PROSPECT ON THE PROJECTED QUANTITIES OF NUCLEAR SYSTEMS IN THE FUTURE

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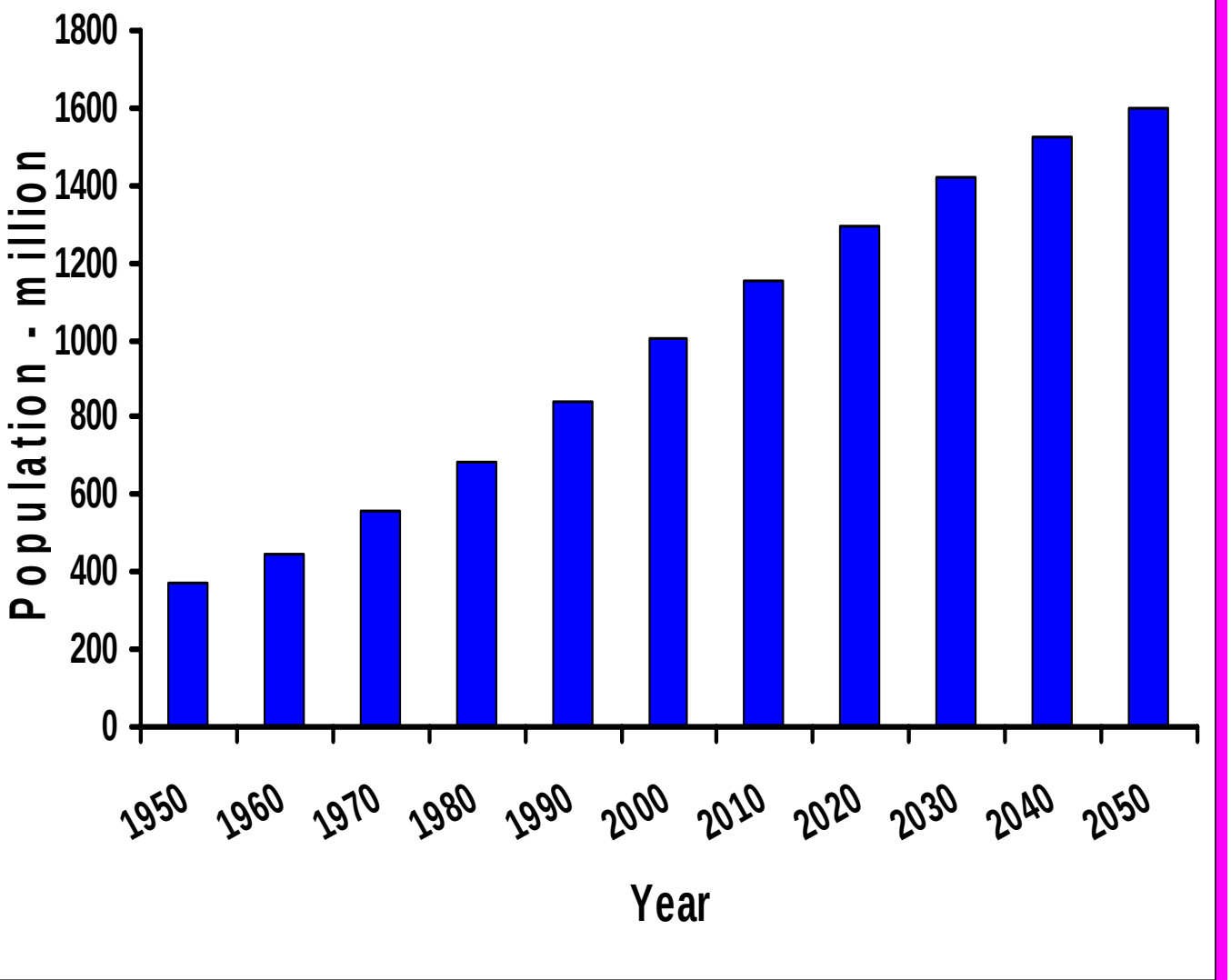
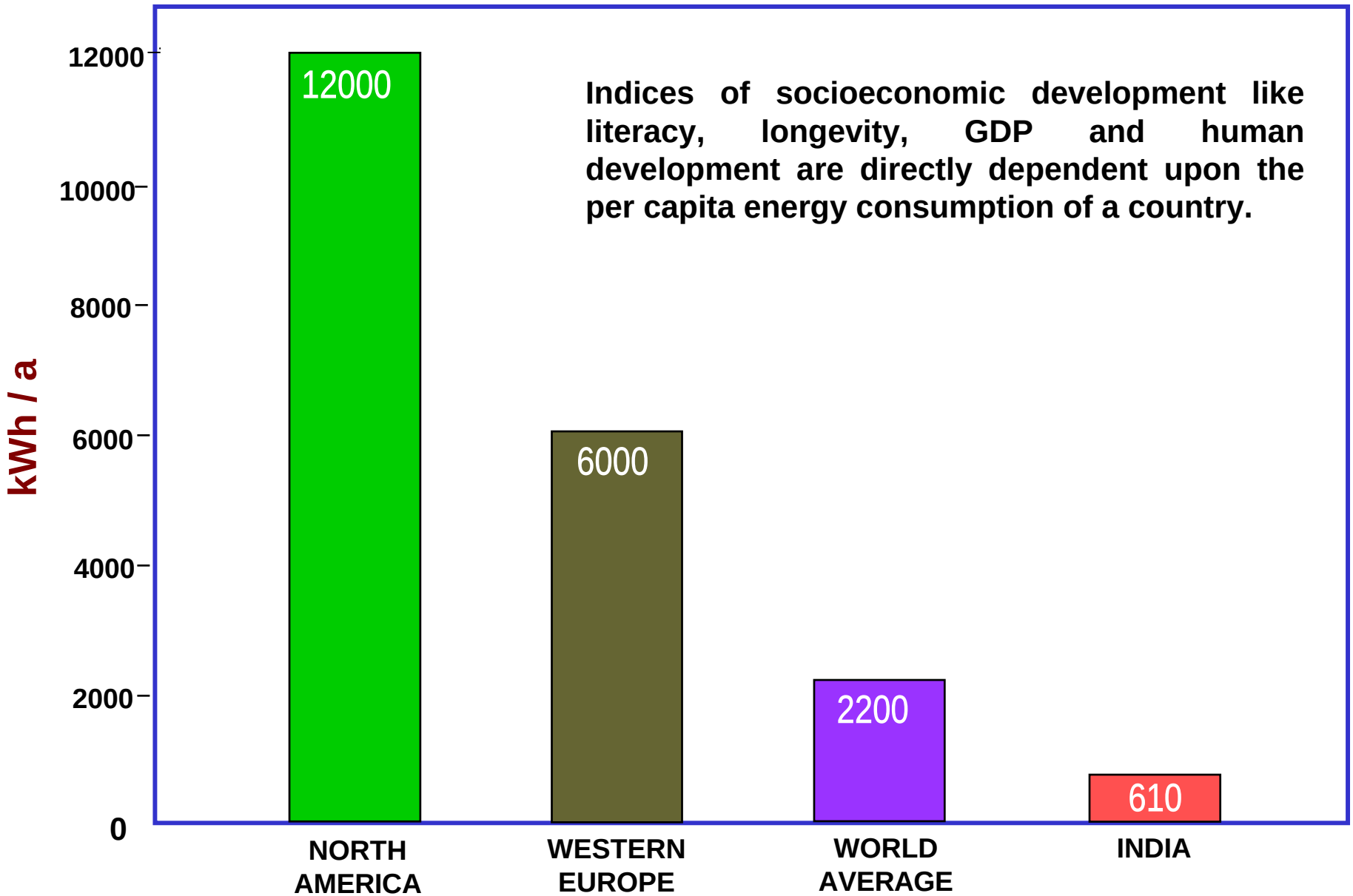
India – Population Growth



