Nuclear terrorism risks in Northeast Asia: Japan’s reactor restart and spent fuel

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NAPSNet Special Report

by Peter Hayes

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I. SUMMARY

In this report Peter Hayes examines the risk of nuclear terrorism in Northeast Asia with particular reference to Japan. He states that Japan is no more immune to nuclear terrorism than it was to a catastrophic reactor accident. In this context, the combination of safety and security concerns represented by spent fuel pools at reactors is a critical variable in the risk profile arising from the threat of nuclear terrorism. Japan's choices have global significance for the threat of nuclear terrorism, and therefore demands serious consideration as part of a national and international risk-benefit assessment of the future evolution of nuclear power.

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ii. REPORT BY PETER HAYES

Nuclear Terrorism Risks in Northeast Asia: Japan's Reactor Restart and Spent Fuel

Introduction

In the post-Fukushima era, spent fuel management is recognized as a significant contributor to increased risk of nuclear terrorism. In the immediate weeks after the tsunami-earthquake, the situation at the spent fuel pools at Fukushima unit 1 was dire. The pools were damaged by debris from the hydrogen explosion, inaccessible due to intense local radiation from the melted reactor core, and losing coolant, underscored the argument that spent fuel pools are potential sources of radiological risk in themselves. The orthodox definition of nuclear terrorism based on the diversion of fissile material for use in a nuclear or radiological weapon, with similar potential scales of damage to entire cities as releases from a spent fuel pool, is only part of the nuclear risk story. The Fukushima incident conjoined the issue of nuclear terrorism conceived of as diversion and use of fissile material and nuclear weapons/nuclear energy dual-use technology with possible radiological attack via a dirty bomb or attack on nuclear facilities or on radiological materials in transport.

The Japanese authorities themselves recognized this linkage: "The accident revealed the possibility that terrorism at a nuclear facility may have the same serious effects on society [as a natural disaster]."[1] Indeed, Japanese nuclear security authorities now recognize not only that nuclear reactors and other nuclear facilities in which nuclear fuel or nuclear fuel materials are stored may be attacked, but that attacks also may target ancillary support systems such as power supply, and reactor core and spent fuel coolant supply, and that terrorists, including insiders, may attack at these points— with potentially the same devastating effect—or worse—than the earthquake and tsunami of March 11, 2011 had on the Fukushima plants.[2]

Post-Fukushima Response

After Fukushima, the global nuclear security community recognized that spent fuel management practices might be revised to reduce the direct risk of radiological release from spent fuel pools, thereby inadvertently increasing the risk of attack on the spent fuel itself by non-state actors on the one hand, and the risk of diversion of separated plutonium or spent fuel for terrorist purposes on the other. This concern proved valid. In Japan, the focus was correctly on stabilizing the spent fuel pools (completed at Fukushima Daichi Unit 4 only in December 2014) by providing cooling at Fukushima while reviewing the safety of the shutdown reactor fleet, none of which as of time of writing (March 2015).

Four years after the accident, about two thirds of the fuel assemblies have been removed from the damaged buildings and placed into dry cask storage on the reactor site.[3] The generic issue of spent fuel vulnerability, however, has yet to be addressed in Japan, including the commercial practice of increasing density of spent fuel pools beyond the evaporative cooling capacity of pools suffering from loss of coolant for whatever reason, including non-state attack. The new Nuclear Regulatory Authority views this issue to be a commercial choice made by utilities and has not systematically reviewed the vulnerabilities of pool racking density. There is little evidence that the risk of nuclear terrorism has played a role in these decisions to date.

Internationally, the US National Academy's *Lessons Learned from the Fukushima Nuclear Accident* study deferred spent fuel issues to 2015;[4] the IAEA Fukushima accident study referred to the spent fuel racking density issue but did not investigate it;[5] the US-Russian joint study on nuclear terrorism identified the spent fuel density issue but issued no specific recommendation except that it deserved further study;[6] and the US Nuclear Regulatory Commission voted to not treat the vulnerability to terrorism as deserving separate analysis and management nor justifying accelerated transfer to dry cask storage—although the then Chair of the Commission Alison MacFarlane voted against this decision.[7] Only in China has the nuclear power industry adopted an inherently safe reduced racking density for spent fuel pools, partly in response to Fukushima.[8] South Korea and Taiwan, with spent fuel pools already nearly full with dense racking, remain at risk, although South Korea has begun to use dry cask storage at a few reactors. Only utility in Japan has announced quietly that it will use dry cask storage on site (at retired units Hamaoka 1 and 2).

