The Status Report of Plutonium Management in Japan - 2021 -

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Office of Atomic Energy Policy
Cabinet Office

1. Preface

Japan has been limiting its research, development and use of nuclear power exclusively for peaceful purposes under the Atomic Energy Basic Act.

From the viewpoint of peaceful use under the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, and under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), all nuclear materials and activities in Japan are subject to the stringent safeguards implemented by the International Atomic Energy Agency (IAEA), thus guaranteeing the peaceful use of nuclear energy in Japan*.

In addition, Japan upholds the principles of not possessing plutonium without specific purposes guided by the policy of peaceful use. Given the importance of enhancing transparency and gaining public understanding on use of plutonium at home and abroad, Japan has published the status report of management of unirradiated separated plutonium (hereinafter referred to as “separated plutonium”) including usage and stockpile both within and outside of Japan since 1994. Moreover, Japan has also reported the status annually to the IAEA in conformity with the “Guidelines for the Management of Plutonium.” In this report, Japan voluntarily publishes the use, storage status and other items at each facility in a more detailed manner than required by ”the Guidelines for the Management of Plutonium” to further improve its transparency.

2. The Current Status of Separated Plutonium Management in Japan

(1) Overview

As of the end of 2021, the total amount of separated plutonium both managed within and outside of Japan was approximately 45.8 tons, approximately 9.3 tons of which was held domestically and the rest of approximately 36.5 tons was held abroad.

In 2021, no additional separated plutonium was recovered in Japan, but approximately 0.2 tons of separated plutonium was consumed at Shikoku Electric Power Company Ikata Unit 3. In addition, approximately 0.6 tons of separated plutonium stored in France by Japanese electric utilities was fabricated into MOX fuel and transported into Japan.

As a result, the amount of plutonium held domestically at the end of 2021 was approximately 9.3 tons, and the amount held abroad was approximately 36.5 tons.

The Status of Separated Plutonium Management

<Unit: t Pu>

			As of the end of 2020	As of the end of 2021
Total			46.1	45.8
Held in Japan			8.9	9.3
Held abroad	(Total)		37.2	36.5
	Breakdown	U.K.	21.8	21.8
		France	15.4	14.8

(Note) All figure are approximate numbers.
The total figures may not agree completely due to rounding.

(2) The Data in the Attachment

The status of separated plutonium management in Japan as of the end of 2021 is given below. The amounts of separated plutonium in tables are given in kilograms unless otherwise mentioned. Figures in brackets are the data published last year.

"Separated plutonium held in Japan" in Section 1-(1) of the Attachment is unirradiated separated plutonium in the process between separation from spent fuel, fabrication into MOX fuel powder at reprocessing facilities, fabrication into MOX fuel assemblies from MOX fuel powder at fuel fabrication facilities, and loaded into a reactor core but yet to be irradiated. Such plutonium is held in the following facilities:

1) Reprocessing facilities: in the state of plutonium nitrate in the separation and purification processes, or of plutonium oxide both in the co-conversion process and in containers.
2) Fuel fabrication facilities: plutonium oxide held as raw materials, in the stage of testing or fabrication, or contained in newly fabricated fuels.
3) Nuclear reactors and other facilities: plutonium oxide contained in unirradiated fuels held at Joyo, Monju and commercial reactor sites (this includes unirradiated MOX fuels loaded into the reactor core but yet to be irradiated, and such fuels unloaded from the reactor core without having been irradiated), and those held for research at R & D facilities of universities or institutes, and those in fuels for critical assemblies.

"Separated plutonium held abroad" in Section 1-(2) of the Attachment is plutonium that has been separated by reprocessors in the U.K. and France under contracts with Japanese electric utilities, but not yet returned to Japan. Basically, such plutonium is to be fabricated into MOX fuels overseas and be utilized at light water reactors (LWRs) in Japan.

"Utilization of separated plutonium from Jan. to Dec., 2021" in Sections 2-(1), (2), and (3) of the Attachment is to provide further clarity of the plutonium management. It shows the amount of plutonium oxide form recovered at reprocessing facilities, the

net amount of plutonium transferred to fabrication process of the fuel fabrication facilities and the amount of unirradiated MOX fuels loaded into the reactors and irradiated.

* : The broader conclusion for Japan （2021）

Under the Treaty on the NPT, based on the Comprehensive Safeguards Agreement concluded with the IAEA and its Additional Protocol, Japan accepts safeguards by the IAEA on all nuclear materials including plutonium in Japan.

