



International Panel Discussion: India

DOE Technology Innovation and
International Partnership Workshop

September 15, 2010

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International Panel Discussion: India

- Historical Perspective
- Current Status
- Used Fuel Management
- Indian Civil Nuclear Program
- Potential R&D Areas for Collaboration Involving Thorium Fuel Cycle
- Nuclear Commerce with India

Historical Perspective

- 1944: Dr. Bhabha (IISc) writes to Tata group to start nuclear program in India
- 1945: Tata Institute of Fundamental Research (TIFR) established
- 1947: India becomes a sovereign nation
- 1948: Atomic Energy Act, 1948 (AEC constituted)
- 1954: Department of Atomic Energy (DAE) established
- 1956: First research reactor in Asia attains criticality at Trombay
- 1962: Atomic Energy Act, 1962
- 1964: Construction of 2 GE BWR's started (TAPS – 1 & 2)
- 1965: Rajasthan Plant (CANDU) construction started (RAPP-1)
- 1968: NPT
- 1969: TAPS-1 & 2 BWR's commence operations
- 1972: RAPP-1 CANDU begins operation
- 1974: Indian nuclear test
- 1974: NSG formed
- 1978: NNPA
- 1994: Beginning of a new US-India partnership (Secretary O'Leary visit)
- 2006: Henry J. Hyde Act (H.R. 5682)
- 2008: India Specific Safeguards (IAEA)
- 2008: NSG exception for India
- 2008: US-India Nuclear Cooperation Approval and Non-Proliferation Enhancement Act (H.R. 7081)
- 2008: 123 Agreement signed
- 2009: IAEA and India sign India Specific Safeguards and Additional Protocol agreements
- 2010: U.S.-India Agreement for Reprocessing
- 2010: Indian Parliament approves a nuclear liability law

Current Status

- 14 of the 22 operating or under-construction reactors will be under IAEA safeguards by 2014
 - BWR: 2
 - PHWR: 10
 - PWR: 2
- New Plants being planned through the 12th 5-year plan (until 2017)
 - LWR: 4 (Imported)
 - PHWR: 4 (Domestic)
 - PFBR: 1+ (Stage 2 – domestic)
 - AHWR: 1 (Stage 3 – domestic)
- Nuclear Plans by the 15th 5-year Plan (2032)
 - 63 GWe (total), out of which 40 GWe will come from imported LWR's and 7 GWe from PHWR's fueled by imported uranium
 - 63 GWe represents 9% of national energy demand in 2032
 - Indian nuclear power program plan is ambitious

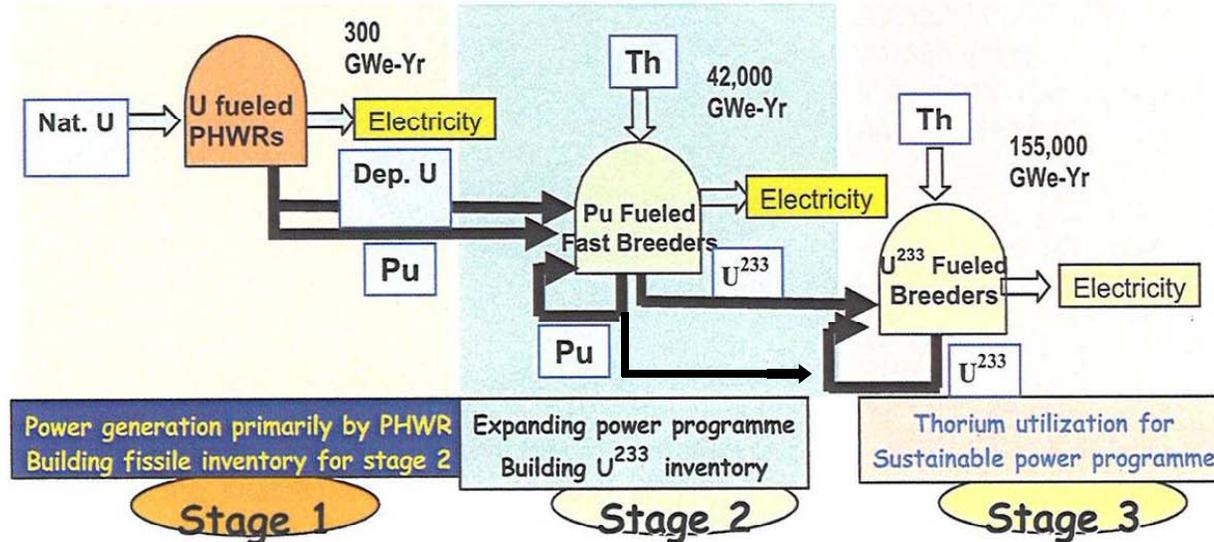
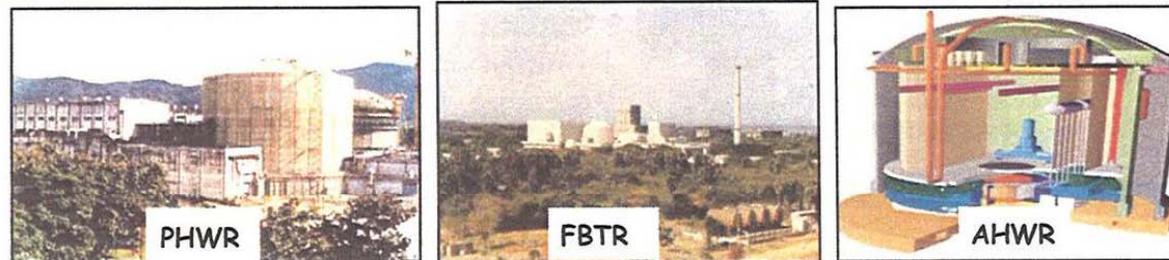
Used Fuel Management

