Development of Nuclear Energy in India & Future program

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50th Annual Conference, JAIF

Enerdata intelligence + consulting

Global Energy Statistical Yearbook 2016

Electricity production

YEAR 2000

Unit: TWh | Highest ten

United States	4,053
China	1,356
Japan	1,059
Russia	878
Canada	606
Germany	577
India	570
France	540
United Kingdom	377
Brazil	349
South Korea	290
Italy	277

7

YEAR 2001

Unit: TWh | Highest ten

United States	3,865
China	1,482
Japan	1,040
Russia	891
Canada	590
India	588
Germany	586
France	550
United Kingdom	385
Brazil	329
South Korea	311
Italy	279

6

YEAR 2002

Unit: TWh | Highest ten

United States	4,051
China	1,655
Japan	1,058
Russia	891
India	611
Canada	601
Germany	587
France	559
United Kingdom	387
Brazil	346
South Korea	332
Italy	285

5

YEAR 2011

Unit: TWh | Highest ten

China	4,716
United States	4,350
India	1,075
Russia	1,055
Japan	1,051
Canada	633
Germany	613
France	561
Brazil	532
South Korea	523
United Kingdom	367
Italy	303

3

YEAR 2015

Unit: TWh | Highest ten

China	5,682
United States	4,324
India	1,368
Russia	1,062
Japan	995
Germany	638
Canada	632
Brazil	586
France	569
South Korea	546
United Kingdom	338
Saudi Arabia	336

3

Growth of Power Production in India

Energy Resources

- All resources have to be optimally deployed.
- Nuclear: Modest uranium and abundant thorium resources

The Nuclear Power Program aims at achieving energy independence in the long run beyond 2050 by following a closed fuel cycle strategy

India's Energy Resource Base

	Amount	Electricity Potential¤ GWe-yr
Coal	53.3 -BT	10,660
Hydrocarbon	12 –BT	5,833
Uranium-Metal	61,000 -T	
- In PHWR		328
- In Fast Breeders		42,231
Thorium-Metal (In Breeders)	2,25,000 –T	155,502
Hydro	150 -GWe	69 GWe-yr / yr
Non-conv. Ren.	100 -GWe	33 GWe-yr / yr

Assuming entire resource is used for generating electricity.

Currently known resources (including coal bed methane) are 3 BT.

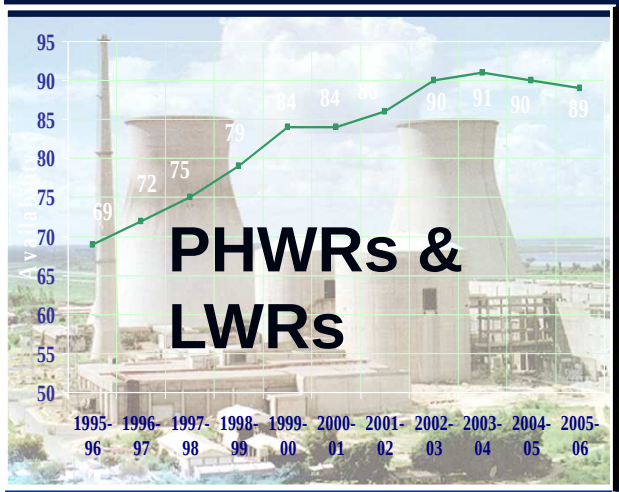
Installed Capacity (March 2017)

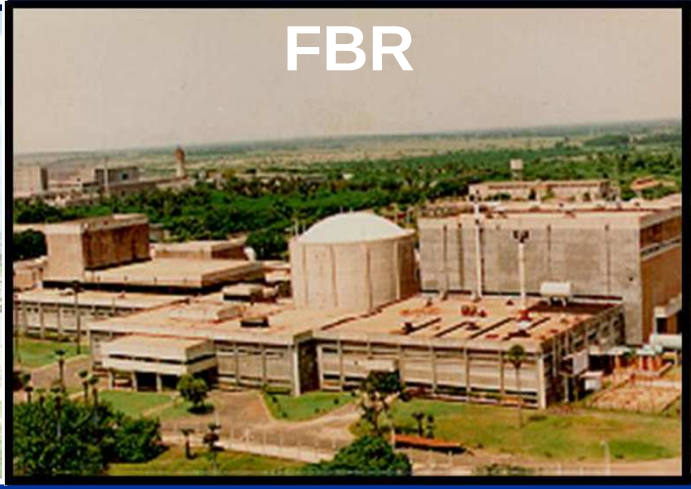
Fuel	MWe
Total Thermal	215,840
Coal	190,000
Gas	25,000
Oil	840
Hydro	44,000
Nuclear	**6,780**
Renewable	50,000
Total	**316,620**

Excluding Captive Generation 47 ,300 MWe

Atomic Energy Commission
ATOMIC ENERGY REGULATORY BOARD
AERB
DAE
ATOMS IN THE SERVICE OF THE NATION
BHAVINI
NPCIL
UCIL
NFC
BARC
IGCAR
RAJA RAMANNA CENTRE FOR ADVANCED TECHNOLOGY, INDORE
Variable Energy Cyclotron Centre
Service Organisations
Aided Institutions