The IAEA's Board of Governors held in June 2022 affirmatively concluded that the safeguards implemented by the IAEA in 2021 found that all nuclear material remained in peaceful activities (the broader conclusion) on the basis that there are no indication of the diversion of declared nuclear material from peaceful nuclear activities and no indication of undeclared nuclear material or activities in Japan.

[References]

Reference 1	The amount of separated plutonium held in nuclear reactors and other facilities in Japan as of the end of the year 2021.
Reference 2	The balance of separated plutonium held in Japan as of the end of the year 2021.
Reference 3	The Status of Separated Plutonium in Japan (2021) (illustration)
Reference 4	The amount of plutonium held in Japan as of the end of the year 2021 published by the IAEA under *the Guidelines for the Management of Plutonium*.
Reference 5	The amount of plutonium held in each country as of the end of the year 2020 published by the IAEA under *the Guidelines for the Management of Plutonium*.

Attachment

The Status of Separated Plutonium Management in Japan as of the end of the year 2021

1. Separated plutonium in storage

(Previous year's figures in brackets)

(1) Separated plutonium held in Japan

<Unit: kg Pu>

			Japan Atomic Energy Agency (JAEA) Tokai Reprocessing Plant	Japan Nuclear Fuel Limited (JNFL) Rokkasho Reprocessing Plant	Total(*)
Reprocessing Facilities	Breakdown (Note 1)	Plutonium nitrate, etc. (Dissolved into nitric acid for reprocessing)	24 (26)	272 (273)	297 (299)
		Plutonium oxide (held as mixed oxide in containers)	167 (167)	3,329 (3,329)	3,496 (3,496)
	Total(*)		192 (193)	3,602 (3,602)	3,793 (3,795)
		Fissile Plutonium	125 (126)	2,339 (2,340)	2,465 (2,466)

(Note 1) Changes of the figures may occur from possible samplings for analysis and inspection purposes and the transfer between the reprocessing, storage and fabrication facilities.

			JAEA Plutonium Fuel Fabrication Facilities
Fuel fabrication Facilities	Breakdown (Note 2)	Plutonium oxide (held in plutonium oxide containers)	2,682 (2,595)
		Plutonium in the stage of testing or fabrication	785 (874)
		Unirradiated fuel, etc. (held as finished fuel assemblies, etc.)	446 (446)
	Total(*)		3,913 (3,916)
		Fissile Plutonium	2,696 (2,698)

(Note 2) Changes of the figures may possibly occur from the movements of materials between material balance areas in a facility caused by samplings for analysis, inspection purposes, safety check of storage materials, and consolidation of nuclear materials.

			Joyo	Monju	Commercial Reactors	R&D Facilities (Note 3)
Reactors and Other Facilities	Unirradiated fuel held at nuclear reactor sites, etc.		134 (134)	279 (280)	1,046 (616)	113 (113)
	Total(*)		1,573 (1,143)			
		Fissile Plutonium	1,065 (799)			

(Note 3) "R&D Facilities" includes critical assemblies and other R&D facilities.

Total(*)		9,279 (8,854)
	Fissile Plutonium	6,226 (5,964)

(2) Separated plutonium held abroad (Note 4)

This is the plutonium that was separated by reprocessors in the U.K. and France under the reprocessing contracts with Japanese electric utilities. Basically, this plutonium is to be fabricated into MOX fuels overseas, and brought into Japan for use in light water reactors (LWRs). Thus, "Separated plutonium held abroad" should not be a concern from the peaceful use point of view. However, for the sake of better transparency, the current status of separated plutonium held abroad for the fabrication of fuel is also shown below.

<Unit: kg Pu>

	Separated plutonium	
		Fissile Plutonium
U.K.	21,780 (21,805)	14,504 (14,528)
France	14,760 (15,411)	9,541 (9,965)
Total(*)	36,540 (37,216)	24,045 (24,493)

(Note 4) Nuclear losses (refer to Note 2 of Reference 2) are taken into account in the assessment of the amount of plutonium held in reprocessing facilities.

2. Utilization of separated plutonium from Jan. to Dec. 2021

(Previous year's figures in brackets)

(1) The amount of plutonium-oxide recovered <Unit: kg Pu>

	JAEA Tokai Reprocessing Plant	JNFL Rokkasho Reprocessing Plant	Total(*)
Amount of plutonium-oxide recovered (Note 5)	0 (0)	0 (0)	0 (0)

(Note 5) "The amount of plutonium-oxide recovered" is defined as the amount of plutonium in oxide form (MOX powder) converted from plutonium nitrate at reprocessing facilities.

