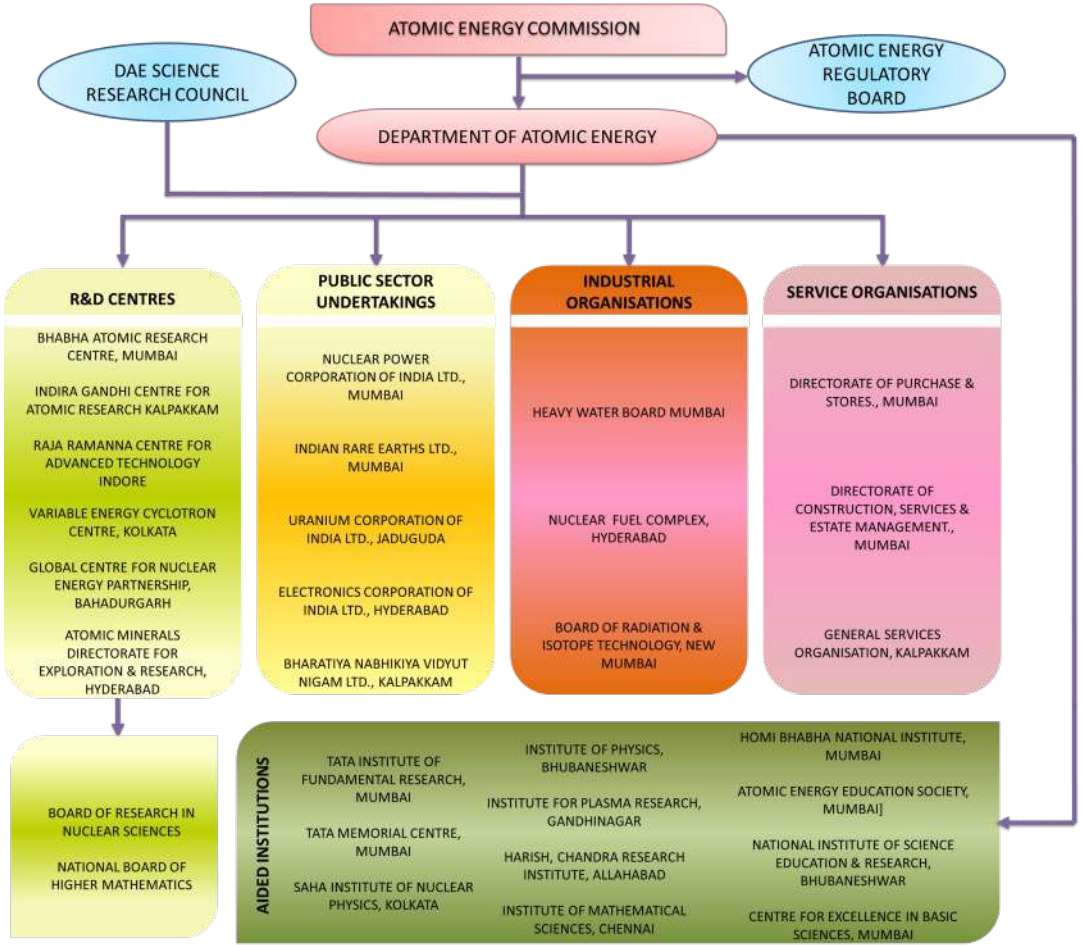
Bharatiya Nabhikiya Vidyut Nigam Ltd (BHAVINI)

Presentation to
Govt. of Kerala
on allocation of site for construction of
4 nos of 500 MWe Fast Breeder Reactor projects with
co-located reprocessing facility

भारतीय नाभिकीय विद्युत निगम लिमिटेड
Bharatiya Nabhikiya Vidyut Nigam Limited

Department Atomic Energy

Organization structure of DAE



Presentation outline

- About BHAVINI
- Site selection criteria
- Benefits and outcome of the project

About BHAVINI

Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) is a wholly owned enterprise of Govt. of India under the administrative control of Dept. of Atomic Energy. BHAVINI is commissioning the first 500 MWe Prototype Fast Breeder Reactor (PFBR) at Kalpakkam. Currently, PFBR is the only project owned by the Company and this is fully funded by GoI.

Vision of BHAVINI

To generate commercial power out of Fast Reactor Technology

Mission of BHAVINI

To construct, commission, operate and maintain an integrated programme of Fast Breeder Technology based nuclear power stations as a safe, environmentally benign and economically viable source of electrical energy.