Three Stage Nuclear Power Programme





Stage – I

Thermal Reactors

- 22– Operating
- 8- Under construction
- Several others planned

Stage - II

Fast Breeder Reactors

- 40 MWth FBTR - Operating since 1985 Technology Objectives realised
- 500 MWe PFBR- Under Construction

Stage - III

Thorium Based Reactors

- 30 kWth KAMINI- Operating
- 300 MWe AHWR- Ready to be launched

Execution of Nuclear Power Program

Only two Central Public Sector Companies can set up Nuclear Power Plants, as per the present Atomic Energy Act

- **Thermal Reactors (First Stage) : NPCIL**
- **Fast Breeder Reactors**

(Second Stage) : BHAVINI

एनपीसीआईएल
NPCIL

THE JOURNEY OF NPCIL

Over 25 years of safe nuclear power generation

2017
6780
MW

PPED
1967

APA
1970

NPB
1984

एनपीसीआईएल
NPCIL
1987

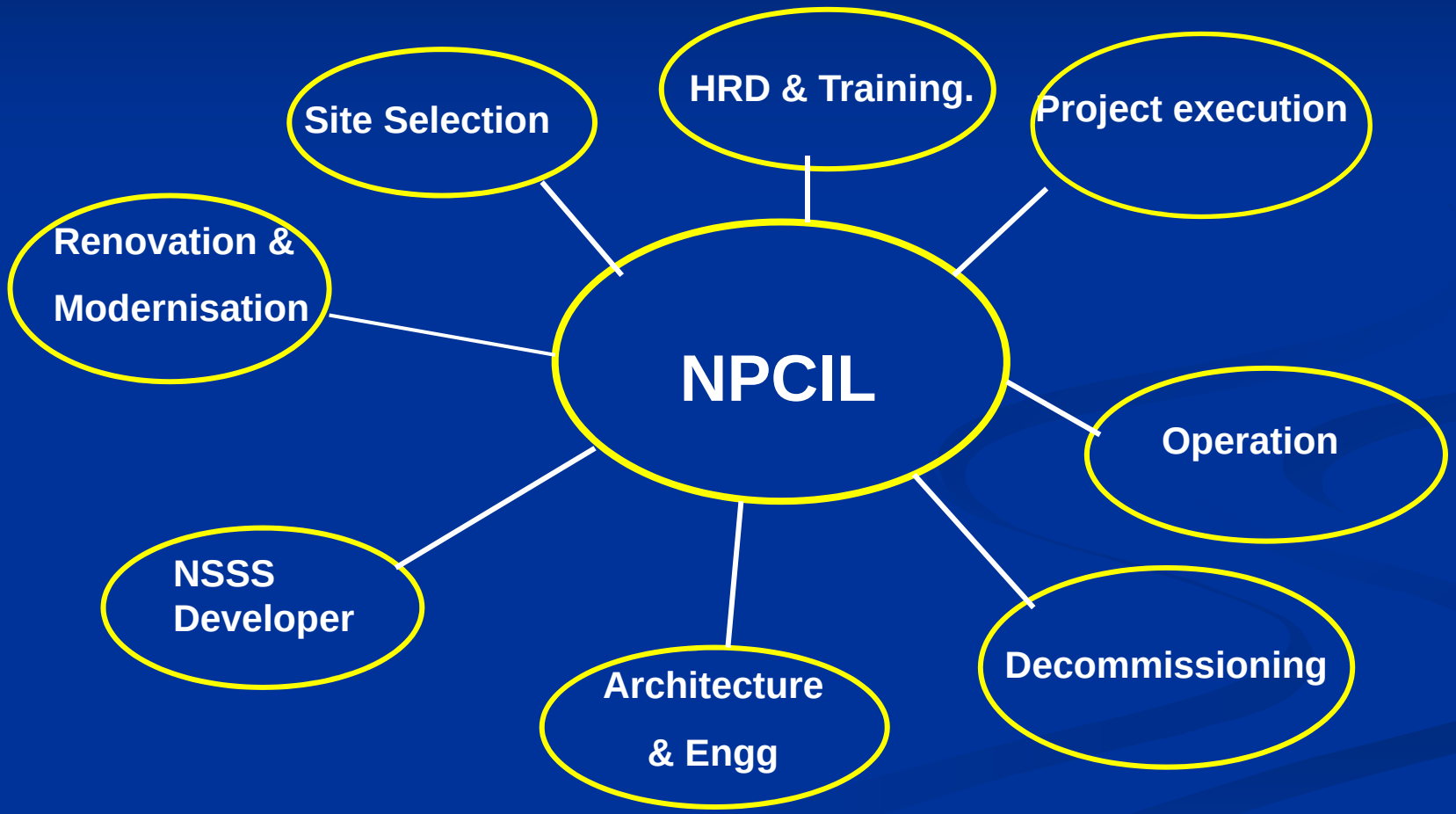
TAPS
1969

RAPS
1973
1981

MAPS
1984
1986

1060
MW

Areas of Expertise in NPCIL



Launch of Program

Technology Demonstration

Tarapur Units 1&2

1969 2x200 Mwe BWRs

M/s GEC USA on Turnkey basis

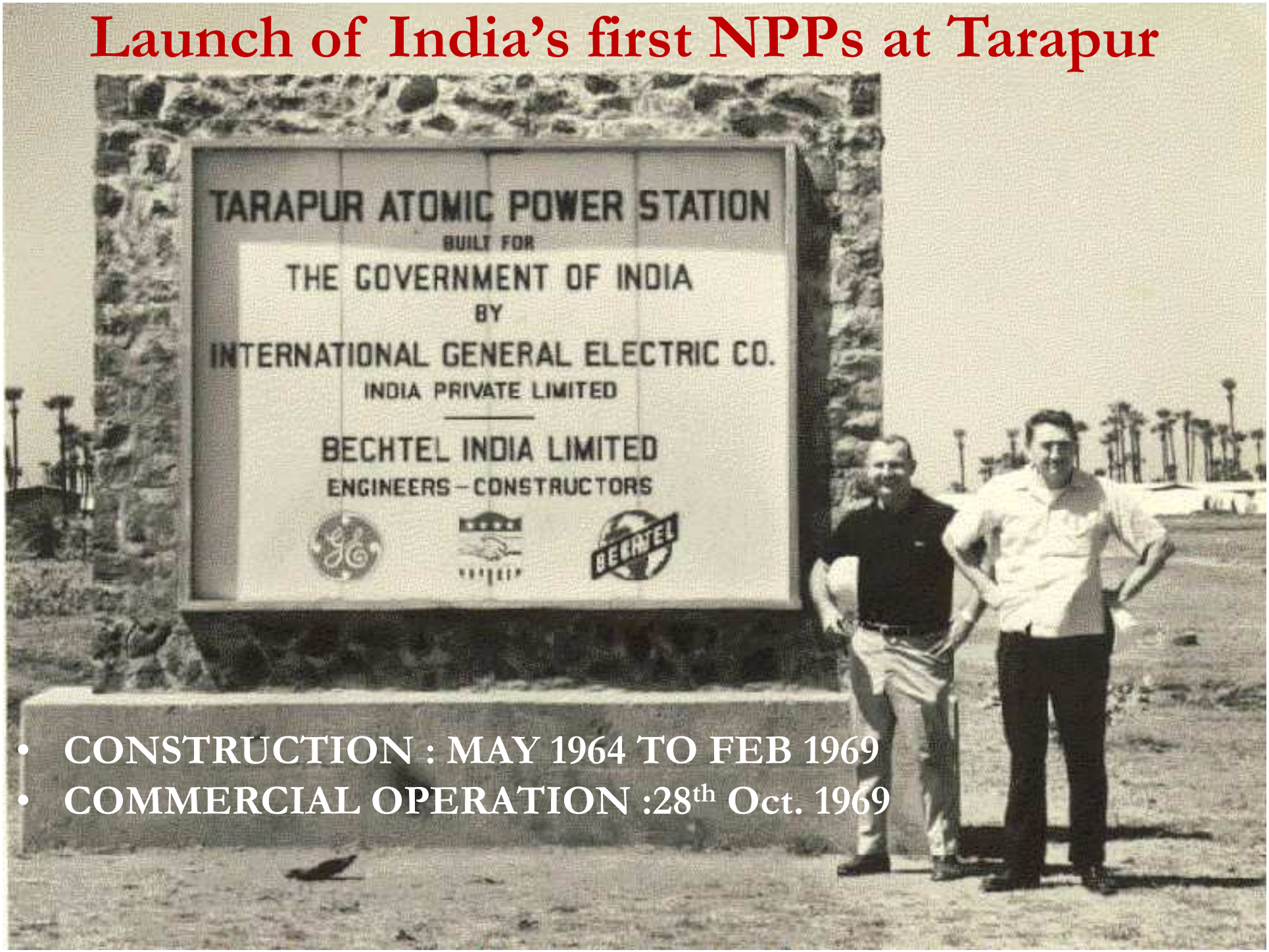
Technology Absorption

Rajasthan 1&2

1971, 2x220 Mwe PHWR

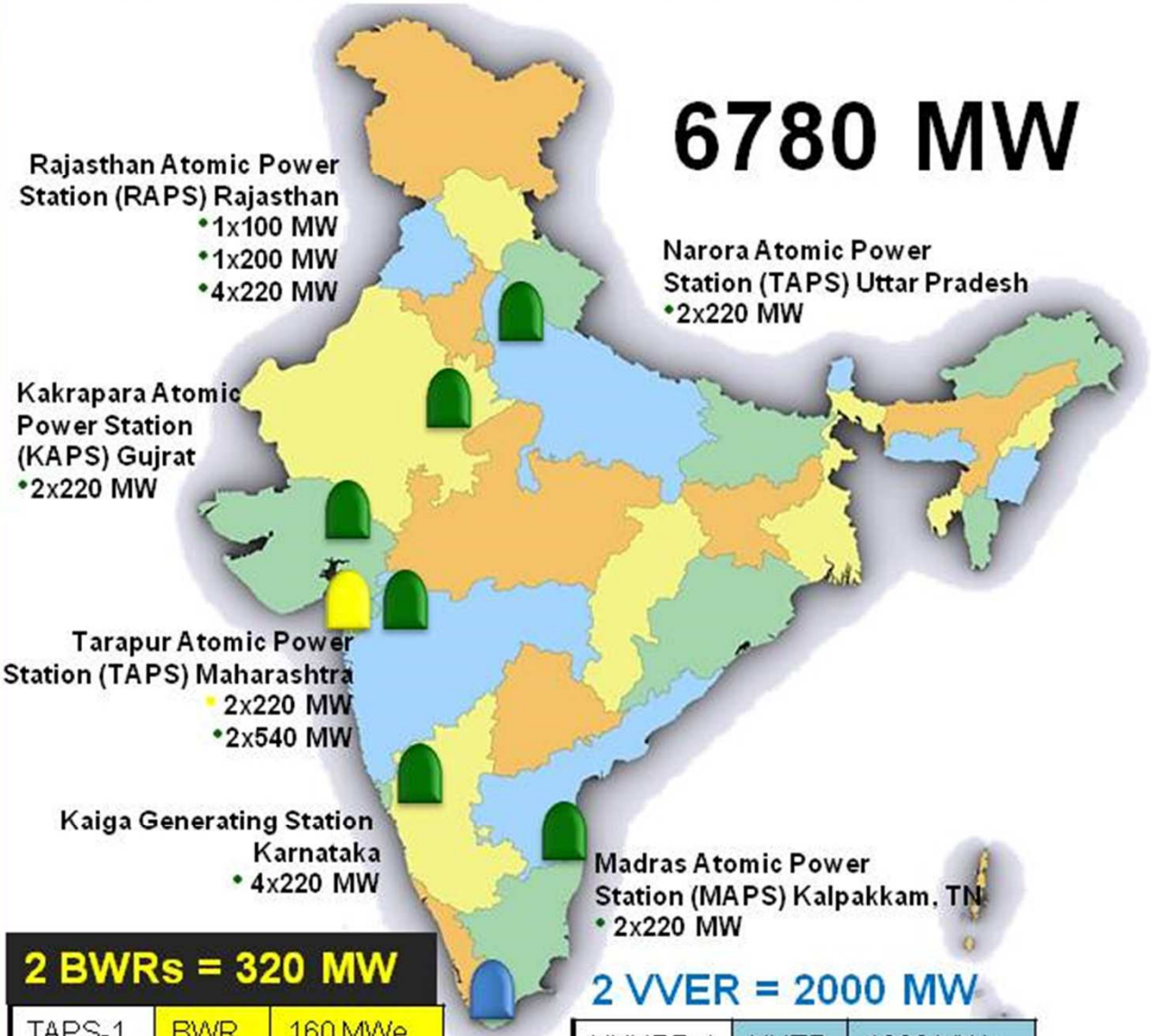
AECL Canada

Launch of India's first NPPs at Tarapur



- CONSTRUCTION : MAY 1964 TO FEB 1969
- COMMERCIAL OPERATION :28th Oct. 1969

Operating Reactors



2 BWRs = 320 MW

TAPS-1	BWR	160 MWe
