Project on Managing the Atom

The Three Overlapping Streams of India's Nuclear Programs

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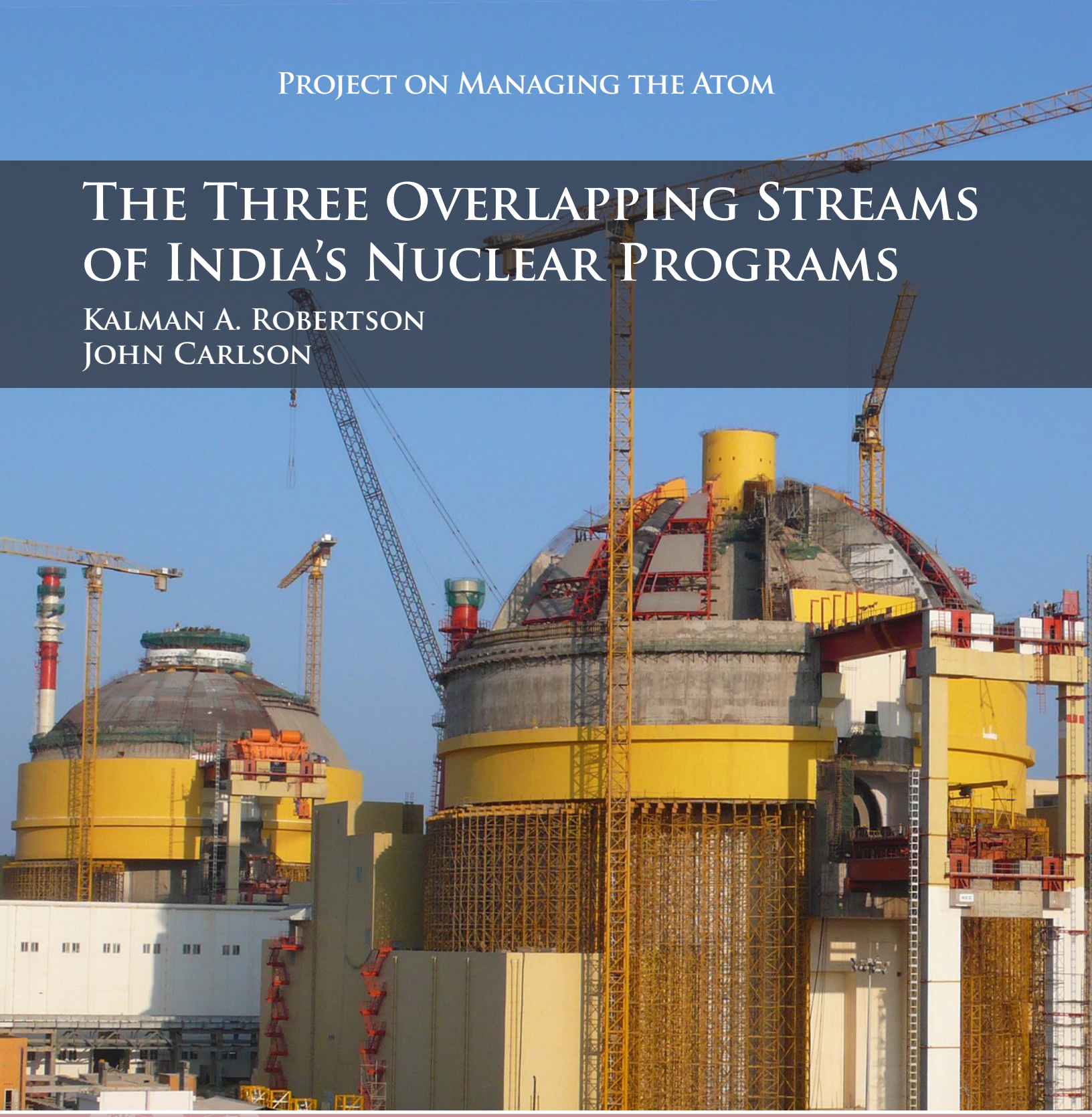

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Cover photo: Nuclear power plants (pressurized water reactors) under construction at Kudankulm, India. Credit: Petr Pavlicek/IAEA

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Introduction

In 2006, Indian Prime Minister Manmohan Singh announced a Separation Plan for India's civilian and military nuclear programs.[1] It is often assumed that the Plan clearly and verifiably separates India's nuclear facilities into two categories, civilian and military. The reality is that the Plan has produced three streams: "civilian safeguarded", "civilian unsafeguarded", and "military." The tables in the annex to this paper contain lists of facilities in each stream. The relationships and overlap between the three streams are not transparent. Some civilian facilities, even when operating under certain provisions of India's safeguards agreement with the International Atomic Energy Agency (IAEA), may contribute to India's stockpile of unsafeguarded weapons-usable nuclear material. Much of this complexity arises from the unique character of India's safeguards agreement with the IAEA and the additional protocol to this agreement.

The overlap between civilian and military nuclear activities is likely to intensify as India scales up its nuclear power program and its enrichment and reprocessing industries. As India's nuclear sector expands, it will be up to India to decide whether or not to place new facilities under continuous safeguards.[2] Currently, the 500MW Prototype Fast Breeder Reactor, scheduled to achieve criticality in April 2016,[3] and which India has not placed under safeguards, is poised to introduce a new pathway for the production of both electricity and unsafeguarded plutonium.

