Global Nuclear Future: A Japanese Perspective

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I. Introduction

Tatsujiro Suzuki, Senior Research Scientist, Socio-economic Research Center, Central Research Institute of Electric Power Industry (CRIEPI), and Visiting Professor, Graduate School of Public Policy, the University of Tokyo, writes, "The primary driving force behind Japan's reprocessing program is the management of spent nuclear fuel. The back-end of the nuclear fuel cycle, i.e. management of spent fuel and waste, would pose significant financial, political, and social risks to

Japan's nuclear power program. Japan should explore alternative socio-political solutions, including multinational approaches, to its complex spent fuel management issues."

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II. Essay by Tatsujiro Suzuki

- Global Nuclear Future: A Japanese Perspective

by Tatsujiro Suzuki

Abstract

There has been renewed interest in nuclear power mainly due to increased concerns about energy security and climate change. In developed countries, utilities will face a decision as to whether they will re-order new nuclear power plants to replace and/or add to existing ones by 2010-2020. It appears inevitable emerging energy hungry countries like China and India, will build large numbers of nuclear power plants to meet rapidly their growing energy demand. Other developing countries like Vietnam and Indonesia, also now have plans to introduce nuclear power beyond 2020 or later. However, in order to realize such a revival of orders of nuclear power plants worldwide, there are four major issues to be overcome. These are: (1) the financial risk of nuclear power plants under liberalized market conditions, (2) public confidence about safety (including improved decision-making processes), (3) spent nuclear fuel and radioactive waste management , and (4) nuclear non-proliferation.

Responding to growing energy security risks, Japan has adopted a new energy strategy in the form of a "comprehensive energy security policy, which puts emphasis on a combination of various measures responding to more diversified risks. Japan has long considered nuclear power a key energy source, and it is now government policy to maintain nuclear power's share in total power generation at around 30~40% or more until 2030. Japan's new nuclear policy introduces various policy measures to accelerate nuclear power developments, including Fast Breeder Reactors (FBR) and a closed fuel cycle. Japan will start full-scale operation of its first commercial reprocessing plant at Rokkasho in Aomori Prefecture in 2007. The primary driving force behind Japan's reprocessing program is the management of spent nuclear fuel. The back-end of the nuclear fuel cycle, i.e. management of spent fuel and waste, would pose significant financial, political, and social risks to Japan's nuclear power program. Japan should explore alternative socio-political solutions, including multinational approaches, to its complex spent fuel management issues.

Introduction

Recently, there have been renewed interest in nuclear power in both developed and developing countries, both in order to meet growing energy security concerns and to overcome climate change problems. At the same time, however, there has also been an increased concern over nuclear proliferation. Can nuclear power make significant contribution to solving those energy and environmental challenge without increasing the risk of nuclear weapons proliferation? What can and will Japan do to meet those challenges? This paper summarizes future prospects of global nuclear energy, and provides a Japanese perspective on this issue.

Renewed Interests in Nuclear Power

There are three major reasons behind renewed interest in nuclear power.

First, many existing nuclear power plants in developed countries will end their expected operating life (30-40 years) between 2010-2020. Energy utilities will thus face a decision as to whether they will re-order new nuclear power plants to replace and/or add to existing plants.

Figure 1: Projection of World Nuclear Capacity Shutdown/Startup between 2005-2047

Source: Mycle Schneider, "World Nuclear Industry Status Report 2004 and The French Plutonium Program," Fukushima Prefecture, March 31, 2005.

Second, the global energy market is under stress due to rising oil prices and a tighter energy/supply demand balance. Especially for large energy consuming developing countries, such as China and India, it seems inevitable that they will expand their nuclear power programs in order to meet their rapidly growing energy demand. Some other developing economies, like Vietnam and Indonesia, have now announced their intentions to introduce nuclear power programs by 2020 or shortly after.

Third, pressure to reduce greenhouse gases from energy consumption has made many countries to introduce policies to encourage non-carbon energy sources.