TAPS-2	BWR	160 MWe

2 VVER = 2000 MW

KKNPP-1	VVER	1000 MWe
KKNPP-2	VVER	1000 MWe

18 PHWRs = 4460 MW

RAPS-1	PHWR	100 MWe
RAPS-2	PHWR	200 MWe
MAPS-1	PHWR	220 MWe
MAPS-2	PHWR	220 MWe
NAPS-1	PHWR	220 MWe
NAPS-2	PHWR	220 MWe
KAPS-1	PHWR	220 MWe
KAPS-2	PHWR	220 MWe
KAIGA-2	PHWR	220 MWe
RAPS-3	PHWR	220 MWe
KAIGA-1	PHWR	220 MWe
RAPS-4	PHWR	220 MWe
TAPS-4	PHWR	540 MWe
TAPS-3	PHWR	540 MWe
KAIGA-3	PHWR	220 MWe
RAPS-5	PHWR	220 MWe
RAPS-6	PHWR	220 MWe
KAIGA-4	PHWR	220 MWe

Kalpakkam, Tamil Nadu Site (KTS)

Rawatbhata Rajasthan Site (RRS)

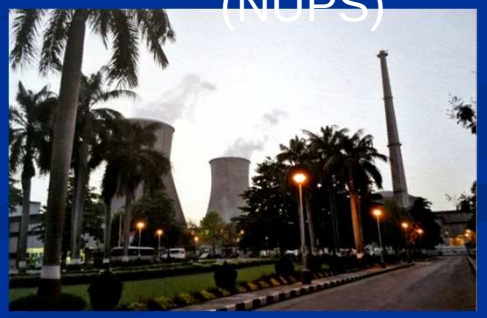
Tarapur, Maharashtra Site (TMS)

NPCIL Head Quarters, Mumbai, Maharashtra (NHQMM

Narora Uttar Pradesh Site (NUPS)

