Originally published in the Bulletin of the Atomic Scientists in September in 2017

Forty years of impasse: The United States, Japan, and the plutonium problem

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Abstract

Recently, records have been published from the internal discussions in the Carter administration (1977-80) on the feasibility of convincing Japan to halt its plutonium-separation program as the United States was in the process of doing domestically. Japan was deeply committed to its program, however, and President Carter was not willing to escalate to a point where the alliance relationship could be threatened. Forty years later, the economic, environmental and nonproliferation arguments against Japan's program have only been strengthened while Japan's concern about being dependent on imports of uranium appears vastly overblown. Nevertheless, Japan's example, as the only non-weapon state that still separates plutonium, continues to legitimize the launch of similar programs in other countries, some of which may be interested in obtaining a nuclear weapon option.

Keywords

Spent fuel reprocessing, plutonium separation, nuclear power, nuclear weapon proliferation, Japan-US relationship, nuclear fuel cycle economics, nuclear waste disposal, spent fuel storage.

In June 2017, the National Security Archive, a nonprofit center in Washington, DC, posted four-decade-old documents from the Carter administration's internal debate over how to best persuade Japan to defer its ambitious program to obtain separated plutonium by chemical reprocessing of spent power reactor fuel.[1]

Foreign civilian plutonium programs had become a high-level political issue in the United States after India used plutonium, nominally separated to provide startup fuel for a breeder reactor program in its first nuclear weapon test in 1974 (Perkovich 1999). The United States reversed its policy of encouraging the development of plutonium breeder reactors worldwide to avoid an anticipated shortage of uranium. The breeder reactors would convert abundant non-chain-reacting uranium 238 into chain-reacting plutonium and then use the plutonium as fuel, while conventional reactors are fueled primarily by chain-reacting uranium 235, which makes up only 0.7 percent of natural uranium.

The Ford administration (1974-77) blocked France's plan to sell spent fuel reprocessing plants to South Korea and Pakistan but did not succeed in persuading Japan to abandon its nearly complete Tokai pilot reprocessing plant. Therefore, when the Carter administration took office in January 1977, it inherited the difficult plutonium discussion with Japan.

[1] See: http://nsarchive.gwu.edu/nukevault/ebb597-Japanese-Plutonium-Overhang/

The earliest document in the newly released trove is a 19-page memo dated January 24, 1977, in which career State Department official Louis Nosenzo briefs the incoming Carter political appointees on the issue.[2] His arguments are strikingly similar to those being made some 40 years later by US and international nongovernmental organizations such as the International Panel on Fissile Materials (IPFM 2015) and by US government officials—most recently, members of the Obama Administration.[3]

These arguments are, in brief, that the separation and use of plutonium as a fuel is not economically competitive with simply storing the spent fuel until its radioactive heat generation has declined and a deep underground repository has been constructed for its final disposal. In this "once-through" fuel cycle, the plutonium remains mixed with the radioactive fission products in the intact spent fuel and therefore is relatively inaccessible for use in weapons.

Nosenzo argued that the separation and recycling of plutonium in "mixed-oxide" (MOX) fuel in light water reactors was uneconomic relative to the purchase of equivalent quantities of low-enriched uranium fuel, and this situation would not change for at least a decade. In fact, over the following decades, as the long-term real price of uranium went down and occupational safety requirements relating to reprocessing and MOX-fuel fabrication ratcheted up, the cost comparison has become much more adverse to MOX. According to a 2011 estimate by Japan's Atomic Energy Commission, including the cost of reprocessing, MOX fuel made with plutonium separated at Japan's new Rokkasho Reprocessing Plant will cost Japan 12 times as much to produce as the equivalent amount of low-enriched uranium fuel (IPFM 2015).

