11), Shikoku(3), Kyushu(6), Hokkaido(2), JAPC(1)

( ):Number of reactors in operation in 2008

Source: Tomoko Murakami, Institute of Energy Economics (2009)

New Reactors --- ABWR and APWR and the others in the World



NRC-DC: Design Certification of Nuclear Regulatory Commission in US

Source: Tomoko Murakami, Institute of Energy Economics (2009)

List of Planned Nuclear Power Projects in the US (2009)

Table 4: US Nuclear Power Plant Projects Announced Since 2006

Plant	Owner	COL Application submitted	Loan Guarantee	Design	Estimated cost ($bn)	Estimated cost $/kW
Calvert Cliffs 3†	UniStar	3/08	Applied	EPR	n/a	
South Texas 3, 4†	NRG/Exelon	9/07	Applied	ABWR	n/a	
Bellefonte 3, 4	TVA	10/07	Not eligible	AP-1000	5.6-10.4+	2500-4600
North Anna 3	Dominion	11/07	Applied	ESBWR	n/a	
Lee 1, 2	Duke	12/07	Applied	AP-1000	11+	4900
Harris 2, 3	Progress	2/08	Not applied	AP-1000	n/a	
Grand Gulf 3	Entergy	2/08	Applied	ESBWR	n/a	
Vogtle 3, 4 †	Southern	3/08	Applied	AP-1000	14*	6250*
Summer 2, 3†	SCANA	3/08	Applied	AP-1000	9.8+	4400
Callaway 2	AmerenUE	7/08	Applied	EPR	n/a	
Levy 1, 2	Progress	7/08	Applied	AP-1000	10.5+	4750+
Victoria 1, 2	Exelon	9/08	Applied	ESBWR	n/a	
Fermi 3	DTE Energy	9/08	Not applied	ESBWR	n/a	
Comanche 3, 4	TXU	9/08	Applied	APWR	n/a	
Nine Mile Point 3	Unistar	10/08	Applied	EPR	n/a	
Bell Bend	PPL	10/08	Applied	EPR	n/a	
Amarillo 1, 2	Amarillo	?		EPR	n/a	
River Bend	Entergy	9/08	Applied	ESBWR	n/a	
Elmore	UniStar	?		EPR	n/a	
Turkey Point 6, 7	FPL	3/09	?	AP-1000	6.9-10.1+	3100-4500

Source: Steve Thomas

Notes:

1. COL: Combined Construction & Operating License.
2. Estimates marked '*' include interest while those marked '+' are overnight costs.
3. In January 2009, Entergy asked the NRC to suspend reviews of the COL for Grand Gulf & River Bend[219]

Projects marked † are reported to have been shortlisted by the US Department of Energy for loan guarantees.

Source: Mycle Schneider et.al "The World Nuclear Industry Status Report 2009," August 2009. http://www.bmu.de/files/english/pdf/application/pdf/welt_statusbericht_atomindustrie_0908_en_bf.pdf

Toshiba-WH deal has changed Japanese nuclear industry structure

- Toshiba-Hitachi-GE and MHI-WH shared (almost equally) the Japanese market since 1960s
- Now, three nuclear groups (Toshiba-WH, Hitachi-GE, and AREVA [with MHI?]) compete in global nuclear market
- METI's "Japanese flag LWR project" has become less significant project
- Toshiba is now expanding global activities through WH network

Strength and Weakness of Japanese Plant Makers

- Key Advantage :
  - Manufacturing Capability
  - High level of Technological Readiness & Quality
  - Seismic design and safety
  - Efficient Construction Management
  - Toshiba-WH team now has both PWR and BWR
- Weakness
  - Lack of nuclear fuel cycle (export) capability and of reactor export experiences
  - High quality may lead to expensive capital cost

Japan’s More Active Nuclear Diplomacy

- With shrinking domestic market, Japan has introduced policy measures to support industry's international activities
  - Resource diplomacy and financial support for oversea uranium exploration
    - New Bi-lateral agreement with Kazakhstan
    - Active cooperation programs with Vietnam, UAE, Indonesia etc..
  - Loan guarantee for nuclear reactor export
    - Helping nuclear revival in the US
- But, very cautious attitude towards India
  - Support at NSG meeting but with conditions attached
  - No commitment yet to bi-lateral agreement
- Stronger Export Control policies and Physical Protection
  - Illegal export by Japanese companies to N. Korea
  - Responding to UN1540, Physical Protection Convention, etc.