Growth Rate

Period	%
1950-60	1.9
1960-70	2.2
1970-80	2.1
1980-90	2.0
1990-00	1.8
2000-10	1.4
2010-20	1.2
2020-30	0.9
2030-40	0.7
2040-50	0.5

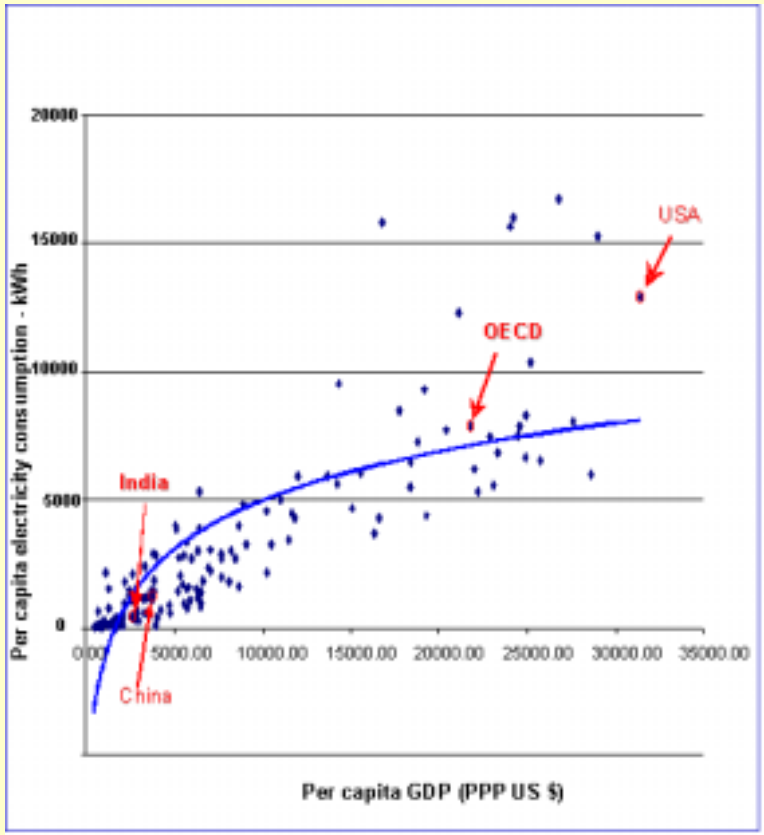
Per Capita Electricity Generation Worldwide



Indices of socioeconomic development like literacy, longevity, GDP and human development are directly dependent upon the per capita energy consumption of a country.

Energy Growth in India

- Strong correlation between per capita GDP and per capita electricity consumption.
- Forecasts point towards a robust GDP growth over the next 3 to 5 decades.
- A group in DAE studied available information on GDP growth forecasts, population growth, trends with regard to energy-GDP elasticity and electricity intensity of industries and developed a scenario for growth of electricity.



- Electricity-GDP Elasticity - 1.213 (3.0 during 60's)
- Primary Energy-GDP Elasticity - 0.907 (1.3 up to 70's)

Electricity growth rate – a scenario

Period	Primary energy % annual growth	Electricity % annual growth
2002-2022	4.6	6.3
2022-2032	4.5	4.9
2032-2042	4.5	4.6
2042-2052	3.9	3.9

Basis

Current GDP growth rate *~ 8 %*

Projected GDP growth rate up to 2050 *5 – 7 %*

Fall in Primary Energy Intensity & Electricity intensity *1.2 % / y*

Primary Energy – Cumulative usage

- Cumulative usage of coal by 2052 will be ~ 943 EJ as against domestic mineable reserves of 667 EJ.
- Cumulative hydrocarbon usage will be 912 EJ, projected availability is 511 EJ.
- Cumulative nuclear generation till 2052 will be 246 EJ, hydro will be 212 EJ and non-conventional will be 72 EJ.
- Cumulative primary energy usage will be 2385 EJ. Shortage of ~ 29% of the total.

Energy Scenario

➢ Energy Production as on March 2005

Power generation in 2004-05 was 587.7 billion KWh. Thermal, hydro and nuclear contribution were 82.7%, 14.5% and 2.8% respectively.

❖ **Total installed capacity (MWe) as on:**

		March	Aug. 2005
Thermal	-	80626	81061
Hydro	-	30818	31745
Nuclear	-	2720	3310
Total	-	114164	116116
Renewable	-	2488	6158
Total (with wind)		116652	122275

