Reducing Stocks of Separated Plutonium and Increasing Transparency

David Albright, President
Institute for Science and International Security

David Albright: I am going to begin by summarizing information about the size of plutonium stocks, and then I will discuss transparency.

Because of INFCIRC/549 arrangements, we understand relatively well how much unirradiated civil plutonium exists (figure 1). Not all countries, including Netherlands, Sweden, and India, have agreed to make declarations under INFCIRC/549. There are also some that do not always make complete declarations, or file their declarations late.

Having said that, you can confidently establish that, by the end of 1999, there existed about 210 tonnes of unirradiated civil plutonium, most of which is located in Britain and France (figure 2).[1] That is about 15 tonnes more than the previous year. There was a significant amount of reprocessing during that time period, and less-than-expected amounts of MOX used.

If you look over the next 15 years until 2015, you see a tendency for reprocessing to continue—at UP-2 and UP-3 in France, at THORP in Britain, and in Russia. Also the Rokkasho-mura plant in Japan is assumed to start separating significant amounts of plutonium in about 2007, and then will slowly ramp up. Overall, we estimate that about 150–250 tonnes of plutonium will be separated over the next 15 years.

The next question is: What is the capacity to use this plutonium over the next 15 years? If the Sellafield MOX Plant (SMP) operates, then there is no shortage of MOX capacity. But whether SMP will operate at near full capacity is still unknown. Japan also has to build a MOX plant, but there is expectation that it will do so successfully.

A finding is that the stock being separated over the next 15 years will absorb most of the MOX capacity. That is the next line on figure 2—about 150–300 tonnes is projected to be fabricated into MOX fuel.

So, as you can see, MOX fuel production capacity is not the controlling factor in using the plutonium to be separated over the next 15 years. Mainly the issue is finding enough reactors to use the plutonium. It is a central problem facing several countries, particularly Japan.

What conclusions can be drawn from these estimates? First, industry can deal with the amount of separated plutonium that accumulates over the next 15 years through MOX use, assuming enough reactors will burn MOX fuel, but MOX use does not cut very deeply into the existing inventory.

---

[1] For more details, see David Albright's presentation Kevin O'Neill (ed.), *Civil Separated Plutonium Stocks—Planning for the Future*, Proceedings of the March 14-15, 2000 Conference (Washington: ISIS Press, 2001). <http://www.isis-online.org/publications/civil_pu_conference/index.html>

Figure 1: Civil Unirradiated Plutonium 1999 [(a)]

	Britain	France	Belgium	Germany[(b)]	Japan	Switz.[(c)]	Russia	United States	China
Was INFCIRC/549 declaration for 1999 submitted to the IAEA as of December 31, 2000?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
INFCIRC/549, Annex B									
1. Unirradiated separated plutonium in product stores at reprocessing plants.	69.5	55.0	0	n.a.	0.5	not submitted	30.9		
2. Unirradiated separated plutonium in the course of manufacture or fabrication and plutonium contained in unirradiated semi-fabricated or unfinished products at fuel or other fabricating plants or elsewhere.	0.8	13.0	2.5	0.58	3.1	not submitted	not submitted		
3. Plutonium contained in unirradiated MOX fuel or other fabricated products at reactor sites or elsewhere.	2.2	8.2	1.4	5.48	1.2	0.6	0.2		
4. Unirradiated separated plutonium held elsewhere.	0	5.0	negligible	1.13	0.4	<0.05	0.9		
Note:									
[1] Ibid. i. Plutonium included in lines 1-4 above belonging to foreign bodies.	11.8	37.7	not submitted	not submitted	0	<0.05	not submitted		
ii. Plutonium in any of the forms in lines 1-4 above held in locations in other countries, and therefore not included above.	0.9	<0.05	0.9	not submitted	27.6	not submitted	not submitted		
iii. Plutonium included in lines 1-4 above which is in international shipment prior to its arrival in the recipient State.	0	0	0	not submitted	0	not submitted	not submitted		

Notes and Comments:

(a) All quantitites in tonnes. The term "not submitted" is used here to indicate that a declaration was left blank, recorded as a "--" or as "not communicated," or otherwise not reported to the IAEA.

(b) Germany declared a total of 6.6 tonnes of unirradiated plutonium in Germany, and said that the 0.1 difference from the total obtained by adding lines 2-4 is doe to rounding.