Japan's "Resource Diplomacy"

BBC World News, August 28, 2006

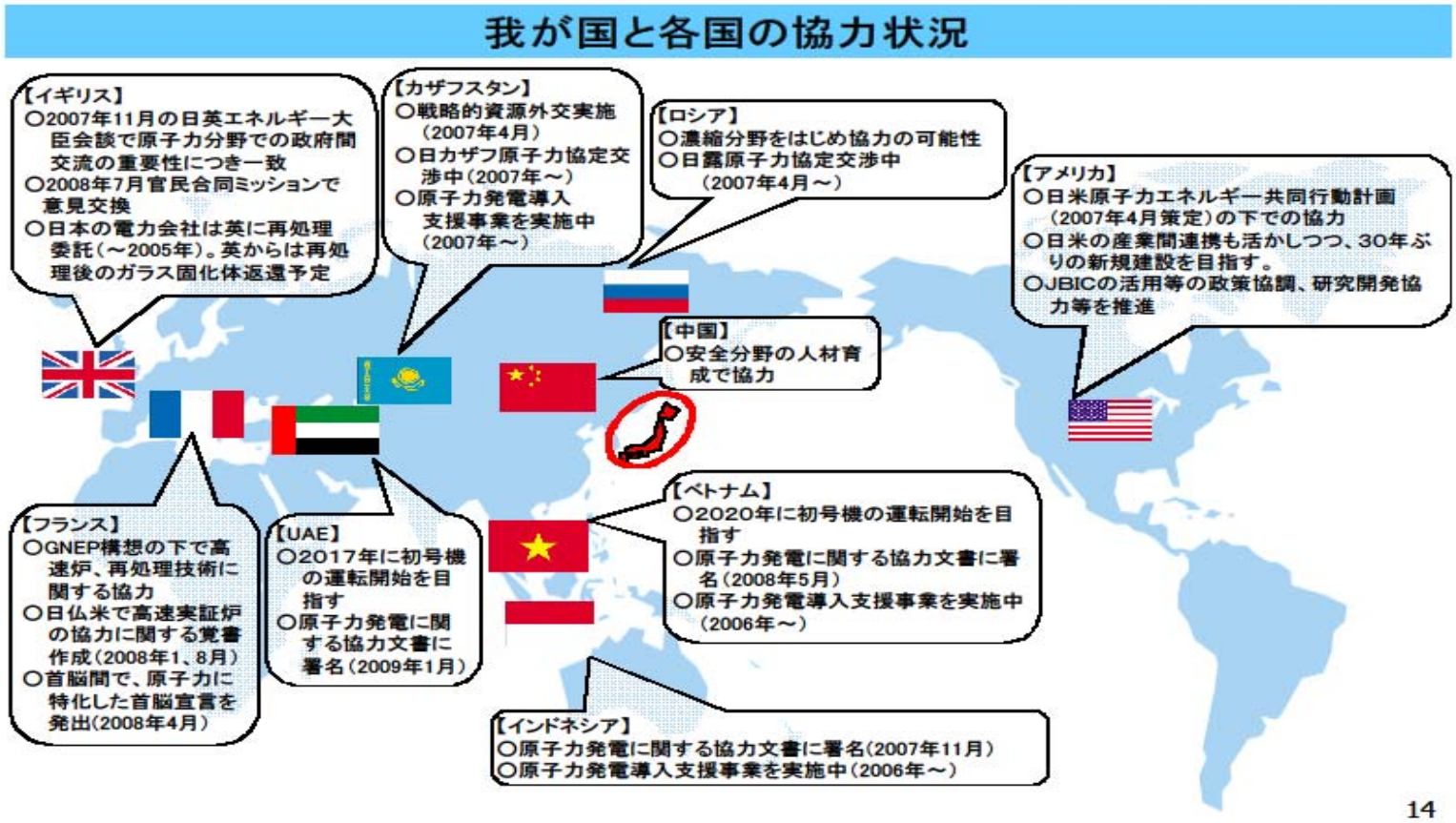
Koizumi begins Central Asia visit

Japanese Prime Minister Junichiro Koizumi has arrived in Kazakhstan to begin the first visit to Central Asia by a Japanese premier

