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The Nuclear Safety Culture in India: Past, Present and Future

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THE NUCLEAR SAFETY CULTURE IN INDIA: PAST, PRESENT AND FUTURE

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I
INTRODUCTION

Global, electricity demand is expected to grow by 76% from 2007-2030[1] resulting in a steep (over 50%) increase in energy related greenhouse gas emissions from coal fired power plants in the absence of concerted efforts by governments to transition to cleaner sources. There is talk of a large increase in nuclear capacity worldwide (Nuclear Renaissance)[2] to meet the twin challenges of energy security and climate security in an energy starved, carbon constrained world. Electricity generation from nuclear power is projected to increase from about 2.7 trillion kilowatt hours in 2006 to 3.8 trillion kilowatt hours in 2030[3] with the fastest growth occurring in Asia (average annual rate of 7.8 per cent from 2006 to 2030, including 9.9 percent per year in India).[4]

India currently has seventeen Pressurized Heavy Water Reactors (PHWR's) with a total installed capacity of 4120 MWe[5] that supply 3% of its electricity.[6] Recently, Prime Minister Singh projected a seven fold increase in installed capacity to 35000 MWe by the year 2022, and to 60,000 MWe by 2032 at the Nuclear Security Summit.[7] Such aggressive expansion targets have been announced in the aftermath of the landmark Indo-U.S nuclear deal that ended the three decade old sanctions regime (imposed after India's 1974 nuclear test) and enables India to buy nuclear reactors, uranium and dual use technologies on the international market despite its NPT holdout status. Five "Nuclear Energy Parks" housing multiple imported reactor units[8] are expected to provide about 40,000- 45,000 MWe.[9] The long term target of the DAE is to supply 25% of India's electricity by 2050.[10] Any substantial increase in nuclear capacity will result in an increase in the number of facilities throughout the fuel cycle having profound implications for nuclear safety. A serious lapse in safety may slow the growth of nuclear power in India.[11] The

1 International Energy. Agency.2009. *World Energy Outlook 2009 Fact Sheet Why Is Our Current Energy Pathway Unsustainable?*

2 World Nuclear Association. *The Nuclear Renaissance.* http://www.worldnuclear.org/info/inf104.html.

3 EIA.International Energy Outlook. 2009. http://www.eia.doe.gov/oiaf/ieo/electricity.html.

4 Ibid.

5 "About Npcil." http://www.npcil.nic.in/main/aboutus.aspx.

6 Jain, S.K., Dr. "Nuclear Power –an Alternative." http://www.npcil.nic.in/pdf/nuclear%20power-%20an%20alternative.pdf.

7 A more realistic estimate may be 17 gigawatts of net installed capacity becoming operational by 2030.

8 Each with 8 new generation 1000 MWe reactors or six reactors of 1600 MWe capacity.

9 " India to Have Five Nuclear Energy Parks by 2032."http://news.outlookindia.com/item.aspx?672533.

10 World Nuclear Association, n.2.

11 EIA. "International Energy Outlook 2009." http://www.eia.doe.gov/oiaf/ieo/electricity.html.

report begins by examining the recent acrimonious debate over the civil nuclear liability bill and the government's response to the radiation poisoning caused by Cobalt 60 at Mayapuri in New Delhi to understand the current attitudes and institutional structures affecting nuclear safety in India. The report then chronicles a few key safety related incidents that have occurred at various Indian nuclear facilities in the recent past. The key question that it tries to answer is whether India's nuclear and radiation policies, institutions and facilities are ready to prevent or respond rapidly to threats ranging from radioactive material in imported scrap to an accident at a nuclear reactor? Finally, some preliminary recommendations are made to sensitize policymakers and civil society to the areas of improvement in current arrangements.

II
CURRENT REGULATORY STRUCTURE

A brief description of the current nodal institutions in India in matters pertaining to nuclear safety may help better understand the following sections of this report. The Atomic Energy Regulatory Board (AERB) is the primary institution concerned with nuclear safety. It was established by the Department of Atomic Energy (DAE) in 1983 to oversee and enforce safety in civilian and military nuclear operations. The AERB reports to the Atomic Energy Commission (AEC) whose chairman also heads the DAE. The chairman of Nuclear Power Corporation of India Limited (NPCIL), the state monopoly that operates all of India's seventeen reactors is also a member of the AEC. The DAE funds the AERB and provides the necessary technical personnel and testing facilities. The current jurisdiction of the AERB is restricted to the civilian side of the nuclear program and strategic nuclear facilities have been kept off limits since 2000.[12]

[12] Ramana, M.V. and Ashwin Kumar. 2010. "Safety First? Kaiga and Other Nuclear Stories." *Economic and Political Weekly* xlv no. 747:51.