Conditions for nuclear revival

In order to realize global resurgence of nuclear power, there are four important issues to be overcome.

1. Financial risks of nuclear power under liberalized market conditions

The competitiveness of nuclear power against fossil power plants (in particular coal and natural gas) is typically measured by a lifetime average power generation cost. Typically, nuclear power plants have much higher capital costs (60~70%) of total power generation costs than coal (~40%) or natural gas (~30%). Once built, therefore, nuclear power typically has lower fuel and operational cost advantage than fossil plants. In fact, most existing nuclear power plants are quite cost competitive against most fossil power plants. According to the recent OECD/NEA study, nuclear power is competitive with fossil power plants in many countries [2] . However, under liberalized markets, where "cost-plus" rate regulations do not exist, utilities must bear financial risk of large capital costs. Utilities are under pressure to reduce capital expenditure in order to secure profits, and tend to make investments on the basis of expected return in the short term (3~5 years). As a result, it is generally believed that it would be difficult for privately-owned utilities to order new nuclear power plants in a liberalized electricity market.

In order to overcome such financial risks, governments have introduced or plan to introduce policy measures to reduce such risks for utility companies. For example, the US government has passed a new law, the Energy Policy Act (2005), incorporating policy measures to provide incentives for utilities to order new nuclear power plants. They include: 1) a 1.8 cent/kWh tax credit to new reactor orders (up to 6000 MWe, $125 million per reactor maximum, up to 2021); 2) insurance protection for licensing delays up to $250 million per reactor; 3) loan guarantees up to 80% of total cost [3] . In addition, the licensing process for new reactors has also been improved to reduce time delays and uncertainties. Similar policy measures have also been announced by the UK Department of Trade and Industry in its latest "Energy Review" paper published in July 2006 [4] .

Such policy measures would be needed in order to assure a series of new reactor orders under the liberalized energy market.

2. Safety and Public confidence (improved decision making process)

Safety concerns remain one of the highest barriers for local communities to accept the siting of nuclear power facilities, including waste storage or disposal facilities. For the long-term sustainable growth of nuclear power, it is essential to establish public confidence on nuclear safety. So-called "risk-based" safety regulation is one possible solution for an effective and transparent safety regulatory regime. Since the 1980s, the US Nuclear Regulatory Commission (NRC) has been working to establish such regulations, with well-established safety regulation by the private industry. "Risk-based regulation" means that safety regulation puts emphasis on the areas with higher probability of accidents (higher "risk"), and reduces regulatory requirements in less important areas. In order to implement such regulations, industry must prove which areas should be the focus, and thus transparency of plant safety has been increased. Such regulation also provides incentives to utilities to improve their performance. As a result, US nuclear power performance has improved significantly during since the 1990s.

But that is not good enough to gain public confidence. For example, public confidence could be easily eroded by non-technical incidents such as data falsification incidents, such as the ones in Japan and in UK. Once confidence is lost, it takes a long time to recover, and that will affect local decisions to accept new nuclear facilities - or even the continued performance of existing facilities. Better social decision-making process may be needed to gain long-term public confidence in nuclear policy.

3. Spent nuclear fuel and radioactive waste management

Unless spent fuel and radioactive waste management issues are resolved, the financial and political risks of nuclear power will never be resolved. There are two primary policy choices with regard to spent fuel management: one is the "Once-through" option which directly disposes of spent fuel to a repository, and the other is the "Recycling" option, which recovers uranium and plutonium from spent fuel, to be then recycled into reactors while the remainder of the spent fuel is vitrified and disposed of as waste. While, in principle, these two options are mutually exclusive, in reality, both options are now merging. This is because "interim spent fuel storage" is an essential step to both options. Eventually, many nations may pursue a "mixed strategy", i.e. combination of "once-through" and "recycling" after long term "interim storage". In short, regardless of future policy choices, it is essential for all countries to secure interim storage capacity of spent fuel and waste. For final disposal of nuclear waste, in addition to various technical options currently being considered, improved decision making process might be necessary to gain public confidence as described above.