"In the game of regional politics, Japan feels it has a role to play in helping offset growing Russian and Chinese influence"
Col Christopher Langton
International Institute of Strategic Studies

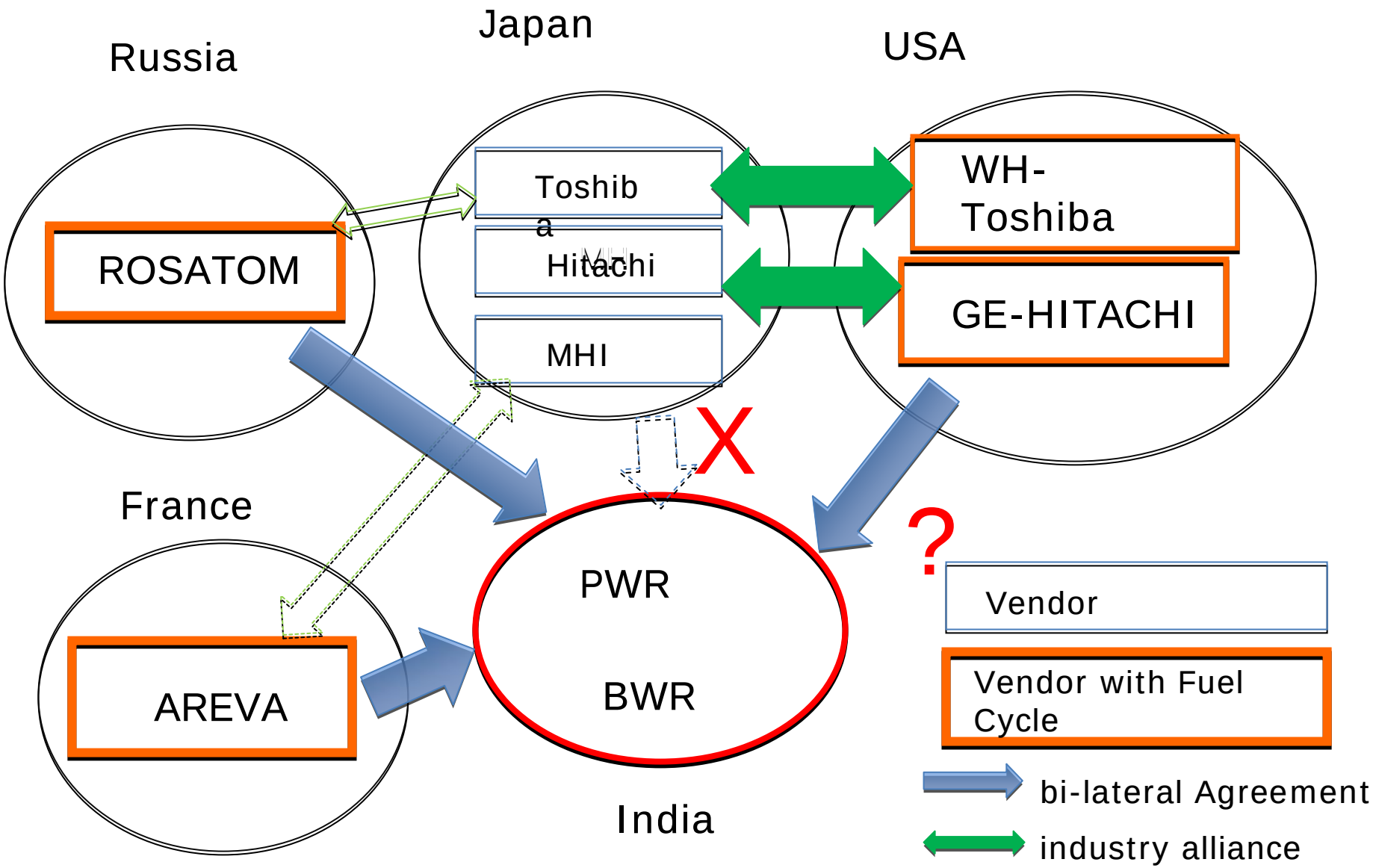
source: BBC News http://news.bbc.co.uk/2/hi/asia-pacific/5291858.stm