III
THE ISSUE OF LIABILITY

The issue of liability in case of a catastrophic accident is currently the subject of an acrimonious debate in India. The country's domestic nuclear law (Atomic Energy Act of 1962) says nothing about nuclear liability or compensation for nuclear damage resulting from a nuclear accident. Until recently, it was understood that since all civil nuclear facilities are owned by the Central Government (Nuclear Power Corporation of India Limited and the Bharat Navbhikiya Vidyut Nigam, both public sector enterprises), the liability issues arising from these installations are its responsibility. The act also does not clarify trans-boundary liability issues and liability during transport of nuclear material. India is not a party to any of the four international nuclear liability instruments (the 1960 Paris Convention, the 1963 Vienna Convention, the 1997 protocol to Amend Vienna Convention and the 1997 Convention on Supplementary Liability for Nuclear Damage).

The government was forced to defer the introduction of a Civil Liability for Nuclear Damage Bill that is essential for American commercial nuclear firms to enter the US$150 billion Indian civil nuclear energy market after fierce opposition from major political parties, legal experts and civil society in March 2010. The provisions in the bill that deal with total compensation in case of a nuclear accident and limits on the liability of the nuclear operator are the most controversial. Clause 6 of the bill caps the maximum amount of liability in case of a nuclear accident at 300 million Special Drawing Rights (SDR's- around US$460 million or Rs 21 billion) while the liability of the operator for each nuclear incident has been capped at Rs 5,000 million. The government will be responsible for liability over Rs 5,000 million. During the debate over the nuclear liability bill, experienced members of the country's atomic energy establishment including Srikumar Banerjee, Chairman of the Atomic Energy Commission, Anil Kakodkar and M. R. Srinivasan, both former Chairmen of the Atomic Energy Commission, came out in support of the government's position on nuclear liability. They stated that India needs a well defined liability framework and claimed that the liability bill will pave the way for the country to join an international liability regime and access additional funds (if compensation claims exceed the overall cap specified in the liability bill, an additional 300 million SDR can be made available through the Convention on Supplementary Compensation). [13]

However, this raises the troubling question as to why successive governments and atomic energy chiefs did not deem it fit to enact a well defined liability framework in the nuclear domain before the current debate, especially in a country that has experienced catastrophic industrial accidents (Bhopal gas tragedy). Anti-nuclear activists, strategic and legal experts were also not particularly concerned about the issue of civil nuclear liability before this debate.

IV
IMPROPER DISPOSAL OF RADIOACTIVE MATERIALS BY ACADEMIC AND RESEARCH INSTITUTIONS

India has developed an extensive civilian nuclear infrastructure and has several research institutes and medical facilities that specialize in using radioactive materials to treat diseases. So the danger of some radioactive materials escaping into the broader environment and being unaccounted for is very real. A case in point is the recent incident in the industrial town of Mayapuri in New Delhi where unsuspecting scrap dealers came into close contact with radioactive Cobalt 60 (a widely used isotope in industrial radiography, medical radiology, large food processing units and nucleonic gauges for thickness measurement)[14] resulting in one death and radiation induced injuries to 8 persons. The International Atomic Energy Agency (IAEA) rated the Mayapuri incident as the most serious case of radiation exposure since 2006.[15] After claiming initially that the Indian nuclear complex was not the source of the Cobalt 60, the officials cited other suspects such as a foreign country, or city hospital.[16] Further investigations have confirmed that the source of origin was the Chemistry Department at Delhi University where the radioactive material, initially procured from Canada, lay unused since 1985 and was finally auctioned off.[17] The callous attitude of university officials raises concerns regarding the enforcement of the guidelines specified by the AERB to enable research institutions to safely dispose used radioactive materials.

The AERB's Board of Radiation and Isotope Technology (BRIT) is the only government controlled institution that manufacturers and sells radioactive isotopes in India.[18] Currently, every radiation source whether domestic or imported has to be registered with the AERB. Institutions that use radioactive materials like Cobalt 60 are issued new stocks only after they return the old ones

[13] "Nuke Establishment Backs Nuclear Liability Bill." *Outlook*.http://news.outlookindia.com/item.aspx?677020.

[14] Government of India, Department of Atomic Energy. *Radioactive Materials Found in the Scrap Dealer's Shops in Mayapuri, New Delhi.* http://www.dae.gov.in/press/pr09042010.htm.

[15] Dastidar, Avishek G. "Aerb Clueless About Machines." http://www.hindustantimes.com/newdelhi/AERB-clueless-about-machines/537802/H1-Article1-537330.aspx.

[16] 2010. "Mayapuri Radiation Source Traced to Delhi University." *Outlook*. April 28.

[17] Ibid.