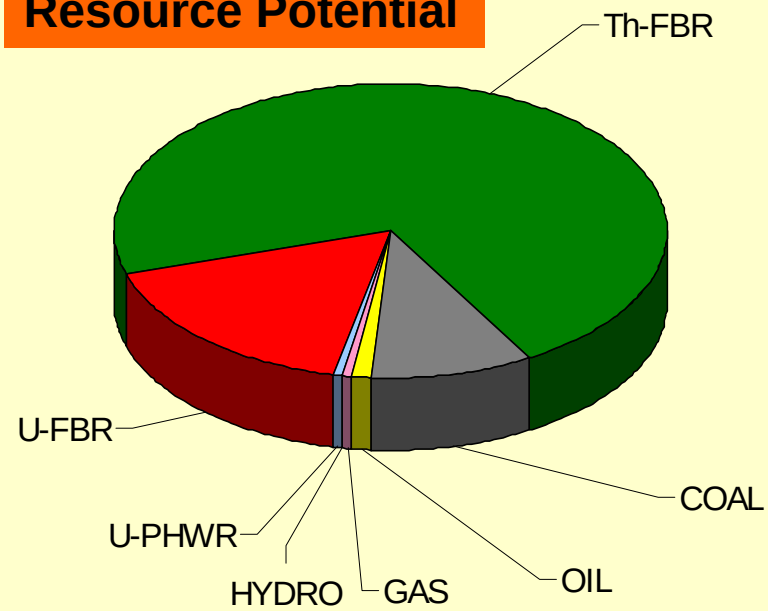
Indian Energy Growth Scenario

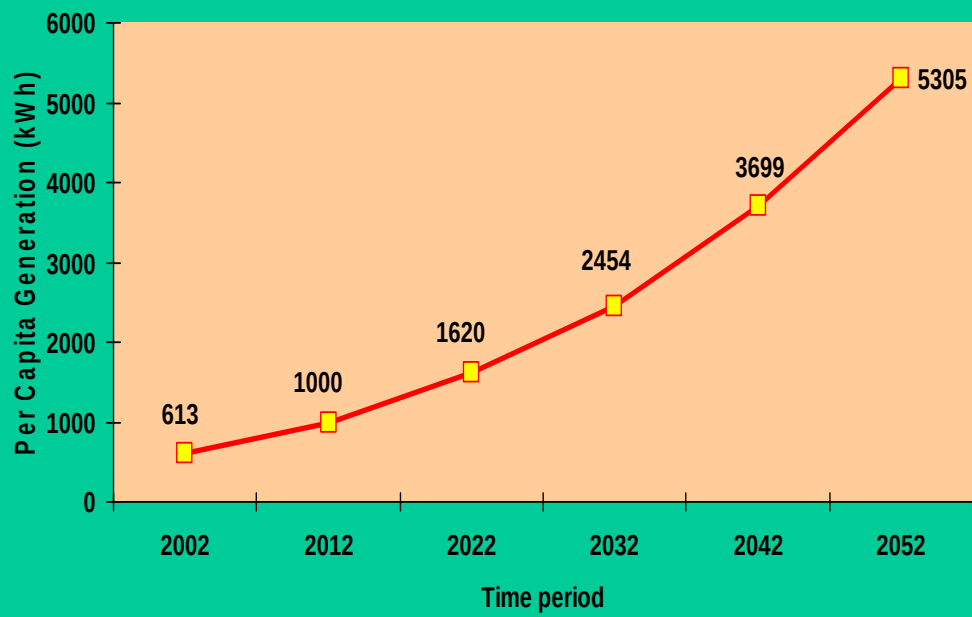
	2003-04	2052
➢ Electricity Generation (GWe)	112.0	~ 1344
➢ Nuclear Energy Share (GWe)	2.72	~ 275
➢ PHWR (GWe)	2.10	~ 0

➢ Faster Growth is needed to reach the target

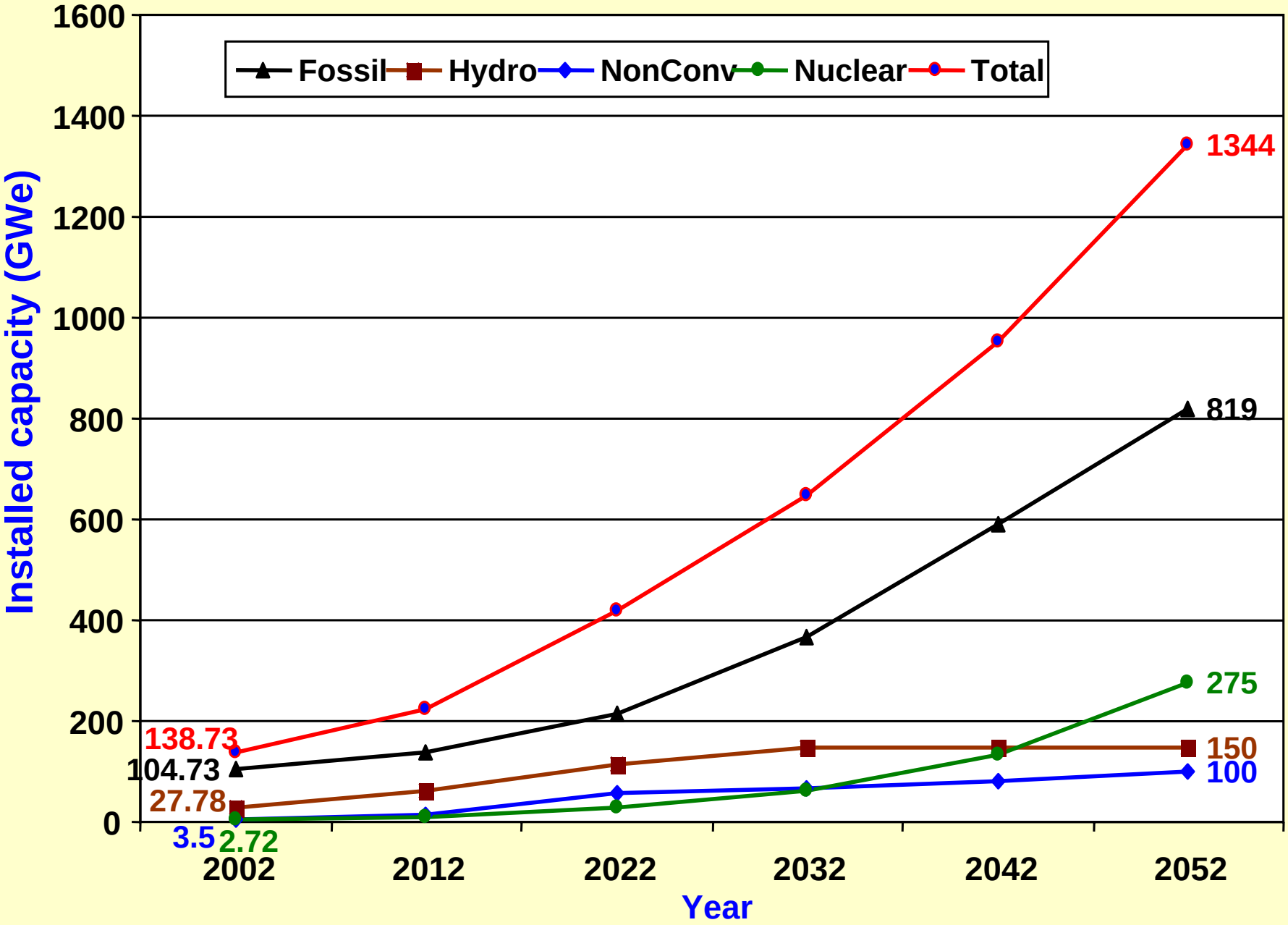
➢ FBR with Closed Fuel Cycle is inevitable

