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CHALLENGES FACED BY FOREIGN SUPPLIERS AND WAY FORWARD

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HISTORICAL PERSPECTIVE

- Dr. Homi Bhabha announced a closed fuel cycle based nuclear power development as early as 1955
 - Chaired the first International Conference on Peaceful uses of Atomic Energy in Vienna
 - This conference laid the foundation for the launch of IAEA later in 1957
 - Legend has it that it was Dr. Bhabha who was pivotal in basing the headquarters of IAEA in Vienna because of his love for opera (Dr. ElBaradai, 2009)
 - The program that Dr. Bhabha laid out for India (well before 1955) envisaged a 3-stage program of thermal reactors, fast reactors, and thorium based advanced reactors
 - Free access to natural uranium and efficient utilization of plutonium (extracted through reprocessing) are key enablers to the success of the 3-stage program
 - Not surprising that India challenged the lecture titled, “Atoms for Peace” made by the U.S. President Eisenhower in the UNGA on 8 Dec 1953, which placed restrictions on control and distribution of fissionable and fissile materials
- India played a big role in creating the charter of the IAEA putting the promise of clean and safe nuclear power equally accessible to all countries, whether rich or poor
- India refused to sign the NPT in 1968 on the grounds that it discriminated against countries that possessed advanced nuclear technologies but chose not to pursue a weapons program



IMPACT OF THE 3-STAGE PROGRAM AND ITS INDIGENIZATION - 1

- Stage 1 envisioned utilization of thermal reactors, both domestically designed and foreign purchases
 - PHWR program was initiated with Canadian assistance
 - LWR program was initiated with American assistance
 - Stage-1 development led to the creation of NPCIL
- Stages 2 and 3 initially were put under BARC until technologies would mature and be ready for industrialization
 - FBR demo, followed by construction of PFBR at Kalpakkam (Stage 2)
 - A separate PSU, BHAVINI, was established as owner-operator of FBR plants
 - AHWR, MSR and other Stage 3 program designs are in development phase under BARC
- The paradigm shifted in 1974
 - India conducted a nuclear explosion, calling it a “Peaceful Nuclear Explosion (PNE)” experiment, which was permissible under IAEA/NPT rules
 - Global community led by the U.S. rejected that argument and the U.S., Canada, and U.K. immediately stopped and withdrew from civil nuclear cooperation with India
 - The Nuclear Suppliers Group (NSG) was formed the same year in London and NSG countries suspended nuclear commerce with India



IMPACT OF THE 3-STAGE PROGRAM AND ITS INDIGENIZATION -2

- India continued with its 3-stage program development, albeit at a slower pace, until it achieved 100% indigenization of its nuclear reactors and fuel cycle programs
 - Impressive accomplishments were achieved
 - National pride went up
 - Trust of foreign nations and foreign nuclear vendors went down
- So when foreign reactors vendors returned to India after 2005, they found a different landscape
 - Fiercely independent and confident nuclear bureaucracy (DAE/AERB)
 - Well established national nuclear utility (NPCIL)
 - Planned need for only a few foreign reactors in Stage 1 of the 3-stage program
- Russians have a lead in the game
 - The 123 civil nuclear Agreement with the U.S. was signed in 2008 after the terms were finalized in 2007. Nuclear Cooperation agreement with France was also signed in 2008
 - IGA with Russia was signed in 1988, revived in 1998 and implemented in 2002. A new broad civil nuclear agreement with Russia was signed in 2009



FOREIGN REACTOR SUPPLIERS IN INDIA

- Russia, France and USA are interested and/or invested, South Korea is looking in
- Russia got a head-start
 - KK-1 and KK-2 were connected to the grid in 2013 and 2016, respectively, at a cost of about \$3 billion, delivering power at about 6.2 ¢/kWh
 - KK-3 and KK-4 under construction, will cost about \$6 billion, and are scheduled for operation in 2025 and 2026. Final negotiations on KK-5 and KK-6 underway
- PM Modi and President Putin met in Vladivostok in September 2019, pledged continuing cooperation in nuclear energy, including Indian assistance to Rooppur reactors in Bangladesh under a 2018 tripartite agreement
 - Russia (TVEL) and India (NFC) will explore the potential for constructing a nuclear fuel plant in India
- Russia and India have signed a memorandum to buy 6 additional reactors to be set up at a site not yet identified
 - Russians will be supplying the top line VVER-1200 Gen 3+ reactors
- NPCIL recently awarded major contracts to Indian suppliers on this project: Reliance Infrastructure (\$166 M), BHEL (\$64M), BGR Energy System (\$63M)



THE FRENCH AND THE U.S. ARE NEGOTIATING - 1

- A positive feature is that NPCIL, MoEFCC and AERB have teams dedicated to addressing EIA, design, construction and regulatory approval of EPR and AP-1000
- EPR at Jaitapur (MH)
 - Six (6) reactors 1650 MWe, 9900 MWe nameplate capacity
 - Received Environmental Clearance in 2010
 - Change of Supplier from Areva to EDF in 2016
 - Construction cost (not made public, but China has reported that Taishan 1/2 have cost about \$7.5 billion)
 - TCO submitted to NPCIL (12/14/2018)
 - “Final Negotiations” are underway. There is some talk of the French investment banks involved in financing are seeking sovereign guarantees
 - PM Modi and French President Macron met in France on August 2019, and both parties reiterated their support for the project



