Civil HEU Watch

Tracking Inventories of Civil Highly Enriched Uranium

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February 2005, *Revised August 2005*

Highly enriched uranium (HEU) is a key ingredient in nuclear weapons, making it one of the most dangerous materials in existence. As a result, governments take extraordinary measures to secure HEU against theft or diversion and to reduce the inventories of HEU in the world.

Table 1 shows that, of the 1,900 tonnes of HEU in the world at the end of 2003, 175 tonnes were in civil stocks, and 1,725 tonnes were dedicated to nuclear weapons and other military stocks. The United States and Russia had by far the largest stocks. For comparison, stocks of plutonium are included.

Although the five acknowledged nuclear weapon states also possess most of the world's civil HEU, many non-nuclear weapon states also possess HEU inventories. Starting in the 1950s, many countries bought research and test reactors to pursue peaceful nuclear activities, and initially many of these reactors were fuelled with HEU. Since the late 1970s, the United States and other countries have worked to convert these reactors from HEU to low enriched uranium (LEU) fuels and discourage the construction of new reactors that require HEU fuel. Nonetheless, at the end of 2003, almost 50 non-nuclear weapon states still possessed HEU. As a result, both the United States and Russia have launched "take-back" programs to retrieve HEU that they provided to these countries for use in their nuclear programs.

Little, if any, HEU is being produced in uranium enrichment plants for civil uses. Increases in civil HEU stocks result mainly from military HEU being declared excess to defense requirements and transferred to civil stocks, as happened when the United States declared excess about 174 tonnes of military HEU in the 1990s.

In general, stocks of civil HEU are decreasing as HEU is blended down into low enriched uranium. In addition, the US and Russian take-back programs are consolidating the existing civil HEU stocks. Although the amount returned or expected to be returned to Russia and the United States is relatively modest, roughly 4-5 tonnes, these take-back

programs will dramatically reduce the number of countries with significant stocks of HEU.

HEU Holdings by Country, end of 2003

Table 2 shows civil HEU holdings by country at the end of 2003, the last year for which there is detailed information. In a few cases, the figures in table 2 and 3 are derived from official public declarations. For countries that do not declare HEU holdings, ISIS estimates are used.

Table 2 shows an estimated global inventory of 165-184 tonnes of civil HEU, with a central estimate of 175 tonnes. A total of 53 countries have one kilogram or more of HEU. Several countries, including Columbia, Denmark, Philippines, and Thailand, are included in the table with an inventory of zero, signifying that they had US-origin HEU but returned it to the United States or sold it to other HEU users. Many other countries have reduced their HEU stocks significantly. For example, over the last decade Sweden has reduced its HEU stock from over 100 kilograms to just a few kilograms through returns to the United States. In total, about one tonne of HEU has been returned to the United States. The Russian return program is just getting started and has focused on retrieving unirradiated HEU stocks, a small but critical stock to reduce.

Table 2 lists several countries, including Chile, Japan, India, and perhaps Brazil, that have HEU from Britain, China, or France that is not subject to transfer to a nuclear weapon state. In addition, South Africa has a relatively large inventory of domestically produced HEU that is also not eligible for transfer to the United States.

Table 3 shows HEU holdings by country with a focus on US- and Russian-origin HEU stocks. This table includes a projection of the amount of civil HEU that will remain in 2020. This projection assumes that existing take-back and blend-down efforts will succeed, although this projection does not assume that more HEU fuels or forms of HEU will become eligible for return to the United States.

In 2020, under this projection, states are projected to have a total of about 46-54 tonnes of civil HEU, or a central estimate of 50 tonnes. Most of this decrease will result from down-blending programs in the acknowledged nuclear weapon states that are projected to reduce civil HEU inventories by about 125 tonnes.

Although non-nuclear weapon states are projected to decrease their total HEU stock by only about four tonnes in the next 15 years, many of these states will no longer have stocks of HEU. The number of countries with a kilogram or more of HEU could decrease from about 50 to no more than 10 to 20 countries. Russia is projected to take back almost all of the HEU that it provided to other countries and to reprocess and blend down the recovered HEU. The relatively large, remaining stocks of US-origin HEU will be concentrated in countries with robust physical protection systems, such as Canada, Germany, Italy, Japan, and the Netherlands. South Africa is also projected to retain a relatively large HEU stock in 2020.