Homi J. Bhabha

No power is costlier than no power

INDIA'S THREE STAGE NUCLEAR POWER PROGRAMME

STAGE 1

Natural Uranium → **PHWR** → **ELECTRICITY**

PHWR → Depleted U → Pu FUELLED FAST BREEDERS

PHWR → Pu → Pu FUELLED FAST BREEDERS

Pressurised Heavy Water Reactors (PHWRs) using natural Uranium as fuel

STAGE 2

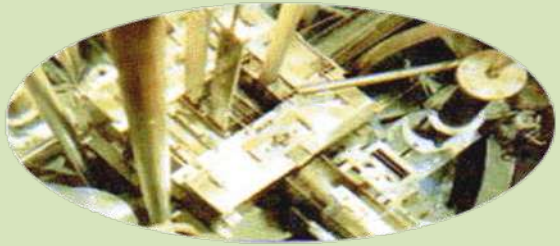
Th → Pu FUELLED FAST BREEDERS → **ELECTRICITY**

Pu FUELLED FAST BREEDERS → Pu → Pu FUELLED FAST BREEDERS

Pu FUELLED FAST BREEDERS → U-233 → U-233 FUELLED BREEDERS

Fast Breeder Reactors using Plutonium as fuel

STAGE 3

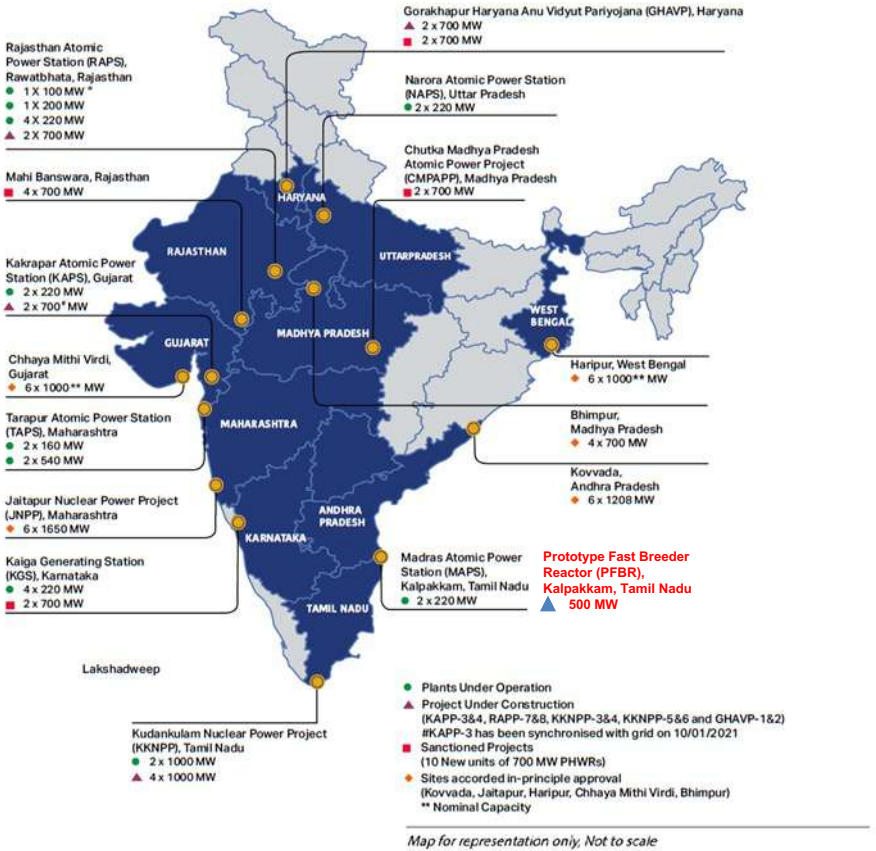


Th → U-233 FUELLED BREEDERS → **ELECTRICITY**

U-233 FUELLED BREEDERS → U-233 → U-233 FUELLED BREEDERS

Advanced Reactors using Thorium in Thorium-Uranium cycle

Overview of Nuclear Power in India



* RAPS-1 (100 MW PHWR), owned by DAE and managed by NPCIL, is under long shutdown since October 2004

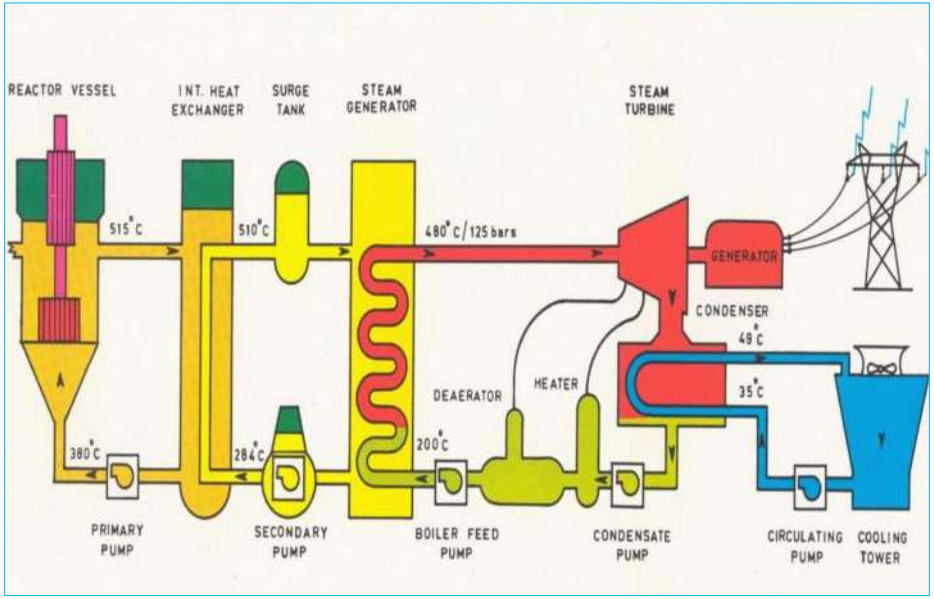
- **Reactors in Operation**
  - **24 reactors 8180 MW**
- **Reactors under Construction**
  - **8 reactors 6800 MW**
  - **PFBR 500 MW**
- **New Reactors accorded Sanction (Pre-project activities in progress)**
  - **10 reactors 7000 MW**
- **Sites approved for future reactors**
  - **5 sites (28 reactors)**