In Japan, decisions related to spent fuel disposition, including spent fuel pool vulnerability, are stalled due to multiple constraints that work against open enquiry and policy change. First, the underlying cultural foundation of the nuclear power industry in Japan has come unstuck due to the massive, undeniable, and on-going impact on civil society arising from the event itself. But the fundamental political deal between the state, the nuclear utilities, and local host communities known as the "nuclear village" has not been reconstituted or revised since Fukushima. In this political (and economic) arrangement, local communities host nuclear power plants and the nuclear reprocessing sites in return for large subsidies while the government commits to removing the spent fuel to an unspecified interim storage site at an undefined date.

Consequently, local communities exercise significant veto power over spent fuel facility siting decisions, including shifting waste from spent fuel pools to dry cask on-site storage in Japan. Indeed, 69 percent of 155 local prefectures and municipalities located within 30 kilometers of nuclear plants say that local governments should have a say in the startup of nuclear power plants whereas only 9 percent of the 32 leaders of prefectures and municipalities that host nuclear facilities favor such a say. [9] Notably, the latter receive large payments from nuclear utilities and are mostly pro-startup as a result. The result is the number of nuclear reactor restarts now hangs in the balance.[10] A broad-based civil society network stokes public opinion that is strongly against restarts, and is pitted against the orchestrated pro-restart positions of national politicians.[11]

Second, the nuclear power industry itself is snared in a web of interdependent uncertainties. These

include:

1. a) How many light water reactors will be restarted and when, and relatedly, will authorities allow reactor operating life to be extended beyond forty years, and will new reactor construction be allowed?
2. b) Will reprocessing continue to separate plutonium?
3. c) When will the Japanese Mixed Oxide (MOx) fuel fabrication plant be complete?
4. d) What level of excess separated plutonium is acceptable domestically and internationally?
5. e) Will the breeder reactor be reactivated and if so, for what purpose?
6. f) Will uranium-235 recovered from spent fuel be recycled (affecting the already dismal economics of Japan's enrichment program); and
7. g) Will another massive unanticipated nuclear accident in Japan or elsewhere occur? Even ardent pro-nuclear advocates admit that such an event likely would end the use of nuclear power in Japan.[12]

With such massive uncertainty affecting each of these linked variables, any one of which can serve as a binding constraint on the others, the key actors in the Japanese nuclear power sector are unable to make strategic decisions and as a consequence are in a holding pattern until political waters clarify.

Consequently, to the outsider, the safety and security of spent fuel pools in Japan remains unsatisfactory. It is even unclear whether the leadership of the Japanese nuclear power sector recognizes that the risk of loss of coolant arising from malevolent attack exists for spent fuel pools.[13] However, the choices that Japan makes with regard to light water reactor (LWR) restart, reprocessing, the recycling of plutonium (Pu) through the production and use in LWRs of MOx fuel, the eventual use of fast reactors for actinide disposal, the future development of a plutonium-breeding fast reactor, and Japan's enrichment activities, are all linked directly to the issue of nuclear terrorism and the risk of diversion of spent fuel and separated plutonium. In turn, choices made in each of these fuel cycle activities will determine how spent fuel is managed in Japan, starting with the management of spent fuel pools.

The risk of nuclear terrorism in Japan originates directly from the accumulation of large quantities of separated Pu in Japan (Japan also owns a stock of Pu now in storage in Europe) for which non-diversion cannot be assured. Pu stocks are vulnerable in bulk reprocessing and MOx fabrication facilities;[14] in the frequent shipments of separated plutonium flowing to and from reprocessing plants, storage sites, fuel fabrication plants, and LWRs and (in the future) to and from fast reactors. Security measures must be adopted for each of these activities to deter and defend against direct attack, at different levels of organization and ferocity on the part of the attacking entity.

Moreover, what Japan does in each of these dimensions sets a precedent for the best—and in some respects, the worst—practice for the rest of the region, with potential follow-on effects in South Korea, Taiwan, and China, as well as in potential importers of Japanese reactors supported by Japanese fuel cycle services as part of the export package. Thus, spent fuel management practices contribute substantially to the risk of terrorist diversion and use or threatened use of fissile materials in nuclear or radiological weapons, *and* also contribute to expanded (or reduced) vulnerability of nuclear fuel cycle facilities to terrorist hostage-taking and/or direct attack. These targets may be attractive in the terrorists' search for a more easily achievable "spectacular" event than the acquisition of a nuclear weapons.

