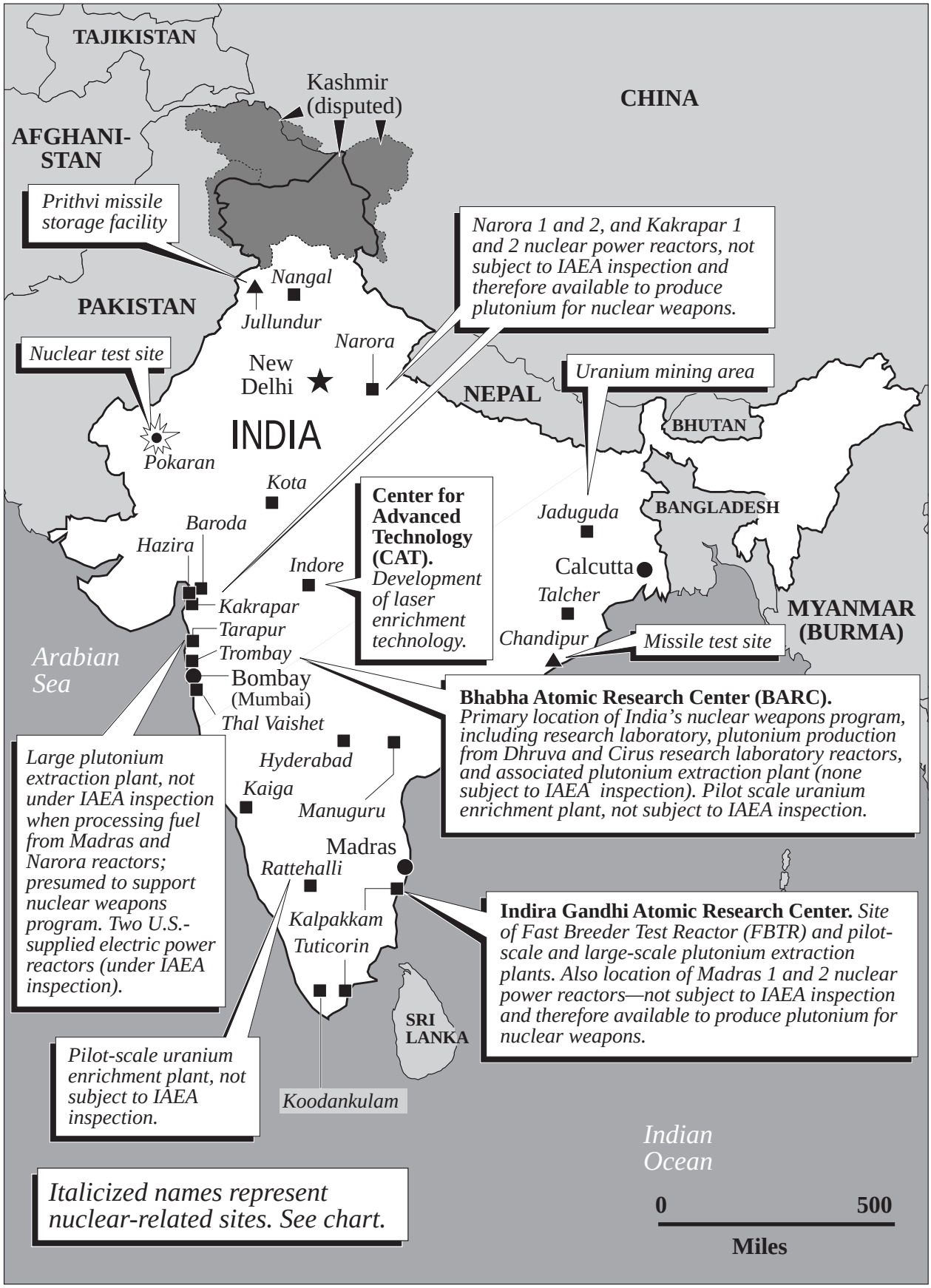
India:
Map and Chart



Carnegie Endowment for International Peace, *Tracking Nuclear Proliferation*, 1998