The US program allows the return of only spent aluminum-based or triga HEU fuels. It excludes HEU in oxide fuels or other chemical forms, which is a substantial portion of the HEU exported by the United States. The United States should consider on a case-by-case basis permitting other HEU forms of US-origin to be returned. In addition, the United States needs to be prepared to accept the transfer of several stocks of non-US-origin HEU, including South Africa's stock, that otherwise would remain in countries that may not be able to provide adequate long-term physical protection.

Table 1 Global Plutonium and Highly Enriched Uranium (HEU), Assigned to Civil or Military Stocks, end 2003 (in tonnes)[a]

Category	Plutonium	HEU	Total
Civil Stocks	**1,675[b]**	**175**	**1850**
Power and Research Reactor Programs[c]	1570	50	
Russian and U.S. Military Excess[d]	102.5	125 (US only)	
Military Stocks	**155**	**1725**	**1880**
Primary	155	1250	
Naval and Other	--	175	
Russian HEU Declared Excess	--	300[e]	
Total	**1830**	**1900**	**3730**

[a] These aggregate numbers are based on an attempt to realistically assign plutonium and HEU to civil or military stocks based on a combination of factors, principally current use and future intended use. The bulk of the plutonium and HEU in military stocks is material in nuclear weapons, reserves, naval and production reactor programs, and in storage from dismantled weapons.

[b] Rounded.

[c] British excess military plutonium is included with civil power reactor values because Britain includes this plutonium in the category of civil, unirradiated plutonium in its INFCIRC/549 declarations to the International Atomic Energy Agency.

[d] Britain and the United States declared that their excess plutonium would be used only for peaceful purposes. The United States made a similar commitment for its excess HEU; Britain did not declare any excess HEU. Russia has made a similar commitment for its excess plutonium, but not for its excess HEU (see below).

[e] Russia has committed to blend down 500 tonnes of HEU to LEU. By the end of 2003, it had blended down 200 tonnes. The remaining 300 tonnes remain in its military stock, probably in nuclear weapons, and not isolated from its primary military stock and committed to peaceful uses. As a result, this stock is assigned to the military stock. As HEU from this category is blended down to LEU, it is removed from this total.

Table 2 Major Holders of Civil HEU, by country (end 2003)

Country	Amount of HEU (in tonnes[a,b])	Enrichment Supplier	Involved in take-back program?[c]
Acknowledged Nuclear Weapon States			
United States	124[d]	USA	
Russia	15-30[e]	Russia	
Britain	1.5	UK, USA	
France	4.0-5.3	USA, France	
China	1	China, Russia	
Subtotal (rounded)	**145.5-161.8**		
Non-Nuclear Weapon States (NNWS)			
Africa			
Ghana	0.001	China	
Libya	0.025	Russia	Yes, to Russia
Nigeria	0.001	China	
South Africa	0.61-0.76	South Africa, USA	Yes, to USA
Asia/Australia			
Australia	0.35	USA, UK	Yes, to USA
DPRK	0.042	Russia	
India	0.005-0.01	UK	
Japan	2.0	USA, UK	Yes, to USA
Pakistan	0.017	USA, China	Yes, to USA
Philippines	0	USA	Yes, to USA
Rep. of Korea	0.002	USA	Yes, to USA
Taiwan	0.003-0.01	USA	Yes, to USA
Thailand	0	USA	Yes, to USA
Europe – Western			
Austria	0.005-0.02	USA	Yes, to USA
Belgium	0.7-0.75	USA	Yes, to USA