THE FRENCH AND THE U.S. ARE NEGOTIATING - 2

- AP-1000 at Kovvada (AP)
 - Initial EWA on a 2-reactor Package at a site in Gujarat (2013)
 - MOU for Six (6) reactors: 1110 MWe, 6660 MWe nameplate capacity (2016)
 - Upgrade: Six (6) reactors, 1208 MWe, 7248 MWe nameplate capacity (2017)
 - Westinghouse declared bankruptcy in 2017, Brookfield Business Partners acquired the company; reframed company priorities and its focus for the future
 - Steady progress on negotiations between Westinghouse and NPCIL is reported but there appears to be no firm timeline to closure
 - Joint U.S. India Strategic Security Dialogue Statement “committed to strengthen bilateral security and civil nuclear cooperation, including the establishment of six U.S. nuclear power plants in India,” (March 2019, Washington)
 - Continuing high interest from both parties to sign a deal
 - Reminder: Tarapur 1 and 2 reactors built with GE and Bechtel assistance and commissioned in 1969 are still operating and considered a success



CHALLENGES ON THE HORIZON

- Price of Electricity produced by nuclear power is a point of contention
 - Indian domestic nuclear reactors produce electricity at very competitive prices when compared to regional power tariffs
 - Foreign reactors in India are finding matching such tariffs very difficult. KK-1 and KK-2 cost about \$3 billion, and are delivering electricity at about 6.2 ¢/kWh
 - New Russian reactors cost about double of that, and the French/American reactors may cost double of the Russian price. Going from overnight cost to busbar price requires a complex set of terms involving discount rates, NPP performance, ROI, etc. which gets all wrapped up in the TCO, which all three foreign suppliers are required to negotiate with NPCIL
 - Reference Point: India's Gorakhpur -1/2 reactors in Haryana will cost about \$2,200/kWe
 - Reference Point: U.S. EIA in 2017 indicated that PWR's brought on line in 2022 will provide LCOE at 9.9 ¢/kWh
- Regional electricity tariffs in India, and indeed around the world, are falling
 - Solar and Renewable are narrowing or even exceeding in some cases the life cycle cost advantages by nuclear power((WNISR, 2019, WNA has disputed WNISR figures)
 - PM Modi at the 2019 UN Climate Change session: put emphasis on renewables, defining a new target of 400 GWe
- Performance of American and French reactors under construction in home countries is an issue
 - Latest project projections on cost and schedule for Vogtle 3/4 and Flamanville3 are of concern



FUTURE OF THE INDIAN NUCLEAR PROGRAM

- India Nuclear Program is falling behind
 - The hope of meeting a goal of 63 GWe by the end of the 16th 5-year plan (2037) has fallen by the way side. Recent revised estimates put the figure at 22,480 MWe by the end of the 15th Plan (2032), and possibly 39 GWe by 2040 (ORF Report, 2016)
 - A key reason for the setback is that construction of Western reactors has been delayed; and GE pulled out
 - But there are domestic factors as well – Construction delays of domestic reactors, slow project approvals especially site clearances,, delays in budget allocations from the Government, and the insurgent role of civil society in blocking or delaying various projects
 - DAE plans to build a stockpile of 15,000 tonnes of uranium to ensure adequate supply of fuel
 - The Government has also stated that denial of the NSG membership to India is limiting country's access to attractive borrowing in world financial markets (India applied for NSG in 2016)
- India should develop a “Plan B” for its civil nuclear future
 - Expeditiously license and construct higher rated capacity indigenous reactors, like 900 MWe IPWR
 - Consider alternatives to Stage 2 of the three-stage program and find innovative paths to U-233 production
 - Down select Stage 3 reactor technology expeditiously and proceed to industrialization of the baselined thorium fuel cycle in tandem with the IPWR program



CONCLUDING REMARKS

- Nuclear power is essential to India in meeting both its energy needs and its climate change goals
 - Collaborating with Western nuclear vendors will significantly help India in meeting its clean energy targets
- Domestic 3-stage program needs a re-evaluation with the succinct objective of commercializing thorium fuel cycle in the most expeditious and efficient manner
- Higher rated IPWR's should be the focus of new indigenous reactor construction program after the current campaign of PHWR construction ends
- Negotiations between various Western entities should be speeded up to get a rapid closure on contracts to begin construction of EPR and AP-1000 reactors in India.
 - If the present track of negotiations is not working, DAE may consider creating a special multidisciplinary team to complete negotiations with foreign entities under IGA's.
- Foreign suppliers should be welcomed by India to strengthen domestic supply chain for indigenously designed and built reactors
 - NPCIL, AERB, and others should develop procurement strategies to encourage foreign vendors into the country with streamlined regulations and import/export controls
 - Innovation is key to sustaining the growth of nuclear industry in India and abroad. Collaboration between Indian nuclear suppliers and Western nuclear vendors will greatly strengthen the Indian nuclear supply chain