(2) The amount of separated plutonium in fuel fabrication processes <Unit: kg Pu>

	for Monju, Joyo, etc.
Amount of separated plutonium in fuel fabrication processes (Note 6)	0 (0)

(Note 6) "The amount of separated plutonium in fuel fabrication processes" is defined as the net amount of plutonium transferred from raw materials storage areas into fabrication process areas at fuel fabrication facilities.

(3) The amount of MOX fuel loaded and irradiated in nuclear reactors <Unit: kg Pu>

	Nuclear Reactors
Amount of MOX fuel loaded and irradiated in nuclear reactors(Note 7)	198 (0)

(Note 7) "The amount of MOX fuel loaded and irradiated in nuclear reactors" is defined as the amount of plutonium contained in unirradiated MOX fuel which was loaded in the nuclear reactor cores for use as fuel and irradiated. The MOX fuels that are loaded into the reactor cores are either unirradiated or in the process of irradiation. For the sake of clarity, the figure here specifically refers to the loaded and irradiated amount.

(*) The total figures may not agree completely due to rounding.

The amount of separated plutonium held in nuclear reactors and other facilities in Japan as of the end of the year 2021.

Facility name			Plutonium held(Note 1) (Unirradiated separated plutonium)		Plutonium loaded into the reactors out of the "Plutonium held" in the left column (Note 2) (Unirradiated separated plutonium)		(Reference Data)"Total amount of unirradiated separated plutonium loaded into the reactor cores by the end of the year 2021 "minus "Total amount of irradiated plutonium unloaded from the reactor cores" (Note 3)	
			Total (kg Pu)	Fissile plutonium in total(kg Puf)	Total (kg Pu)	Fissile plutonium (kg Puf)	Total (kg Pu)	Fissile plutonium (kg Puf)
Japan Atomic Energy Agency		Joyo	134	98	—	—	261	184
		Monju	279	190	121	83	502	351
Commercial Reactors	Tokyo Electric Power Company Holdings	Fukushima Daiichi Unit 3	—	—	—	—	210	143
		Kashiwazaki Kariwa Unit 3	205	138	—	—	—	—
	Chubu Electric Power Company Hamaoka Unit 4		213	145	—	—	—	—
	Kansai Electric Power Company	Takahama Unit 3	—	—	—	—	901	585
		Takahama Unit 4	629	403	—	—	703	446
	Shikoku Electric Power Company Ikata Unit 3		—	—	—	—	198	136
	Kyushu Electric Power Company Genkai Unit 3		—	—	—	—	801	516
Research and Development Facilities	Japan Atomic Energy Agency	Deuterium Critical Assembly in Oarai R&D Institute	87	72				
		Static Experiment Critical Facility and Transient Experiment Critical Facility in Nuclear Science Research Institute	15	11				
	Other facilities		11	9				

(Note 1) Unirradiated separated plutonium held at the end of the year 2021
(Note 2) Plutonium loaded into the reactors out of the unirradiated separated plutonium held at the end of the year 2021
During the year 2021, unirradiated separated plutonium equivalent to 198kg Pu was irradiated at Ikata Unit 3.
(Note 3) It is equivalent to the weight of plutonium of the unirradiated MOX fuel staying in the reactor cores at the end of the year 2021. For commercial reactors, some irradiated fuels may be removed to spent fuel pools temporarily for facility periodic inspection.

Additional information for reference (as of the end of the year 2021):

- Irradiated plutonium contained in spent fuel in the storage facilities at reactor sites: 151,789kg Pu
- Irradiated plutonium contained in spent fuel in the storage facilities at reprocessing facilities: 26,734kg Pu
- Small amount of plutonium contained in radioactive waste and recognized as irrecoverable for the time being: 135kg Pu

[Reference 2]

The Balance of Separated Plutonium held in Japan as of the end of the year 2021.

Unit: kg Pu

< Variations during the year 2021> (Note 1)	
Total amount of plutonium newly loaded in reactors and irradiated	△ 198
Plutonium shipped in and out at facilities	629
Variance in processes at facilities	△ 5
Balance	426

[JAEA Reprocessing Facility]

From separation and purification process to storage of raw material at co-conversion process in the reprocessing facility (Note 1)				
Inventory as of Jan. 1, 2021 (the end of the year 2020)				193
increase and decrease	Plutonium shipped in (in 2021)			0
	Plutonium shipped out (in 2021)			△ 0
	Variance in processes at reprocessing facility (Note 2)			△ 1
		Breakdown	Transfer to retained waste	△ 2.2
			Retransfer from retained waste	2.5
			Nuclear loss	△ 0.0
			Measured discard	△ 1.8
			Material unaccounted for (MUF)	0.2
Inventory as of Dec. 31, 2021				192