INDIA: Nuclear Infrastructure

NAME/ LOCATION OF FACILITY	TYPE AND CAPACITY: GROSS DESIGN (NET) OUTPUT[a]	COMPLETION OR TARGET DATE	IAEA SAFEGUARDS
POWER REACTORS: OPERATING			
Tarapur 1	Light-water, LEU and MOX 210 (150) MWe.	1969	Yes
Tarapur 2	Light-water, LEU[b] 210 (160) MWe.	1969	Yes
Rajasthan, RAPS-1, Kota	Heavy-water, natural U 220 (90) MWe.	1972	Yes
Rajasthan, RAPS-2, Kota	Heavy-water, natural U 220 (187) MWe.[c]	1980	Yes
Madras, MAPS-1, Kalpakkam	Heavy-water, natural U 235 (170) MWe.	1983	No
Madras, MAPS-2, Kalpakkam	Heavy-water, natural U 235 (170) MWe.	1985	No
Narora 1	Heavy-water, natural U 235 (202) MWe.	1989	No
Narora 2	Heavy-water, natural U 235 (202) MWe.	1991	No
Kakrapar 1	Heavy-water, natural U 235 (170) MWe.	1992	No
Kakrapar 2	Heavy-water, natural U 235 (202) MWe.	1995	No
POWER REACTORS: UNDER CONSTRUCTION			
Kaiga 1	Heavy-water, natural U 235 (202) MWe.	1998	No
Kaiga 2	Heavy-water, natural U 235 (202) MWe.	1998	No
Rajasthan, RAPP-3, Kota	Heavy-water, natural U 235 (202) MWe.	1999	No
Rajasthan, RAPP-4, Kota	Heavy-water, natural U 235 (202) MWe.	1999	No
POWER REACTORS: PLANNED AND PROPOSED			
Tarapur 3	Heavy-water, natural U 500 (450) MWe.	2004	No
Tarapur 4	Heavy-water, natural U 500 (450) MWe.	-	No
Kaiga 3	Heavy-water, natural U 235 (202) MWe.	-	No
Kaiga 4	Heavy-water, natural U 235 (202) MWe.	-	No
Kaiga 5	Heavy-water, natural U 235 (202) MWe.	-	No
Kaiga 6	Heavy-water, natural U 235 (202) MWe.	-	No

INDIA (cont'd.)

NAME/ LOCATION OF FACILITY	TYPE AND CAPACITY: GROSS DESIGN (NET) OUTPUT[a]	COMPLETION OR TARGET DATE	IAEA SAFEGUARDS
Rajasthan, RAPP-5, Kota	Heavy-water, natural U 500 (450) MWe.	-	No
Rajasthan, RAPP-6, Kota	Heavy-water, natural U 500 (450) MWe.	-	No
Rajasthan, RAPP-7, Kota	Heavy-water, natural U 500 (450) MWe.	-	No
Rajasthan, RAPP-8, Kota	Heavy-water, natural U 500 (450) MWe.	-	No
Koodankulam 1	Russian VVER Light-water, LEU 1000 (953) MWe.[d]	-	Yes
Koodankulam 2	Russian VVER Light-water, LEU 1000 (953) MWe.	-	Yes
RESEARCH REACTORS			
Apsara BARC, Trombay	Light-water, medium-enriched Uranium, pool type, 1 MWt.	1956	No
Cirus BARC, Trombay	Heavy-water, natural U 40 MWt.	1960	No
Dhruva BARC, Trombay	Heavy-water, natural U 100 MWt.	1985	No
Kamini IGCAR, Kalpakkam	Uranium-233 30 KWt.	1996	No
Zerlina BARC, Trombay	Heavy-water, variable fuel, 100 Wt, decommissioned.	1961	No
Purnima 1 BARC, Trombay	Fast neutron, critical assembly, zero power, decommissioned.	1972	No
Purnima 2 BARC, Trombay	Uranium-233 .005 KWt, dismantled.	1984	No
Purnima 3 BARC, Trombay	Uranium-233.[e]	-	No
BREEDER REACTORS			
Fast Breeder Test Reactor (FBTR) IGCAR, Kalpakkam	Plutonium and natural U 40 MWt.	1985	No
Prototype Fast Breeder Reactor (PFBR) IGCAR, Kalpakkam	Mixed-oxide fuel, 500 MWe, planned.	2008[f]	No
URANIUM ENRICHMENT			
Trombay	Pilot-scale ultracentrifuge plant; operating.	1985	No
Trombay	Laser enrichment research site.	early 1980s	No
Rattehalli (Mysore)	Pilot-scale ultracentrifuge plant; operating.[g]	1990	No
Center for Advanced Technology, Indore	Laser enrichment research site.	1993[h]	No

INDIA (cont'd.)