Resource Potential

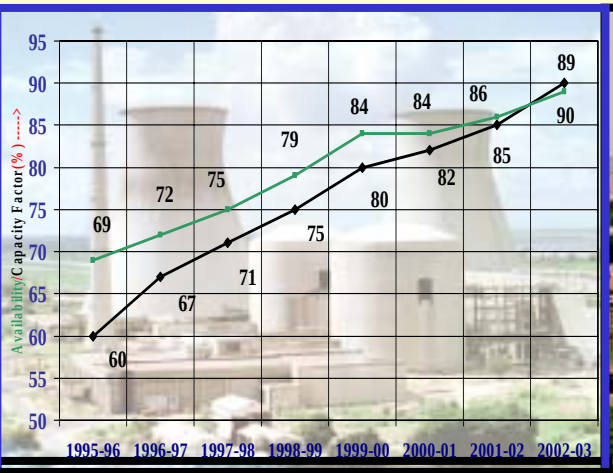


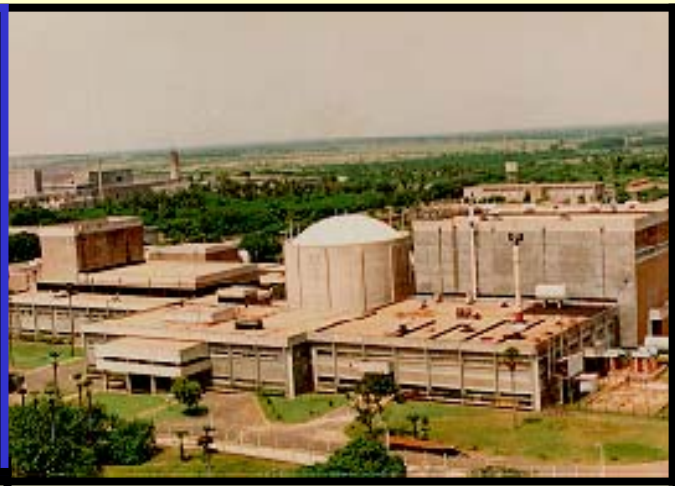


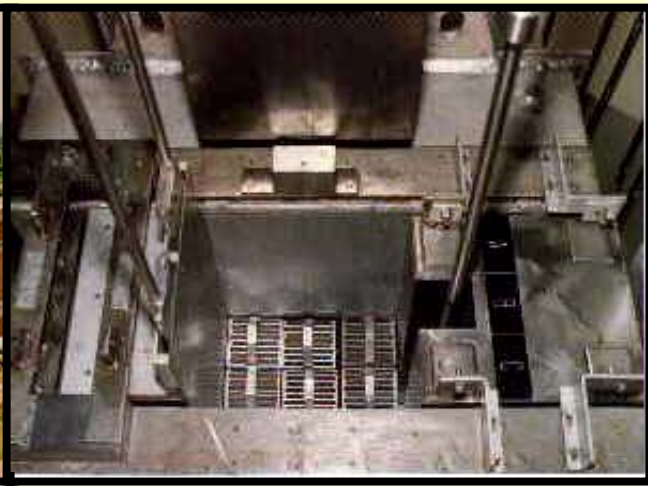
Projected Installed Power Capacity



THREE STAGE NUCLEAR POWER PROGRAM







Stage – I PHWRs

- 15- Operating
- 5 - Under construction
- Several others planned
- Scaling to 700 MWe
- Gestation period being reduced
- POWER POTENTIAL ≅ 10,000 MWe

LWRs

- 2 BWRs Operating
- 2 VVERs under construction

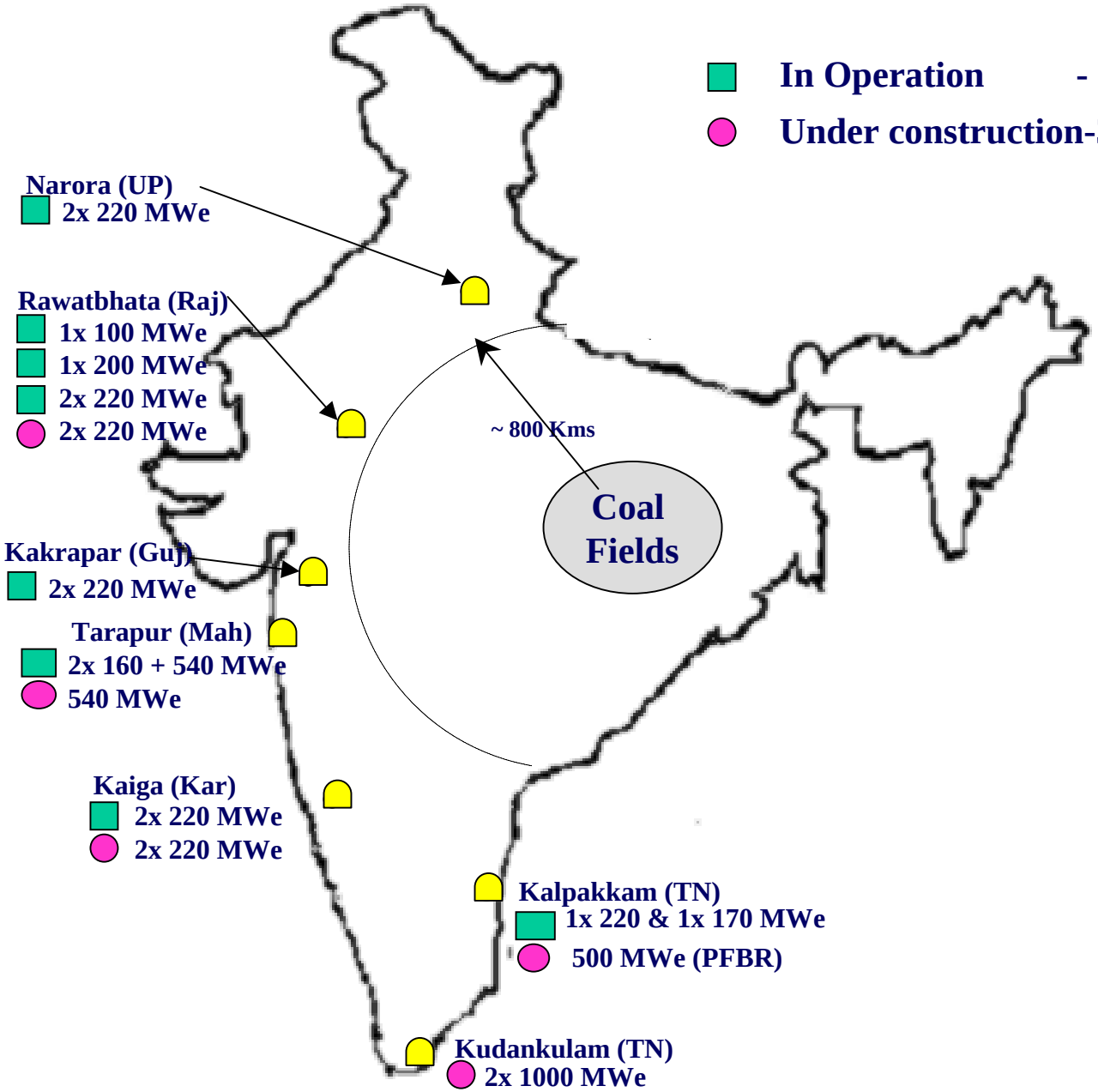
Stage - II
Fast Breeder Reactors

- 40 MWth FBTR - Operating
  Technology Objectives realised
- 500 MWe PFBR- construction commenced
- POWER POTENTIAL ≅ 540,000 MWe