Fast Breeder Reactors (FBRs)

- Mark the beginning of the **second stage of India's indigenous Three Stage Nuclear Power Programme.**
- Fast reactors play important and essential role to **exploit the thorium resources**.
- Fast breeder reactor with **closed fuel cycle** is an inevitable technology to **maximise the resource base** and **minimise high-level wastes**.
- Fast breeder reactors and the associated objectives are:
  - **Effective utilization** of natural uranium resources
  - **Breeding,** growth and consequent energy security
  - **Burning of Actinides** arising from first stage thermal reactors
  - **Waste minimization** and **environmental consideration**
  - **Thorium Utilisation for power production**

Evolution of indigenous PFBR from FBTR

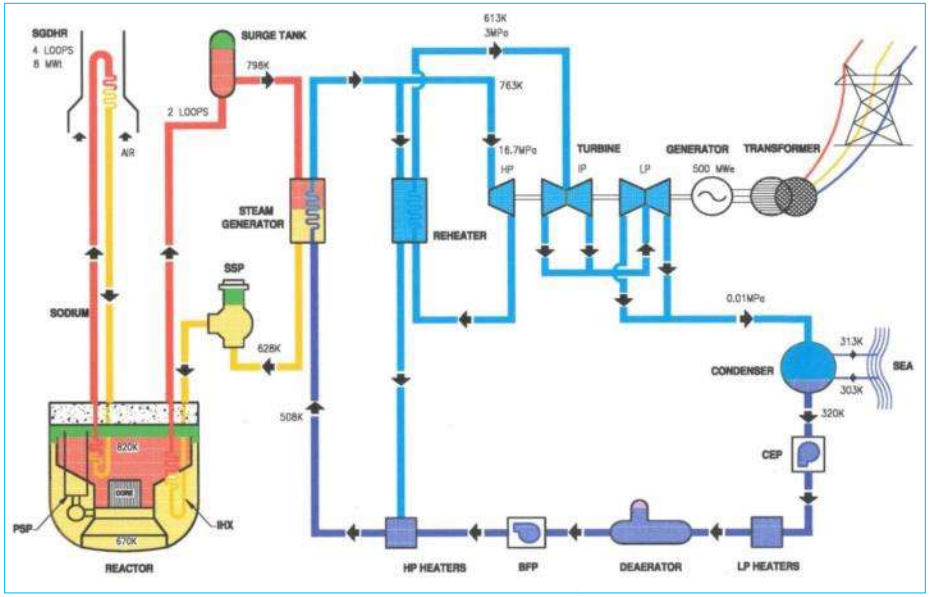
FBTR - Loop Type Reactor



40 MWt, 13.6 MWe

Fuel – UC- PuC
Coolant - Sodium

PFBR - Pool Type Reactor