Denmark	0	USA	Yes, to USA
Germany	1.4-2.7	USA, Russia	Yes, to USA
Greece	0.003-0.016	USA	Yes, to USA
Italy	0.1-0.2	USA	Yes, to USA
Netherlands	0.73-0.81	USA	Yes, to USA
Norway	0.004	USA	
Portugal	0.007-0.008	USA	Yes, to USA
Spain	0	USA	Yes, to USA
Sweden	0.002	USA	Yes, to USA
Switzerland	0.005-0.01	USA	Yes, to USA
Europe – Eastern			
Belarus	0.25-0.37	Russia	Yes? (to Russia)
Bulgaria	0.006	Russia	Yes, to Russia
Czech Republic	0.08-0.14	Russia	Yes, to Russia
Georgia	0-0.001	Russia	Yes, to Russia
Hungary	0.15-0.25	Russia	Yes, to Russia
Kazakhstan	10.59-10.94[f]	Russia	Yes, to Russia
Latvia	0.02-0.025	Russia	Yes, to Russia
Poland	0.49	Russia	Yes, to Russia
Romania	0.033-0.044	Russia, USA	Yes, to Russia, USA
Serbia	0.013	Russia	Yes, to Russia
Slovenia	0-0.005	USA	Yes, to USA
Ukraine	0.16-0.25	Russia	Yes, to Russia
Uzbekistan	0.12	Russia	Yes, to Russia
Vietnam	0.0056	Russia	Yes, to Russia
Middle East			
Iran	0.007	USA, China	Yes, to USA
Israel	0.034	USA	Yes, to USA
Syria	0.001	China	
Turkey	0.008	USA	Yes, to USA
North America			
Canada	1.35	USA	Yes, to USA

Jamaica	0.001	USA	Yes, to USA
Mexico	0.012	USA	Yes, to USA
South America			
Argentina	0.02	USA	Yes, to USA
Brazil	0-0.001	USA, China	Yes, to USA
Chile	0.005	USA, France	Yes, to USA
Colombia	0	USA	Yes, to USA

Subtotal of all NNWS (rounded) 19.4-21.8

Total HEU (rounded) 165-184

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[a] The highly enriched uranium (HEU) inventories in South Africa and the acknowledged nuclear weapon states (United States, Russia, Britain, France, China) are the actual masses of the HEU. The inventories of the other countries are given in terms of the initial mass of the HEU, defined as the mass of HEU before it was inserted into a reactor and irradiated, a process which reduces the amount of contained uranium 235. This convention is adapted to permit comparisons and be consistent with other available estimates.

[b] When zero is used in this table, it is typically a rounded figure. HEU is used in gram quantities for standards, samples, fission chambers, exempt materials and waste. Those amounts are not tracked in this table and are not typically subject to return to the United States or Russia.

[c] The United States and Russia have instituted take-back programs to bring back for storage or blending down HEU that they provided to other countries for use in certain types of research and test reactors. The US program allows the return of only spent aluminum-based or triga HEU fuels. In the case of Russia, most fuel types are eligible.

[d] The value for the United States includes the remaining 123 tonnes of HEU declared excess to military purposes and scheduled for disposition, as well as 1 tonne of HEU that was returned from foreign research reactors since 1996.

[e] The estimate for Russia is highly uncertain.

[f] This value was provided to the IAEA by the government of Kazakhstan. It is unknown if this value represents an initial mass of HEU or one reflecting burn-up of the HEU fuel in the BN-350 fast reactor.

Table 3 Major Holders of Civil Highly Enriched Uranium (HEU), by country and origin, in tonnes

Country	HEU end of 2003[a,b]	HEU 2020 projection[c]
Acknowledged Nuclear Weapon States		
United States	124[d]	22[e]
Russia	15-30[f]	5-10
Britain	1.5[g]	0.2
France	4.0-5.3[h]	1-3[i]
China	1[j]	1.5[k]
Subtotal (rounded)	**145-162**	**30-37**
Non-Nuclear Weapon States (NNWS) that received US-origin HEU[l]		
Argentina	0.020[m]	
Australia	0.35[n]	
Austria	0.005-0.020[o]	
Belgium	0.70-0.75[p]	
Brazil	0-0.001[q]	
Canada	1.35[r]	1.0[s]
Chile	0.005[t]	
Colombia	0	
Denmark	0	
Germany	1.4-2.7[u]	1.5-2.0[v]
Greece	0.003-0.016[w]	
Iran	0.006	
Israel	0.034	
Italy	0.10-0.20	0.1[x]
Jamaica	0.001	
Japan	2.0[y]	1.3-1.8[z]
Rep. of Korea	0.002	
Mexico	0.012	
Netherlands	0.73-0.81[aa]	0.8[bb]
Norway	0.004	
Pakistan	0.016	
Philippines	0	
Portugal	0.007-0.008	
Romania	0.033-0.044[cc]	
Slovenia	0-0.005	
South Africa	0.61-0.76[dd]	0.2-0.5[ee]
Spain	0	
Sweden	0.002	
Switzerland	0.005-0.010	
Taiwan	0.003-0.010[ff]	
Thailand	0	
Turkey	0.008	
15 others	0-0.001[gg]	
Subtotal (rounded)	**7.4-9.3**	**4.9-6.2[hh]**