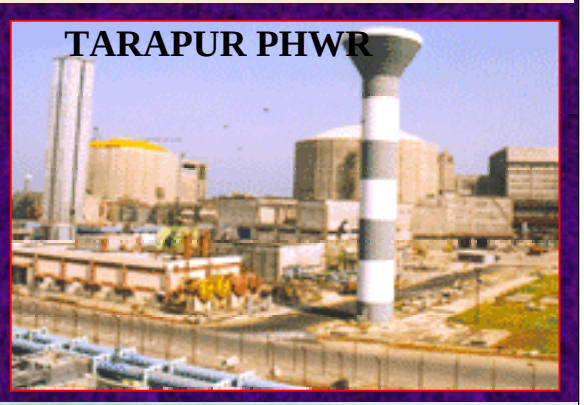
Stage - III
Thorium Based Reactors

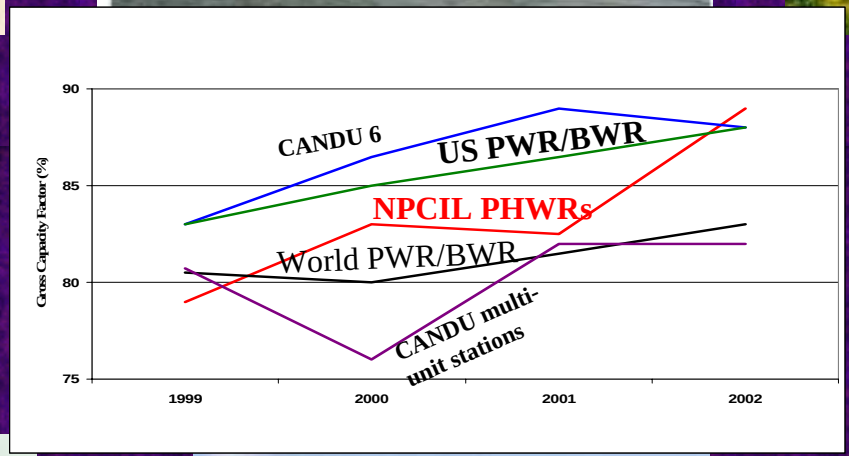
- 30 kWth KAMINI- Operating
- 300 MWe AHWR- Under Regulatory Examination
- POWER POTENTIAL ≅ Very Large. Availability of ADS can enable early introduction of Thorium on a large scale

Nuclear Power Plants in India



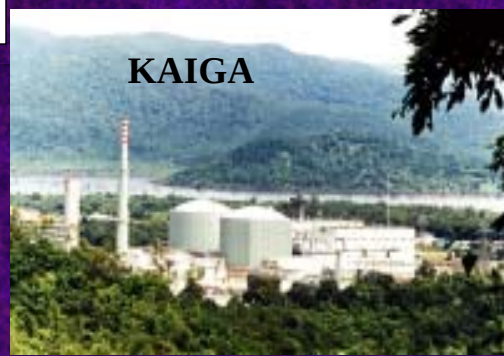
Operating Nuclear Power Plants in India





Participation in IAEA programmes

ISO 14001 and 9000 Certification



X PLAN CAPACITY ADDITION TARGET– 1300 MWe

Performance of Nuclear Power Plants

Unit	Rated capacity (MWe)	Generation (MU)	Capacity factor %
TAPS-1	*160*	*1276*	*91.0*
TAPS-2	*160*	*1311*	*93.5*
RAPS-2	*200*	*1321*	*75.4*
RAPS-3	*220*	*1470*	*76.3*
RAPS-4	*220*	*1649*	*85.6*
MAPS-1	*170*	*-*	*-*
MAPS-2	*220*	*1482*	*76.9*
NAPS-1	*220*	*1237*	*64.2*
NAPS-2	*220*	*1523*	*79.0*
KAPS-1	*220*	*1250*	*64.9*
KAPS-2	*220*	*1263*	*65.5*
KGS -1	*220*	*1515*	*78.6*
KGS -2	*220*	*1411*	*73.2*
TOTAL	*2670* **2500***	*16708****	*76.3****

*** Excluding MAPS-1

For April 2004 - March 2005

NPPs Under Construction

TAPS 3

Kaiga 3&4

KNPP-1&2

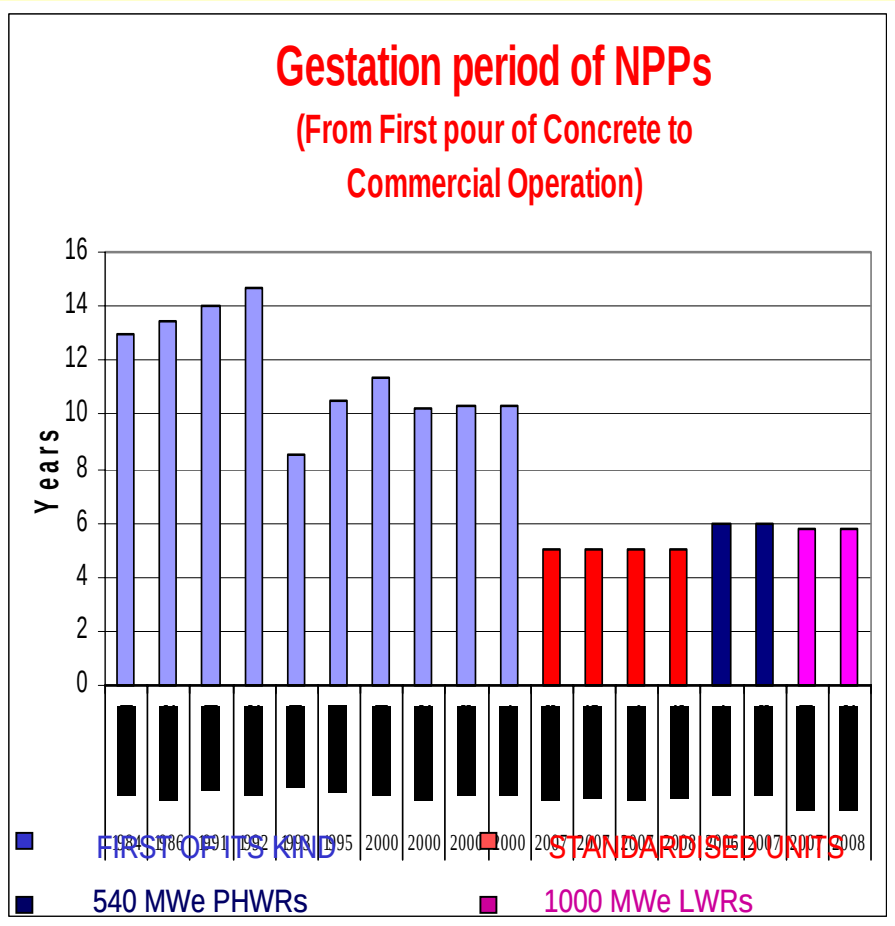
RAPP 5&6

Progress of Ongoing Projects

Project	Capacity MWe	Physical Progress June 05	Commercial Operation
TAPP -3&4 Tarapur , Maharashtra	2X540 PHWR	91.4% Completed	U3 – Jan 07 U4 – In operation
Kaiga -3&4 Kaiga Karnataka	2X220 PHWR	75.8% 55.7%	U3 – Mar 07 U4 – Sep 07
KK -1&2 Kudankulam Tamil Nadu	2X1000 LWR	57.3% 44.9% Ahead of schedule	U1 – Dec 07* U2 – Dec 08
RAPP -5&6 Rawatbhata Rajasthan	2X220 PHWR	66.1% 47.2%	U5 – Aug 07 U6 – Feb 08
PFBR Kalpakkam Tamil Nadu	500 FBR	Sanctioned in Sep. 2003, ~9%	Mar -2011

* EFFORTS ARE BEING MADE TO ADVANCE THIS PROJECT.