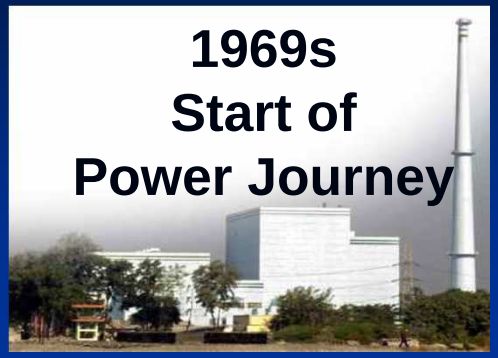
Kudankulam, Tamil Nadu Site (KTNS)

Kaiga, Karnataka Site (KKS)



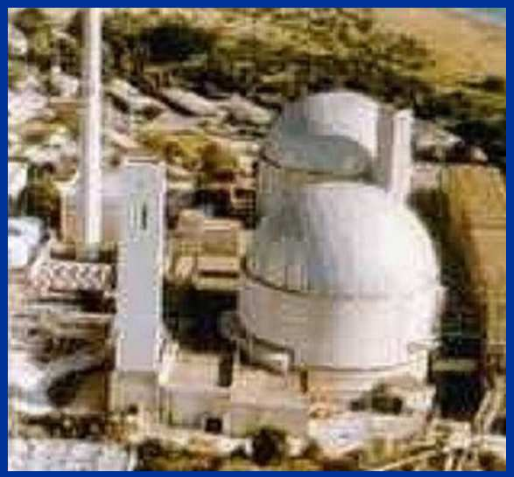
Kakrapar, Gujrat Site (KGS)