Non-Nuclear Weapon States (NNWS) that received Russian-origin HEU: Former Soviet States		
Belarus	0.25-0.37[ii]	
Georgia	0-0.001[ij]	
Kazakhstan (research and development activities)	0.09-0.14	
Latvia	0.020-0.025	
Ukraine	0.16-0.25	
Uzbekistan	0.12[kk]	
Subtotal (rounded)	**0.64-0.91**	**0.1[ll]**
Non-Nuclear Weapon States (NNWS) that received Russian-origin HEU: Other Countries with Russian-supplied research reactors		
Bulgaria	0.006	
China[mm]		
Czech Republic	0.08-0.14	
DPRK	0.042	
Germany[nn]		
Hungary	0.15-0.25	
Libya	0.025[oo]	
Poland	0.490	
Romania[pp]		
Serbia	0.013	
Vietnam	0.0056	
Subtotal (rounded)	**0.81-0.97**	**0.1[qq]**
Kazakhstan (Russian-origin HEU used in BN-350 breeder reactor)	10.5-10.8[rr]	10.5-10.8 [rr]
India	0.005-0.01[ss]	
Countries with Chinese-supplied research reactors		
Ghana	0.001	
Syria	0.001	
Iran	0.001	
Nigeria	0.001	
Pakistan	0.001	
Subtotal (rounded)	**0.005**	
Subtotal of all NNWS	**19.4-21.8**	**15.6-17.2**
Total HEU (rounded)	**165-184**	**46-54**

[a] The values in this table are derived from a variety of open sources, including official declarations, country- and facility-specific information, interviews with knowledgeable officials and experts, public documents, and public records of US and Russian HEU exports, retransfers, and returns. The highly enriched uranium (HEU) inventories in South Africa and the acknowledged nuclear weapon states (United States, Russia, Britain, France, China) are

estimates or declarations of the actual masses of the HEU. Except where specifically noted, the inventories of the other countries are given in terms of the initial mass of the HEU, defined as the mass of HEU before it was inserted into a reactor and irradiated, a process which reduces the amount of contained uranium 235. This convention is adapted to permit comparisons and be consistent with other available estimates.

[b] Zero signifies a country that originally had a stock of civil HEU dedicated to its civil reactor programs but has eliminated it. However, when zero is used in this table, it is typically a rounded figure. HEU is used in gram quantities for standards, samples, fission chambers, exempt materials and waste. Those amounts are not tracked in this table and are not typically eligible for return to the United States or Russia.

[c] The projection presented here assumes that reactors continue to convert from HEU to LEU fuels consistent with current plans, Russia institutes an effective, on-going program to convert its reactors to LEU and take back spent HEU fuel from overseas, and Russia and France reprocess foreign HEU spent fuel and down-blend it to LEU. The scenario also assumes that the United States will not expand its take-back policy to other types of fuel or materials, but otherwise takes back spent HEU as expected.

[d] The value for the United States includes the remaining 123 tonnes of HEU declared excess to military purposes as of the end of 2003 and scheduled for disposition, as well as 1 tonne of HEU that was returned from civil foreign research reactors since 1996.

[e] The total for the United States' projected 2020 inventory includes about one tonne (initial mass) of HEU projected to be returned to the United States between 2003 and 2020 under current plans. It also includes about 21 tonnes of excess US HEU in forms that are not suitable for down-blending and use. See ISIS report: *The Disposition of US and Russian Military Excess Highly Enriched Uranium (HEU)*, February 2005.

[f] The value for Russia is highly uncertain. This value includes about 5-10 tonnes of HEU that has been used in a wide variety of civil research and test reactors. It also includes about 10-15 tonnes of irradiated HEU from the BN-600 fast reactor. The initial enrichment of the BN-600 fuel was less than 30% uranium 235. Although Russia's policy is to reprocess BN-600 and research reactor spent fuel at the RT-1 reprocessing facility at the Mayak complex, these estimates assume that a backlog has developed. This backlog would have resulted from less than anticipated throughputs at the RT-1 plant, the development of inventories of spent fuel that are difficult to reprocess, and normal build-ups of BN-600 irradiated HEU inventories associated with the necessary cooling of the spent fuel prior to reprocessing.