4. Nuclear non-proliferation

Finally, in order to have sustainable nuclear power growth, it is essential that such expansion of nuclear power will not lead to increased proliferation risk of nuclear weapons. The biggest proliferation risk comes from nuclear fuel cycle facilities, such as enrichment and reprocessing, which can produce weapons-usable material (WUM, i.e. highly enriched uranium [HEU] and plutonium). Expansion of nuclear power can naturally lead to proliferation of sensitive facilities and technologies. In this context, there have been various proposals to have tighter control over nuclear fuel cycle activities since Mr. Elbaradei, Director General of the International Atomic Energy Agency (IAEA) proposed "multilateral approaches" to nuclear fuel cycle facilities. Those proposals include the following key components: 1) tighter control over WUM; 2) improving nuclear fuel supply assurance; 3) multilateral control over *new* fuel cycle facilities; 4) and proposals suggesting taking back spent nuclear fuel to supplier countries. In February 2006, the United States government announced the new Global Nuclear Energy Partnership (GNEP) in which new "partners" (advanced nuclear countries) will provide nuclear fuel supply guarantees to those countries which give up having such nuclear fuel cycle facilities on their own. The GNEP also proposes to accept spent fuel and waste from those recipient countries and to develop advanced fuel recycling technologies [5] .

As the detail of the GNEP implementation plan is still uncertain, it is premature to judge the prospect of GNEP. Most recently, the Weapons of Mass Destruction (WMD) Commission recommended that the IAEA should be utilized more to discuss various policy proposals, while we should reduce stockpile of WUM first [6] . It seems that tighter control on sensitive facilities/technologies would be unavoidable.

Japan's new energy policy

In May 2006, Japan's Ministry of Economy, Trade and Industry [METI] published the Japanese government's new National Energy Strategy [7] . METI emphasized the importance of "energy security", which is now much more diverse and complex in nature than the one discussed during the 1970s. METI now adopts a much more "comprehensive" approach towards energy security (Fig 2).

Figure 2: Basic Perspective of "Comprehensive Energy Security"
Source: Ministry of Economy, Trade and Industry, "New National Energy Strategy", May 2006, page 12.

Realizing the state-of-the-art energy supply- demand structure	**Comprehensive strengthening of Resource Diplomacy and, Energy and Environment Cooperation**	**Enhancement of emergency response measures**
Improving efficiency in energy utilization Maintaining or upgrading our status as the world's most advanced energy-saving-conscious country by taking advantage of our technological strengths	Strengthening multilateral connections with oil/gas-producing countries Strengthening mutual exchanges and cooperation in various fields in addition to the energy field	Strengthening the maneuverability of energy stock systems
Diversifying energy sources for increasing options Developing the advanced next-generation scheme in the transport sector	Strengthening the relationship with Asian countries Making commitment to the improvement of their energy supply-demand conditions through cooperation in energy saving programs	
Retaining the strength to secure reserve energy Securing appropriate reserve energy to survive tight supply-demand conditions	Strengthening overseas activities of prospecting projects for diversifying supply sources Improving Japanese companies'procurement capability Contributing to global issues Climate change, nuclear nonproliferation, etc.	Reviewing and strengthening emergency measures

The new policy clearly sets numerical targets for national energy policy until 2030. It includes the following:

1. Energy conservation: at least another 30% improvement of efficiency will be attained by 2030.
2. Reduction of oil dependence: the ratio will be reduced from current 50% to be lower than 40% by 2030.
3. Reduction of oil dependence in the transport sector: the percentage will be reduced from 100% to around 80% by 2030**.**
4. Maintaining or increasing nuclear power generation: the ratio of nuclear power to all power production will be maintained or increased at the level of 30 to 40% or more up to 2030 or later.

5. Overseas natural resources development: oil volume ratio will be increased from current 18% to around 40% by 2030.

While those policy targets are considered possible, many believe they are too ambitious and/or not necessarily rational goals based on detailed analysis.