(c) In Annex C, declarations of the amount of plutonium contained in spent civil reactor fuel, Switzerland declared that it had 5 tonnes of plutonium contained in spent fuel sent for reprocessing and held in locations in other countries. Switzerland reported that this plutonium may be in the form of spent fuel, or in any of the separated forms listed in this table.

As mentioned, the stock of civil separated plutonium could be greater than projected in figure 2. It has been very difficult for some countries to use MOX, and things have moved more slowly on that side of things in general.

There are some exceptions, and the proceedings of our March 2000 conference,[2] which is available here today, discusses this at the country level. Countries like Belgium and Switzerland are expected to use

[2] Ibid.

up their stocks; Germany should be able to use up its stock—it doesn't actually have to get too much plutonium made into MOX each year, it just has to do so in a steady way for the next 15 years. Two exceptions are Japan and perhaps France. France may or may not have a problem; for the French, the issue is not a lack of reactors, but rather that the French MOX capacity has been limited by the government.

Figure 2: Unirradiated Civil Plutonium (tonnes)

	End of 1999	2000 - 2015
Plutonium Separated	n/a	150 - 250
Plutonium Used as MOX	n/a	150 - 300
Plutonium Balance	**210***	**~ 200**

* An increase of 15 tonnes from the end of 1998.

I'd like to turn now to excess military plutonium stocks (figure 3). We also expect this inventory to increase. Cumulatively today, it is at about 107 tonnes, essentially all of which is in the United States and Russia. I would expect that amount to increase to at least 150 tonnes, but the amount could go much higher. We would expect—with the reductions in nuclear arsenals now being discussed—that at least 150 tonnes would be declared excess by 2015.

Figure 3: Excess Military Plutonium, Declared or Committed (tonnes)

	2001	2015
Plutonium	107	150

In total, if you combine the civil and military categories, you are looking at about 300–350 tonnes of plutonium to deal with over the next 15 years (figure 4).

That is all I wanted to say about inventories. Are there any questions?

Figure 4: Civil and Excess Military Plutonium Scheduled for MOX use or other Disposition Options, (tonnes)

	2000	2015
Unirradiated Plutonium	310*	350

*About 10 tonnes of the excess military plutonium is in spent fuel and not included in this value.

Question: You said that over the next 10–15 years there will be 150–250 tonnes of plutonium separated. Do you mean separated annually over that time period, or is that the total amount at the end of that period?

David Albright: This is the cumulative amount that will be separated over that time period—from now to 2015.

Question: On the civil side, you are showing a balance of about 200 tonnes. Over the next 15 years, the amount of plutonium that would be separated would be essentially off set by the amount fabricated into MOX. So would the balance remain essentially as it is today?

David Albright: Under this estimate, that is correct. But there are alternative scenarios. Some of the curves that look into the balance between separation and use were presented by Jor-Shan Choi and I at the March 2000 conference. These curves tend to increase and then decrease over that time period, but they end up at roughly 200 tonnes in the year 2015. Some estimates end up at considerably more than 200 tonnes; a few are below 200 tonnes. But all of these remain uncertain. The estimate that I presented here assumes, for example, that Japan will use significant amounts of plutonium in MOX over that time period.

Question: How did you arrive at the conclusion of 150 tonnes of excess military plutonium? It seems arbitrary.

David Albright: This estimate is really a post-START II analysis, taking into account a generous reserve. The bulk of the excess would be from U.S. and Russian dismantled weapons. We described the methodology for arriving at this estimate in *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies*.[3] If you assume a certain amount of plutonium per weapon, and assign a certain quantity for a reserve, you still end up with a large excess stock.

Actually, I think the estimate of 150 tonnes is pretty modest. It could be that the United States and Russia decide not to declare these amounts to be excess. But if we are considering reducing nuclear arsenals to 1,000–2,000 weapons, then you end up with a lot of excess plutonium.

When we did this estimate, we assigned eight kilograms of plutonium per weapon. If you believe that the amount of plutonium per nuclear weapon is substantially less, then our estimate is pretty generous, even if you take into account a large reserve stockpile of weapons or material that is not declared excess.

If there are no other questions about stocks, then I'd like to talk about transparency. I think that the attacks on September 11 have made transparency a difficult topic to discuss, but nuclear industries have had to wrestle with the balance between security and transparency for decades. It is important that transparency initiatives continue.

I'd like to focus on Japan. ISIS Analyst Holly Higgins and I went to Japan and South Korea in the summer of 2001, and we toured many nuclear sites. We found the trip to be very rewarding.