[g] Britain makes an annual declaration of its civil HEU stocks to the IAEA. Britain's declared stock of civil HEU at the end of 2003 was 1.5 tonnes. (IAEA Information Circular, Communication received from the United Kingdom of Great Britain and Northern Ireland Concerning its Policies regarding the Management of Plutonium, *Statements on the Management of Plutonium and of Highly Enriched Uranium,* INFCIRC/549/Add.8/7, 13 September 2004). A small fraction of this HEU could be owned by other countries, including Belgium, Germany, and the Netherlands. However, foreign-owned HEU in Britain has largely been returned to the owner of the HEU, or to the US, in the case of Spain.

[h] France makes an annual declaration of its civil HEU stocks to the IAEA. France's declared stock of civil HEU at the end of 2003 was 6.4 tonnes. (IAEA Information Circular, Communication received from France Concerning its Policies regarding the Management of Plutonium, *Statements on the Management of Plutonium and of Highly Enriched Uranium,* INFCIRC/549/Add.5/8, 23 December 2004) This amount has been reduced by 1.1 to 2.4 tonnes, to account for foreign-owned HEU stored in France. Australia had an estimated 190 kg (initial mass) of HEU stored in France at the end of 2003 awaiting reprocessing at the La Hague plant. Similarly, Belgium had about 400-500 kilograms (initial mass) of HEU awaiting reprocessing. During reprocessing, which is expected to start in 2005, this HEU will be blended down to one percent enriched uranium. The Netherlands also had about 65 kg stored in France awaiting fabrication into fuel at the end of 2003. About 400 kg of HEU from Russia were stored in France for Germany's FRM-II reactor (one core, 8 kg, was shipped to Germany in the summer of 2003). In addition, Germany contracted with France to reprocess spent HEU from the closed KNK-II at its fast reactor reprocessing facility. The actual status of this HEU is unknown, although most of the recovered HEU would be expected to be blended down to slightly less than 20 percent enriched for use in research reactor fuel. Thus, it is estimated that France has 0-1.3 tonnes of HEU fuel from the KNK-II reactor. These inventories are reflected in the entry for the country of origin.

[i] France is expected to reprocess most of its own spent HEU reactor fuel and blend it down to LEU, leading to a net reduction of its HEU inventory. All or a major portion of the HEU in its large critical facility, Masurca, is assumed to be converted into LEU. France may continue to fabricate fresh HEU fuel for a few domestic reactors. Additionally, some of its spent HEU fuel may be judged as uneconomic to reprocess and disposed as irradiated fuel. Finally, France is not expected to send its eligible US-origin HEU to the United States.

[j] An unknown, but relatively small, amount of China's HEU is Russian-origin.

[k] China is expected to continue using HEU fuel in some of its existing research reactors, and it does not appear to have the means to reprocess HEU spent fuel. Consequently, its civil HEU inventory is expected to increase.

[l] Countries with zero values in this portion of table have returned their HEU to the United States or sold it to other HEU users. In total, about one tonne of HEU had been returned to the United States by the end of 2003. By the year 2020, however, not all of the US-origin HEU is expected to be returned to the United States or blended down overseas to LEU.

[m] About 8.8 kg of Argentina's HEU stock is at the RA-6 reactor with about 6.3 kg in core and 2.5 kg in storage. The remaining 13 kg of Argentina's HEU stock has been used as targets in the production of molybdenum 99.

[n] Australia sent 21 kg HEU in spent fuel to the Dounreay reprocessing plant in Britain in 1996. This HEU may have been reprocessed and returned to Australia, or it may have been blended down at Dounreay. It is ignored in this table. At the end of 2003, Australia had 190 kg of HEU in spent fuel stored at the La Hague reprocessing facility in France awaiting reprocessing. During reprocessing, it will be down blended to 1% uranium 235. Reprocessing is scheduled to start in 2005.

[o] Some of the HEU held in Austria may be owned by the IAEA.

