THE FUTURE OF ENERGY
CAETS – 2021 ARGENTINA

STATUS OF NUCLEAR POWER IN INDIA

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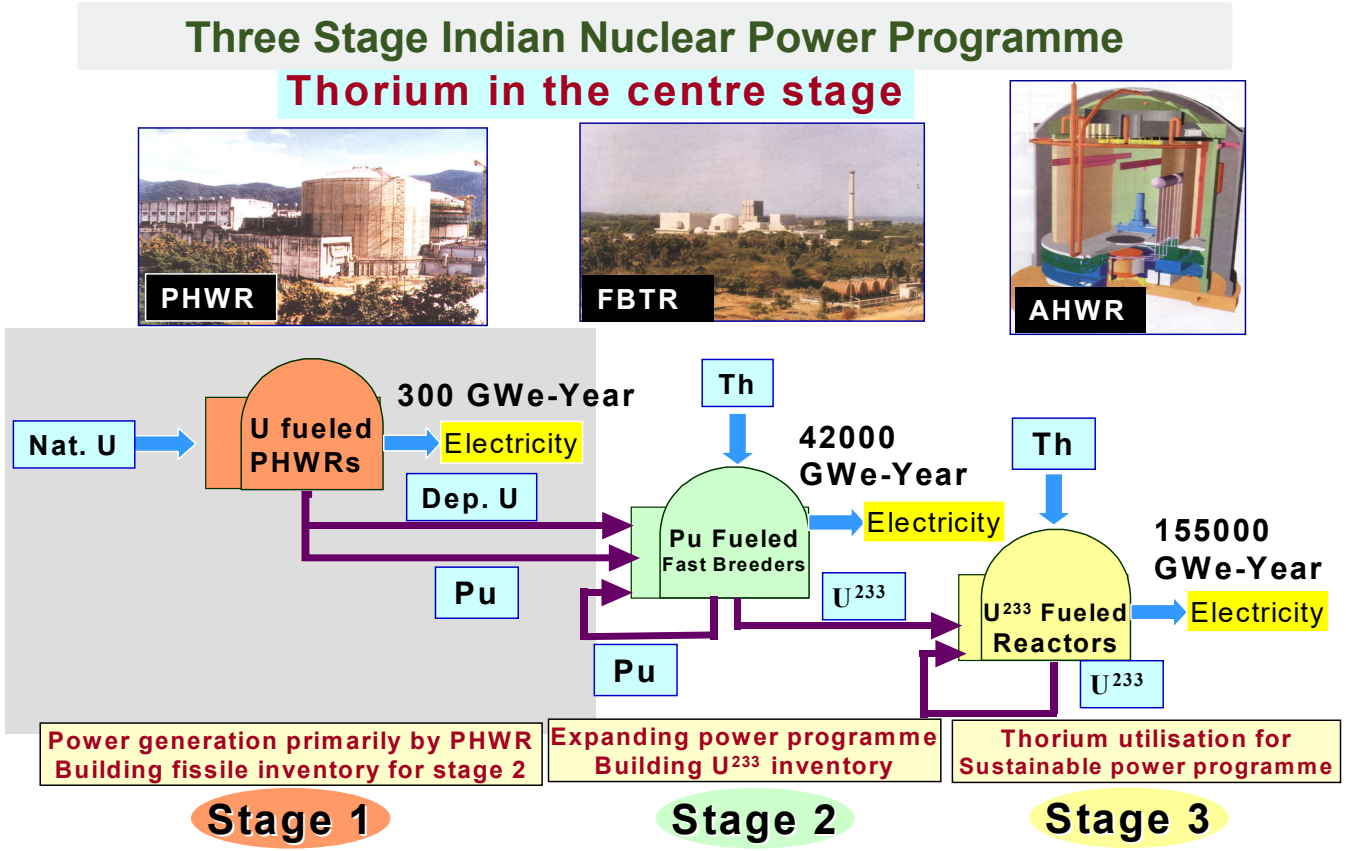
Introduction

- India has been pursuing a robust three stage nuclear power programme as outlined by Dr. Homi J. Bhabha.
- It is based on self-reliance and exploitation of vast thorium reserves and domestic industrial capabilities in the country.