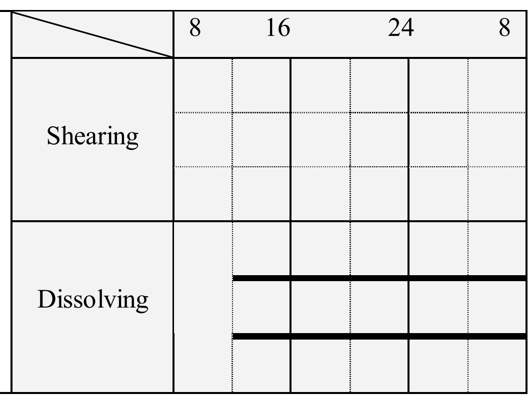
Figure 5: Situation of Tokai Reprocessing Facility (Daily Report)

Tuesday December 4, 2001 8am ~ Wednesday, December 5, 2001 8am

The 01-02 campaign was started on Oct. 14th 2001 and spent fuel was sheared on Nov. 28th as scheduled. (Total weight of sheared spent fuel is about 12.1 tonnes.) Treatment of dissolved solution of spent fuel continues and this campaign will be finished in the middle of December.

Main Operating Situation

- Spent fuel (ATR; 34 assemblies, About 5 tonnes were received.
- Operation to remove fission fragment and plutonium from extraction process is underway in the Main Plant.



(Each vertical line in the table represents four hours)

Others:

[3] David Albright, Frans Berkhout and William Walker, *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies* (Oxford: SIPRI and OUP, 1997).

Our trip focused on discussions about security in Northeast Asia, and much of our attention was directed towards South Korea. From a security viewpoint, one of the things that resonated in South Korea was what Japan was doing on transparency. We found, for example, that when we went to South Korea, suspicions that Japan would get nuclear weapons in the future were held more deeply than we had expected. So while we were in Japan, Holly and I were impressed by some of the things that the Japanese are doing to make their nuclear program more transparent.

Japan's transparency is motivated by something different than security, however. The Japanese utilities and nuclear industry are trying to be more open to the local communities. To do so, they are publishing much more information about their nuclear activities.

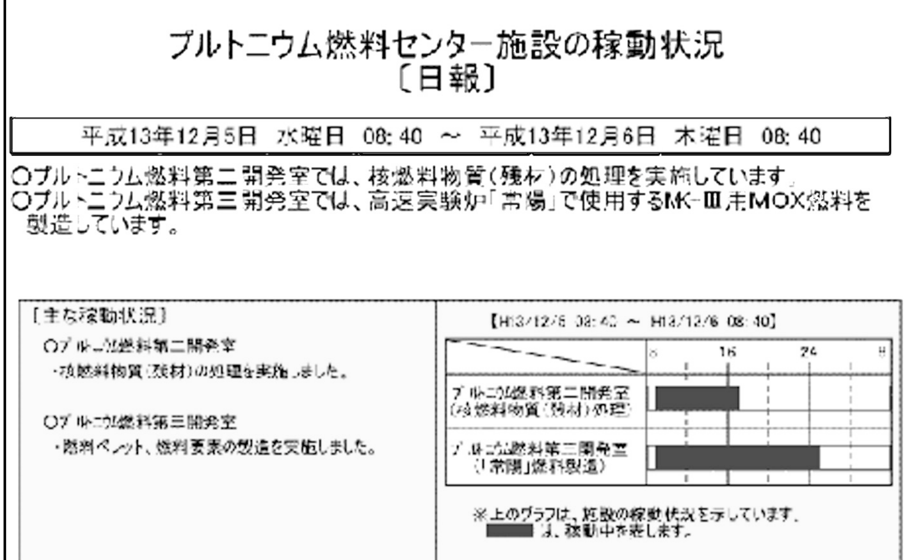
So, for example, the Japan Nuclear Cycle Development Institute (JNC) now has a web site[4] where they are reporting on their facilities on a daily basis. We've translated a few of these pages. Figure 5 on the previous page shows activities at the recently reopened Tokai reprocessing facility, with activities given in four-hour increments over a 24-hour period. The page is updated every day to give a summary report of how much fuel has been sheared and how much has been dissolved. In this case, you can see that there was no shearing done on that day. It also shows that there was no dissolving done on that day, but these lines indicate that the equipment was operating.

Figure 6 presents the same information for the following day in the original Japanese. You can see that, when there are operations involving the fuel and the dissolved product, there are solid bars on the figure.