Nosenzo then turned to the argument that was being made by France, Germany, Japan, and Sweden at the time—and is still made by reprocessing advocates in France, Japan, and South Korea—that reprocessing reduces the volume of radioactive waste that requires deep burial by about 95 percent. Presumably with tongue in cheek, he opined that "[s]pace limitations are a real problem only for countries like Luxemburg." (Luxemburg, about equal in area to St Louis, Missouri, did not and still does not have a nuclear program.) Subsequently, it was pointed out that the volume of an underground repository for highly radioactive waste is determined not by the volume of the waste but by its heat output; the waste has to be spread out to limit the temperature increase of the surrounding buffer clay and rock (IPFM 2015). Reprocessing waste would contain all the heat-generating fission products in the original spent fuel, and the heat generated by the plutonium in one ton of spent MOX fuel would be about the same as the heat generated by the plutonium in the approximately seven tons of spent low-enriched uranium fuel from which the plutonium used to manufacture the fresh MOX fuel had been recovered.

With regard to the issue of the need for plutonium to provide startup fuel for breeder reactors, Nosenzo noted that "experimental breeders currently utilize uranium [highly enriched in the chain-reacting isotope uranium 235] rather than plutonium for start-up and this will probably also be true of commercial breeder start-up operations."[4]

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[2] See: http://nsarchive.gwu.edu/dc.html?doc=3859705-Document-01-Louis-Nozenzo-Bureau-of-Political

[3] *Japan Times*, "U.S. would back a rethink of Japan's plutonium recycling program: White House," May 21, 2016.

[4] This was not entirely correct. Although the U.S., Russian and Chinese experimental and prototype breeder reactors started up with enriched uranium fuel and all breeder reactors could have been, plutonium fuel was used to start up the prototypes in France, Japan and the UK. See International Fuel Cycle Evaluation, *Fast Breeders* (IAEA, 1980) Table III. M. Ragheb, "Fermi I Fuel Meltdown Incident" (2014). Available at

"[T]here is a strong need for a US position paper presenting the above rationale with supporting analysis," Nosenzo wrote. "This would be of value, for example, with other governments in the nuclear suppliers context and more generally … for use by sympathetic foreign ministries attempting to cope effectively with their ministries of energy, of technology and of economics."

The last point reflected the reality that the promotion of breeder reactors was central to the plans of powerful trade ministries around the world, including Japan's Ministry of International Trade and Industry (now the Ministry of Economy, Trade and Industry), and that foreign ministries sometimes use independent analyses to push back against positions of other ministries that seem extreme to them. A few years ago, an official of South Korea's Foreign Ministry, for example, privately described the Korea Atomic Energy Research Institute, the driving force behind South Korea's demand for the same "right" to reprocess as Japan, as "our Taliban".

Japan planned to start operation of its Tokai reprocessing plant later that spring, and it appeared clear to Nosenzo that it would be impossible to prevent the operation of the almost completed plant. Another memo cited Prime Minister Fukuda as publicly calling reprocessing a matter of "life and death" for Japan.[5] Japan's government had committed itself to achieving what Glenn Seaborg, chairman of the US Atomic Energy Commission from 1961-71, had relentlessly promoted as a "plutonium economy," in which the world would be powered by the element he had co-discovered.

Why would the Fukuda administration have seen the separation and use of plutonium as so critical? We believe that the Prime Minister had been convinced by Japan's plutonium advocates that the country's dependence on imported uranium would create an economic vulnerability such as the country had experienced during the 1973 Arab oil embargo, still a recent and painful memory. Indeed, according to a popular view in Japan, further back, in 1941, it was a US embargo on oil exports to Japan that had triggered Japan's attack on Pearl Harbor. The plutonium advocates argued that breeder reactors would eliminate resource-poor Japan's vulnerability to a uranium cutoff by turning already imported uranium into a virtually inexhaustible supply of plutonium fuel for its reactors.