NAME/ LOCATION OF FACILITY	TYPE AND CAPACITY: GROSS DESIGN (NET) OUTPUT[a]	COMPLETION OR TARGET DATE	IAEA SAFEGUARDS
REPROCESSING (PLUTONIUM EXTRACTION)			
Trombay	Medium-scale, 50 tHM/y; operating.	1964/1985	No
Tarapur (Prefre)	Large-scale, 100 (25) tHM/y; operating.[i]	1977	Only when safeguarded fuel is present.
Kalpakkam	Laboratory-scale, operating.[j]	1985	No
Kalpakkam	Large-scale, two lines, 100 tHM/y each; under construction.[k]	1998/2008[l]	No
URANIUM PROCESSING			
Rakh, Surda, Mosaboni[m]	Uranium recovery plant at copper concentrator; operating.		N/A (Not Applicable)
Jaduguda, Narwpahar, Bhatin[n]	Uranium mining and milling; operating.		N/A
Hyderabad	Uranium purification (UO_2); operating.		No
Hyderabad	Fuel fabrication; operating.		Partial
Trombay	Uranium conversion (UF_6); operating. Fuel fabrication.[o]		No
Tarapur	Mixed uranium-plutonium oxide (MOX) fuel fabrication; operating.		Only when safeguarded fuel is present.
HEAVY-WATER PRODUCTION			
Trombay	Pilot-scale; operational?[p]		-[q]
Nangal	14 t/y; operating.	1962	-
Baroda	67 t/y; intermittent operation.	1980	-
Tuticorin	71 t/y; operating.	1978	-
Talcher phase 1	62 t/y; operating.	1980	-
Talcher phase 2	62 t/y; operating.	1980	-
Kota	100 t/y; operating.	1981	-
Thal-Vaishet	110 t/y; operating.	1991	-
Manuguru	185 t/y; operating, under expansion.	1991	-
Hazira	110 t/y; operating.	1991	-

Abbreviations:

HEU = highly enriched uranium
LEU = low-enriched uranium
nat. U = natural uranium
MWe = millions of watts of electrical output
MWt = millions of watts of thermal output
KWt = thousands of watts of thermal output
tHM/y = tons of heavy metal per year
MOX = mixed natural U and plutonium oxide fuel

NOTES (India chart)

[a]The gross design capacity of the reactor is its original power rating, while the net operating capacity refers to *current* output as reported for the latest operational use. See *Nuclear Engineering International: 1997 World Nuclear Industry Handbook*.

[b]Up to 30 percent mixed oxide (MOX) fuel was planned for loading in late 1995, but no subsequent reporting has confirmed this. See Marks Hibbs, "Tarapur-2 to Join Twin BWR in Burning PHWR Plutonium," *Nuclear Fuel*, September 25, 1995, p. 18f. Under contract, China supplied enough LEU to India to operate both units at Tarapur at 125 MWe until 2007. Mark Hibbs, "India to Equip Centrifuge Plant With Improved Rotor Assemblies," *Nuclear Fuel*, December 1, 1997, p. 7f.

[c]RAPS-2 was shut down in 1994 for at least three years, and as of late 1997 had not been restarted. "Rajasthan-2 Down for 3 Years to Replace All Pressure Tubes," *Nucleonics Week*, May 25, 1995, p. 3.

[d]Based on a general agreement reached in October 1995, Russia plans to supply the two VVER reactors to India. The original provisions were for turnkey reactors, but India wants to change the sales terms so that it can build the reactors itself. This would amount to a technology-transfer, which Russia has not yet agreed to. Russia is reportedly under strong U.S. pressure to change the agreement to include a safeguards requirement, which would also cover spent fuel. See Mark Hibbs, "India Seeks China-style Deal for Two VVERs, MINATOM Says," *Nucleonics Week*, January 11, 1996, p. 4; and Jyoti Malhotra, "U.S. Pressure Cited for Faltering Russian Nuclear Deal," *Business Standard* [India], April 23, 1996, in *FBIS-NES-96-080*, April 24, 1996, p. 67.