The incompleteness of the separation of India's civilian and military programs should be taken into consideration by nuclear suppliers when determining conditions for nuclear cooperation. This paper explains the existing overlap between India's military and civilian programs and how this could become problematic for nuclear suppliers seeking to ensure

1 IAEA, "Communication dated 25 July 2008 received from the Permanent Mission of India concerning a document entitled 'Implementation of the India-United States Joint Statement of July 18, 2005: India's Separation Plan'," INFCIRC/731, July 2008, https://www.iaea.org/sites/default/files/publications/documents/infcircs/2008/infcirc731.pdf (accessed April 12, 2016).

2 This discretion applies to indigenous facilities. Presumably, any state that supplies a nuclear facility to India in the future will require that India place it under safeguards. See IAEA, "India's Separation Plan," paragraphs 6 and 14. See also paragraph 14 of India's safeguards agreement: IAEA, "Agreement between the Government of India and the International Atomic Energy Agency for the Application of Safeguards to Civilian Nuclear Facilities," INFCIRC/754, February 2009.

3 "India Plans to Construct Six More Breeder Reactors," *Economic Times* (December 1, 2015), http://economictimes.indiatimes.com/industry/energy/power/india-plans-to-construct-six-more-fast-breeder-reactors/articleshow/49999373.cms (accessed April 12, 2016); "Fast Breeder Reactor Awaits AERB Clearance for Sodium Loading," *Business Standard* (March 26, 2016), http://www.business-standard.com/article/news-ians/fast-breeder-reactor-awaits-aerb-clearance-for-sodium-loading-116032600534_1.html (accessed April 12, 2016). See also, IAEA, "India's Separation Plan." IAEA, "India's Separation Plan," paragraph 14(ii).

that they are not contributing to an arms race in South Asia. The paper then proposes a pathway by which India could achieve a fuller separation of its civilian and military activities. Firstly, India should renounce options, currently available under the IAEA safeguards agreement, that facilitate the use of safeguarded items to produce unsafeguarded nuclear material. Secondly, India should place the proliferation-sensitive components of its nuclear power industry under continuous safeguards.

The U.S.-India Nuclear Cooperation Agreement and India's Separation Plan

Manmohan Singh and U.S. President George W. Bush made a joint statement on July 18, 2005 declaring their intentions to cooperate on civil nuclear energy.[4] As part of the statement, the Prime Minister conveyed that India would separate its "civilian and military nuclear facilities and programs in a phased manner", implying that India would only have two categories of facilities: civilian facilities under IAEA safeguards and military facilities outside of safeguards.

The 2005 joint statement was significant in part because the Nuclear Suppliers Group (NSG) Guidelines indicated that suppliers should only transfer nuclear materials and technologies to non-nuclear-weapon states that have comprehensive safeguards agreements.[5] India is not a party to the *Treaty on the Non-Proliferation of Nuclear Weapons* (NPT) and it is not a "nuclear-weapon state" for the purposes of the treaty.[6] India is not under a legal obligation to accept a comprehensive safeguards agreement with the IAEA over all of its nuclear materials and facilities. Instead, India has a more limited form of IAEA safeguards, which cover some of its nuclear activities.[7] In order to ensure that nuclear supply to India would be permissible under the Guidelines, it was necessary to grant an exception (referred to as the "clean waiver") for India.

4 "Joint Statement between President George W Bush and Prime Minister Manmohan Singh," White House Press Release, July 18, 2005, http://2001-2009.state.gov/p/sca/rls/pr/2005/49763.htm (accessed April 12, 2016).

5 The text of the guidelines is contained in IAEA information circular INFCIRC/254 (as amended).

6 See Kalman A Robertson, "The Legality of the Supply of Australian Uranium to India," Security Challenges, Vol 8(1) (Autumn 2012) 8(1), pp. 25–34.

7 IAEA, "Agreement between the Government of India and the IAEA."

As part of the implementation of the India-U.S. Joint Statement, India announced its Separation Plan for its nuclear facilities in 2006. The NSG granted the clean waiver for India in September 2008 citing, among other commitments, India's decision "to separate civilian nuclear facilities in a phased manner and to file a declaration regarding its civilian nuclear facilities with the IAEA, in accordance with its Separation Plan".[8]

India's Separation Plan did not produce the implied two categories of facilities. The Separation Plan only provides for some of India's nuclear power reactors, associated fuel fabrication, and spent fuel storage to be placed under continuous safeguards. The Separation Plan did not extend safeguards to a number of the nuclear facilities that serve civilian functions, and consequently these facilities may also be used in India's military program.

IAEA Safeguards in India

Traditionally, safeguards in India have primarily applied to nuclear facilities and materials supplied to India by other states on condition that they remain subject to safeguards. If India imports nuclear materials subject to safeguards, the IAEA accounts for these materials as they progress through India's nuclear fuel cycle and verifies that they are not being diverted to nuclear weapons. As part of the U.S.-India nuclear cooperation agreement,[9] India concluded a new safeguards agreement with the IAEA in 2009 that includes a list of facilities that are subject to continuous (permanent) safeguards.[10] The list includes some indigenous facilities.