Active Nuclear Cooperation by Japan



Source: METI, "Recent Developments in Nuclear Power Programs in Japan, " February 2009 (in Japanese)

Cooperation with India?



Spent fuel and Waste Management and Nuclear Fuel Cycle

- No country has successfully completed spent fuel (HLW) repository facility
- Pressure is increasing on governments and utility industry to reduce “burden” of HLW/SF programs
  - Expectations for advanced fuel cycle technologies
  - Benefits and potential risks are not certain
- Financial, political and social risks associated with back-end of fuel cycle are increasing
  - **Need for securing spent fuel storage capacity to avoid unnecessary reprocessing**

Global Pu Stockpile (2008)

250 ton each for civilian/military

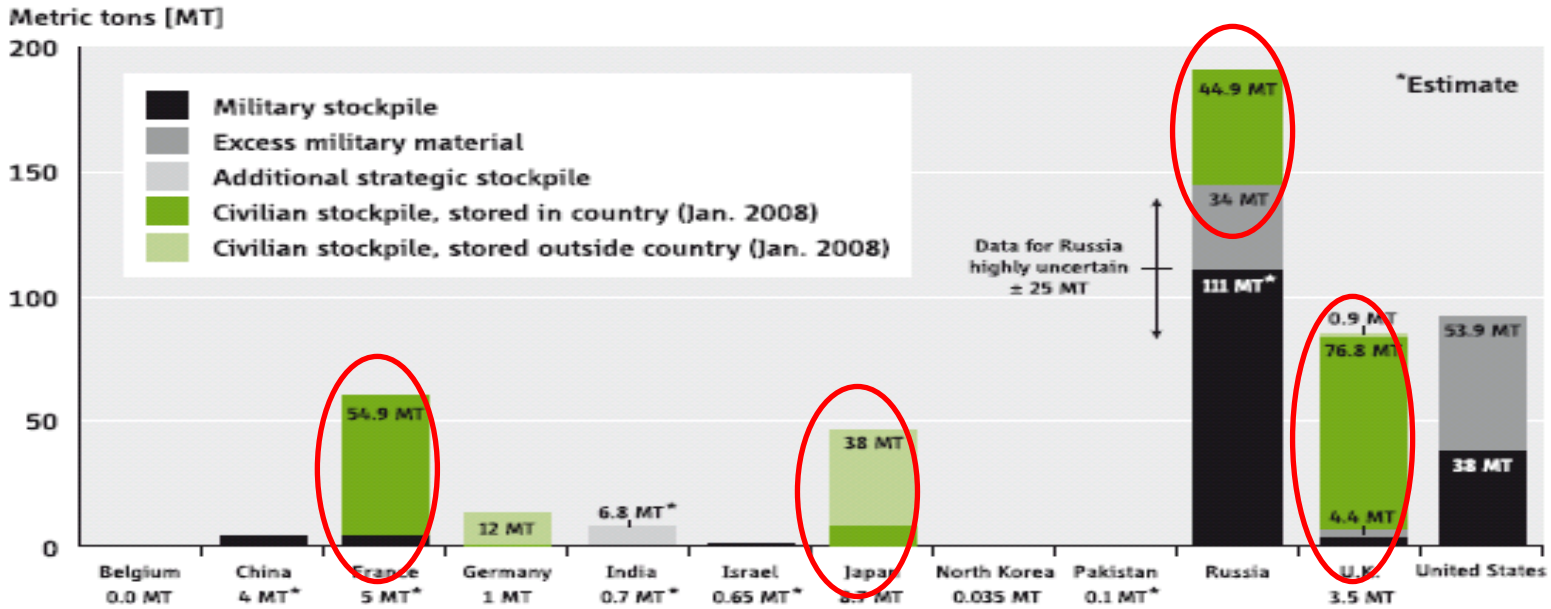


Figure 1.3. National stocks of separated plutonium. Civilian stocks are based on the most recent INFCIRC/549 declarations for January 2008 and are listed by ownership, not by current location. Weapon stocks are based on non-governmental estimates except for the United States and United Kingdom whose governments have made declarations. Uncertainties of the military stockpiles for China, France, India, Israel, Pakistan, and Russia are on the order of 20%. The plutonium India separated from spent heavy-water power-reactor fuel has been categorized by India as "strategic," and not to be placed under IAEA safeguards. Belgium holds 1.4 tons of foreign-owned plutonium, but has no stockpile of its own (Appendix 1C).