During the past 40 years, however, uranium has been abundant, cheap, and available from a variety of countries. Furthermore, as some foreign observers have suggested, if Japan was really concerned about possible disruptions of supply, it could have acquired a 50-year strategic reserve of uranium at a much lower cost than its plutonium program (Leventhal and Dolley 1994). Indeed, because of the low cost of uranium, globally, utilities have accumulated an inventory sufficient for about seven years.[6]

Although it took several years for Congress to accept the Carter administration's proposal to end the US reprocessing and breeder reactor development programs, Congress did support the administration's effort to discourage plutonium programs abroad. The Nuclear Nonproliferation Act of 1978 required that nuclear cooperation agreements with other countries be renegotiated so that any spent fuel that had either originally been produced in the United States or had been irradiated in a reactor containing components or design information subject to US export controls

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http://mragheb.com/NPRE%20457%20CSE%20462%20Safety%20Analysis%20of%20Nuclear%20Reactor%20Systems/Fermi%20I%20Fuel%20Meltdown%20Incident.pdf

[5] See: http://nsarchive.gwu.edu/dc.html?doc=3859730-Document-05-Memorandum-from-Ambassador-at-Large

[6] *World Nuclear News,* "Uranium inventories driving markets," September 15, 2015.

could not be reprocessed without prior consent from the US government. Internally, however, the administration was divided over whether the United States could force its allies to accept such US control over their nuclear programs.

One of the final memos in the National Security Archives file, written in May 1980, toward the end of the Carter administration by Jerry Oplinger, a staffer on the National Security Council, criticized a proposal by Gerard Smith, President Carter's ambassador at large for nuclear nonproliferation. Smith proposed that the administration provide blanket advance consent for spent fuel reprocessing in Western Europe and Japan.[7] Oplinger characterized Smith's proposal as "surrender" and argued that, even though the danger of further proliferation in Europe or by Japan was low, their examples could be used by other countries as a justification for launching their own plutonium programs.

The Carter administration did not surrender to the Japanese and the West European reprocessing lobbies but, in 1988, in exchange for added requirements for safeguards and physical protection of plutonium, the Reagan Administration signed a renegotiated US-Japan agreement on nuclear cooperation with full, advance, programmatic consent to reprocessing by Japan for 30 years. In the original 1968 agreement, the United States had been given the right to review each Japanese shipment of spent fuel to the British and French reprocessing plants on a case-by-case basis and to make a joint determination on reprocessing in Japan. This right had allowed the United States to question whether Japan needed more separated plutonium. As a result of the 1988 agreement, by the time of the 2011 Fukushima accident, Japan had built up a stock of some 44 tons of separated plutonium, an amount sufficient for more than 5,000 Nagasaki-type bombs (Japan Atomic Energy Commission 2012), and the largest amount of MOX fuel it had loaded in a single year (2010) contained about one ton of plutonium (IPFM 2015).

The initial period of the 1988 agreement will expire in 2018, after which either party may terminate it by giving six months written notice. This provides an opportunity for the US Government to re-raise the issue of reprocessing with Japan.

Unlike the 1968 agreement with Japan, the 1958 US-EURATOM agreement did not have a requirement of prior US consent for reprocessing of European spent fuel in West Europe. The Europeans refused to renegotiate this agreement, and, starting with President Carter, successive US presidents extended the US-EURATOM agreement by executive order year by year (*Bulletin of the Atomic Scientists* 1994). Finally, in 1995, the Clinton administration negotiated language in a new agreement that the European reprocessors accepted as a commitment to noninterference (Behrens and Donnelly 1996). By that time, the non-nuclear weapon states in Europe—notably Germany and Italy—had lost interest in breeder reactors and the only reprocessing plants listed in the agreement were those of UK and France. Reprocessing proponents in Japan often say that Japan is the only non-weapon state trusted by the international community to reprocess. In reality, Japan is the only non-weapon state that has not abandoned reprocessing because of its poor economics.

As Oplinger pointed out, Japan played a central role in sustaining large-scale reprocessing in Europe as well as at home. In addition to planning to build their own large reprocessing plant, Japan's nuclear utilities provided capital, in the form of pre-paid reprocessing contracts, for

[7] See: http://nsarchive.gwu.edu/dc.html?doc=3859749-Document-22-Jerry-Oplinger-to-Leon-Billings-and.

building large new merchant reprocessing plants in France and the UK. France also played a leading role in promoting reprocessing and in designing Japan's reprocessing plant.