This risk is not hypothetical in Japan. Not only has Japan been the host for Aum Shinrikyo,[15] one of the most notorious and prolonged efforts at terrorist acquisition and use of weapons of mass destruction, including nuclear weapons; but its counter-terrorism and nuclear security culture is weak,[16] even in the aftermath of Fukushima. In the view of many experts, including US officials reporting from Japan before and after Fukushima, Japan presents an inviting target for domestic and international terrorists and is poorly prepared to deter, let alone respond, to such an attack.[17] Not least, privately-owned facilities normally do not post armed guards in Japan[18], nuclear facility staff are not subject to official background "trustworthiness" checks, and security response forces must come from off-site as licensees are not permitted to respond to armed attackers. Even at Fukushima's damaged reactors and perilous situation with spent fuel in unit 1, the site security appeared weak, especially with regard to night time attack from the air (using drones) or from the ocean, even during the daytime.

Japan's Post-Fukushima Choice

Due to Fukushima, Japan now must choose to go in one of two directions that are largely exclusive: either towards a reactor restart choice that leads to a **minimalist phase-out of separated plutonium** over time; or towards **a maximalist reliance on separated plutonium over time in a closed fuel cycle**.

The train of logic embodied by a minimum spent fuel arising in a "once-through" fuel cycle in Japan is as follows:

- Slower and fewer reactor restarts eases pressure on almost full spent fuel pools
- Reserve capacity for spent fuel storage is extended by technical measures, or dry cask storage is adopted
- Provides fewer reactors in which to burn plutonium as MOx fuel
- Thereby increasing the life of the existing stock of separated and un-separated plutonium (today about 10.8 tonnes in Japan itself) into the indefinite future
- Thereby postponing for political and economic reasons the resumption of reprocessing
- Thereby postponing or terminating MOx fuel fabrication and Pu recycling
- Thereby effectively terminating the fast reactor for waste disposal or plutonium breeding.

Should Japan elect to start relatively few reactors, it is unlikely to restart its plutonium fuel cycle, although no-one knows where that threshold lies (some insiders suggest the number might be 25-28 reactors, with all the older plants being retired). The implication for spent fuel pool management following from the minimalist once-through fuel cycle is that *more* spent fuel storage space will be required in the short and interim term; that the local-central consensus and associated set of cultural-political understandings must be renegotiated; and that the side payments to local communities must be recast to facilitate hosting of short-term and interim spent fuel storage, in pools and/or dry cask storage. This alternative trajectory would also minimize the possibility of terrorist diversion of separated plutonium from reprocessing, MOx fuel fabrication, and storage sites and between-site transport. It also minimizes the number and volume of spent fuel short-term storage sites that must be created and that could be attacked directly. If coupled with spent fuel pool de-densification and accelerated on or off-site dry cask storage, it would also minimize Japan's vulnerability to terrorist attack on the spent fuel pools as a form of radiological warfare over the next thirty years.

Should Japan opt to start enough reactors to justify reactivating the plutonium fuel cycle, then the

implications for nuclear terrorism would be substantial. The train of logic for maximum spent fuel arising from a closed nuclear fuel cycle is radically different to that for the once-through fuel cycle. In this trajectory, the following would occur:

- Japan starts many more light water reactors, sooner rather than later, and extends reactor lifetimes beyond forty years, and constructs new reactors
- This choice enables far more MOx fuel fabrication and recycling of MOx fuel to these reactors than in the once-through fuel cycle usage; this choice would either slowly reduce or rapidly increase the stockpile of separated plutonium that would be supplemented (if the central state is willing to subsidize heavily the utilities for using MOx fuel) by reprocessing the spent fuel from the operation of the light water reactors
- Thereby generating a new stream of separated and un-separated plutonium in Japan to store and secure, and available for diversion or attack.

Although it does not follow automatically, this vision of the revived closed fuel cycle also implies that:

- The fast reactor is developed in order to burn actinides to reduce the waste disposal problem (whether it would do so is debatable)
- The fast reactor would be developed to breed plutonium based on the argument that doing so makes Japan more independent from external nuclear fuel supply.

All the steps in this second path which maximizes separated fuel involves more transport, more bulk processing and storage, and creates more opportunity for non-state actors to divert fissile material or to attack directly the spent fuel stocks in pools or other nuclear materials process sites in the envisioned "closed" fuel cycle. In short, this trajectory maximizes the nuclear terrorist threat, directly and indirectly, over the next thirty years, especially when the demonstration effect on other states to follow suit are taken into account. For exactly this reason, the United States has reaffirmed recently that it does not favor MOx use and breeder activity in Japan or elsewhere.[19]

All of these elements are also contested in Japan. Currently, the majority (more than sixty percent) of Japanese adults favor the shutdown of nuclear power, as do many former and current political and business leaders, including two recent prime ministers. Another major nuclear catastrophe anywhere, but especially in Japan, would almost certainly lead to a rapid shutdown of Japan's nuclear power sector—a fear underscored by the October volcanic eruption in Japan.[20]

In this gridlock, decisions about Japan's fuel cycle are made today on largely political grounds. These include the aspirations of some politicians to maintain Japan's nuclear fuel cycle in order to present Japan to its external adversaries as having a "technological deterrent"[21]—that is, an immediately available nuclear weapons option that is understood to be such (as distinct from a "latent nuclear weapon" by virtue of Japan having requisite industrial capacities for a nuclear weapons program, but also being totally devoid of present or future intention to develop such).