[18] Dastidar, Avishek G. 2010. "Lurking Danger, No One to Check." *Hindustan Times*. April 9.

to the AERB. [19] Even if an isotope has lost its radioactivity, it has to be returned to the AERB. Institutions using radioactive materials are expected to self-regulate by retaining a Radiation Safety Officer in their premises who sends annual reports to the BARC on his/her institution's use of radioactive material.[20] There are no physical inspections conducted by the AERB because of its limited manpower. However, permission is required before changing the location of radiation sources and the use of public transportation to move such materials is strictly prohibited.[21] However, a major problem is the lack of information regarding the radioactive sources procured by medical and research institutions before the establishment of the AERB leading to fears that some materials may have escaped into the public domain.

The fact that the source of origin was a science department at a large state run university does not diminish the threat posed in the future by radioactive materials in imported scrap. India imports nearly 4000 tons of junk metal every day to meet its rising demand for steel. Its guidelines on importing scrap are at par with international standards. However, poor enforcement and lack of screening mechanisms at India's ports may result in imported scrap with a significant fraction of radioactive substances ending up in dense population centers and causing fatal radiation sickness among unsuspecting victims.[22] Currently the Bhabha Atomic Research Center (BARC), Atomic Energy Regulatory Board (AERB), Department of Atomic Energy (DAE) or the National Disaster Management Authority have no control over dangerous materials like Cobalt 60 that are shipped into India. The four agencies have drawn up a plan to install scanners at all major ports (sea, air and land), but that plan is currently behind schedule.[23] The acrimonious debate over the liability issue and the state incapacity displayed in tackling the Mayapuri crisis leads to the conclusion that issues pertaining to nuclear safety need to occupy a higher place on the government's agenda.

The report now summarizes a few key safety related events of varying severity that occurred at Indian nuclear facilities across the fuel cycle.

On 29 December 2009, a fire broke out in a chemistry laboratory at the Bhabha Atomic Research Centre (BARC), at Trombay killing two doctoral students .Top scientists insisted that it was an accident and that there was no danger of radioactive contamination.[24] The cause of the fire has not yet been established. Following the incident, BARC ordered a safety review of its labs and has committed to decongest key facilities.[25] On 24 November 2009, a radiation leak at the Kaiga Nuclear Plant exposed 55 employees to radiation. According to authorities, the source of the radiation was a water cooler contaminated with radioactive tritium (a heavier form of hydrogen that is produced as a byproduct in a heavy water reactor).[26] Investigations into the incident have been inconclusive so far. On January 21, 2003, six employees at

[19] Iyer, Kavitha. 2010. "Lessons to Be Learnt from Mayapuri." *Indian Express*.

[20] Dastidar, Avishek G. 2010. "Lurking Danger, No One to Check." *Hindustan Times*. April 9.

[21] Ramachandran, R. 2010. "Lessons from Mayapuri." *The Hindu*. May 1.

[22] Yardley, Jim. 2010. "Scrap Metal Radiation Raises Concerns in India." *The New York Times*. April 23.

[23] Ibid.

[24] Laxman, Vijay Singh and Srinivas. 2009. "Fire in N-Hub: 2 Researchers Burnt Alive in Barc Lab." *Times of India*. December 30.

[25] Bagla, Pallava. 2010. "We May Never Know What Caused Barc Fire: Govt." January 3. http://www.ndtv.com/news/india/we_may_never_know_what_caused_barc_fire_govt.php.

[26]"Kaiga Incident a Mischief: Npcil." 2009. *Indian Express*. November 30.

the Kalpakkam Reprocessing Plant (a radiochemical plant that separates plutonium and uranium from the spent fuel of the Pressurised Heavy Water Reactors and one of the three reprocessing facilities in the country along with Trombay and Tarapore)[27] were exposed to radiation exceeding the annual dosage limit prescribed by the regulatory authorities.[28] BARC authorities admitted that the incident was a "serious" one.[29] The KARP main plant was closed for more than six months.[30] The incident took place when the employees sent to collect samples of low-level radioactive waste were exposed to radiation due to malfunctioning of a separating valve that resulted in the mixing of high level radioactive waste with low level waste. [31] The safety record of uranium mining facilities in India has also come under the scanner. A study conducted in 2000 by scientist couple, Surendra and Sanghamithra Gadekar, in the vicinity of Jaduguda in Jharkhand (home to uranium mines and a processing plant that has supplied India's nuclear programme for decades)[32] showed that incidence of TB (80 per 1000) among miners (belonging to the Santhali and Ho communities)[33] was much higher than the incidence in the normal population (8 per 1,000).[34] They also found a higher incidence of congenital deformities (60 in the vicinity of Jaduguda as against 10 in distant but similar villages) among children. [35]