Status of Indian Nuclear Power Programme

Stage I: PHWRs

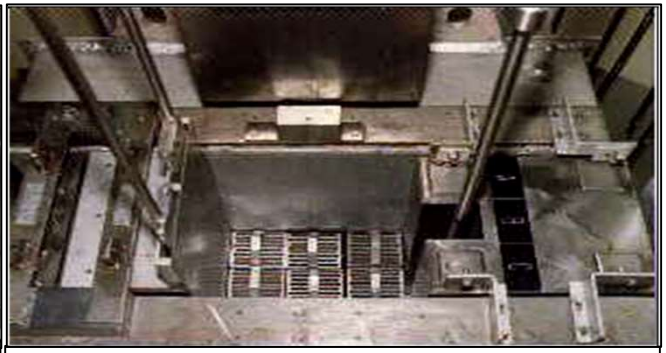
- 18 – Operating
- 5 – Under Construction
- Several others planned
- Potential ~ 12GWe

LWRs

- 2BWRs – Operating
- 2 VVER – Operating
- 4 VVER - Under Construction

Stage II : FBRs

- 40 MWth FBTR – Operating
- 500 MWe PFBR – Under Construction
- Potential ~300 GWe



Stage III: Th Based Reactors

- 300MWe AHWR – Under Development
- MSR – Under Design
- High Temperature Reactors
- Potential ~ Very Large

Theme of Nuclear Power Programme

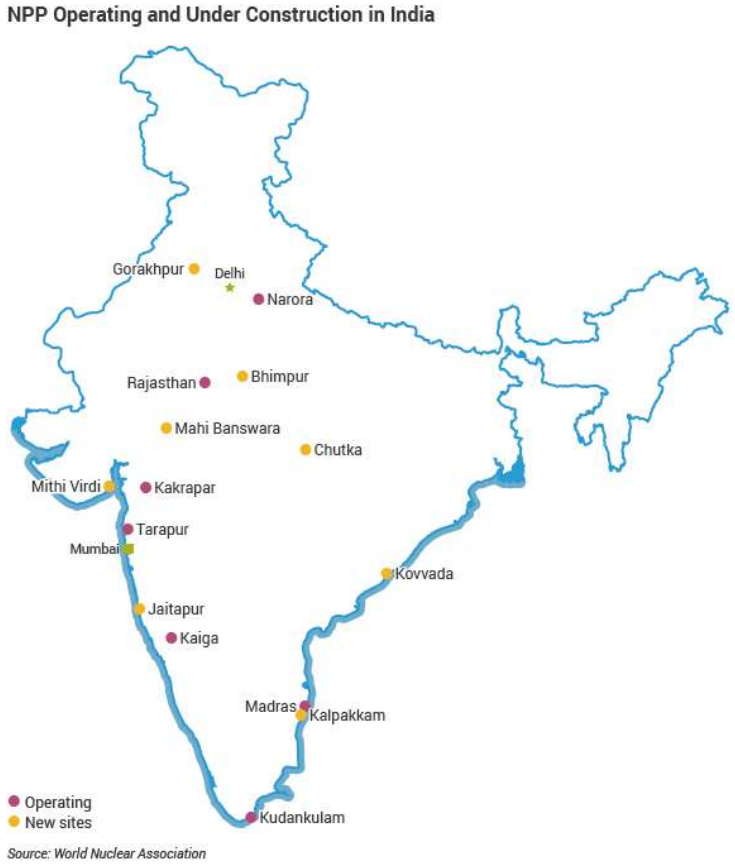
- **Self reliance through R & D has been the hallmark**
- **Three stage power programme is based on modest Uranium and abundant Thorium resources. Plan is based on 'Closed Nuclear Fuel Cycle'**
- **Spent Fuel is reprocessed to Plutonium and residual Uranium-238, which fuels the breeder reactors of second stage.**
- **PHWR is selected being efficient producer of Pu required for the second stage.**

Nuclear Power in India

Operating Nuclear Power Plants

- India was the first country in Asia to operate a nuclear reactor
- India presently operates 22 nos. of Nuclear Reactors producing nearly 7520 MWe energy, which constitutes about 3% total energy production

PHWRs	Mwe
Tarapur	2 x 540
Kota	5 x 220
Kalpakkam	2 x 220
Narora	2 x 220
Kakrapar	2 x 220; 1 x 700
Kaiga	4 x 220
LWRs	
Tarapur	2 x 220
Kudankulam	2 x 1000
Total	**7520 MWe**



Upcoming Nuclear Power Plants

- The Government has recently accorded administrative approval and financial sanction for construction of 12 nuclear power reactors, making total number under this category to 16.