Journey SO- FAR



TAPS-1&2

1970s & 1980s
TECHNOLOGY DEMONSTRATION & INDIGENISATION of 220 MW



RAPS-1&2

MAPS-1&2

Journey SO- FAR

1990 & 2000
STANDARDISATION & CONSOLIDATION OF 220 MW

RAPP-3&4

KAIGA-3&4

NAPS-1&2

KAPS-1&2

KGS-1&2

RAPP-5&6

Journey SO- FAR

Scaling up & Serial Production

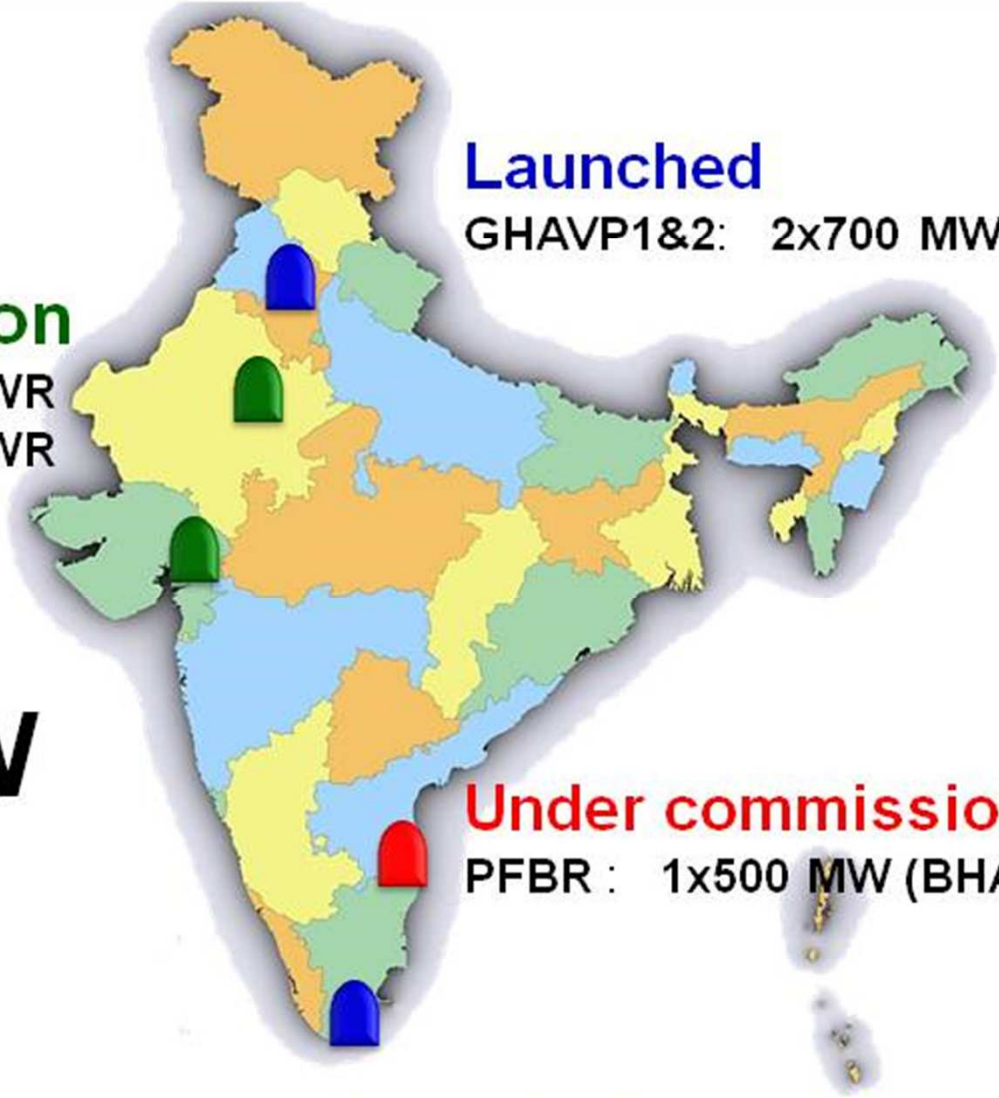
1000MW LWR KKNPP-1&2

Additionalities for rapid growth

700MWe
KAPP-3&4, RAPPP-7&8

540 MWe
TAPS-3&4

Reactors under Commissioning, Construction & launched



Launched

GHAVP1&2: 2x700 MW PHWR

Under construction

KAPP 3&4 :2x700 MW PHWR

RAPP 7&8 :2x700 MW PHWR

6700 MW

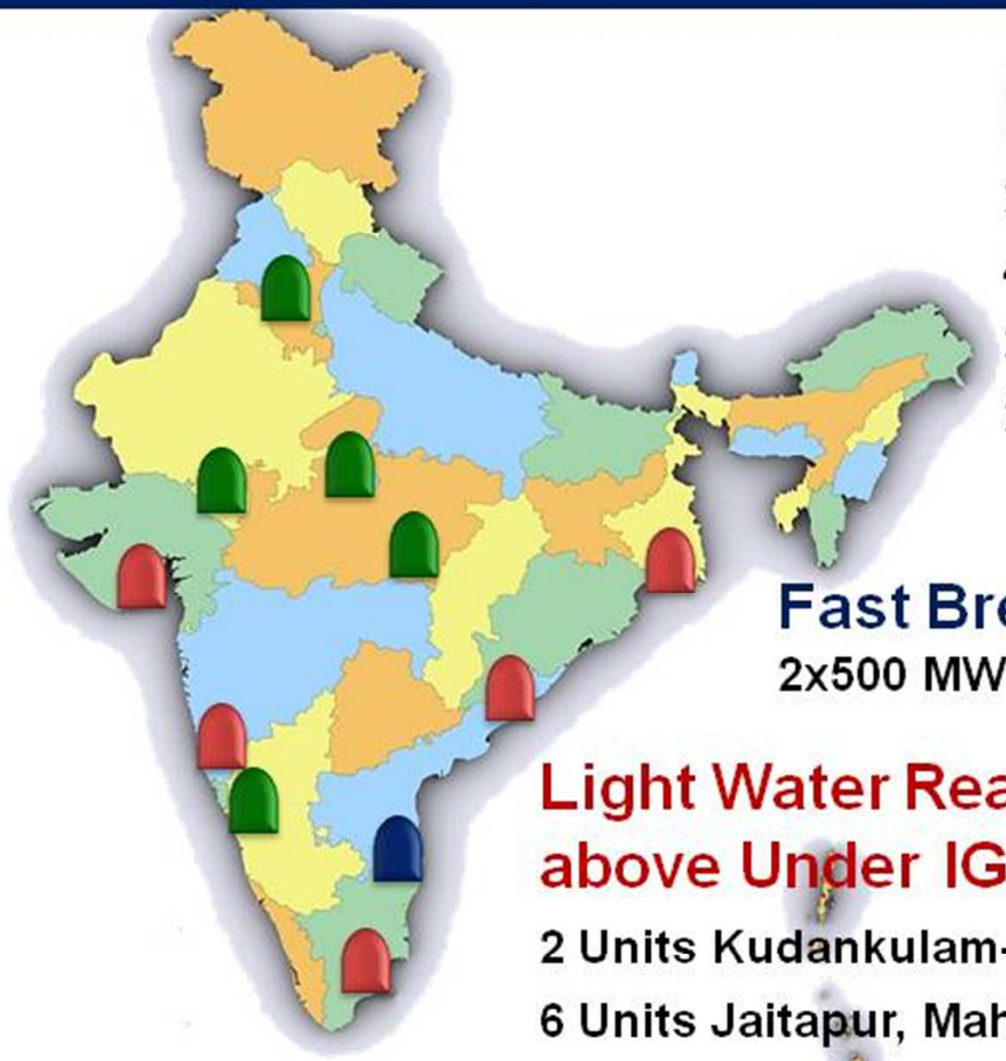
Under commissioning

PFBR : 1x500 MW (BHAVINI)

Launched

KKNPP 3&4 : 2x1000 MW LWR

Reactors under planning



Indian PHWRs

2x700 MW, Chutaka,MP

4x700 MW, Mahi-Banswara, Raj

2x700 MW, Kaiga,Karnataka

2x700 MW, GHAVP, Haryana

Fast Breeder Reactors

2x500 MW by Bhavini

Light Water Reactors OF 1000 MW and above Under IGA

2 Units Kudankulam-5&6, Tamil Nadu

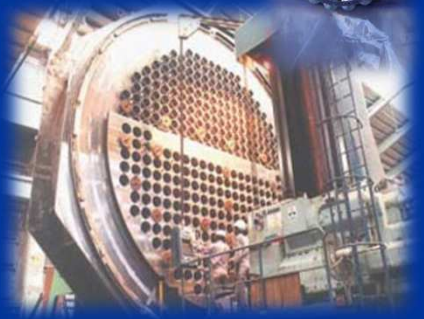
6 Units Jaitapur, Maharashtra

6 Units Kovvada, Andra Pradesh

6 Units Chhaya-Mithi Virdi,Gujarat.

6 Units Haripur, West Bengal

Established Indian industry



Indian industries have successfully developed comprehensive capabilities to meet the critical requirements of various nuclear components.