Source: IPFM (2009)

Civilian Pu Stockpile is increasing (~2007)

- 在庫量は増え続けている（とくに、英・仏・露・日）

	Belgium (Addendum 3)		France (Addendum 5)		Japan (Addendum 1)		Russia (Addendum 9)		United Kingdon (Addendum 8)		United States (Addendum 6)	
1996	2.7	n.d. ?	65.4	30.0 0.2	5.0	0.0 15.1	28.2	0.0 0.0	54.8	6.1 0.9	45.0	0.0 0.0
1997	2.8	n.d. 0.8	72.3	33.6 <0.05	5.0	0.0 19.1	29.2	0.0 0.0	60.1	6.1 0.9	45.0	0.0 0.0
1998	3.8	n.d. 1.0	75.9	35.6 <0.05	4.9	0.0 24.4	30.3	0.0 0.0	69.1	10.2 0.9	45.0	0.0 0.0
1999	3.9	n.d. 0.9	81.2	37.7 <0.05	5.2	0.0 27.6	32.0	0.0 0.0	72.5	11.8 0.9	45.0	0.0 0.0
2000	2.7	n.d. 0.6	82.7	38.5 <0.05	5.3	0.0 32.1	33.4	0.0 0.0	78.1	16.6 0.9	45.0	0.0 0.0
2001	2.9	n.d. 1.0	80.5	33.5 <0.05	5.6	0.0 32.4	35.2	0.0 0.0	82.4	17.1 0.9	45.0	0.0 0.0
2002	3.4	n.d. 0.4	79.9	32.0 <0.05	5.3	0.0 33.3	37.2	0.0 0.0	90.8	20.9 0.9	45.0	0.0 0.0
2003	3.5	n.d. 0.4	78.6	30.5 <0.05	5.4	0.0 35.2	38.2	0.0 0.0	96.2	22.5 0.9	45.0	0.0 0.0
2004	3.3	n.d. 0.4	78.5	29.7 <0.05	5.6	0.0 37.1	39.7	0.0 0.0	102.6	25.9 0.9	44.9	0.0 0.1
2005	2.8	n.d. 0.0	81.2	30.3 <0.05	5.9	0.0 37.9	41.2	0.0 0.0	104.9	26.5 0.9	45.0	0.0 0.0
2006	0.6	0.3 0.0	82.1	29.7 <0.05	6.7	0.0 38.0	42.4	0.0 0.0	106.9	26.5 0.9	44.9	0.0 0.0
2007	1.4	1.4 0.0	82.2	27.3 <0.05	8.7	0.0 37.9	44.9	0.0 0.0	108.0	26.8 0.9	53.9	0.0 0.0

Inventory held in country　Foreign-owned (included in local inventory)
Stored outside the country (not included in local inventory), n.d. = not disclosed

Source: IPFM (2009)

Pu Stockpile Projection
(Japan vs Germany)