As a general rule, the agreement requires the application of safeguards to nuclear material, including subsequent generations of material, produced, processed or used in a listed facility or by the use of safeguarded material (article 11(c)). However, there are some exceptions to this rule (see pages 7–9 of this paper) that introduce the potential for

8 "Communication dated 10 September 2008 received from the Permanent Mission of Germany to the Agency regarding a 'Statement on Civil Nuclear Cooperation with India,'" INFCIRC/734/Corrected, September 19, 2008, Paragraph 2(a), https://www.iaea.org/sites/default/files/publications/documents/infcircs/2008/infcirc734c.pdf (accessed April 12, 2016). See also, See also, Sharon Squassoni, "India's Nuclear Separation Plan: Issues and Views" (Washington, D.C.: Congressional Research Service Report for Congress, December 22, 2006), http://fas.org:8080/sgp/crs/nuke/RL33292.pdf (accessed April 12, 2016).

9 *Agreement for Cooperation between the Government of the United States of America and the Government of India Concerning the Peaceful Uses of Nuclear Energy*, TIAS 08-1206, October 10, 2008, available at http://www.state.gov/documents/organization/122068.pdf (accessed April 12, 2016).

10 The most up-to-date version of the list is available in IAEA doc INFCIRC/754/Add.7 (February 5, 2015).

safeguarded nuclear activities to contribute to India's military program. The safeguards agreement also allows India to store, use, or process nuclear material subject to safeguards at a facility that is not under continuous safeguards, provided that India opens the facility to safeguards temporarily while the safeguarded material is present (article 11(f)). In addition, the agreement contains provisions for the substitution of unsafeguarded material for safeguarded material (articles 27, 30(d)). As explained below, these provisions introduce the potential for safeguarded nuclear activities to contribute to India's nuclear weapons program.

For states with comprehensive safeguards agreements, the additional protocol creates additional reporting obligations and extends the IAEA's right of access to nuclear-related sites.[11] However, India negotiated with the IAEA a much more limited additional protocol: the reporting and access provisions of India's additional protocol are effectively restricted to India's export activities.[12] Consequently, India's safeguards agreement and its additional protocol do not have any practical application to its uranium and thorium mines, heavy water production facilities, nuclear fuel cycle-related research activities, or plants where it manufactures equipment for its nuclear facilities.

The Civilian Safeguarded Stream

India operates 22 nuclear facilities under continuous IAEA safeguards (the "civilian safeguarded" stream). This includes 14 of India's power reactors, six conversion and fuel fabrication facilities for these reactors, and two spent fuel storage sites. The U.S.-India agreement foreshadows the construction of new reprocessing plants for U.S.-obligated nuclear material; if built, India has agreed to place these under continuous IAEA

11 See IAEA, "Model Protocol Additional to the Agreements between State(s) and the International Atomic Energy Agency for the Application of Nuclear Safeguards," INFCIRC/540(Corrected), September 1, 1997.

12 See India's additional protocol: IAEA, "Protocol Additional to the Agreement between the Government of India and the International Atomic Energy Agency for the Application of Safeguards to Civilian Nuclear Facilities," INFCIRC/754/Add.6, signed May 15, 2009, (entered into force July 25, 2014).

safeguards as well.[13]

The Civilian Unsafeguarded Stream

India operates a number of facilities, including eight of its pressurized heavy water power reactors (PHWRs), that serve a civilian or commercial function and that are not listed in India's safeguards agreement (the "civilian unsafeguarded" stream). These facilities are not subject to safeguards (except in specific circumstances, explained below, where India may introduce safeguarded nuclear material into them). This category includes three heavy water production plants that India expressly designated for civilian use as part of the Separation Plan but that are not subject to safeguards because they are not listed in India's safeguards agreement and India's additional protocol does not extend to them.

Arguably, India's fast breeder reactor (FBR) and thorium fuel cycle programs fall into the category of civilian unsafeguarded (as opposed to military), although both are capable of producing unsafeguarded weapons-usable material. In March 2006, Singh stated that FBRs would be excluded from safeguards during the development stage in order to avoid "encumbrances" on the program.[14] India has maintained the option of using its FBRs to produce plutonium for nuclear weapons.

In deciding whether or not to place a facility under safeguards, India's Separation Plan points to "a judgment [by India] whether subjecting a facility to IAEA safeguards would impact adversely on India's national security."[15] A facility could be excluded from safeguards simply because it is co-located with military facilities or otherwise related to activities of strategic significance. This appears to be the basis for excluding all of India's existing reprocessing and enrichment facilities from being listed for continuous safeguards.

13 Arrangements and Procedures Agreed between the Government of the United States and the Government of India, Pursuant to Article 6(iii) of Their Agreement for Cooperation Concerning Peaceful Uses of Nuclear Energy, March 29, 2010, Article 1(3), http://www.state.gov/p/sca/rls/139194.htm (accessed April 12, 2016). See also, Paul K Kerr, "U.S. Nuclear Cooperation with India: Issues for Congress" (Washington, D.C.: Congressional Research Service, June 26, 2012), pp. 5, 11, and 41, https://www.fas.org/sgp/crs/nuke/RL33016.pdf (accessed April 12, 2016).

14 See *suo motu* statement in India's Parliament, excerpted in "Energy Is the Lifeblood of Our Economy, Says PM," India Review, Vol. 2(3), March 2006, pp. 6–7.

15 IAEA, "India's Separation Plan," paragraph 13.

India also has five plus or minus three tons of unsafeguarded separated plutonium (and considerably more unsafeguarded spent fuel) from power reactors, which is available to its nuclear weapons program and could hypothetically be used to significantly increase the size of India's nuclear arsenal.[16] India may be deliberately holding some of this material to enhance its nuclear deterrent.