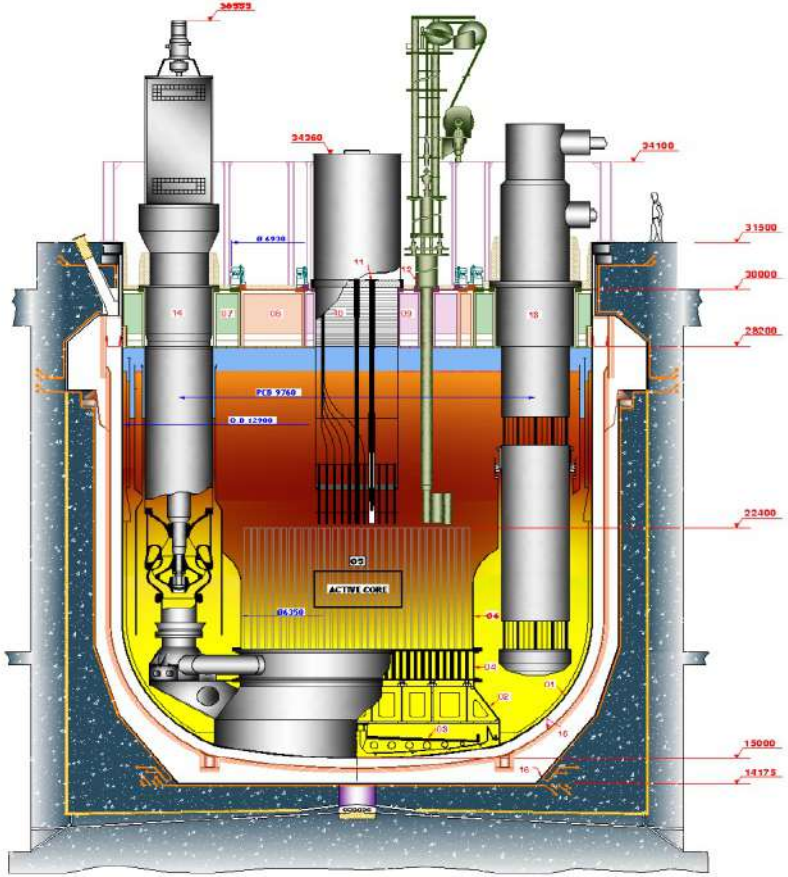
1250 MWt, 500 MWe

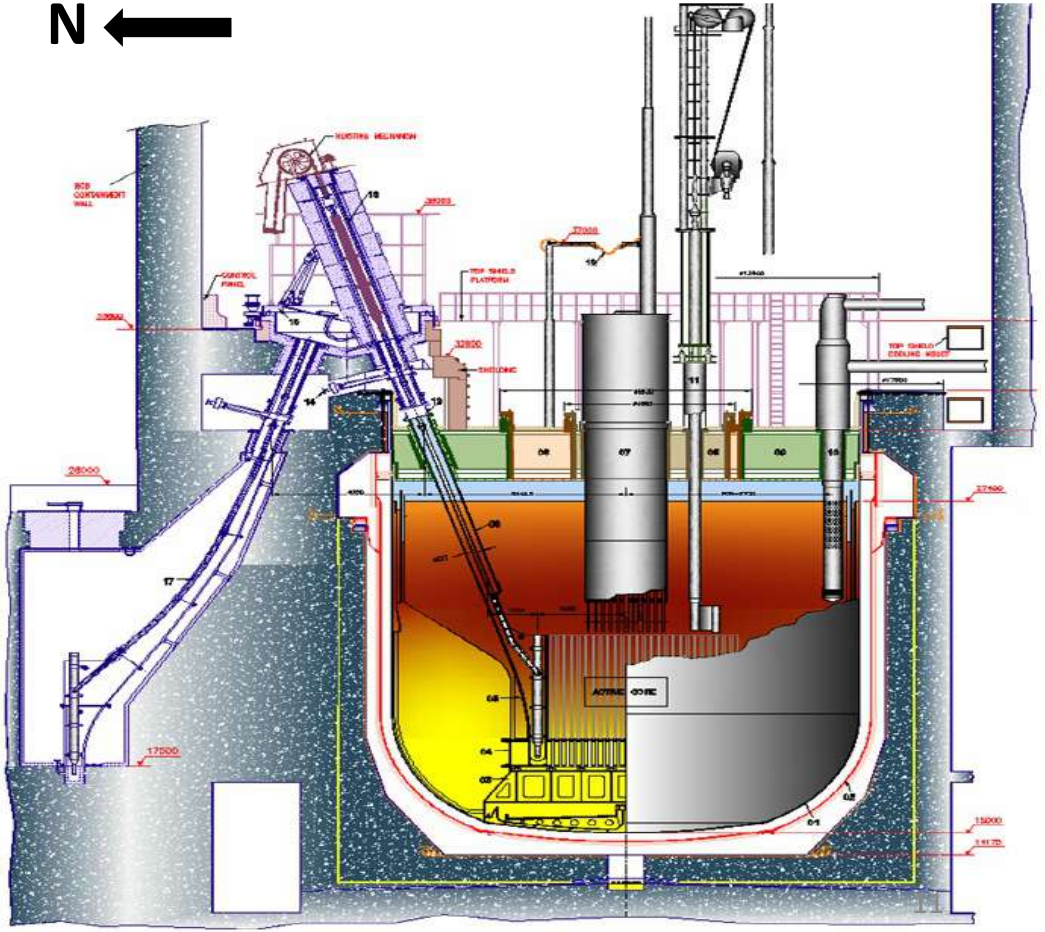
Fuel – UO_2-PuO_2
Coolant - Sodium

PFBR Project Details

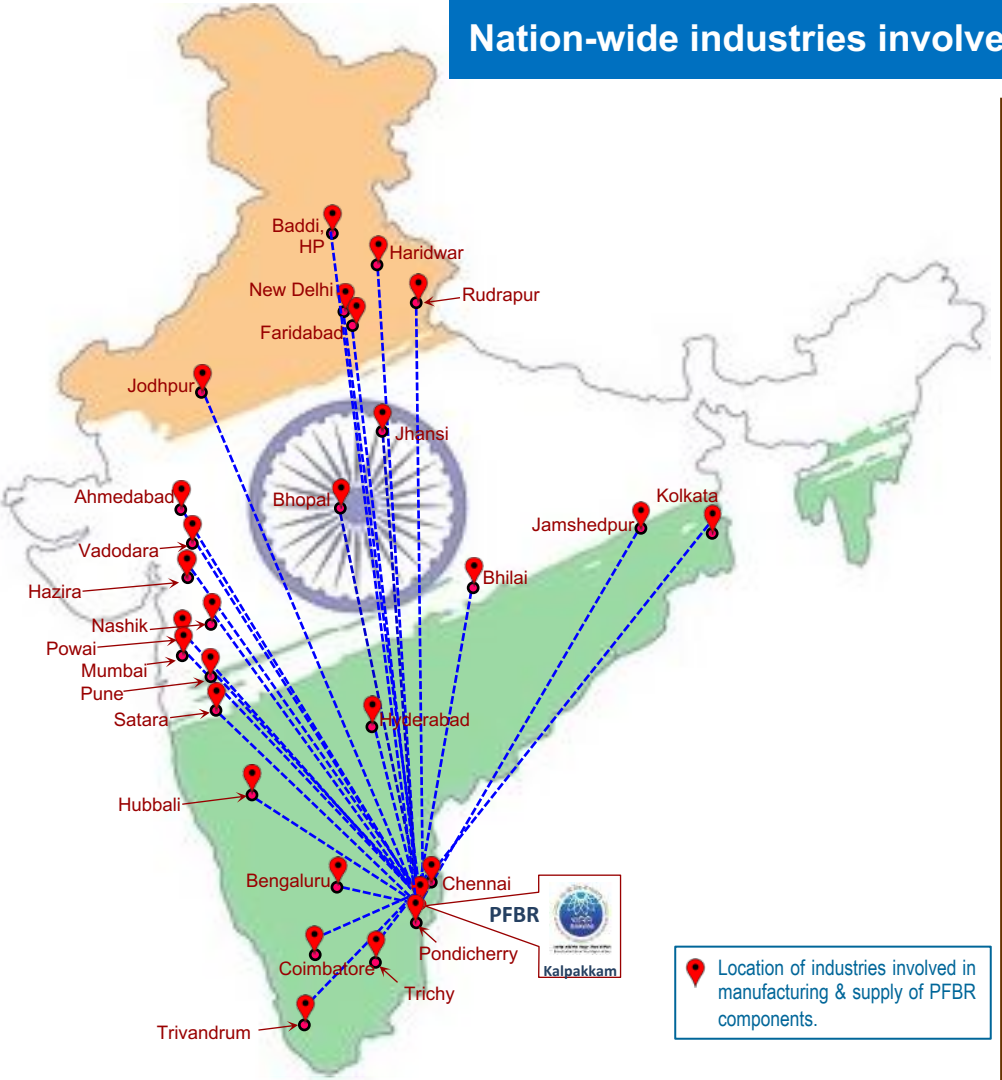
- Type : Fast Breeder Reactor (Gen 3+ reactor)
- Fuel : $PuO_2 + UO_2$
- Inner & Outer zone enrichment : 20.7% & 27.7 %
- Reactor thermal Power : 1250 MWth
- Electrical output : 500 MWe
- Coolant : Liquid Sodium
- Gross thermal Efficiency : 40% (28% - PHWR)