Japan's nuclear fuel recycling program and plutonium issue

In October 2005, Japan's Atomic Energy Commission (JAEC) released its latest Long Term Program on Development and Utilization of Nuclear Energy (now called, "Framework for Nuclear Energy Policy") [8] . In August 2006, the Subcommittee on Nuclear Energy Policy of METI's Advisory Council on Energy published a new report, "Nuclear Power Nation Plan, [9] " which outlines major policy programs to implement JAEC's basic policy. Their main points are:

- Realization of replacement and new orders under the liberalized market
- Higher utilization of existing reactors with enhanced safety performance
- Steady progress in nuclear fuel cycle
- Early commercialization (2050) of Fast Breeder Reactors
- Strengthening industry's technical and human resources
- Promotion of international activities of the nuclear industry
- Active contribution to an effective international regime in reconciling expansion of nuclear power and non-proliferation
- Strengthening confidence building between local community and the government
- Steady progress in waste disposal

While its commitment to nuclear power remains unquestioned, one of the most controversial issues was whether Japan continues its commitment to nuclear fuel recycling policy. While JAEC compared alternatives to reprocessing options for the first time (Table 1), it concluded that Japan maintains its commitment to a closed nuclear fuel cycle.

Table 1: Comparison of Four Scenarios of Spent Fuel Management in Japan

	1: Full reprocessing	**2: Partial reprocessing**	**3: Direct disposal**	**4: Temporarily storage**

Nuclear fuel cycle cost	**Front-end**	**Uranium fuel**	0.57	0.57	0.61	0.61
		MOX fuel	0.07	0.05	-	0.00
	Back-end	**Reprocessing**	0.63	0.42	-	0.16
		HLW storage, transport and disposal	0.16	0.10	-	0.06
		TRU storage, transport and disposal	0.11	0.07	-	0.03
		Interim storage	0.04	0.06	0.14	0.13
		Spent fuel direct disposal	-	0.12-0.21 (0.09-0.21)[2]	0.19-0.32 (0.14-0.32)[2]	0.09-0.16 (0.07-0.16)[2]
	Total nuclear fuel cycle cost		1.6 (1.5)[1]	1.4-1.5	0.9-1.1	1.1-1.2
Generation cost[3]			**5.2 (5.1)**[1]	**5.0-5.1**	**4.5-4.7**	**4.7-4.8**
Cost for Policy Change[4]			**-**	**-**	**0.9-1.5**	
Total Cost			**5.2 (5.1)**	**5.0-5.1**	**5.4-6.2**	**5.6-6.3**

Note: HLW = High Level Radioactive Waste, TRU = Transuranics
[1] Cost of the second reprocessing plant is assumed to be half that of the Rokkasho reprocessing plant.
[2] Assuming horizontal placement of the casks.
[3] Cost excluding fuel cycle (i.e. capital, operation and management cost) is assumed as 3.6 Yen/kWh in all scenarios.
[4] 1) Construction cost of Rokkasho reprocessing plant: □.2/kWh,
2) Thermal power generation cost that replace nuclear power plants which would be shut down early due to shortage of spent fuel storage capacity: □.7-1.3/kWh.
Source: Japan Atomic Energy Commission, 2005.

As a result, Japan Nuclear Fuel Ltd. (JNFL), a private commercial fuel cycle company, started hot testing of its first commercial scale (800 tHM/y) reprocessing plant on March 31, 2006. The newly published METI Nuclear Energy Policy report (draft) further accelerated this fuel recycling policy including the commercialization of Fast Breeder Reactor (FBR) [10] .

This may create significant financial, political and social risks to Japan's nuclear power program.