Oplinger insisted that the planned reprocessing programs in Europe and Japan would produce huge excesses of separated plutonium beyond the requirements of planned breeder programs: "Any one of these three projected plants would more than swamp the projected plutonium needs of all the breeder R&D programs in the world. Three of them would produce a vast surplus…amounting to several hundred tons by the year 2000."

He attached a graph projecting that, by the year 2000, the three plants would produce a surplus of 370 tons of separated plutonium beyond the requirements of breeder research and development. The actual stock of separated civilian plutonium in Europe and Japan in 2000 was huge— using the IAEA's metric of 8 kilograms per bomb, enough for 20,000 Nagasaki bombs—but about half the amount projected in Oplinger's memo (IPFM 2015). This was due in part to operating problems with the UK reprocessing plant and delays in the operation of Japan's large reprocessing plant. On the demand side, breeder use was much less than had been projected, but, in an attempt to deal with the surplus stocks, quite a bit of plutonium was fabricated into MOX and irradiated in Europe's conventional reactors.

Forty years later, Japan's breeder program, the original justification for its reprocessing program, is virtually dead. Japan officially abandoned its *Monju* prototype breeder reactor in 2016 after two decades of failed efforts to restore it to operation after a 1995 leak of its sodium secondary coolant and a resulting fire. Japan's Government now talks of joining France in building a new Advanced Sodium Technological Reactor for Industrial Demonstration (ASTRID) in France, and France's nuclear establishment has welcomed the idea of Japan sharing the cost.[8] The mission for ASTRID-type fast-neutron reactors would be to fission the plutonium and other long-lived transuranic elements in spent low-enriched uranium fuel and MOX fuel, for which Japan will have to build a new reprocessing plant. According to France's 2006 radioactive waste law, ASTRID was supposed to be commissioned by the end of 2020.[9] Its budget has been secured only for the design period extending to 2019, however. In an October 2016 briefing in Tokyo, the manager of the ASTRID program showed the project's schedule with a "consolidation phase" beginning in 2020 (Devictor 2016). The next day, the official in charge of nuclear issues at France's embassy in Tokyo stated that ASTRID would not start up before 2033 (Félix 2016). Thus, in 10 years, the schedule had slipped by 13 years.

It has been obvious for four decades that breeder reactors and plutonium use as a reactor fuel will be uneconomic. The latest estimate of the total project cost for Japan's Rokkasho Reprocessing Plant, including construction, operation for 40 years, and decommissioning, is now 13.9 trillion yen ($125 billion), with the construction cost alone reaching 2.95 trillion yen ($27 billion), including 0.75 trillion yen for upgrades due to new safety regulations introduced after the Fukushima accident. The total project cost of the MOX fuel fabrication facility, including some 42 years of operation and decommissioning, is now estimated at 2.3 trillion yen ($21 billion) (Nuclear Reprocessing Organization of Japan 2017). In the United States, after it became clear in 1977

[8] See: https://mainichi.jp/english/articles/20161022/p2a/00m/0na/005000c

[9] See: http://www.andra.fr/download/andra-international-en/document/editions/305va.pdf, Article 3.1.

that reprocessing and breeder reactors made no economic sense and could create a proliferation nightmare, it took only about five years for the government and utilities to agree to abandon both programs, despite the fact that industry had spent about $1.3 billion in 2017 dollars on construction of a reprocessing plant in South Carolina (GAO 1984), and the government had spent $4.2 billion on the Clinch River Demonstration Breeder Reactor project (Peach 1983).

How could Japan's government have allowed reprocessing advocates to drive its electric-power utilities to pursue its hugely costly plutonium program over 40 years?