The post-Fukushima fuel cycle decisions on each of these elements are still made by the "nuclear village" in Japan, consisting of the utilities, the nuclear facility operators, key officials in the industry ministry, and a thin layer of newly established regulatory oversight authorities. Except for reactor restarts,[22] local communities still have almost no proactive say in these decisions today. Even the veto over on-site storage by local communities is mostly reactive, not proactive, at this stage. Thus, the issue of the maximalist scaling up of a revived closed fuel cycle in Japan is almost immune to external intervention until the gridlock over restart of the Japan's nuclear fleet is resolved.

Reactor Restart is the Crucial Variable Affecting Nuclear Terrorism Potential

"Except for reactor restarts." This is the crucial decision step at which the psychological fallout of the Fukushima catastrophe makes it possible for ordinary citizens and local and provincial governments to understand viscerally what is at stake; and where local decisions on nuclear futures have real power to direct government policy. Thus, some courts have ruled in favor of local communities on reactor restarts in Japan;[23] and even central government decisions to restart reactors remain subject to local veto.[24] However, whether local communities are concerned about this issue—and many are not given the abstruse nature of the issue and the opacity of decision-making and regulation of the nuclear security issue in Japan—depends on many factors. Some local governments and provinces that oppose nuclear power do not want to propose a safer spent fuel strategy that might enable nuclear power to continue at lower risk. Others are too implicated and dependent upon nuclear-generated funding from utilities and the central government to open a discussion on spent fuel related risks, including nuclear terrorism.

It is at this interface between local community and government with individual reactor decisions that spent fuel safety and security concerns arising from the threat of terrorist radiological attack are conjoined with the potential diversion of fissile material for nuclear terrorism. If the decisions at the local and national levels are to be informed fully, then it is urgent that the risk of nuclear terrorism arising from the post-Fukushima management of spent fuel in Japan and the Northeast Asian region be included in the public discussions. Research is needed badly on the realistic potential for nuclear terrorism in Japan, via terrorist diversion and detonation of a nuclear weapon; or terrorist attack on nuclear facilities to conduct radiological warfare—in particular, spent fuel pools. Relatedly, estimates are needed of the differential quantities of separated plutonium that would be produced in a minimalist once-through nuclear fuel cycle versus a maximalist closed nuclear fuel cycle in Japan and the region, along with the implications of these pathways for the risk of nuclear terrorism.

Japan is no more immune to nuclear terrorism than it was to a catastrophic reactor accident. In this context, the combination of safety and security concerns represented by spent fuel pools at reactors is a critical variable in the risk profile arising from the threat of nuclear terrorism. In turn, how many reactors Japan decides to restart will set it either onto a maximalist closed fuel cycle pathway or onto a minimalist once-through fuel cycle pathway. These pathways present dramatically different opportunities for terrorists to divert fissile material from Japan's fuel cycle facilities for nuclear or radiological weapons for terrorist use or threatened use; or to attack spent fuel pools and other fuel cycle facilities in acts of spectacular radiological warfare.

Japan's choices have global significance for the threat of nuclear terrorism, and therefore demands serious consideration as part of a national and international risk-benefit assessment of the future evolution of nuclear power.

Banner image credit: TEPCO to participants on Fukushima site visit, including the author, September 2014.

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iii. References

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[4] The Congressional tasking: "Re-evaluation of the conclusions from previous NAS studies on safety and security of spent nuclear fuel and high-level radioactive waste storage, particularly with respect to the safety and security of current storage arrangements and alternative arrangements in which the amount of commercial spent fuel stored in pools is reduced" will be conducted in a subsequent report to the National Research Council, *Lessons Learned from the Fukushima Nuclear Accident for Improving Safety of U.S. Nuclear Plants.* Washington, DC: The National Academies Press, 2014, p. S-10.