First, its total cost of 18.8 trillion yen (about US$150 billion) over 40 years) is too large for utilities to bear under liberalized market conditions. In order to reduce such huge financial risk, a law establishing the new "reprocessing fund" was passed by the Diet in May 2005. The fund will be formed through special cost charges on both electricity transmission and retail electricity -- non-nuclear as well as nuclear. However this does not entirely eliminate the financial risks of the reprocessing option. The fund only covers the costs of reprocessing 32,000 tonnes of spent fuel (i.e. 40 years of operation of the Rokkasho reprocessing plant) and does not cover storage costs of all spent fuel during that period and future reprocessing costs. [11] In addition, use of the fund is subject to METI approval and losses due to accidents and other adverse developments caused by the operators will not be covered by the fund.

Second, spent fuel management politics could become more complex. Figure 3 shows future cumulative inventory of spent fuel in Japan.

Figure 3: Japan's Cumulative Spent Fuel Inventory and its Management until 2050

Source: T. Katsuta, T. Suzuki, "Japan's Civilian Nuclear Fuel Cycle and Nuclear Spent Fuel Management Issue," International Panel on Fissile Material (IPFM) Report (Draft), August 2006.

Japan has sufficient spent fuel storage capacity, with a recently agreed away-from-reactor (AFR) interim storage facility (5,000 tons) at Mutsu city, until mid 2020s. However, one of the conditions for the local community's agreement to accept spent fuel storage is that the reprocessing policy be maintained, since the local community are concerned that spent fuel will stay there forever without reprocessing. In Japan, spent fuel is not defined as "high level waste (HLW)" and thus legally not allowed to be disposed of with other HLW.

Third, the plutonium stockpile issue could raise further international concern. If the Rokkasho reprocessing plant starts its full-scale operation, Japan will produce a maximum of 8 tons of plutonium annually. Japan currently has already 43 tons [37 tons in Europe, 6 tons in Japan] of plutonium stockpiled, and this amount may grow to more than 70 tons by the middle of the 2010s. In order to avoid such plutonium stockpile, deferring the operation of the Rokkasho reprocessing plant is desirable.

Figure 4: Japan's Plutonium Stockpile; Three Scenarios up to 2020

Three scenarios for Japan's separated plutonium: a) and b) assume that the Rokkasho reprocessing plant operates as planned. In a) Plutonium stockpile in Europe is consumed first. In b) only stockpile in Japan is consumed while stockpile in Europe is left in Europe. In c) operation of the Rokkasho reprocessing plant is deferred.

Source: T. Katsuta, T. Suzuki, "Japan's Civilian Nuclear Fuel Cycle and Nuclear Spent Fuel Management Issue," International Panel on Fissile Material (IPFM) Report (Draft), August 2006.

Reconciling nuclear energy and non-proliferation: a Multilateral Approach?

Japan is, in principle, in favor of multilateral approaches to the nuclear fuel cycle, as long as they do not undermine Japan's fuel cycle programs. But, should Japan continue its commitment to a "closed fuel cycle" policy on a national basis, there will be tension with these multilateral approaches. Instead, Japan should explore multilateral approaches toward its own fuel cycle prorgams, such as regional spent fuel storage, that may provide socio-political solutions to its both domestic and international tensions associated with spent fuel management issues.

Conclusion

Global energy and environmental pictures now put pressures on many countries to rethink their nuclear power options. For both developed and developing nations, new orders of nuclear power plants are possible and likely by 2010-2020. However, in order to realize such policy goals, important policy issues need to be overcome. They are: financial risk, public confidence, spent fuel and waste management, and nuclear non-proliferation. Japan has released new energy and nuclear energy policies to meet new energy security challenges, including acceleration of the closed fuel cycle and Fast Breeder Reactors. But committing to a commercial scale reprocessing program may create financial, political and social risk to Japan's nuclear power program. In order to avoid such risk, Japan needs socio-political solutions, including multilateral approaches, to its complex spent fuel management issue.

III. Citations

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IV. Nautilus Invites Your Responses

The Northeast Asia Peace and Security Network invites your responses to this essay. Please send responses to: bscott@nautilus.org. Responses will be considered for redistribution to the network only if they include the author's name, affiliation, and explicit consent.

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