India has indicated that it is willing to engage in a degree of transparency with respect to some of its facilities in the "civilian unsafeguarded" stream. As part of its Separation Plan, India declared nine nuclear-related research centers as civilian. Although these centers have not been placed under safeguards, the Separation Plan indicates "that they will play a prominent role in international cooperation."[17] Furthermore, the IAEA concluded an Integrated Regulatory Review Service (IRRS) review of India's regulatory framework for safety of nuclear power plants in March 2015.[18] This review evidently extended to all of the power reactors under the authority of India's Atomic Energy Regulatory Board, including the eight operating nuclear power reactors that are not under safeguards and six reactors under construction that have not yet been designated for safeguards.[19]

The Military Stream

India has military nuclear facilities, which are primarily designed to produce fissile material for nuclear weapons and naval propulsion. India is currently expanding its fissile material production capability.

India's enrichment plants are probably best characterized as military facilities, although they may also have civilian applications (e.g., producing low enriched uranium (LEU) fuel for use in the Apsara research reactor, once its conversion from high enriched uranium (HEU) to LEU is complete). If India proceeds with construction of the Special Material Enrichment Facility (SMEF), it may eventually scale it up to the point where it can produce LEU fuel for

16 See International Panel on Fissile Materials, "Global Fissile Material Report 2015" (Princeton, N.J.: IPFM, December 2015), p. 32, http://fissilematerials.org/library/gfmr15.pdf (accessed April 12, 2016); David Albright and Serena Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium, End 2014" (Washington, D.C.: Institute for Science and International Security, November 2015), pp. 2, 10, and 11, http://isis-online.org/uploads/isis-reports/documents/India_Fissile_Material_Stock_November2_2015-Final.pdf (accessed April 12, 2016).

17 IAEA, "India's Separation Plan," paragraph 14(vii).

18 "IAEA Mission Concludes Peer Review of India's Nuclear Regulatory Framework," IAEA Press Release, March 27, 2015, https://www.iaea.org/newscenter/pressreleases/iaea-mission-concludes-peer-review-indias-nuclear-regulatory-framework (accessed April 12, 2016). IRRS missions are carried out at the invitation of the state.

19 Atomic Energy Regulatory Board, *Annual Report for the Year 2014–2015*, Chapter 10: International Co-operation (Mumbai: India AERB, 2015) http://www.aerb.gov.in/AERBPortal/pages/English/t/annrpt/2014/chapter10.pdf (accessed April 12, 2016).

its power reactors.[20]

The Overlap Between Civilian and Military

In general, there is no formal verification whether facilities in the "civilian unsafeguarded" stream are contributing nuclear material to India's nuclear weapons program. Indeed, many of India's PHWRs have reportedly been used as sources of weapons-grade plutonium for its military program, both through recovery from low burnup first irradiated fuel discharges and through at least one dedicated campaign in the late 1990s.[21] Pakistan has reason to be concerned that India could use its unsafeguarded PHWRs to produce more nuclear weapons in the future. Furthermore, most of India's current stockpile of reactor-grade plutonium from power reactors is not subject to safeguards and may be made available to India's nuclear weapons program. There is significant potential for India's "civilian unsafeguarded" stream to feed into the "military" stream.

India's "civilian safeguarded" stream also overlaps with its "civilian unsafeguarded" stream. India's safeguards agreement permits the transfer of nuclear material subject to safeguards into a facility in the "civilian unsafeguarded" stream, provided that the facility is placed under temporary safeguards while that material is present (articles 11(f) and 14(b)). Consequently, facilities in the "civilian unsafeguarded" stream have periodically fallen under safeguards. For example, the Tarapur Power Reactor Fuel Reprocessing (PREFRE) plant has been placed under safeguards periodically for campaigns involving the reprocessing of spent fuel subject to safeguards, thereby producing the 0.4 tons of safeguarded separated plutonium in India's inventory.[22]

India's Separation Plan indicates that it is willing to once again accept safeguards periodically in the "campaign" mode (i.e., temporary safeguards) at PREFRE.[23] As India

20 David Albright and Serena Kelleher-Vergantini, "India's New Uranium Enrichment Plant in Karnataka," Institute for Science and International Security Imagery Brief, July 1, 2014, http://isis-online.org/uploads/isis-reports/documents/SMEF_Brief_July_1_2014_FINAL.pdf (accessed April 12, 2016). See also, David Albright and Susan Basu, "Separating Indian Military and Civilian Nuclear Facilities" (Washington, D.C.: Institute for Science and International Security, December 19, 2005), http://isis-online.org/uploads/isis-reports/documents/indiannuclearfacilities.pdf (accessed April 12, 2016).

21 Some of the reactors that were used in this way were later placed under continuous safeguards. See Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium," pp. 13–14.

22 See IPFM, "Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing Around the World" (Princeton, N.J.: IPFM, September 2015), http://fissilematerials.org/library/rr14.pdf (accessed April 12, 2016), pp. 54 and 57.

23 IAEA, "India's Separation Plan," paragraph, 14(vi).

reprocesses spent fuel from its safeguarded power reactors, the quantity of separated plutonium under safeguards will rise. It is therefore increasingly important to consider whether or not this safeguarded plutonium could contribute to India's nuclear weapons program.

The provision for temporary safeguards over otherwise unsafeguarded facilities is most likely to become problematic if India uses it in combination with provisions that allow safeguarded material to be used alongside unsafeguarded material (e.g., articles 25 and 96 of India's safeguards agreement). Article 25 allows nuclear material (including spent fuel containing weapons-grade plutonium) that "has been produced in or by the use of safeguarded nuclear material" to be removed (exempted) from safeguards under particular conditions. Specifically, article 25 exempts a proportion of the plutonium produced in a reactor provided that less than 30% of the fissionable material in each loading is safeguarded material.