For context, it must be remembered that the United States, a nuclear superpower, has been much more concerned about nuclear proliferation and terrorism than Japan. Tetsuya Endo, a former diplomat involved in the negotiations of the 1988 agreement, depicted the difference in the attitude of the two governments as follows: "Whereas the criterion of the United States, in particular that of the US government … is security (nuclear proliferation is one aspect of it), that of the Japan side is nuclear energy. …[I]t can be summarized as security vs. energy supply and the direction of interests are rather out of alignment" (Endo 2014).

As we have seen, in the US, after India's 1974 nuclear test, both the Ford and Carter administrations considered the spread of reprocessing a very serious security issue. Indeed, a ship that entered a Japanese port on October 16, 1976 to transport spent fuel to the United Kingdom could not leave for nine days due to the Ford administration's objections (Ibara 1984). In Japan, the US concerns about nuclear proliferation and terrorism have been generally considered interference in Japan's energy policy by a country that possesses one of the worlds' largest nuclear arsenals. Even the eyes of parliament members opposed to reprocessing, anti-nuclear weapon activists and the media sometimes got blurred by this nationalistic sentiment.

Nevertheless, reprocessing is enormously costly and the willingness of Japan's government to force its nuclear utilities to accept the cost requires explanation.

One explanation, offered by the Japan Atomic Energy Commission (JAEC) (Japan Atomic Energy Commission 2005), involves the political challenge of negotiating arrangements for storing spent fuel indefinitely at reactor sites. The government and utilities had promised the host communities and prefectures that spent fuel would be removed from the sites. The reprocessing policy provided destinations—first Europe and the Tokai pilot plant, and then the Rokkasho Reprocessing Plant. The JAEC argued that, since it would take years to negotiate indefinite onsite storage of spent fuel, nuclear power plants with no place to put spent fuel in the meantime would be shut down one after another, which would result in an economic loss even greater than the cost of reprocessing.

Japan's nuclear utilities have had to increase on-site storage of spent fuel in any case due to delays in the startup of the Rokkasho Reprocessing Plant, which was originally to start commercial operations in 1997. Indeed, the utilities have adopted the dangerous US practice of dense-packing their spent-fuel cooling pools with used fuel assemblies. Storing spent fuel in dry casks, onsite or offsite, cooled by natural convection of air would be much safer (von Hippel and Schoeppner 2016). In the United States spent fuel is transferred to onsite dry cask storage after the dense-packed pools get completely full. It's better to make this transfer as soon as the spent fuel gets cool enough. Such a shift to dry cask storage policy would require stronger nuclear safety regulation in both countries (Lyman, Schoeppner, and von Hippel 2017).

Second, there is the bureaucratic explanation. The bureaucracy has more power over policy in Japan than in the United States. In Japan, when a new prime minister is elected in the Diet, only the ministers change whereas, in the United States with a two-party system, policy making is shared by Congress and the executive branch to a greater extent, and a new president routinely replaces more than 4,000 officials at the top of the bureaucracy.[10] (This works both for the better and worse as can be observed in the current US administration.) Also, in Japan, unlike the United States, the bureaucracy is closed. There are virtually no mixed careers, with people working both inside and outside the bureaucracy (Tanaka 2009).

Third, the provision of electric power has been a heavily regulated regional monopoly in Japan. Utilities therefore have been able to pass the extra costs of reprocessing on to consumers without eroding their own profits. This monopoly structure has given utilities enormous power both locally and nationally, making it possible for them to influence both election results and the policy making process. Thus, even if the original reprocessing policy was made by bureaucrats, it is now very difficult to change because of this complicated web of influence.

Japan has been gradually shifting toward deregulation, especially since the Fukushima accident, but a law has been passed to protect reprocessing by requiring the utilities to pay in advance, at the time of irradiation, for reprocessing the spent fuel and fabricating the recovered plutonium into MOX fuel (Suzuki and Takubo 2016). The fact that nuclear utilities didn't fight openly against this law, which will make them pay extra costs in the deregulated market, suggests that they expect the government to come up with a system of spreading the cost to consumers purchasing electricity generated by non-nuclear power producers, for example, with a charge for electricity transmission and distribution, which will continue to be regulated.