State	Location	Project	Capacity
Gujarat	Kakrapara	KAPS 3 & 4	2 x 700 MW
Rajasthan	Rawatbhata	RAPS 7 & 8	2 x 700 MW
Madhya Pradesh	Chutka	Chutka 1 & 2	2 x 700 MW
Karnataka	Kaiga	Kaiga 5 & 6	2 x 700 MW
Rajasthan	Mahi Banswara	Mahi Banswara 1 & 2	2 x 700 MW
Haryana	Gorakhpur	GHAVP 1 & 2	2 x 700 MW
Rajasthan	Mahi Banswara	Mahi Banswara 3 & 4	2 x 700 MW
Light Water Reactor (LWR) to be set up in co-operation with Russian Federation			
Tamil Nadu	Kudankulam	KKNPP 5&6	2 x 1000 MW

LWRs Under Planning

Sl. No.	Site	Type of Reactor	Unit Capacity (MWe)	No. of Units	Total Capacity (MWe)
1	Kudankulam (2-6)	VVER	1000	4	4000
2	Kudankulam (7-12)	VVER	1200	6	7200
3	Jaitapur (1-6)	EPR	1650	6	9900
4	Kovvada (1-6)	AP-1000	1000	6	6000
5	Kavali	VVER	1000	6	6000
6	Chhya-Mithi Virdi	AP-1000	1250	6	7500
				Total	40,600

Expansion of Nuclear Power in India

- The 220 MWe PHWR design has been standardized by utilizing the vast experience in the construction, operation and maintenance
- PHWR design has been successfully scaled up to higher capacities of 540 MWe (TAPS 3 & 4) and 700 MWe
- Based on this, 20 GWe is proposed to be generated through PHWRs out of the ambitious plan of generating 65 GWe of nuclear energy by the year 2050
- Towards this, 22 nos. of PHWRs of 700 MWe capacity are planned by NPCIL
- Presently 3 nos. of 700 MWe PHWRs are under advanced stages of completion at Rajasthan and Kakrapara

Programme	No. of Units	Capacity (MWe)
PHWR (Ind U))	18	9,400
PHWR (Imp U)	22	10,460
LWR	34	40,600
FBR	9	4,500
Total Installed By year 2050	83	64,960