[JAEA Plutonium Fuel Fabrication Facility]

From raw material of MOX to fuel assembly products (Note 1)				
Inventory as of Jan. 1, 2021 (the end of the year 2020) (Note 3)				3,916
increase and decrease	Plutonium shipped in (in 2021)			0
	Plutonium shipped out (in 2021)			△ 0
	Variance in processes at fuel fabrication facilities (Note 2)			△ 2
		Breakdown	Nuclear loss	△ 1.8
			Material unaccounted for (MUF)	△ 0.4
Inventory as of Dec. 31, 2021				3,913

[Nuclear Reactors and Other Facilities]

"Joyo", "Monju", "Commercial Reactors", and "R&D Facilities" (Note 1)				
Inventory as of Jan. 1, 2021 (the end of the year 2020)				1,143
increase and decrease	Plutonium shipped in (in 2021)			629
	Decrease by plutonium newly loaded in reactors and irradiated (in 2021)			△ 198
	Plutonium shipped out (in 2021)			△ 0
	Variance at reactor sites (Note 2)			△ 1
		Breakdown	Transfer to retained waste, etc.	△ 1.0
Inventory as of Dec. 31, 2021				1,573

[JNFL Reprocessing Plant]

From separation and purification process to storage of raw material at mixed conversion process in the reprocessing facility (Note 1)				
Inventory as of Jan. 1, 2021 (the end of the year 2020)				3,602
increase and decrease	Plutonium shipped in (in 2021)			0
	Plutonium shipped out (in 2021)			△ 0
	Variance in processes at reprocessing facility (Note 2)			△ 1
		Breakdown	Transfer to retained waste	△ 0.0
			Nuclear loss	△ 0.6
			Material unaccounted for (MUF)	0.1
Inventory as of Dec. 31, 2021				3,602

(Note 1) The total may not agree due to rounding. "△" indicates consequential decrease.

(Note 2) The variances in processes at each facility includes, in addition to receipts into and shipments from the facility, inventory change in the material control and accounting (shipper/receiver difference, transfer to retained waste, retransfer from retained waste, nuclear loss, measured discard and so on), and material unaccounted for. The definition of inventory change and material unaccounted for are described below. These are concepts recognized internationally in the measurement and control of nuclear fuel materials. The variance that causes the reduction of inventory is shown with "△".

- ○ Shipper/receiver difference:
  The difference between the quantity of nuclear fuel materials as status by the shipping side and that as measured by the receiving side when nuclear fuel materials are transferred between different facilities.
- ○ Transfer to retained waste:
  Amount of the nuclear fuel materials that are removed from the book inventory, which is deemed to be in unrecoverable status for the time being but which is held, such as plutonium contained in high-level radioactive liquid or low level radioactive liquid generated in the process of recovering nuclear fuel materials from spent fuel solution.
- ○ Retransfer from retained waste:
  Amount of the nuclear fuel materials that had been retained as waste but was re-classified as the book inventory in order to be processed for volume reduction and other purposes.
- ○ Nuclear loss:
  Amount of the loss (decrease) of nuclear fuel materials as a result of natural decay.
- ○ Measured discard:
  Amount of the nuclear fuel materials that has been measured or estimated on the basis of measurements, and disposed of in such a way (verification, etc.) that is not suitable for further nuclear use.
- ○ Material unaccounted for (MUF):
  The difference between the book inventory and the physical inventory that is defined by actual measurement. MUF is inevitably generated from measurement error or adhesion of plutonium to equipment in a facility where plutonium is treated in powder or liquid state.

Provisional Translation

[Reference 3]

The Status of Separated Plutonium in Japan (2021)

Unit: kg Pu

[Separated plutonium held abroad]

Total amount abroad	36,540

Total amount transported from abroad	629

(Transferred amount in a facility and variances in processes at facilities)

[Total amount irradiated] Amount of plutonium loaded into reactors and irradiated	△198
Variances in Other Facilities	△1

[Amount of Holdings]

New fuel and for R&D	1,573

Nuclear Reactors and Other Facilities

Spent Fuels

Total amount shipped out	0

Total amount in Japan	9,279

(Transferred amount in a facility and variation in processes at a facility)

[Total amount separated] Amount of reprocessed spent fuel	—
[Amount recovered] Amounts converted from plutonium nitrate to plutonium oxide	—
Variances in processes	△2

Reprocessing Facilities

[Amount of Holdings]

Plutonium nitrate, etc.	297
Plutonium oxide	3,496
Total	3,793

Total amount shipped out	—

(Transferred amount in a facility and variation in processes at a facility)

[Used amount] Amount of plutonium in fuel fabrication processes	—
Variances in processes	△2

Fuel Fabrication Facilities

[Amount of Holdings]

Plutonium oxide	2,682
Plutonium in the stage of testing or fabrication	785
New fuel, etc.	446
Total	3,913

(Note 1) "Amount of Holdings" is the figure as of the end of the year 2021.
(Note 2) "Transferred amount in a facility and variances in processes at facility" shows the figure for one year in 2021.
(Note 3) "△" indicates decrease.