Construction- eight units under construction to add 3920 MWe in X & XI plan



Gestation period being reduced to nearly half of earlier.

For example, TAPP 4 completed in less than 5 yrs.

Efforts are also on to complete KK project ahead of schedule

NUCLEAR POWER CAPACITY ADDITION PROGRAMME

DETAIL	CAPACITY MWe	CUMULATIVE CAPACITY (MWe)
EXISTING CAPACITY		2820
X-PLAN ADDITION	1300	4120

PROJECTS UNDER CONSTRUCTION AND TO BE COMPLETED IN XI -PLAN.

KAIGA-4 – 220 MWe		
KK-1&2 – 2X1000 - 2000 MWe		
RAPP-5&6 – 2X220 - 440 MWe		
PFBR (Kalpakkam) – 500 MWe	3160	7280

PROJECTS TO BE TAKEN UP IN X PLAN AND TO BE COMPLETED IN XI –PLAN

AHWR-300 300 MWe		
LWR-3&4–2X1000- 2000 MWe*		
7NP-1 (PHWR) - 700 MWe$	3000	10280

*** Depending upon the developments – Access to nuclear fuel and reactors from the international market**
$ First of twin unit 700 MWe PHWRs.

The programme is to setup 20,000 MWe BY 2020

New starts in the X Plan

Units	Projected Financial Sanction
2X1000 MWe LWRs	2005-06
2X700 MWe PHWRs	December 2005
300 MWe AHWR	2005-06

Necessity of launching pre-project activities for additional 2X1000 MWe LWRs and 2X700 MWe PHWRs to enable project approval and commencement of construction in early XI Plan.

Construction of 4 NPP
Govt. of India accorded approval in Sep. 2005

COST REDUCTION MEASURES

- **Reduction of gestation period**
- **Increasing unit size**
- **Standardisation of designs, building a series of reactors of same design**
- **Reduction of other input costs (fuel and heavy water)**
- **Pooling of tariff at station level in the first instance and national level eventually will even out the tariffs of old and new stations.**

FURTHER NUCLEAR CAPACITY ADDITION

Additions to Nuclear Capacity

Import of PWR – Under Consideration

30,000 – 40,000 MWe; Unit size 1000 / 1400 MWe

Phased Manner & Reciprocal Basis

Public Acceptance

Safety Features and Safe Operating History

Additional sites

Identified in Central and Western India

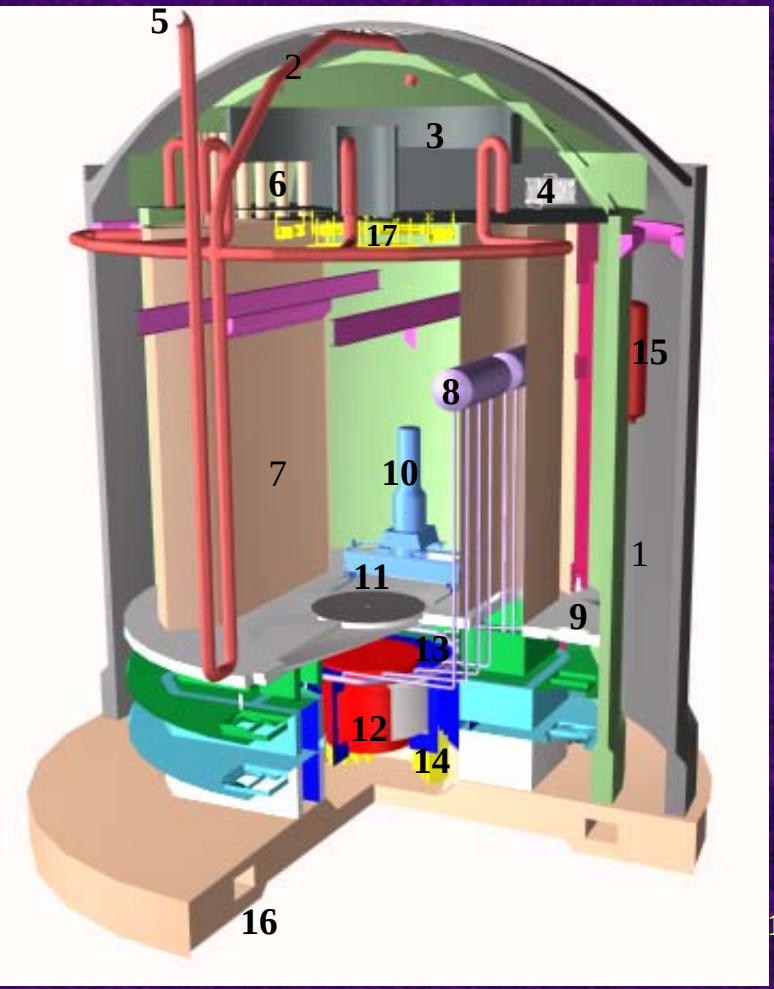
Inland Sites for 700 MWe & Coastal Sites for 1000 MWe

Augmentation at the existing sites – Sharing Infrastructure

Long term Energy Security

Three Stage Nuclear Power Program

ADVANCED HEAVY WATER REACTOR



1 Secondary Containment
2 Primary Containment
3 Gravity Driven Water Pool
4 Isolation Condenser
5 Passive Containment Isolation Duct
6 Vent Pipe
7 Tail Pipe Tower
8 Steam Drum
9 100 M Floor
10 Fuelling Machine
11 Deck Plate
12 Calandria with End Shield
13 Header
14 Pile Supports
15 Advanced Accumulator
16 Pre - Stressing Gallery
17 Passive Containment Cooler