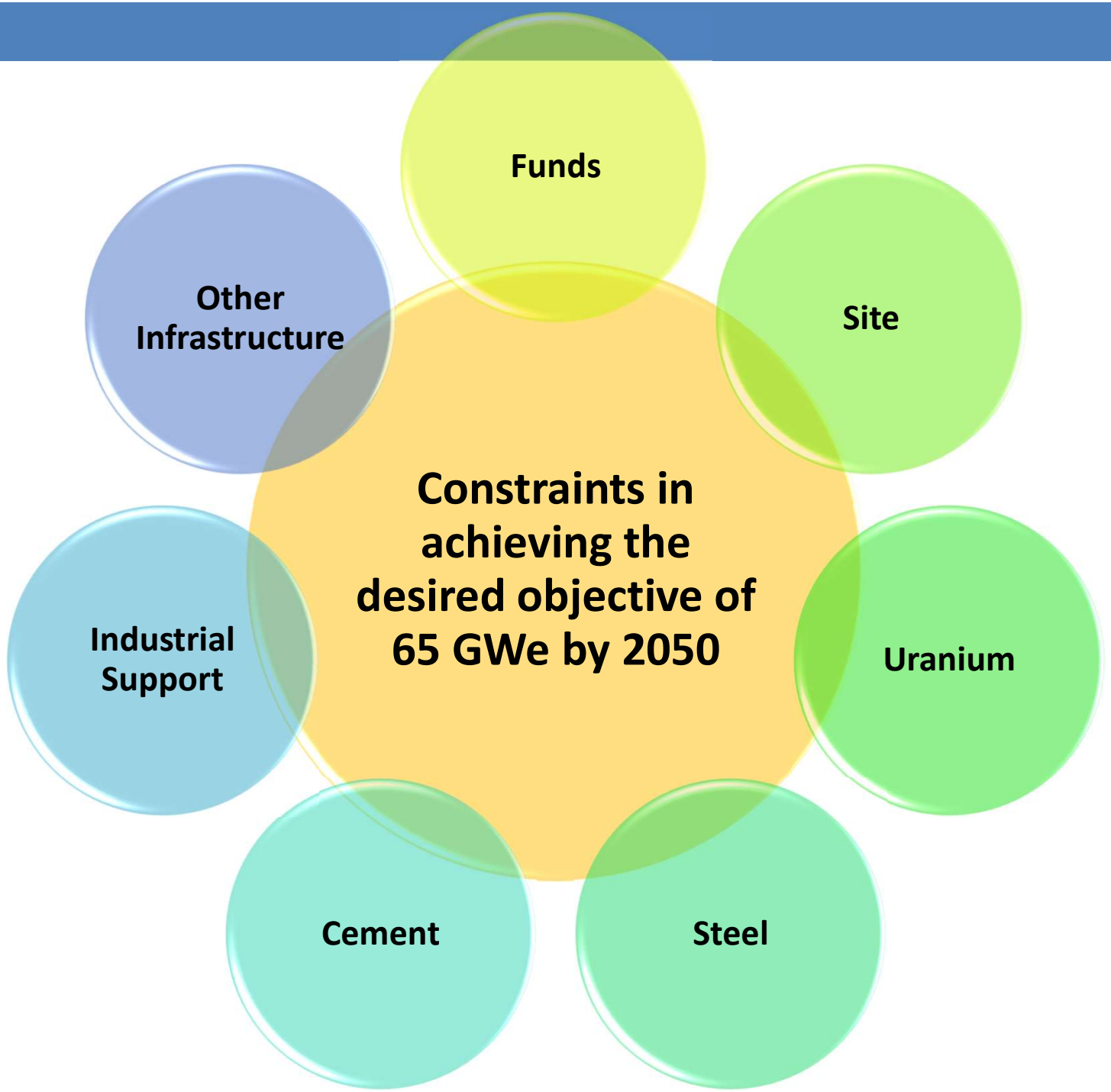
220 MWe RAPS - 1

540 MWe TAPS - 3

700 MWe KAPS - 3

Indian Nuclear Power Programme by 2050

- Energy consumption per capita in India is 1208 kWh, which is around 3 times lower than world average.
- To cope up with the current rate of rise of population and match world average per capita energy consumption, energy production in the country has to *increase at least 4 to 5 folds by 2050*.
- Nuclear, being the best alternative source of energy, needs to enhance its capacity to meet about *10%* of nation's total energy demand through PHWRs, LWRs and FBRs.
- By 2050, some of the present reactors will be decommissioned and accordingly the power generation will vary.


Funds
Other Infrastructure
Site
Constraints in achieving the desired objective of 65 GWe by 2050
Industrial Support
Uranium
Cement
Steel

Sites

- Densely populated country and difficult to find potential sites for nuclear power plants. Maximize utilisation of sites by locating multiple units and co-locating other facilities.
- Sites for PHWRs: Kakrapara, Gujarat; Kota & Mahi Banswara, Rajasthan; Gorakhpur, Haryana; Chutka & Bargi, Madhya Pradesh; Kaiga, Karnataka
- Sites for LWRs: Kudankulam, Jaitapur, Mithi Virdi, Kovvada, Kavali.

Sites …contd

- Sites for FBRs: Needs to be located at coastal sites due to large water requirement. Finding suitable sites is likely to be a big challenge, as the coast line is heavily populated.
- FBR 1&2 (MOX) will come up at Kalpakkam. Sites are also required for Structural and other reactor components, Fuel Production Facilities, Reprocessing and Waste Management Plants, Sodium and Boron Production.
- Capacity addition planned through existing well developed reactor & fuel cycle technologies and with inputs from industries.

PHWRs

- Reached a stage of commercial maturity after successful passage through Demonstration, Indigenisation, Standardization and Commercialization. Availability factors are quite high with continuous runs and capability to handle all the related activities comprehensively by NPCIL.
- Moved from 220  540  700 MW Sizes
- Can be run on natural Uranium or reprocessed Uranium or SEU.
- Lowest specific capital cost. Long operating experience of around **540 reactor-years**.

Fuel Cycle Facilities

- Uranium Mining and Milling
- Fuel Fabrication and Core Structurals
- Heavy Water
- Reprocessing and Waste Management

LWRs with International Cooperation

- Introduced as additionality to set up about 40,000 MW
- Vast experience with Boiling Water Reactors at Tarapur with over 50 years of operation
- Carried out major life extension and safety upgrades indigenously
- Valuable experience gained through implementation of VVER type Russian reactors at Kudankulam.
- Can confidently implement these nuclear power plants
- Planned from Areva-France, Westinghourse Electric Company of USA, Atomstroyexport-Russian Federation.

LWRs with International Cooperation ….Contd.

- Low enriched Fuel during the initial period will be imported. In the long term, enrichment facilities and fuel fabrication facilities will be created.
- Many key equipment like Reactor vessel, Steam Generators, will be indigenized.
- Spent fuel from LWRs will be cooled for about 5 years and reprocessed. Technology for reprocessing exists..

Fast Breeder Reactors

- Initially MOX based Fast Breeder Reactors will be used.
- The fuel from FBR core will be taken out in batches and reprocessed for extraction of Pu and U.
- New assemblies will be made with this material for fuelling the same FBR.
- Surplus Pu is accumulated over a period of time for fuelling future reactors.
- Sufficient experience has been gathered with over thirty year operation of Fast Breeder Test Reactor at Kalpakkam.
- Later, Metallic Fuel based FBRs, with shorter doubling time, will be launched.

Thank You

for your attention