[Reference 4]

The Amount of Plutonium Held in Japan as of the end of the year 2021 published by the IAEA under *the Guidelines for the Management of Plutonium*

(Previous year's figures in brackets)

Annual figures for holdings of civil unirradiated plutonium [*1] (Unit: t Pu)

1. Unirradiated separated plutonium in product stores at reprocessing plants	3.8	(3.8)
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	3.5	(3.5)
3. Plutonium contained in unirradiated MOX fuel, including that loaded into a reactor core prior to use, or other unirradiated plutonium in fabricated products at reactor sites or elsewhere	1.9	(1.5)
4. Unirradiated separated plutonium held elsewhere	0.1	(0.1)
[Sum of lines 1-4 above][*2]	[9.3	(8.9)]
(ⅰ) Plutonium included in lines 1-4 above belonging to foreign bodies.	0	(0)
(ⅱ) Plutonium in any of the forms in lines 1-4 above held in locations in other countries and therefore not included above.	36.5[*3]	(37.2[*3])
(ⅲ) Plutonium not included in lines 1-4 above which is in international shipment prior to its arrival in the recipient State.	0	(0)

Estimated amount of plutonium contained in spent civil reactor fuel [*4] (Unit: t Pu)

1. Plutonium contained in spent fuel at civil reactor sites.	152	(149)
2. Plutonium contained in spent fuel at reprocessing plants.	27	(27)
3. Plutonium contained in spent fuel held elsewhere.	<0.5	(<0.5)
[Sum of lines 1-3 above][*5]	[179	(176)]
(Definition)		
Line 1: covers estimated amounts of plutonium contained in fuel discharged from civil reactors		
Line 2: covers estimated amounts of plutonium contained in fuel received at reprocessing plants but not yet reprocessed.		

*1: Rounded to 100 kg plutonium.

*2, *5: The sum is calculated for the sake of convenience and it is out of the scope of the report under the Guidelines.

*3: Loss of Pu-241 due to radioactive decay is taken into account in the assessment of the amount of fissile plutonium held at the overseas reprocessing plants.

*4: Rounded to 1,000 kg plutonium.

[Reference 5]

The Amount of Plutonium Held in Each Country as of the end of the year 2020 published by the IAEA under *the Guidelines for the Management of Plutonium*

（Unit：t Pu）

	Unirradiated plutonium*1	Plutonium contained in spent fuel*2
U.S.	49.4	765
Russia	63.3	185
U.K.	140.2	26
France	95.0	299.7
China	—*3	—*3
Japan	8.9	176
Germany	0.0	126.3
Belgium	（< 50kg）*4	45
Switzerland	< 2kg	22

The figures in the column of Japan is corresponded to those appeared in Reference 4.
The figures of the other countries are computed by the Office of Atomic Energy Policy Cabinet office of Japan based on the data taken from IAEA publication.

*1：The total amount of unirradiated separated plutonium in product storage of reprocessing plants, in the course of manufacture, plutonium contained in unirradiated MOX fuel product in reactor sites etc., and elsewhere (Rounded to 100 kg plutonium). The items reported as less than 50 kg are not included.

*2：The total amount of plutonium contained in spent fuel at civil reactor sites, at the reprocessing plants and held elsewhere (Rounded to 1,000 kg plutonium), The items reported as less than 500 kg are not included.

*3：Not available at the time of IAEA publication.

*4：The items reported as less than 50 kg which are in the course manufacture, plutonium contained in unirradiated MOX fuel product in reactor sites etc. or elsewhere.

[A short history of *the Guidelines for the Management of Plutonium*]

In Feb.1994, the nine countries, i.e. U.S., Russia, U.K., France, China, Japan, Germany, Belgium and Switzerland started to deliberate on the establishment of an international framework aimed at enhancing the transparency of plutonium utilization.

In Dec.1997, these nine countries decided on *the Guidelines for the Management of Plutonium* that provided the basic norms about plutonium management, transparency through publication of the amount of plutonium held in each country and the importance of non-proliferation.

In Mar.1998, the IAEA published for the first time the amount of plutonium held in each country and the policy of each country about plutonium utilization reported to the IAEA under the Guidelines.