- **BASIC DATA**

FUEL : U-233/THORIUM MOX + Pu-239/THORIUM MOX

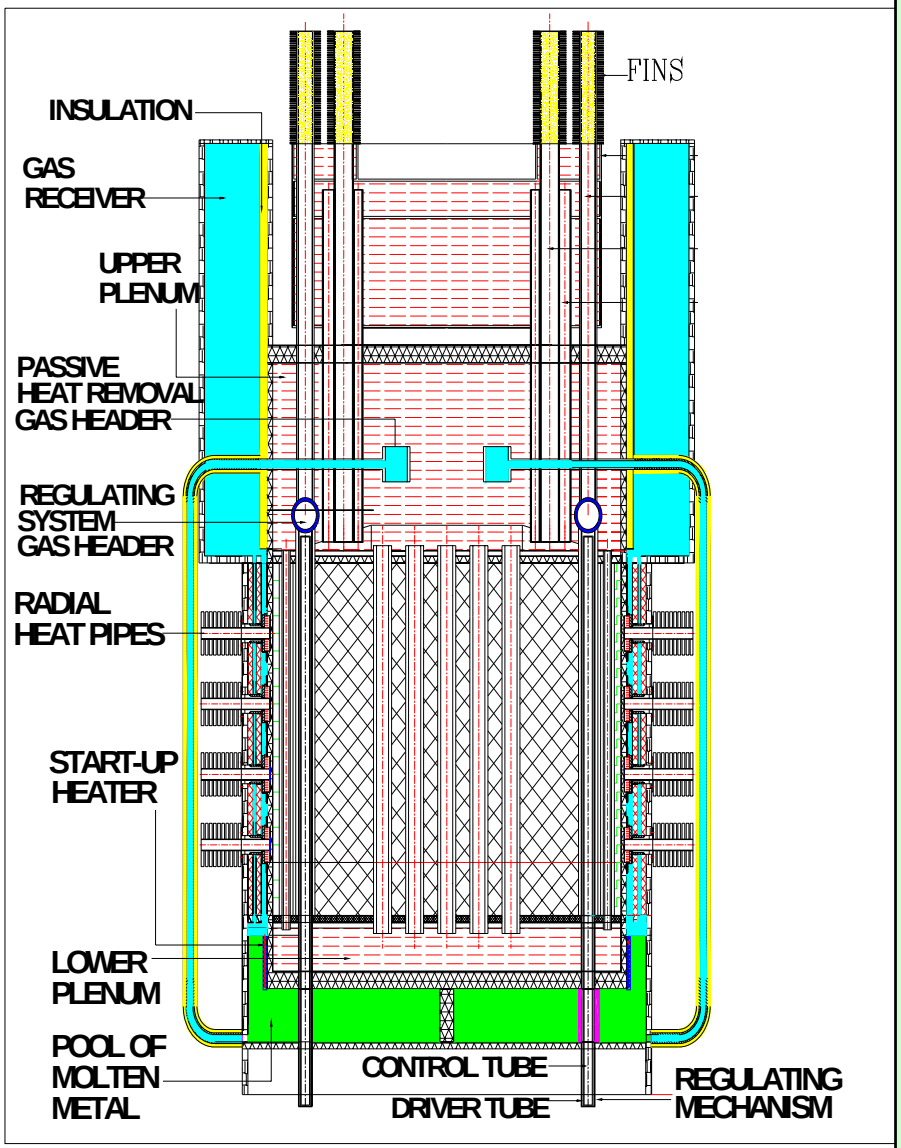
COOLANT : BOILING LIGHT WATER

MODERATOR : HEAVY WATER

POWER : 300 MW(e) 920 MW(t)

- **Structured peer review completed**
- **Pre-licensing design safety appraisal by AERB being initiated**

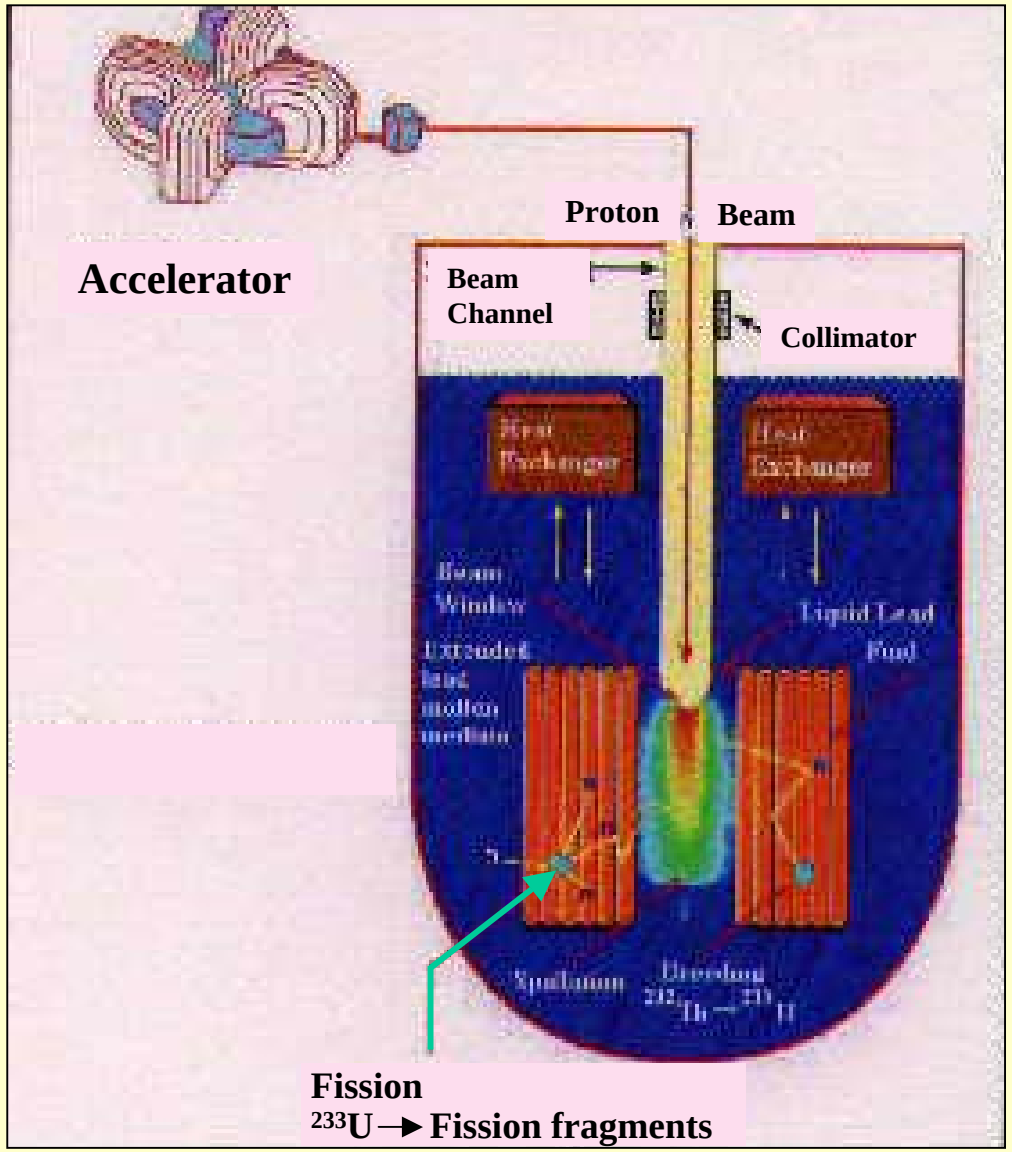
Compact High Temperature Reactor



- **Fluid fuel substitutes (Hydrogen)**
- **Other High Temperature heat applications**

ACCELERATOR BASED ENERGY TECHNOLOGY

- **Growth with Thorium systems**
- **Transmutation of long lived radionuclides**