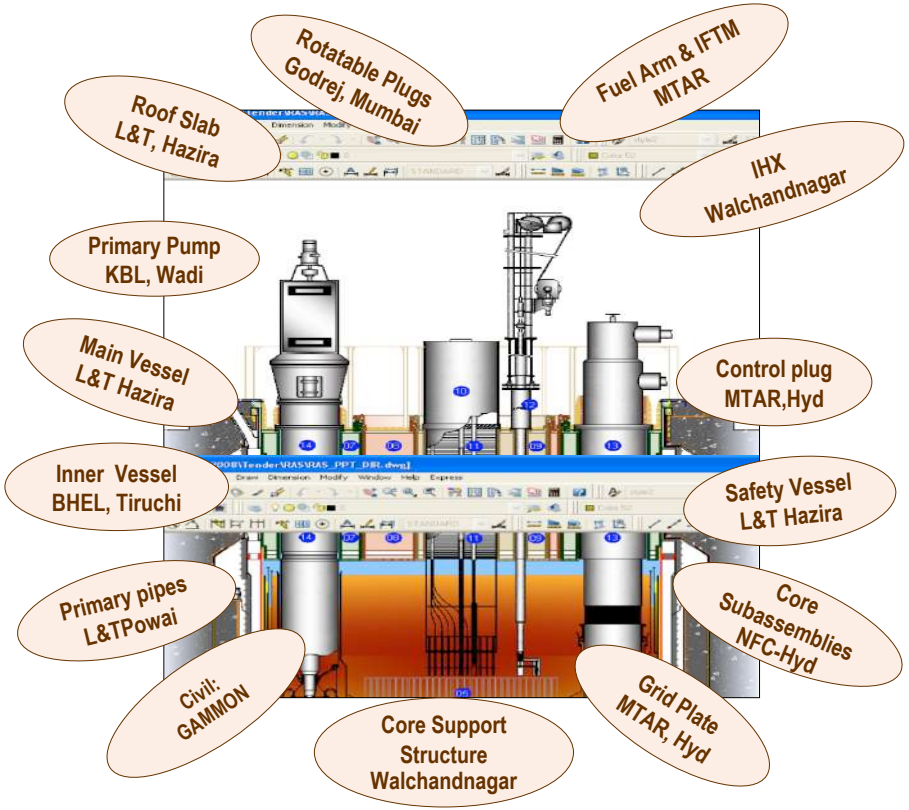
PFBR Reactor Assembly





Nation-wide industries involved in manufacturing & supply of PFBR components





Erection of Large diameter thin vessel for PFBR

Safety Vessel

Main Vessel

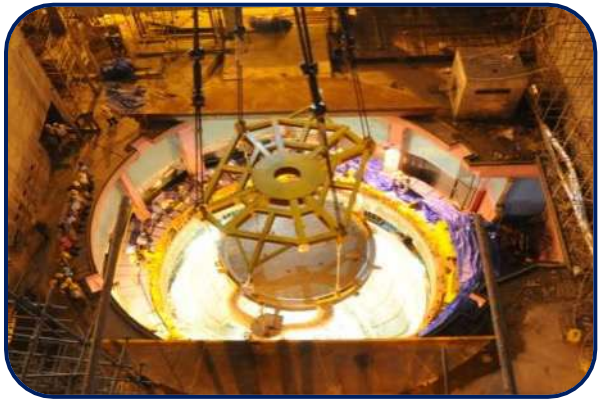
Thermal Baffle

Erection of complex & heavy reactor components

Grid Plate

Inner Vessel

Roof Slab



Erection of long slender components

Dummy Core Sub-Assembly Erection

Turbine-Generator

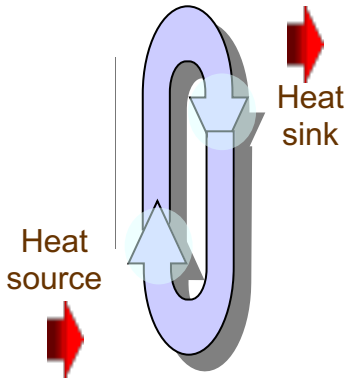
Power Transmission system

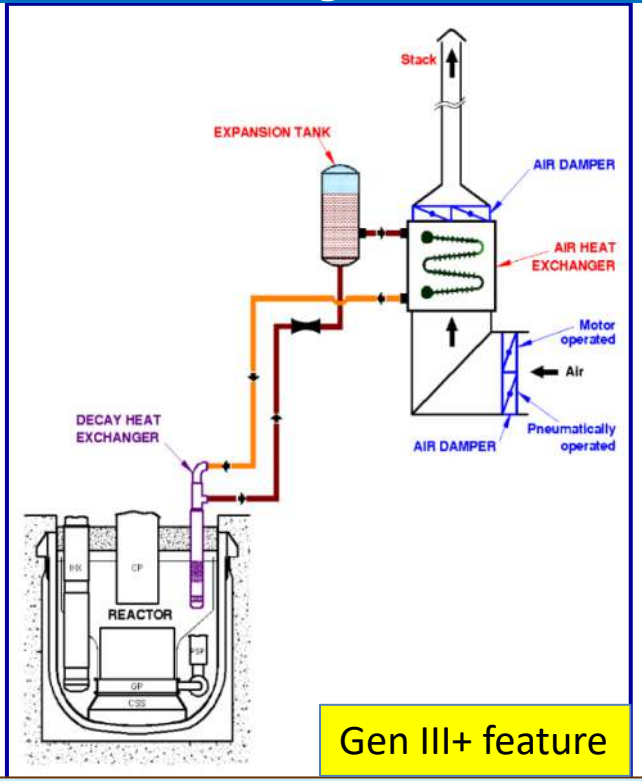
PFBR power allocation by Ministry of Power

Tamil Nadu	:	151.8 MWe
Andhra Pradesh	:	67.7 MWe
Telangana	:	79.2 MWe
Karnataka	:	84.4 MWe
Kerala	:	35.7 MWe
Puducherry	:	6.2 MWe
Unallocated	:	75.0 MWe

230 kV Indoor Type Gas Insulated Switchyard

SGDHR – Passive Decay Heat Removal System





No power supply required for removing the decay heat; natural circulation of coolant is achieved by

- 30 m high chimney
- ~ 41.9 m elevation difference between thermal center of Decay Heat Exchanger & Air Heat Exchanger

4 independent loops with a total decay heat removal capacity of 32 MW_{th} against the requirement of 24 MW_{th}

Other Safety Features of FBRs

- Containment to prevent release of radioactivity in case of postulated incident
- Two shutdown systems working on diverse principles to shutdown the reactor
- Passive decay heat removal systems
- Advance safety design (Generation III+)
- No radiation exposure to workers and public