The JNC web site also gives a more detailed daily report. For example, figure 7 on the following page shows the major operations for each of the steps for plutonium separation and purification, as well as the main exhaust stack. You can just go down the list of operations for the day at the facility.

They also have weekly reports and year-to-date reports. Figure 8 on page 13 shows the quantity of spent fuel that has been received at the Tokai works during that week, during the fiscal year, and cumulatively since the plant started operating in 1977.

Figure 6: Status of Tokai Reprocessing Facility (Daily Report)



Reference: The daily report can be found at <http://www.jnc.go.jp/ztokai/facilities/sisetu/PuHP/report/Today/pudaily1.htm>

[4] The JNC Home Page is located at < http://www.jnc.go.jp/jncweb/index.htm>

What the local communities are most interested in, I believe, is information about releases from the plant. To address this need, you can see that the web site reports fairly detailed information about how much radioactivity is being emitted by the facility.

Figure 7: Operating Situation of Tokai Reprocessing Facility (Detail)
December 4, 2001 8:00 am ~ December 5, 2001 8:00 am

Facilities		Operating Situation			Maintenance work situation, etc..
		1 8:00	2 16:00	3 24:00	
Main Stack	Exhaust				
Separation and Purification Facility	Receiving	Handling	of Fugen	fuel cask	
	Shearing				
	Dissolving		Dissolver Washing		
	Clarifying				
	Separation and Purification	FP/Pu flush out			
	Pu Concentration	PuA-1070		PuA-1071	
	U Concentration				
	U denitration				
	High Active Level Liquid Waste Concentration				
	Acid Recovering				

Reference: The updated JNC detailed report of the operating situation at the Tokai Reprocessing Facility may be found at <http://www.jnc.go.jp/ztokai/repro/Today/unten.htm>

One of the things that came up in discussions with South Korean nuclear scientists and officials is that there is a need for greater regional transparency. Having this information published, particularly in English, can help reduce South Korea's suspicions. So, we decided that we would publish a few of these pages and put them on the ISIS web site. The translations are to serve as a template; the forms stay the same on the web site, except perhaps for some notes. But once you have the translation of these pages, they become much easier to follow. And we would encourage the Japanese to publish some of their web site in English.

Figure 8: Situation of Tokai Reprocessing Facility (Weekly Report)

Term: Thursday November 22, 2001 8:00am ~ Friday, November 30, 2001 8:00am

[Operation Record]

	This week	This Fiscal Year (Japanese fiscal year is 4/1-3/31	Cumulative amount after starting operations (approx.) [1]
Received Spent Fuel	0.0 tonnes	21.2 tonnes (approx.)	1058 tonnes
Reprocessed Spent Fuel[2]	1.5 tonnes (approx)	30.1 tonnes (approx)	980 tonnes (approx)
Production of Vitrified Waste	0 canisters	26 canisters	123 canisters

[Discharged Radioactivity]

Discharge	Discharged nuclide	Discharge amount of this week (GBq)[3]	Cumulative amount of the fiscal year (GBq)	% Compared with standards[4]
Stack	Krypton	$2.1 \text{x} 10^5$	$3.7 \text{x} 10^6$	4%
Ocean Discharge	Nuclides Emitting α-ray	N.D.[5)]	N.D.[5)]	-
	Nuclides Emitting ß-ray (except for Tritium)	N.D.[6)]	N.D.[6)]	-
	Tritium	$5.6 \text{x} 10^3$	$1.1 \text{x} 10^5$	6%

[1] Both the receiving of spent fuels and operation of reprocessing started in 1977. The production of vitrified waste started in 1995.
[2] Reprocessing of spent fuel indicates the amount of sheared spent fuel.
[3] The Becquerel (Bq) is the unit of radioactivity. 1GBq means 10^9Bq
[4] This means the fraction of the maximum emitted amount for this fiscal year to the maximum emitted amount stipulated in the safety regulations. (Krypton: $8.9 \text{x} 10^7$GBq, α-ray emitting nuclide: 4.1GBq, ß-ray emitting nuclide (excluding tritium): $9.6 \text{ x } 10^2$GBq, Tritium: $1.9 \text{x} 10^6$GBq.
[5)] N.D. (not detectable) indicates concentration less than detectable limit (0.0011Bq/cm^3)
[6)] N.D. (not detectable) indicates concentration less than detectable limit (0.022Bq/cm^3)

Reference: The updated JNC weekly report may be found at < http://www.jnc.go.jp/ztokai/repro/week/now/weekly.htm>

As the situation develops with North Korea, I think that steps like this could become more important. Such steps not only would help involve Japan more deeply in the regional situation, but also could provide a basis for cooperation on regional safeguards, other kinds of cooperation, or—off in the future—a regional inspection regime.