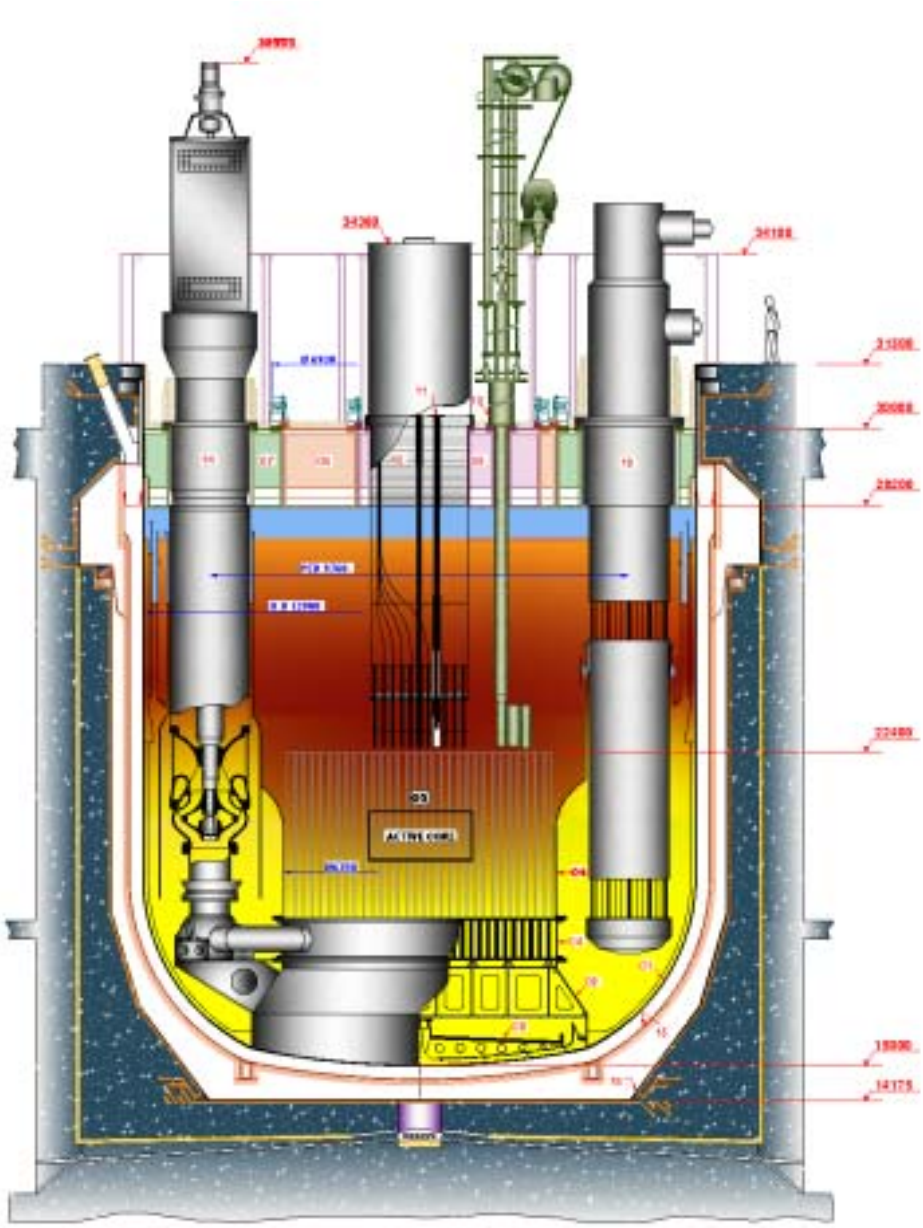


LONG TERM R&D EFFORTS NEEDED

Current FBR Programme

- India started FBR programme with the construction of FBTR
- FBTR is a 40 MWt (13.5 MWe) loop type reactor. The design is same as that of Rapsodie-Fortissimo except for incorporation of SG and TG (agreement signed with CEA, France in 1969).
- FBTR is in operation since 1985.
- 500 MWe Fast Breeder Reactor Project (PFBR) through Indigenous design and construction
- Govt granted financial sanction for the construction in Sep 2003.
- Construction of PFBR is in progress.

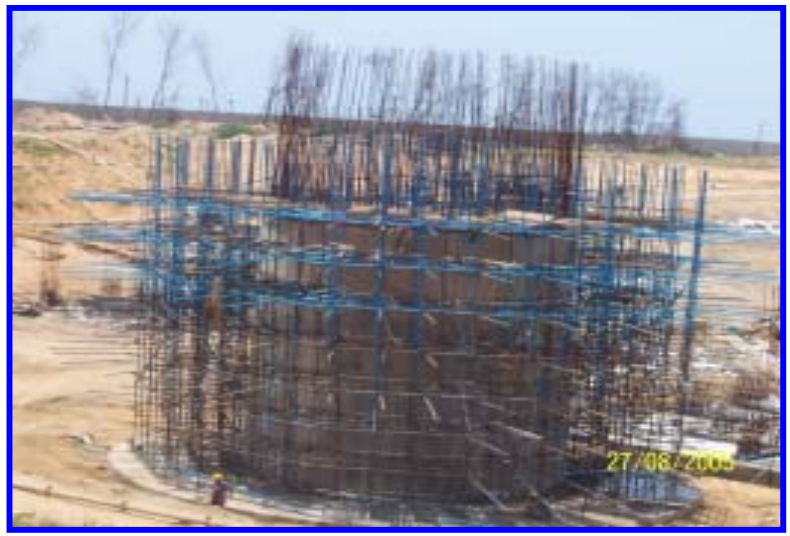
PFBR Reactor Assembly



01	Main Vessel
02	Core Support Structure
03	Core Catcher
04	Grid Plate
05	Core
06	Inner Vessel
07	Roof Slab
08	Large Rotating Plug
09	Small Rotating Plug
10	Control Plug
11	CSRDM / DSRDM
12	Transfer Arm
13	Intermediate Heat Exchanger
14	Primary Sodium Pump
15	Safety Vessel
16	Reactor Vault

Civil Construction Status of PFBR

Overall view of NICB



Ventilation stack

NICB at SGB1 side

DGB2 Footing and columns

PFBR Architectural View

PFBR will be commissioned by 2009.

PFBR and Its Fuel Cycle : Ensuring Its Success

HRD - Expertise in multi-disciplinary technologies over entire fuel cycle

Design - Choice of sound design concepts

- Peer reviews and Regulatory approvals

Comprehensive R&D

- Full scale testing of components in Air & Sodium
- Large Involvement within DAE
- Collaboration with Reputed R&D and Academic Institutions

Technology Development with Industrial Partnership

National Mission with Full support from academic and R&D institutions

Closing the Fuel Cycle- Industrial Expertise from Fabrication to Waste Management

FBRs beyond PFBR

- Design of FBR-500 with improved economy and enhanced safety (one design with possibility of changing to metallic fuel).
- Start of construction of two units of FBR-500 (one twin unit) by 2011 at Kalpakkam
- Start of construction of two units of FBR-500 (one twin unit) by 2012 at other prospective site
- Subsequent Reactors would be 1000 MWe units with metallic fuel.

Fast Breeder Reactors

Towards sustainable energy