Alexander Glaser and M V Ramana have produced figures for the annual loading and discharge of India's Prototype Fast Breeder Reactor.[24] Applying the provisions of India's safeguards agreement to these figures, it becomes clear that safeguarded nuclear material could contribute significantly to the production of unsafeguarded plutonium.

Annual Loading (kg)		Annual Discharge (kg)	
Pu—core (reactor-grade)	1012	Pu—core (reactor-grade)	903
U—core	3082	Pu—blankets (weapons-grade)	144
U—radial and axial blankets	5078		
Fissionable material total	9172		

Nuclear material flow figures for India's Prototype Fast Breeder Reactor (PFBR)[25]

India's safeguards agreement would allow India to load safeguarded plutonium into the core of the PFBR alongside unsafeguarded uranium in the core and blankets. Calculating on the basis of Glaser and Ramana's figures, a core consisting of entirely safeguarded plutonium would constitute 11% of the total fissionable material in the reactor. While the reactor is operating, it must be under temporary safeguards and would therefore be subject to IAEA inspections. However, once irradiation in the reactor is complete and the spent fuel is unloaded, only 11% of the produced plutonium (corresponding to the 11% of the total fissionable material initially under safeguards) must remain under safeguards. India may claim an exemption from safeguards for the other 89% of the plutonium (i.e., all of the weapons-grade plutonium in the blankets and part of the reactor-grade plutonium in the

24 Alexander Glaser and M V Ramana, "Weapon-Grade Plutonium Production Potential in the Indian Prototype Fast Breeder Reactor," *Science & Global Security,* Vol. 15(2), 2007, pp. 85–105.

25 Glaser and Ramana, "Weapon-Grade Plutonium Production Potential in the Indian Prototype Fast Breeder Reactor."

core). The use of this proportion of the plutonium would no longer be subject to any form of verification. In effect, this provision of India's safeguards agreement permits India to use its safeguarded plutonium to produce many significant quantities of unsafeguarded plutonium per year.

In the safeguards agreement, India undertakes not to use items subject to the agreement, including any facility under temporary safeguards while safeguarded material is present, to further any military purpose (article 1). However, due to the absence of any verification, the international community has no assurance that India is not building nuclear weapons with plutonium that has been exempted from safeguards in the manner described above. In this respect, the Canadian-supplied Cirus reactor provides an example of how nuclear material can be diverted to nuclear weapons when safeguards are not applied. Prior to shutting down the Cirus reactor in 2010, India used it to produce unsafeguarded plutonium for nuclear weapons, despite being under an obligation not to use the reactor or any products resulting from its use for military purposes.[26] This example illustrates that a simple undertaking not to use plutonium for military purposes is not adequate to prevent such misuse in absence of verification.

A similar situation could arise if India chose to load the core of the PFBR with unsafeguarded uranium and plutonium, while making the blankets out of a mixture of safeguarded and unsafeguarded uranium (as long as the safeguarded uranium makes up less than 30% of the total fissionable material at loading). After unloading the spent fuel, India could claim an exemption from safeguards for up to 70% of the plutonium in this fuel. To make up this 70%, the agreement appears to allow India to claim exemption for all of the weapons-grade plutonium in the blankets and part of the reactor-grade plutonium in the core. If India's nuclear weapons program ever faces a temporary shortage of unsafeguarded uranium from indigenous sources, it may be able to use this method to continue generating unsafeguarded weapons-grade plutonium.

India's safeguards agreement also provides for the substitution of unsafeguarded nuclear material for safeguarded material with the IAEA's consent (article 30(d)). For uranium, the IAEA takes into consideration isotopic quality, so safeguarded HEU cannot be removed from safeguards by replacing it with LEU. However, for plutonium, it is not clear whether the IAEA takes into consideration the isotopic composition. In other words, it may be possible for India to remove weapons-grade plutonium from safeguards and use it in nuclear weapons, provided that it places an equivalent amount of reactor-grade plutonium

26 On the peaceful-use obligation, see Agreement on the Canada-India Colombo Plan Atomic Reactor Project, April 28, 1956, Article III. On the shutdown of the reactor, see IAEA, "India's Separation Plan," paragraph 14(iv).

under safeguards. In principle, this could also allow India's safeguarded program to contribute to nuclear weapons.

Achieving a Fuller Separation of Civilian and Military Activities

There are a number of steps that India could take to assure the international community that its civilian nuclear program is effectively separated from its military program. In particular, it could declare that it does not intend to use the substitution and exemption provisions in its safeguards agreement to acquire unsafeguarded sensitive nuclear material.

India's stated reason for not placing certain facilities, including some power reactors, under continuous safeguards is that they are connected with its strategic program. As illustrated above, the use of safeguarded nuclear material in these reactors raises the possibility of contributing to the strategic program.[27] Nuclear suppliers should call on India to renounce the provisions in its safeguards agreement that permit safeguarded material to be used in reactors that are not subject to continuous safeguards. Limiting safeguarded material to reactors under continuous safeguards would remove the potential for that material to end up supporting India's nuclear weapons program.