[e]India listed Purnima 3 as an operating research reactor when it exchanged lists of nuclear facilities with Pakistan; no power rating was given. See "India and Pakistan exchange lists of nuclear facilities," *Nucleonics Week*, January 9, 1992.

[f]According to Indian Department of Atomic Energy Secretary Rajagopol Chidambaram, the design engineering for PFBR is complete, construction is expected to begin in 2000, and completion is expected in 2008. Mark Hibbs, "Despite Chronic Delays, DAE Maintains Prototype Breeder to Be Built Soon," *Nuclear Fuel*, December 1, 1997, p. 9.

[g]The Mysore plant, operated by India Rare Earths Ltd. (IRE), is intended to produce a small amount of HEU, enriched to 30-45 percent U-235, for use in a nuclear submarine reactor, which has thus far not been designed or built. Although the nuclear-powered submarine program has been under development since the 1980s, little progress has been made. India may also have requested centrifuge technology from Brazil based on a nuclear cooperation agreement signed between the two in 1996. In 1997 the U.S. Department of Commerce placed IRE on a list of companies that may not receive any U.S.-origin technology due to its procurement of unsafeguarded nuclear and ballistic missile equipment. Mark Hibbs, "India to Equip Centrifuge Plant with Improved Rotor Assemblies," *Nuclear Fuel*, December 1, 1997, p. 7; and Mark Hibbs and Mike Knapik, "U.S. Aims to Kill Our Program, India Says After Brazil Trade Cutoff," *Nuclear Fuel*, November 3, 1997, p. 4f.

[h]Construction on the Indore research center continued in 1993, but some of the facilities, perhaps including the laser enrichment site, were operational. See "India Funds Nuclear Construction, Operations, and Research in FY-92," *Nucleonics Week*, March 19, 1992.

[i]The Power Reactor Reprocessing Plant (Prefre) has a nominal output capacity of 100 tHM/y, but has operated for more than a decade at about 25 tHM/y. Hibbs, "Tarapur-2," op. cit., p. 19.

[j]Reportedly built to reprocess spent fuel from the FTBR. Mark Hibbs, "First Separation Line at Kalpakkam Slated to Begin Operations Next Year," *Nuclear Fuel*, December 1, 1997, p. 8.

[k]According to a recent report, the first line is scheduled to begin hot operations in 1998, reprocessing spent fuel from the Madras heavy water power reactors. The second line, reportedly identical to the first but still under construction, is scheduled to begin operations when the first closes, in approximately 2008. While not fully clear on this point, this report may imply that a separate large-scale (1000 tHM/y) facility devoted to reprocessing fuel from India's fast-breeder reactors, also planned for Kalpakkam according to the *1997 World Nuclear Industry Handbook*, p. 122, has been shelved due to financial constraints. Given this possibility, the second line could be adapted to separate this type of fuel. Mark Hibbs, "First Separation Line," op. cit., p. 8f.

[l]The initial target date for completion of the first line was 1990, but it was delayed by subcontractors' failure to supply key equipment. See *1997 World Nuclear Industry Handbook*, op. cit., p. 122; Mark Hibbs, "First Separation Line," op. cit., p. 8f.; and Hibbs, "Tarapur-2," op. cit., p. 18f.

[m]Sites listed in OECD Nuclear Energy Agency and International Atomic Energy Agency, *Uranium: 1991 Resources, Production, and Demand*, p. 197.

[n]These uranium milling sites are located in a 10-km area near Jaduguda. Listed in the Wisconsin Project *Risk Report*, March 1995, p. 9.

[o]This is a small plutonium fuel fabrication facility for Purnima II (5 KWe) that was expanded to produce fuel for the FBTR. David Albright, Frans Berkhout and William Walker, *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies* (New York: Oxford University Press for Stockholm International Peace Research Institute, 1997), p. 206.

[p]See Andrew Koch, "Nuclear Testing in South Asia and the CTBT," *Nonproliferation Review*, Spring-Summer 1996, p. 99.

[q]The non-proliferation regime does not include the application of safeguards to heavy-water production facilities, but safeguards are required on the export of heavy water.