[5] "Analysis of severe accidents in spent fuel pools has not been widely carried out. Studies should be undertaken related to hydrogen production and accumulation in spent fuel pools. *The implications of the increased use of high density spent fuel storage systems should be considered,* and the scope of SAMGs [Severe Accident Management Guidelines] should be expanded to include spent fuel pools." Italics added. *IAEA Report on Reactor and Spent Fuel Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant,* International Experts Meeting, Vienna, 19–22 MARCH 2012, Organized in connection with the implementation of the IAEA Action Plan on Nuclear Safety, IAEA, Vienna, 2012, pp. 26-27.

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[6] "Overfilled spent fuel pools may also be potential sabotage targets; in some cases, if terrorists managed to drain the cooling water—as occurred without human intervention at Fukushima—a zirconium fire and large-scale dispersal of radioactivity could potentially result." In M. Bunn, K. Valentin, Martin Malin, Y. Morozov, S. Saradzhyan, W. Tobey, V. Yesin, and P. Zolotarev. *Steps to Prevent Nuclear Terrorism*, Belfer Center for Science and International Affairs, Harvard Kennedy School, October 2, 2013, p. 21, at: http://belfercenter.ksg.harvard.edu/publication/23430/steps_to_prevent_nuclear_terrorism.html

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[11] Naohito Maeda, “COMMENTARY: Now is the time to listen to nuclear pessimists,” The Asahi Shimbun, October 12, 2014, at: http://ajw.asahi.com/article/views/column/AJ201410120009

[12] Private discussions with Japanese fuel cycle leaders, CSIS workshop, Tokyo, September 19, 2014. Many analysts believe that China is the likely candidate given the rapid growth of nuclear power, widespread corruption in the nuclear and construction sectors, multiple reactor control technologies and reactor systems, poor grid support, etc.

[13] Some Japanese nuclear utility experts argue that Japanese dense racking practice in spent fuel pools precludes meltdown by carefully arranging newly arrived hot fuel assemblies in the racking configuration so as to maintain effective convective cooling absent water coolant. However, advisors to the NRA inform us that there is no evidentiary basis for this position in the regulatory community. This matter is a critical issue that needs urgent investigation.

[14] Today, the IAEA does not claim more than on the order of 1% accuracy in keeping track of the plutonium going through a reprocessing plant. Given this situation, the IAEA relies on containment and surveillance to give itself the extra confidence that no significant diversion has taken place. But, if containment and surveillance fails (that is, a seal is broken or power to a surveillance camera is lost) there is no way to reconstruct the material flows account to an accuracy of better than about 1 percent. Given the scale of flows at Rakkosho, this could be many significant quantities before detection. See M. Miller, “Are IAEA Safeguards on Plutonium Bulk-Handling Facilities Effective?” Nuclear Control Institute, August 1990, at: http://www.nci.org/k-m/mmsgrds.htm and S. Johnson, *The Safeguards at Reprocessing Plants under a Fissile Material (Cutoff) Treaty*, IPFM Research Report #6, February 2009, at**:**

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[17] An excellent account of this state of affairs is summarized in D. Birch, R. Jeffrey Smith, J. Adelstein, “The US struggles to make Japan fear nuclear terrorism. A behind-the-scenes debate over Japan's plans to develop a giant plutonium stockpile reveals big cultural clashes,” Center for Public Integrity, March 11, 2014, at:

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[18] The National Police Agency and prefectural police are assumed to take key roles in armed response activities by the stationed police officers. staffed force and dispatched forces; and the Japan Coast Guard is assumed to take the role in getting hold of terrorists escaping to the sea for backup of the security activities on land. Police stationing at facilities has increased marginally since 2012. Exercises show little work has been done to coordinate and prepare these forces. See “Japan

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[20] Jacob Adelman, Masumi Suga, "Volcanoes May Be Next Hurdle for Nuclear Restarts in Japan," Bloomberg News, September 29, 2014

http://www.bloomberg.com/news/2014-09-29/volcanoes-may-be-next-obstacle-for-japan-s-atomic-power-industry.html

[21] "Technological deterrent" may refer to either technical skills or technological hardware needed to make a nuclear weapon. A senior LDP politician, Shigeru Ishida , who stated in an interview with Masakatsu Ota on October 25, 2011 in *Shinano Mainichi Shinbun* newspaper: "We should keep nuclear fuel cycle, which is backed by enrichment and reprocessing, cycling" in order to maintain "technical deterrence."" In Ota's view, Ishida meant both in this interview. Personal communication, October 5, 2014.

[22] D. Aldrich, J. Platte, "After the Fukushima meltdown, Japan's nuclear restart is stalled," Washington Post, August 15, 2014, at: http://www.washingtonpost.com/blogs/monkey-cage/wp/2014/08/15/after-the-fukushima-meltdown-japans-nuclear-restart-is-stalled/

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