The majority of India's nuclear power is produced by PHWRs. India should place its remaining eight operational PHWRs under safeguards and undertake to do the same with its future PHWRs. This would help to alleviate concerns that the centerpiece of India's nuclear power program may continue to be used to produce plutonium for nuclear

27 Article 96 of India's safeguards agreement also permits India to process a blend of safeguarded and unsafeguarded nuclear material in conversion, enrichment, fuel fabrication, and reprocessing facilities. Once processing in a facility is complete, a proportion of the resulting nuclear material (determined by a pro-rating formula) may be removed from safeguards. In general, it is difficult to see how blending in facilities (other than reactors) could result in a net increase in unsafeguarded nuclear material but it is also difficult to foresee all situations that could arise. To completely exclude the possibility of safeguarded material enhancing the production of unsafeguarded material, India could undertake not to use safeguarded and unsafeguarded materials together in any type of facility.

weapons. This would also provide an assurance to nuclear suppliers that, if they transfer information to India to assist with the operation of its safeguarded PHWRs, then Indian personnel will not apply this information to similar unsafeguarded reactors. The international community has a legitimate expectation that nuclear power stations are civilian in nature and will be subject to safeguards.

The IAEA is obligated to apply safeguards to every facility that India places under its safeguards agreement.[28] Placing the remaining eight PHWRs under safeguards would create a small but significant burden on IAEA resources. The IAEA may be able to offset this burden through greater use of efficiency measures at PHWRs with India's consent, including short-notice random inspections or containment and surveillance with remote monitoring.[29] By comparison, if India builds the new safeguarded reprocessing plants proposed under the U.S.-India agreement, they would almost certainly represent a larger burden on IAEA resources than eight PHWRs.[30]

The PHWRs that are under safeguards represent a growing source of safeguarded spent fuel. India should be open to discussing with suppliers its options for reprocessing, long-term storage, and/or repatriation of this spent fuel. Where safeguarded spent fuel is to be reprocessed, India should clarify in advance which reactors will be using the resulting fuel and how safeguards will apply to them.

India should revisit the question of applying safeguards to FBRs in the lead up to bringing the Prototype Fast Breeder Reactor on line. FBRs both use and produce large quantities of plutonium and they will be a major proliferation concern. If India is unwilling to place FBRs under continuous safeguards, then suppliers should require that India not introduce safeguarded material into them at all.

Finally, if India's Special Material Enrichment Facility (SMEF) is to become a source of LEU for its light water power reactors, it will need to be considerably larger than India's existing enrichment plant, the Rare Materials Plant (RMP), which is estimated to have a

28 See Article 2 of India's safeguards agreement. By contrast, the IAEA selects for inspection only a small number of the facilities designated by each of the five nuclear-weapon states recognized by the NPT under their safeguards agreements (referred to as "voluntary offer agreements") with the IAEA, see John Carlson, "Expanding Safeguards in Nuclear-Weapon States" (NTI Paper expanding on a presentation to the Annual Meeting of the Institute of Nuclear Materials Management, Palm Desert, July 2011), http://www.nti.org/analysis/articles/expanding-safeguards-nuclear-weapon-states/ (accessed April 12, 2016).

29 The use of short-notice random inspections would be assisted by article 5 of India's additional protocol, which entitles inspectors to multiple entry visas.

30 Based on experience at the Rokkasho reprocessing plant, safeguarding an operating commercial-scale reprocessing plant is expected to cost more than $2 million per year and require an annual inspection effort of approximately 1000 person-days of inspection. See Shirley Johnson, "The Safeguards at Reprocessing Plants under a Fissile Material (Cutoff) Treaty" (Princeton, N.J.: IPFM, Research Report No. 6, February 2009), http://fissilematerials.org/library/rr06.pdf (accessed April 12, 2016), p. 12.

capacity of 15–25 ton-SWU/year.[31] Such a buildup in unsafeguarded enrichment capacity is likely to produce significant concerns because of its potential to produce large quantities of enriched uranium for thermonuclear weapons. India should clarify whether it intends to pursue a capability to produce LEU fuel and, if so, undertake to place the SMEF under continuous safeguards.

Unlike the five recognized nuclear-weapon states, India is still producing fissile material for nuclear weapons.[32] However, India has committed its support for the negotiation of a fissile material cutoff treaty and this commitment formed part of the basis for the NSG's clean waiver.[33] By placing all of its power reactors and associated facilities under continuous IAEA safeguards, India could demonstrate significant progress toward establishing the conditions for successful negotiation of a fissile material cutoff treaty.

Conclusion

India's civilian nuclear power program is undergoing a significant expansion, thanks in part to a series of nuclear cooperation agreements concluded with other states over the last eight years. This expansion is creating new pathways to the acquisition of fissile material, and it is happening at a time when India is still producing fissile material for nuclear weapons. Safeguards should be used to provide a meaningful assurance to all states, including Pakistan, that elements of India's civilian nuclear buildup, particularly those that are being supported by international nuclear suppliers, are not contributing fissile material to India's growing nuclear arsenal. India should take the opportunity to more fully and verifiably separate its civilian and military programs by placing proliferation-sensitive components of its nuclear power industry under permanent IAEA safeguards.

31 See Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium," p. 20.

32 See IPFM, "Global Fissile Material Report 2015," p. 3.

33 See IAEA, "Statement on Civil Nuclear Cooperation with India," paragraph 2(g).

Annex: India's Civilian Safeguarded, Civilian Unsafeguarded, and Military Facilities

The following tables outline the facilities in each of the three streams of India's nuclear program, "civilian safeguarded", "civilian unsafeguarded", and "military", as of 2015. Except where otherwise indicated by footnotes, these tables are based on data in:

- IAEA Power Reactor Information System
- IAEA Research Reactor Database
- IAEA Integrated Nuclear Fuel Cycle Information System
- List of Facilities Subject to Safeguards Under [India's Safeguards] Agreement: INFCIRC/754/Add.7 (February 5, 2015)
- Separation Plan: INFCIRC/731 (July 25, 2008)

These tables do not include decommissioned facilities.