The other thing that we saw in South Korea was a desire to work more incrementally towards long-term goals. This was something new. In South Korea, there has been a history to declare something—such as a new bilateral inspection system—and then just hope that it evolves and takes place. The experience has been that it does not. The new attitude among the scientists to explore these things more incrementally is encouraging. Transparency steps such as those taken by Japan become more important in this context.

Let me stop there, and ask if there are any comments or questions.

Question: How does transparency help if it only shows that Japan is separating plutonium and storing it?

David Albright: It helps by showing that the reprocessing is not being done in secret. Secrecy breeds suspicion; I think that if you asked the South Koreans whether Japan has nuclear weapons, most would say no. But they have many concerns, based on historical experience, about what Japan may do in the future. I think if Japan undertakes its nuclear activities openly, then it will help build confidence in South Korea that it is not doing so with an underlying motive of building nuclear weapons in the future.

Of course, there is much more that needs to be done. This is only a small step. But we thought that it was useful to translate this.

There is another reason why this is important. U.S. policy has really treated these issues differently in Japan and South Korea. In a sense, U.S. policy is that it is basically all right for Japan to use separated plutonium, but it is unacceptable for South Korea to do so. This makes it hard to build a regional dialogue about what to do about these separated plutonium stocks. Therefore, ISIS is increasingly getting involved in the region; we can do things that the U.S. government would have difficulty doing.

Question: You mentioned that some countries had not joined INFCIRC/549, the Guidelines for the Management of Plutonium. These are mostly minor countries that hold kilogram levels of plutonium—Sweden, Italy, Netherlands, Canada. Do you see any movement by these countries to report their holdings?

David Albright: Some do report their holdings. For example, the figures from the Netherlands were published in a parliamentary report, and Sweden publishes its figures. Others do not; Italy is completely opaque. In addition, the first three countries you mentioned held, or will hold, hundreds of kilograms, if not a few tonnes, of plutonium.

Regarding the guidelines, I think there have been requests by the nine adherents to INFCIRC/549 to other countries to join, but I do not know the status of these requests.

Question: I'd like to ask a question regarding your estimate of 300 tonnes of MOX that is to be used by 2015. Assuming that the MOX fuel will contain five percent plutonium, you arrive at about 6,000 tonnes of heavy metal to be consumed over 15 years, at the rate of 450 tonnes per year. That is pretty much the full reactor capacity that exists. Were you were simply taking into account the capacity factor in your projection?

David Albright: Yes.

Question: That is a problem that I wanted to point out. Currently, there are only 32 reactors using MOX. Your projection will require 45 reactors to use MOX. So, you would require about 15 more reactors.

David Albright: This is not unrealistic. If Japan had 15–20 reactors, for example, and France used all of its reactors, then that would close the gap. There are 12 more reactors in Germany, and three in Switzerland. It could be done.

Question: But you are assuming that Switzerland and Belgium will continue to use MOX, even though the MOX does not belong to them. You are also assuming that the majority of the UK plutonium will be burned somewhere else, which is more problematic. So, you have a discrepancy in there.

But you have stated the problem correctly: The ultimate constraint is the number of reactors that can use MOX. France has 20 reactors using MOX; it could use MOX in 38 reactors. Japan could have additional reactors use MOX. But we need a minimum of 45 reactors to use the 300 tonnes of plutonium by 2015.

Let's assume that half of the separated plutonium is in the UK, which has no reactors to use it? What then?

David Albright: Well, it's not half. The 200 tonnes given in figure 2 as the plutonium balance in 2015 is an average, and it assumes that Britain's civil plutonium will remain in storage. In terms of the upper bound of 300 tonnes, that *really is* an upper bound—an optimistic one, at that. That is as good as it is going to get; countries would have to be hard pressed to use more civil plutonium as MOX fuel. Using this upper bound is important because it reinforces the conclusion that the overall stocks are only going to change significantly if countries do start accelerating disposition options, or if there is less reprocessing.

I think that it can be assumed that countries would deploy more reactors for MOX use in this scenario. But you don't need to have "country X" burn "country Y's" MOX to arrive at this projection. Rather, you need countries across the board, excepting the UK, to use all the plutonium that they are producing, plus a little more.

PAGE 12 INTENTIONALLY BLANK