[p] At the end of 2003, Belgium had 400-500 kg spent fuel stored at La Hague, France, awaiting reprocessing. During reprocessing, it will be down blended to 1% uranium 235. Reprocessing is scheduled to start in 2005.

[q]The value for Brazil remains uncertain. Brazil received about 200 kilograms of HEU (20.05%) from China in the 1980s. About 30-50 kilograms of this HEU was mixed with low enriched uranium and used in a small indigenous reactor. A couple of years ago, Brazil blended down the remainder of this Chinese supplied stock of HEU to slightly below 20%. Thus, it is classified as LEU, rather than HEU. The NRC records 9 kg of US-origin HEU exported to Brazil, while an Argonne National Laboratory study counts only 8 kg US-origin HEU in spent fuel. All spent fuel has been returned to the United States, but the additional kilogram of US-origin HEU recorded by the NRC may remain in Brazil.

[r] About 700 kilograms of this Canadian HEU was leftover from the production of molybdenum 99 and not subject to return to the United States under its fuel return policy.

[s] Canada's stock of HEU in irradiated molybdenum 99 targets is expected to be disposed in Canada. This HEU is imported from the United States, but it is an example of a form of HEU that is not eligible for return to the United States.

[t] Chile's inventory at the end of 2003 included about 5 kilograms of French-origin HEU (90%) and possibly some US-origin HEU.

[u] Germany makes an annual declaration of its civil HEU stocks to the IAEA. Germany's declared stock of civil HEU at the end of 2003 was 1.04 tonnes. (IAEA Information Circular, Communication received from the Federal Republic of Germany Concerning its Policies regarding the Management of Plutonium, *Statements on the Management of Plutonium and of Highly Enriched Uranium,* [official citation not yet available]) About 400 kg of HEU enriched to 90% arrived in France from Russia in 2001 for Germany's FRM-II reactor. One core (8 kg) was shipped to Germany in 2003. Germany also had about 0.73 tonnes of HEU in irradiated material in storage domestically at the end of 2003, including about 380 kg of HEU (post-irradiation mass or roughly 500 kg weapon-grade uranium in initial mass) in spent fuel from the THTR reactor and about 100-150 kilograms (initial mass) of

Russian-origin HEU. About 1.3 tonnes (initial mass) of HEU from the closed KNK-II reactor was sent to France for reprocessing. The fate and location of this HEU is unknown, but a fraction is believed to remain in France.

[v] Germany is expected to have an inventory of mainly irradiated HEU in 2020. About half will be US-origin HEU and the other half Russian-origin HEU purchased as fuel for the FRM-II reactor. Much of the US-origin HEU would be in forms that are not eligible for return to the United States. HEU recovered from KNK-II spent fuel, the bulk of which was initially enriched to less than 60 percent, would be expected to be blended down to LEU. The recovered KNK-II HEU that was originally weapon-grade, less than 100 kilograms, is likely to be used as HEU in German reactors or sold to a foreign reactor. As a result, no HEU from KNK-II is included in the 2020 estimate.

[w] The range in the Greek estimate results from uncertainty about whether some of the fuel known to have been returned to the United is HEU or LEU.

[x] Italy has about 100 kilograms of US-origin HEU in irradiated fuel, partially recovered HEU, or difficult to recover material that is not eligible for return to the United States and cannot be recovered by Italy. Most of this HEU was originally irradiated in the Elk River reactor in the United States and exported to Italy in the late 1960s for use in research.

[y] Japan's FCA critical facility has up to 500 kilograms of HEU provided by Britain.

[z] The Japanese Joyo reactor has about 1.3 tonnes (initial mass) in spent fuel, which will likely be disposed in Japan. HEU may also continue to be used in Japan's critical facilities.

[aa] The Netherlands had an estimated 65 kg of HEU in spent fuel stored in France at the end of 2003.

[bb] The Netherlands plans to store the vast bulk of its US-origin spent HEU fuel domestically.

[cc] Romania returned 14 kg of fresh HEU fuel to Russia in September 2003. Its holdings at the end of 2003 included 33-39 kg of US-origin TRIGA fuel. An estimated 0-5 kg of 36% enriched Russian-origin spent fuel may also have remained in Romania.

[dd] This estimate reflects losses of U-235 due to irradiation in the 20 megawatt-thermal Safari reactor. Although most of South Africa's stock is unirradiated, a portion has been irradiated in the Safari reactor both in fuel and in molybdenum 99 targets.