- Waste handling facilities to dispose LLW set up at all nuclear power plant sites
- India currently generates about 600 MTU of used fuel annually. The used fuel is cooled/stored in reactor pools.
- Three reprocessing plants:
 - Trombay: Used fuel from Research Reactors (pilot plant)
 - Tarapur: Used fuel from PHWR's
 - Kalpakkam: Used fuel from FBTR and KAMINI (~100 T/yr.)
- Two new reprocessing plants under the U.S. – India Agreement
 - Kalpakkam (Imported LWR's and future FBR's under IAEA safeguards)
 - Trombay (PHWR's using imported uranium and those under IAEA safeguards)
- HLW is stored in stainless steel tanks
 - Underground Waste Tank Farm (WTF), 60,000 – 130,000 gallons each
 - 304L stainless steel construction
- Vitrification facilities for HLW (Waste Immobilizations Plants – WIP)
 - Trombay (Pilot and industrial scale plants)
 - Tarapur
 - Kalpakkam

Used Fuel Management (cont'd)

- Monitored Interim Storage – Solid Storage Surveillance Facility (SSSF)
 - Located at Tarapur (1999); Second facility being set up at Kalpakkam
 - Underground engineered storage facility with continuous cooling for 30 years
 - Storage for vitrified waste product (VWP) in 1700 “overpacks” containing 2 to 3 canisters
 - Transport from WIP Tarapur done in 30 MT vertical shielded casks
 - Transport from WIP Trombay done in a specially designed 60 MT multiple unit cask (MUC) containing 3 overpacks having 3 canisters each (“Type – B package”)
- Geological Repository for final disposal
 - Site selection among “target regions” underway (study of rock characteristics)
 - Granites are the preferred choice. The underground chambers will be 500 – 600 meters deep
 - Pilot program initiated