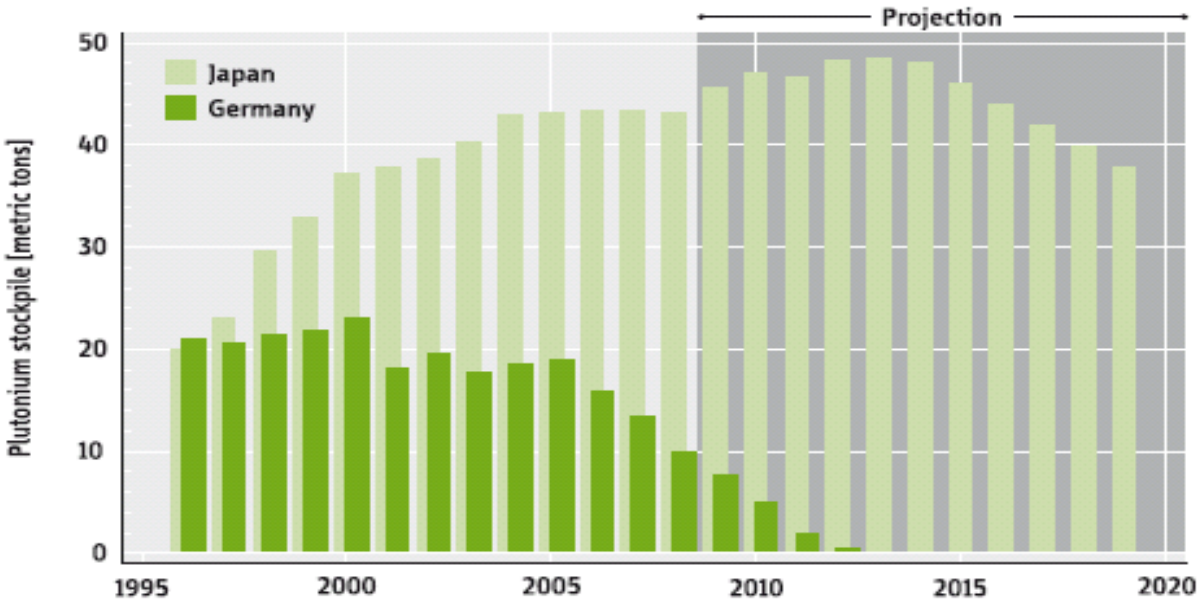


Figure 1.5. Stockpiles of separated civilian plutonium owned by Germany and Japan. Germany stopped shipping spent fuel for reprocessing (in France and the United Kingdom) in 2005. Since then, it has been able to gradually reduce its stockpile of separated plutonium from almost 20 tons to about 13 tons in 2008, and plans to consume the remaining material by the end of 2014. In contrast, if Japan's Rokkasho reprocessing plant operated at full capacity sometime, its plutonium stockpile would increase until the Rokkasho MOX fuel plant is completed.[79] Japan's reprocessing and MOX plants are both years behind schedule, however.

Source: IPFM (2009)

Conditions for A Multilateral Approach?

- Universality
  - Discrimination between “have” and “have not” should be avoided
- Transparency
  - IAEA Additional Protocol or equivalent safeguards arrangements should be applied
  - Additional layer of “verification”
- Economic Viability
  - Should be consistent with global nuclear fuel market activities
  - Economic rationale should be clearly defined to support nuclear fuel cycle programs

A Proposal on Multilateral Nuclear Fuel Cycle for Japan*

5 Packages：

1. Reduction of “Surplus Weapons-Usable Materials”
2. Internationalization of Nuclear Fuel Cycle facilities and Establishment of Joint Stockpile
3. Voluntary Code of Conduct of the Nuclear Industry and Nuclear non-proliferation and disarmament Fund
4. Reexamination of Japan’s nuclear fuel cycle programs and Research Initiative for Advanced Nuclear Power Systems without Weapons-Usable Materials
5. Adopting best practices in nuclear security through international cooperation

*Japan Cooperative Security Initiative, “10 Recommendations for Nuclear Disarmament and Non-proliferation based on A-MAD (Asian Mutually Assured Dependence)”, September 2009. http://a-mad .org/