Major advantages of FBRs

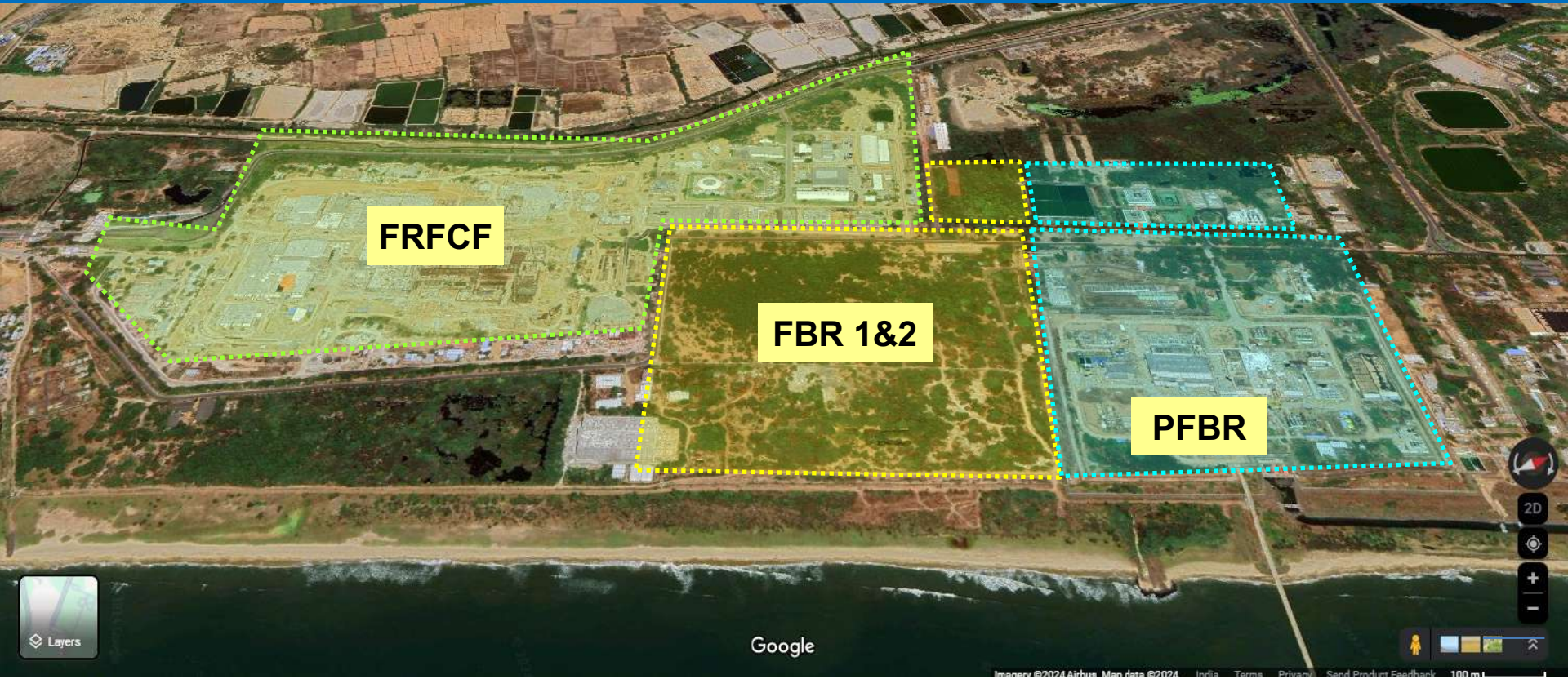
- Produces more fuel than it is consumed
- Low pressure system in sodium loops; thereby minimising leakages
- Enhanced usage of natural resources and less waste Generation
- Waste utilisation and converting to energy

Present status of PFBR

- Construction completed and commissioning in advance stage
- Filling of 1150 t of liquid sodium in Main vessel and purification
- Primary & Secondary Sodium Pumps commissioned and are in operation
- Isothermal testing at 400°C completed
- Core Loading commenced in the august presence of Honorable Prime Minister Shri Narendra Modi on 4th March 2024.
- All absorber rods and blanket Sub assemblies have been loaded in the core.
- Regulatory clearance for Fuel Loading, First Approach to Criticality and low power physics experiments is obtained and fuel loading is in progress. This will be followed by raising power in steps towards full power operation.
- All Conventional, Auxiliary & Power evacuation systems are ready.

Commencement of Core Loading - 4th March 2024

FBRs with Closed Fuel Cycle at Kalpakkam



The co-located facility will be self contained and have all facilities for recycling the fuel from PFBR, including fuel fabrication & assembly plants, reprocessing and waste management facility

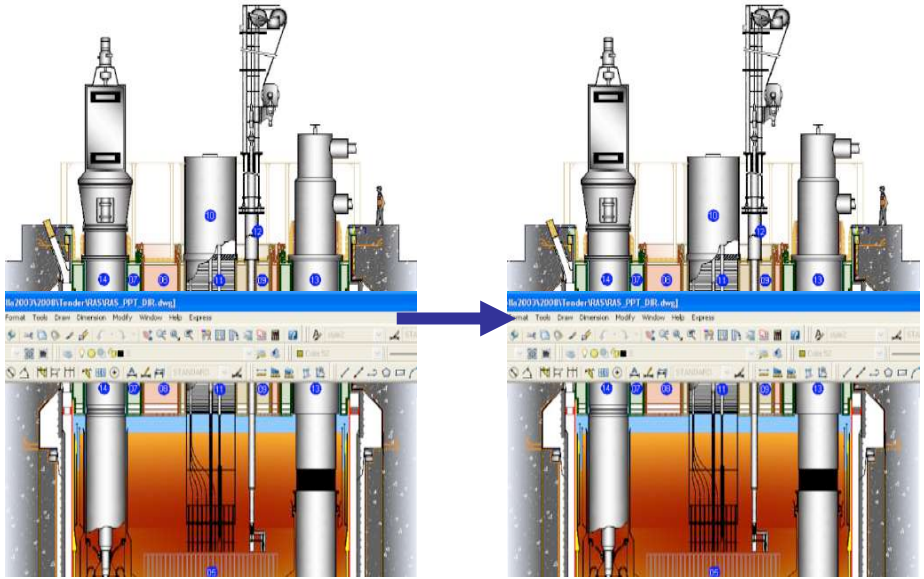
- Funds for Pre- Project activity approved by GoI
- Environmental Impact Assessment Report resubmission under progress
- Site Evaluation Report submission to AERB under progress
- DPR is under preparation
- Cost of the project will be around Rs 22 Cr/MWe
- Government will be approached for financial sanction/budgetary support after FAC of PFBR
- Construction time: 8 & 8.5 years (2025-34)