On 26 March 1999, a heavy water leak was discovered in the second unit of the Madras Atomic Power Station (MAPS) caused by an improperly positioned sealing plug in one of the coolant channels during previous routine maintenance work.[36] While Dr. K.S Parthasarathy, Secretary Atomic Energy Regulatory Board (AERB) claimed that approximately four tons of heavy water had leaked, Dr. A. Gopalakrishnan,a former Chairman of the AERB alleged that 14 tons had been lost.[37] Reportedly, 42 workers were involved in stopping the leak and recovering the heavy water.[38] Later the representatives of workers revealed that seven workers involved in the clean up and had been barred from working in any radioactive areas in the future [39] indicating that they had received high doses during the clean up.[40] A few years earlier, on 13 May 1994, the inner containment dome of Unit-1 of the Kaiga nuclear power plant collapsed during the final stages of reactor construction. The Atomic Energy Regulatory Board (AERB) cited design deficiencies and absence of quality control as key reasons for the accident.[41] Fourteen workers were reported to have sustained minor injuries.[42] However, the most serious accident at an Indian nuclear

[27]"The Kalpakam Incident." 2003. *Frontline*, August 16 - 29.

[28] Ibid

[29] Ibid

[30] Ibid

[31] Ibid

[32] Krishnan, Lina. "Jadugoda: Four Decades of Nuclear Exposure." http://www.cised.org/wp-content/uploads/infochange-jaduguda.pdf.

[33] Ibid

[34] S. Anand , Nitin A. Gokhale. "Tick-Tock of Doom." *Outlook.* http://www.outlookindia.com/article.aspx?221512.

[35] Ibid

[36] Subramanian, T.S. 1999. "An Incident at Kalpakkam." *Frontline*, April 10 – 23. http://www.thehindu.com/fline/fl1608/16080270.htm.

[37] Ibid

[38] Ibid

[39] M.V.Ramana and Ashwin Kumar. 2010. "Safety First? Kaiga and Other Nuclear Stories." *Economic and Political Weekly* xlv no. 747: 49.

[40] Ibid.

[41] 1999. "Issues of Nuclear Safety." *Frontline*, March 13 - 26.

[42] Ramana, et.al, n.39, p.50.

reactor occurred on 31 March 1993. A devastating fire in Narora Unit-1 brought the reactor core very close to partial fuel meltdown. Only the timely use of the GRAB system (a fourth and last level of safety protection in which gravity addition of boron solution into the reactor core occurs, in the event of a prolonged station power blackout) saved the employees and the surrounding communities from a runaway chain reaction.[43] The fire began when two steam turbine blades broke at their roots and destroyed the turbine A few years prior to the accident, the turbine designer (U.K based GEC) warned the Department of Atomic Energy (DAE) about the fault and even offered a revised design.[44] The accident could have been averted even after the destruction of the turbine, if the cables supplying power to it and four back up power supply systems had been encased in separate fire resistant ducts.[45]

V
CONCLUSION

Prime Minister Singh projects that nuclear power could expand to as much as 4,70,000 MW of power by 2050.[46] Even if a small percentage of this target were to be achieved, it would still constitute a large expansion in nuclear capacity. At the same time the use of radioactive materials in medical and research establishments and their transport across borders has increased exponentially. India's nuclear and radiation policies need to take stock of such developments and various future scenarios. The government must direct the Atomic Energy Regulatory Board to constitute a panel of eminent experts from various disciplines to comprehensively review the past and present nuclear safety culture and make recommendations for the future. The panel must focus on new sources of concern such as the possibility of a large amount of highly radioactive material entering the country via imported scrap, or the improper disposal of radioactive substances procured before the establishment of the AERB by academic, research and medical institutions. More specifically, the AERB must come up with a comprehensive inventory of all radioactive materials procured by research and medical establishments before 1983. The AERB may also need to retain a substantial independent, technically competent workforce to enable it to conduct surprise physical inspections at multiple sites in the country. Strict action taken against defaulters will serve as an incentive to other institutions to comply with the norms. Most current radiation safety officers do not have the necessary skills required for their job. It is necessary to begin systematic training programs for radiation safety officers in order to impart the necessary skills preferably in the form of a certificate course. During the nuclear security summit, the government announced its plans to set up a world class center that specializes in nuclear security with four schools that perform cutting edge research on proliferation resistant nuclear technologies. The government can set up a new division within this center that deals exclusively with nuclear safety issues in India. The government must incentivize think-tanks to retain experts that specialize in nuclear safety and begin such courses at several universities. The aim should be to build up expertise in matters pertaining to nuclear safety in the country that is independent of the DAE.

[43] "Issues of Nuclear Safety," n.41.

[44] Ibid.

[45] Ramana, et.al, n.39, p.51.

[46] 2009. "India's Nuclear Industry Set for Major Expansion." *The Hindu*. September 30.

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