Evolution of Construction methodology

Open top construction
Mega Packages
Parallel Construction and Commissioning

The Indian Nuclear Industry Today

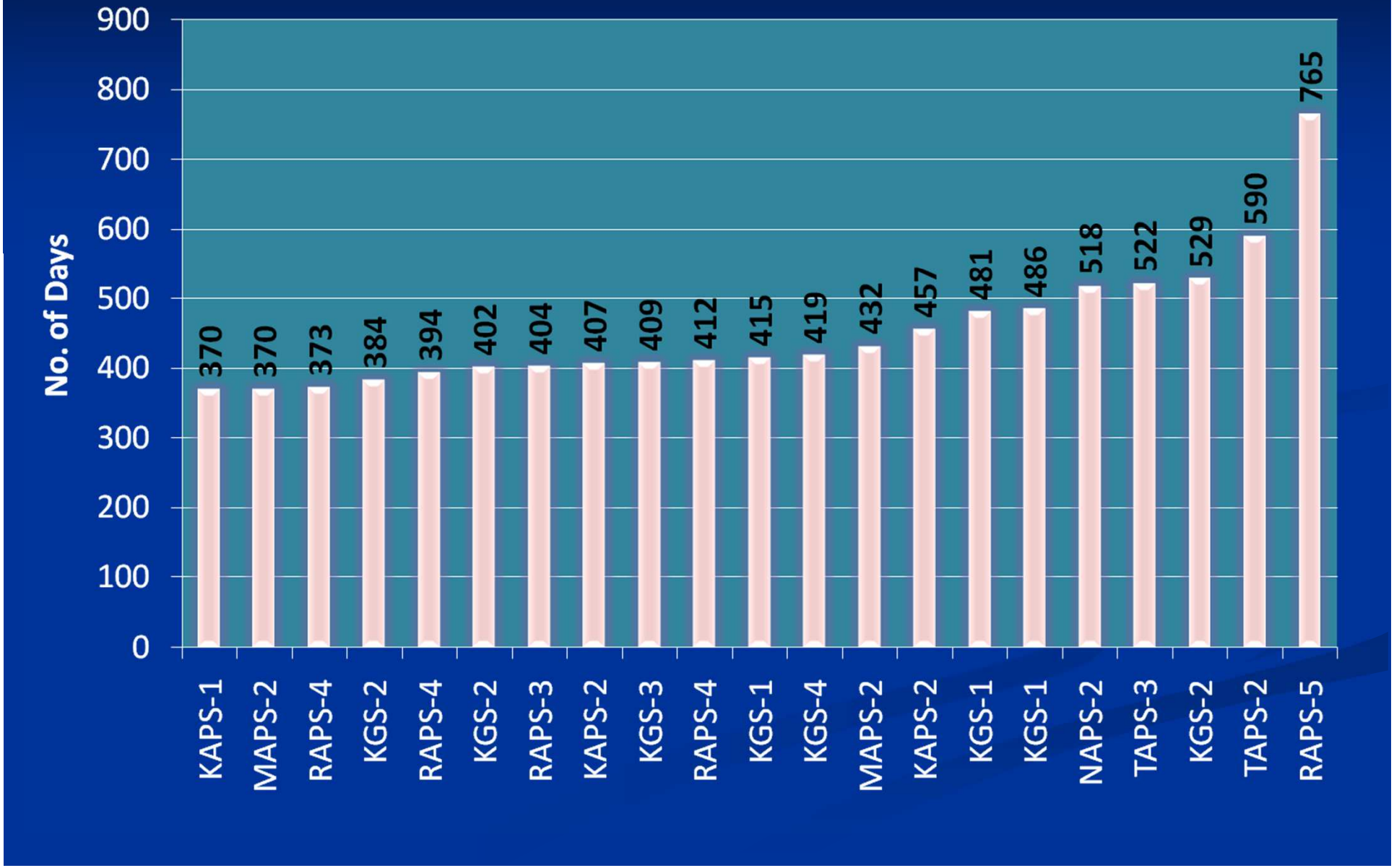
- Major Equipment Manufacturers
  - Pumps, Valves and Motors
  - Turbine Generators
  - Transformers & Switchgear
  - Instrumentation & Control Systems
  - Heat Exchangers

The Indian Nuclear Industry Today

- Engineering consultants
  - Civil
  - C &I
  - Conventional Systems
- Mega Package and EPC contractors.
- Reactor component manufacturers
  - Reactor vessel
  - Reactivity Mechanisms
  - Fuelling Machines
  - Steam Generators