Table 1: Civilian Nuclear Facilities Under Continuous Safeguards

Type	Facility, Location	Purpose, Design Capacity
Thorium and uranium mines and mills	None—India's additional protocol does not apply to mines and mills	
Enrichment	None—India has not placed any enrichment facilities under safeguards	
Uranium conversion and fuel fabrication—natural uranium for PHWRs	Nuclear Fuel Complex, Hyderabad: Uranium Oxide Plant (Block A)	Conversion to UO_2 (450t/yr)
	Nuclear Fuel Complex, Hyderabad: Ceramic Fuel Fabrication Plant (Pelletizing)(Block A)	Fuel fabrication (335t/yr)
	Nuclear Fuel Complex, Hyderabad: Ceramic Fuel Fabrication Plant (Assembly)(Block A)	Fuel fabrication (300t/yr)
	Nuclear Fuel Complex, Hyderabad: Gadolinia Facility	Zirconium alloy tubing and production
Uranium fuel fabrication—enriched uranium for light water power reactors	Nuclear Fuel Complex, Hyderabad: Enriched Uranium Oxide Plant and Enriched Fuel Fabrication Plant	Fuel fabrication using imported LEU (24t/yr)
Heavy water production	None – India's additional protocol does not apply to its heavy water production	
Power reactors—PHWRs	Rajasthan Atomic Power Station (RAPS1-6), Kota	PHWR, 90MW, 187MW, 202MWx4
	Kakrapar Atomic Power Station (KAPS1-2), Surat	PHWR, 202MWx2
	Narora Atomic Power Station (NAPS1-2), Narora	PHWR, 202MWx2
Power reactors—LWRs	Tarapur Atomic Power Station (TAPS1-2), Boisar	BWR, 150MWx2 (spent fuel to Tarapur storage)
	Kudankulam Nuclear Power Plant (KK1-2), Kudankulam	VVER-PWR, 917MWx2[A]

[A] According to media reports in June 2014, Russia has confirmed that India may reprocess the spent fuel from these reactors at PREFRE, rather than requiring return to Russia. See Vanita Srivastava, "India Has Right to Reprocess Spent Nuclear Fuel, Says Russia" *New Indian Express* (June 9, 2014), http://www.hindustantimes.com/india/india-has-right-to-reprocess-spent-n-fuel-russia/ (accessed April 12, 2016).

Research reactors	None—India has not placed any research reactors under safeguards	
Fuel storage	Tarapur—Away from Reactor (AFR) Wet Spent Fuel Storage, Boisar	275t spent fuel
	Tarapur—NPP site, Dry Spent Fuel Storage, Boisar	20t spent fuel
	Other safeguarded spent fuel from PHWRs in storage	About 1500t spent fuel[B]
Reprocessing and separated plutonium	Option to construct safeguarded reprocessing plants for PHWR fuel under U.S.-India Nuclear Cooperation Agreement	
	Approximately 0.4t of separated plutonium currently under safeguards, having been reprocessed at PREFRE-1, while the facility was under temporary safeguards[C]	
Other research centres	None—India's additional protocol does not apply to sites where India conducts nuclear fuel cycle-related research and development	

[B] See IPFM, "Plutonium Separation in Nuclear Power Programs," p. 57.

[C] See IPFM, "Plutonium Separation in Nuclear Power Programs," p. 54.

Table 2: Facilities that Are Used Primarily for Civilian Purposes and that Are Not Subject to Continuous Safeguards

Type	Facility, Location	Purpose, Design Capacity
Thorium and uranium mines and mills	See Table 3 on military facilities below—in addition to being a source of nuclear material for India's military program, domestic mines are an important source for several reactors	
Enrichment	See Table 3 on military facilities—RMP has both military and civilian applications	
Uranium conversion and fuel fabrication	Some facilities in Nuclear Fuel Complex, Hyderabad	For unsafeguarded PHWRs
	Plan for second Nuclear Fuel Complex, Kota	
	Trombay Fuel Fabrication	Small-scale production for Fast Breeder Test Reactor
Heavy water production—declared civilian as part of Separation Plan	Hazira	80t/yr
	Thal-Vaishet	78t/yr
	Tuticorin	49t/yr
Power reactors—PHWRs[D]	Tarapur Atomic Power Station (TAPS 3-4), Boisar	PHWR, 490MWx2
	Madras Atomic Power Station (MAPS 1-2), Madras	PHWR, 202MWx2
	Kaiga (KGS 1-4), Kaiga	PHWR, 202MWx4
Power reactors—FBRs	Prototype Fast Breeder Reactor, Kalpakkam	FBR, 500MW (scheduled for April 2016)
Power reactors—other	Advanced Heavy Water Reactor[E]	HWR, 300MW (not yet operational)

[D] These reactors may be a source of tritium for nuclear weapons. See T.S. Gopi Rethinaraj, "Tritium Breakthrough Brings India Closer to an H-Bomb Arsenal," *Jane's Intelligence Review*, January 1998, Vol. 10(1); Mark Hibbs, "Indian PHWR Safeguards Offer Not Impressive, NPT States," *Nucleonics Week*, April 2003, Vol. 44(16).