[ee] A projected estimate for South Africa's inventory in 2020 is necessarily a broad range. The broad range results mainly, because South Africa has not yet converted its Safari reactor to the use of LEU fuel, although it is expected to do so in a few years. If it converts this reactor, South Africa would be expected to blend down a large portion of its HEU to LEU for use in the new fuel. If it does not convert either the reactor fuel or molybdenum targets, then it is expected to develop a large inventory of HEU in spent fuel and irradiated molybdenum targets, approaching 0.5 tonnes (actual mass) by 2020. In addition, all but about 10 kilograms of HEU in South Africa was produced domestically and is ineligible for transfer to the United States.

[ff] The ZPRL reactor in Taiwan continues to operate with 93% enriched fuel.

[gg] About 15 other countries received a combined total of less than 1 kg US-origin HEU, including Bolivia, Czechoslovakia, India, Indonesia, Ireland, Malaysia, Uruguay, Venezuela, Vietnam and Zaire. In this category, one of the largest was Vietnam, but this quantity was removed by the United States at the end of the Vietnam war. Shipments to the IAEA are also included in this category.

[hh] The subtotal includes 100 kilograms of HEU expected to remain in several countries in 2020 and not listed explicitly by country in this subcategory of countries that received US-origin HEU. In total, about 4.9-6.2 tonnes (initial mass) of HEU are expected to remain in these countries in 2020 out of a 2003 stock of 7.4-9.3 tonnes. The difference is expected to be blended down outside the United States, stored domestically by various countries, or returned to the United States. Between 2003 and 2020, the amount estimated to be returned from these countries to the United States under current plans is about one tonne of HEU.

[ii] At the end of 2003, about 234 kg of Belarus' holdings was HEU enriched to 20% uranium 235. Its stock of HEU enriched more than 20% was estimated at 22-135 kg.

[jj] No HEU remained at Georgia's IRT reactor at the end of 2003. Georgia had an estimated one kilogram of HEU stored at Sukhumi, but it has been missing since that city was taken over by Abkhazian separatists in 1993. (*Footnote 1, p. 75 Monterey Nuclear Status Report, June 2001*)

[kk] Uzbekistan returned 2.5 kg fresh HEU enriched to 36% and 0.5 kg fresh HEU enriched to 90% to Russia in September 2004.

[ll] All the HEU in this subcategory is projected to be returned to Russia by 2020, except for a small amount of HEU that could remain in some of these countries, estimated at 100 kilograms of HEU in total.

[mm] See above entry for China.

[nn] See above entry for Germany.

[oo] Libya returned 17 kg of 80% enriched HEU to Russia in March 2004.

[pp] See above entry for Romania.

[qq] All the HEU in this subcategory is projected to be returned to Russia by 2020, except for a small amount of HEU that could remain in some of these countries, estimated at 100 kilograms of HEU in total.

[rr] This value was provided to the IAEA by the government of Kazakhstan. It is unknown if this value represents an initial mass of HEU or one reflecting burn-up of the HEU fuel in the BN-350 fast reactor. The HEU used in the BN-350 was typically enriched to less than 26%. The HEU is in the form of fresh and spent fuel. Current plans are for the spent fuel to be stored for many decades in Kazakhstan. The fresh HEU is scheduled to be blended down to LEU. This will reduce the projected inventory of HEU in 2020 but at press time the amount slated to be blended down was uncertain.

[ss] India received a small initial stock, estimated at about 6 kilograms, of HEU in fresh fuel elements from Britain for its 1 megawatt-thermal Apsara reactor that went critical in 1956. Reloads were provided by Britain up until India's nuclear test in 1974, which led Britain and other countries to halt nuclear assistance to India. Up to 1994, Britain reprocessed 83 irradiated fuel elements from the Apsara reactor containing 14 kg of HEU. India has a small uranium enrichment plant that may have been able to provide HEU for this reactor. In total, India is estimated to have a stock of 5-10 kg of HEU for the Apsara reactor. In addition, prior to 1974 Britain and/or France were planning to provide HEU for India's test breeder reactor. The designs and many key items for the test breeder were obtained from France, but India's 1974 test appears to have put an end to the plan to export HEU.