Operating Performance

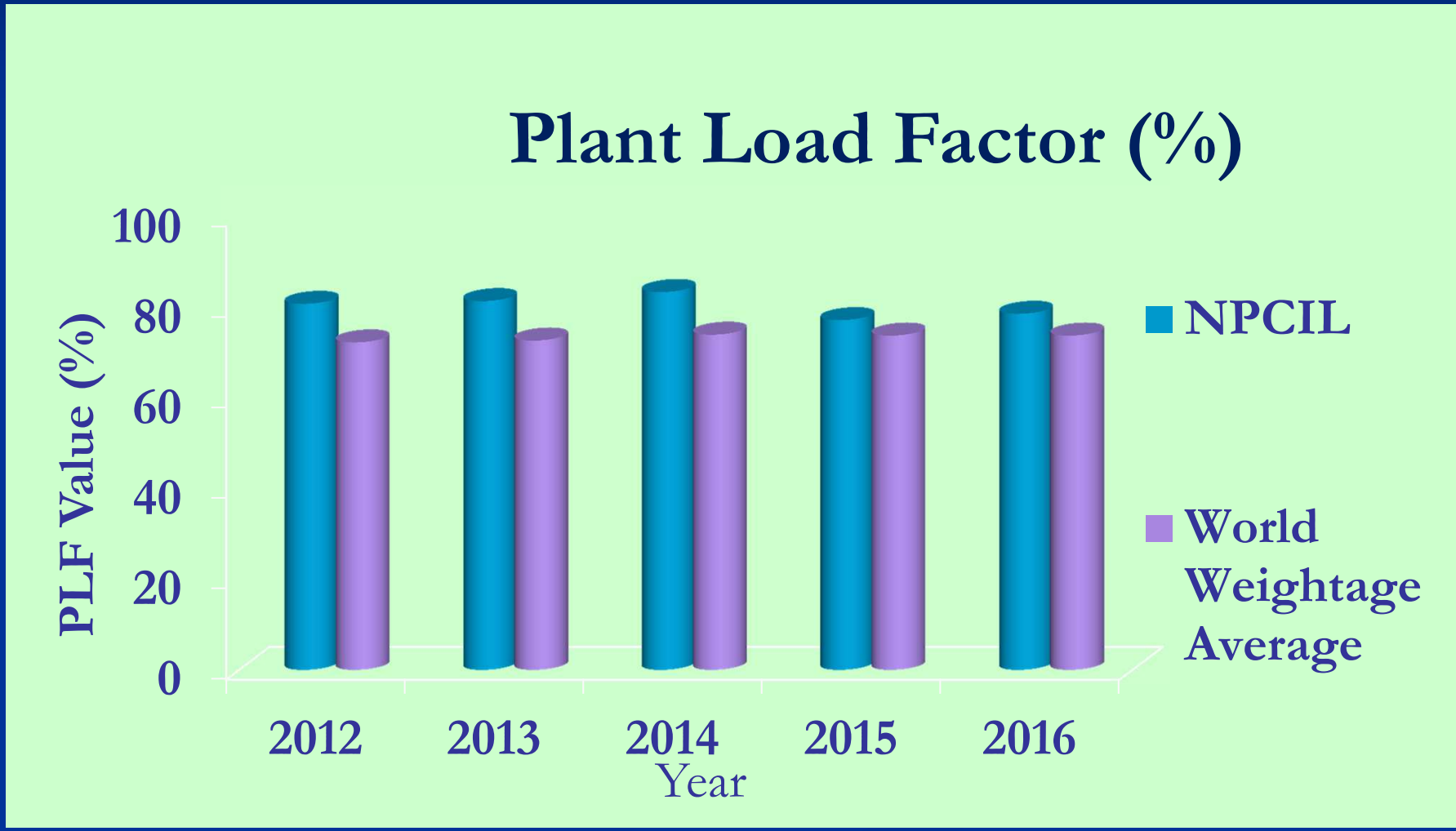
Continuous Run (more than a year) recorded by NPCIL's Reactors (21 times)



Operating Performance

Life Extension and safety Upgrades done

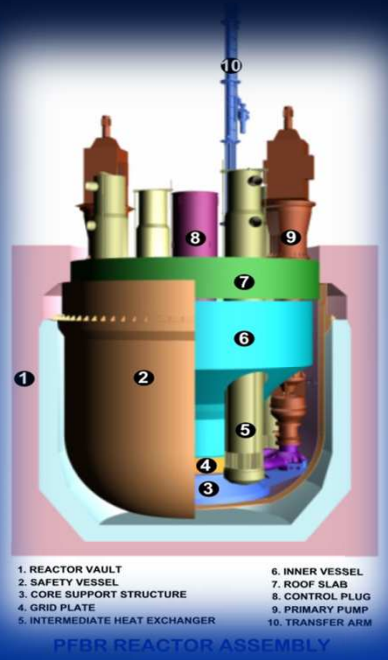
456 Reactor years of Safe Operations



Launch of Second Stage

500 MWe Fast Breeder Reactor under Commission

Criticality 2017



India Japan Civil Nuclear Cooperation
Nov 2016

Potential of India Japan cooperation

- Japan is a major source for major nuclear and conventional component forgings
- AP 1000, EPR source their larger forgings from Japan
- Toshiba being owner of Westinghouse AP 1000 implementation will become easier
- Indian industry will benefit from technical cooperation

Nuclear Power is Clean & Green