[E] See R K Sinha, "Bhabha Atomic Research Centre Highlights: Reactor Technology and Engineering" (Bhabha: Bhabha Atomic Research Centre, India Department of Atomic Energy, 2015), http://www.barc.gov.in/publications/eb/golden/reactor/toc/chapter1/1.pdf (accessed April 12, 2016), p. 6.

Research reactors	Fast Breeder Test Reactor, Kalpakkam	FBR, 40MWt
	Purnima reactor, Trombay	Small-scale U-233 LWR
	Kamini reactor, Kalpakkam	U-233 fuelled LWR, 30kWt
	Apsara reactor, Mumbai	LWR, 1MWt (undergoing conversion from HEU fuel to LEU)[F]
	Compact High Temperature Reactor, Trombay	U-233 and Th fuel (under construction)
Fuel storage	Rajasthan NPP site, Away from Reactor (AFR) Dry Spent Fuel Storage, Rajasthan	570t spent fuel
	Spent fuel storage for unsafeguarded PHWRs to be reprocessed	2500–3600t spent fuel[G]
Reprocessing and separated plutonium	Kalpakkam Spent Fuel Reprocessing (KARP)	PUREX (used for both military purposes and reuse in civilian reactors), 100t/yr spent fuel
	Tarapur Power Reactor Fuel Reprocessing (PREFRE-1 and 2) Center	PUREX (used to reprocess spent fuel from PHWRs for reuse in civilian reactors; temporary safeguards apply on "campaign" basis), 100–150t/yr spent fuel[H]
	CORAL reprocessing plant, Kalpakkam	Pilot plant for reprocessing spent fuel from FBRs, 12 kg/yr
	Tarapur Advanced Fuel Fabrication Facility	MOX fuel fabrication for various reactors[I]

[F] Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium," pp. 2, 33.

[G] IPFM, "Plutonium Separation in Nuclear Power Programs," p. 57.

[H] This facility has tended to run well below its design capacity. Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium," p. 6.

[I] India has about 1.9t of plutonium in FBR fuel as of 2014. See Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium," p. 10.

Table 3: Facilities that are Primarily Used for Military Purposes

Type	Facility, Location	Purpose, Design Capacity
Thorium and uranium mines and mills	Jaduguda Mill	200t/yr
	Turamdih Mill	190t/yr
	Tummalapalle Mill	220t/yr
	More mills to enter operation in the next few years	
	Mines in Jharkland, Andhra Pradesh, Telengana, Karnataka, Meghalaya	
Enrichment[J]	Rare Materials Plant (RMP), Bhabha Atomic Research Center, Mysore/Rattehalli (Karnataka)	Gas centrifuge enrichment for naval reactor fuel, LEU for Apsara reactor, possibly also for nuclear weapons, 15–25 tSWU/yr (capacity to produce 60–100 kg of weapons-grade uranium/yr from natural uranium feed)[K]
	Apparent second RMP under construction at same site	Larger than original RMP
	Special Material Enrichment Facility (SMEF), Khudapura (Karnataka) in initial stages of construction	Gas centrifuge enrichment for civilian and military purposes, larger than RMP
	Uranium Enrichment Plant, Trombay	Pilot-scale research on ultracentrifuges
	Laser enrichment research, various locations	
Uranium conversion and fuel fabrication—natural uranium	Uranium metals plant, Trombay	Fuel fabrication for Cirus and Dhruva reactors
Heavy water production—not declared civilian as part of "Separation Plan"	Baroda	17t/yr
	Kota	85t/yr
	Manuguru	185t/yr
	Talcher	62t/yr

[J] The military applications of enrichment include thermonuclear weapons and naval reactors.
[K] Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium," p. 20.

Research reactors	Dhruva, Mumbai	HWR, 100MWt (historically a major source of weapons-grade plutonium for nuclear weapons)
	Cirus, Mumbai	HWR, 40MWt (historically a major source of weapons-grade plutonium, despite being supplied by Canada in the 1950s on condition that it only be used for peaceful purposes; shut down in 2010 as part of India's Separation Plan)
Naval reactors	Advanced Technology Vessel naval prototype PWR (HEU fuel), Kalpakkam	80–100MWt each[L]
	INS Arihant SSBN with PWR (HEU fuel)	
	Two similar SSBNs under construction, two more planned	
Reprocessing	Trombay plutonium separation plant, Bhabha Atomic Research Center	400–700 kg weapons-grade plutonium separated as of 2014[M] PUREX, approximately 50t spent fuel per year, including reprocessing weapons-grade plutonium from Dhruva, primarily for nuclear weapons[N]

[L] Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium," p. 29.

[M] See Albright and Kelleher-Vergantini, "India's Stocks of Civil and Military Plutonium and Highly Enriched Uranium."

[N] IPFM, "Global Fissile Material Report 2015," p. 26.

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The Project on Managing the Atom (MTA) is the Harvard Kennedy School's principal research group on nuclear policy issues. Established in 1996, the purpose of the MTA project is to provide leadership in advancing policy-relevant ideas and analysis for reducing the risks from nuclear and radiological terrorism; stopping nuclear proliferation and reducing nuclear arsenals; lowering the barriers to safe, secure, and peaceful nuclear-energy use; and addressing the connections among these problems. Through its fellows program, the MTA project also helps to prepare the next generation of leaders for work on nuclear policy problems. The MTA project provides its research, analysis, and commentary to policy makers, scholars, journalists, and the public.

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