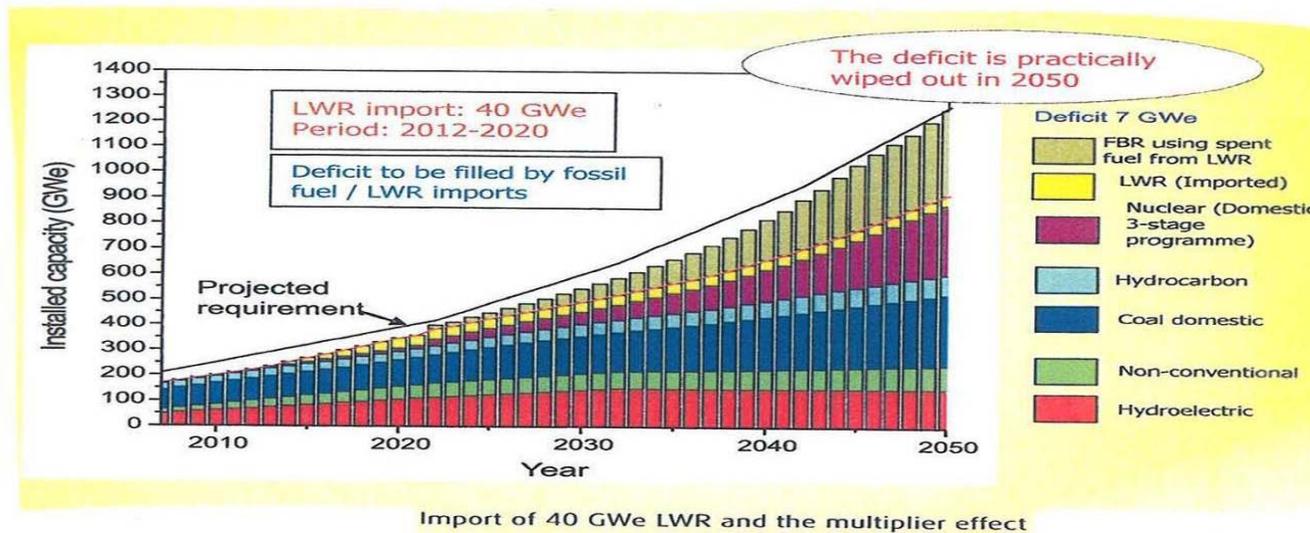
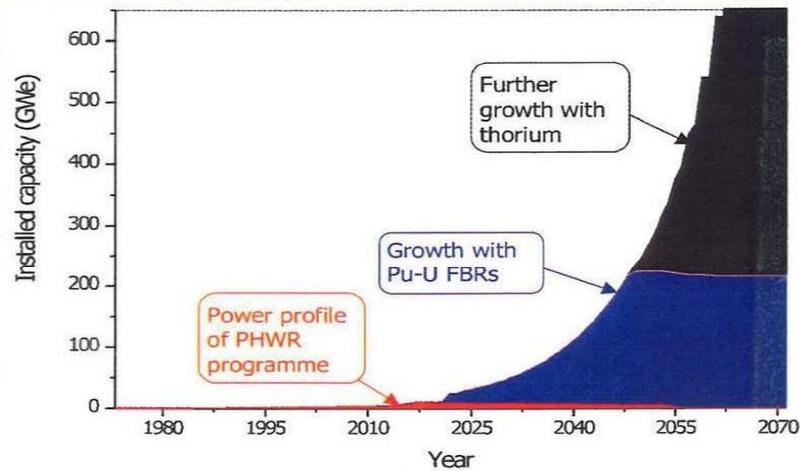
Indian Civil Nuclear Program (1)



India's Three-Stage Nuclear Power Program

Indian Civil Nuclear Program (2)

Optimum Strategy for thorium introduction in the third stage



Potential R&D Areas for Collaboration Involving Thorium Fuel Cycle

- “Thorium Energy Independence and Security Act of 2008” introduced in the U.S. Senate by Reid and Hatch in October 2008
- The U.S. House of Representatives directs the Navy to look at Thorium fueled reactors for Naval propulsion – bill introduced by Sestak in March 2009
- International Conference on Access to Civil Nuclear Energy (March 2010):
 - “Reliance on Uranium will not be sustainable beyond this century. Unless thorium is used, it will not be possible to have sustainable energy on this planet.”
- Nuclear Energy R&D Road map Report to Congress (April 2010):
 - “Sustainable fuel cycle options are those that improve uranium resource utilization, maximize energy production, minimize waste generation, improve safety and limit proliferation risk.”
- U.S. – India Energy Dialogue formed a Civil Nuclear Working Group in May 2005, and the U.S. – India Joint Working Group on Civil Nuclear Energy Cooperation was formed in July 2005
- Third meeting of the Indo – United States Energy Working Group was held in Mumbai on Feb. 3-4, 2010. U.S. team was led by NE-1.
- Technology challenges using a closed thorium fuel cycle:
 - Handling high concentrations of Pa-233
 - Economic fuel fabrication
 - Recycle technology (THOREX and pyroprocessing)
 - Accelerator Driven Systems (ADSs) and Pu alternatives for Stage 3

Nuclear Commerce with India

- 123 Agreement Follow-up (Legislative requirements)
- Ratification of IAEA Additional Protocol
- Technology Transfer Assurances (“810”)
- Nuclear Liability Law in India
- Amendments to the Indian Atomic Energy Act
- U.S. Regulatory Export Licenses
- U.S. – India industry partnerships (supply chain and human capital diversification)
- Trade Promotion Facilities and Assistance
- Political Engagement