Plutonium separation programs also persist in France, India and Russia. China, too, has had a reprocessing policy for decades, although a small industrial reprocessing plant is only at the site-preparation stage and a site has not yet been found for a proposed large reprocessing plant that is to be bought from France. Central bureaucracies have great power in these countries, as they do in Japan. France's government-owned utility has made clear that, where it has the choice—as it has had in the United Kingdom, whose nuclear power plants it also operates—it will opt out of reprocessing. This is why reprocessing will end in the UK over the next few years as the pre-existing contracts are fulfilled (IPFM 2015).

A final explanation put forward from time to time for the persistence of reprocessing in Japan is that Japan's security establishment wants to keep open a nuclear weapon option. There already are about 11 tons of separated plutonium in Japan, however (the rest of Japan's plutonium resides in France and the UK), and the design capacity of the Rokkasho Reprocessing Plant to separate eight tons of plutonium, enough to make 1,000 nuclear warheads per year, is far greater than Japan could possibly need for a nuclear weapon option. Also, Japan already has a centrifuge enrichment plant much larger than that planned by Iran. Iran's program precipitated an international crisis because of proliferation concerns. Japan's plant, like Iran's, is designed to produce low-enriched uranium for nuclear power plants, but the cascades could be quickly re-organized to produce enough weapon-grade uranium for 10 bombs per year from natural

[10] See: "Help Wanted: 4,000 Presidential Appointees" (Center for Presidential Transition, 16 March 2016) at: http://presidentialtransition.org/blog/posts/160316_help-wanted-4000-appointees.php.

uranium. Japan plans to expand this enrichment capacity more than 10-fold.[11] It is therefore hard to imagine that the hugely-costly Rokkasho reprocessing project is continuing because security officials are secretly pushing for it.

The idea that Japan is maintaining a nuclear weapon option has negative effects for Japan's security, however, raising suspicions among its neighbors and legitimizing arguments in South Korea that it should acquire its own nuclear weapon option. It also undermines nuclear disarmament. According to the *New York Times*, when President Obama considered adopting a no-first-use policy before leaving office, Secretary of State John Kerry "argued that Japan would be unnerved by any diminution of the American nuclear umbrella, and perhaps be tempted to obtain their own weapon" (Sanger and Broad 2016). It's about time for both the security officials and anti-nuclear weapon movements to examine this concern more seriously.

Given the terrible economics of reprocessing, its end in Japan and France should only be a matter of time. As the 40-year-long impasse over Japan's program demonstrates, however, the inevitable can take a very long time, while the costs and dangers continue to accumulate. The world has been fortunate that the stubborn refusals of Japan and France to abandon their failing reprocessing programs has not resulted in a proliferation of plutonium programs, or the theft and use of their plutonium by terrorists. The South Korean election of President Moon Jae-in—who holds anti-nuclear-power views—may result in a decrease in pressure from Seoul for the "right" to reprocess.

The combined effects of the "invisible hand" of economics and US policy therefore have thus far been remarkably successful in blocking the spread of reprocessing to non-weapon states other than Japan. China's growing influence in the international nuclear-energy industry and its planned reprocessing program, including the construction of a large French-designed reprocessing plant, could soon, however, pose a new challenge to this nonproliferation success story. Decisions by France and Japan to take their completely failed reprocessing programs off costly government-provided life support might convince China to rethink its policy.

Disclosure statement
No potential conflicts of interest were reported by the authors.

Funding
This research was supported by grants from the Carnegie Corporation [B 8620.R02] and the John D. and Catherine T. MacArthur Foundation [14-107404-000-INP].

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[11] For Japan Nuclear Fuel Limited's current and planned enrichment capacities, see http://www.jnfl.co.jp/en/business/uran/. It takes about 5,000 separative work units (SWUs) to produce enough HEU for a first-generation nuclear weapon – defined by the IAEA to be highly enriched uranium (usually assumed to be 90-pecent enriched in U-235) containing 25 kilograms of U-235.

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