FBR 1 & 2 at Kalpakkam (2 x 500 MWe) – Same design as PFBR

Commercial Fast Breeder Reactor (CFBR) 3,4,5 &6

- As FBRs are to be co-located with reprocessing facility
- To achieve better economy, the site is proposed for 4 nos of 500 MWe reactors for sharing the above facility
- Metallic fuel (6% Zr) with high breeding ratio (1.35-1.4) & low doubling time (9.4 y)
- Effective Thorium utilisation as Blanket
- Gen-IV reactor - sustainability, economics, safety, reliability and proliferation-resistance.

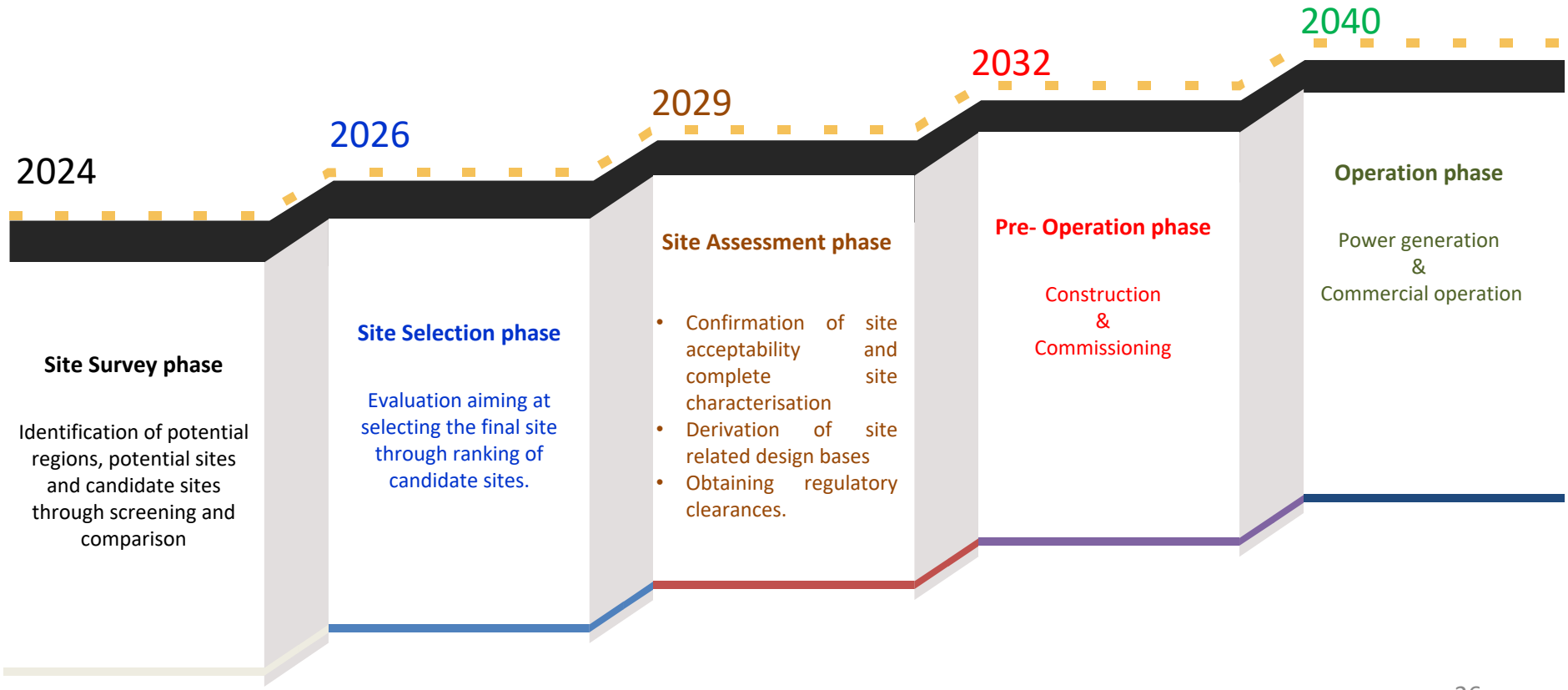
Site location to be identified



FBR-3&4 (500 MWe)

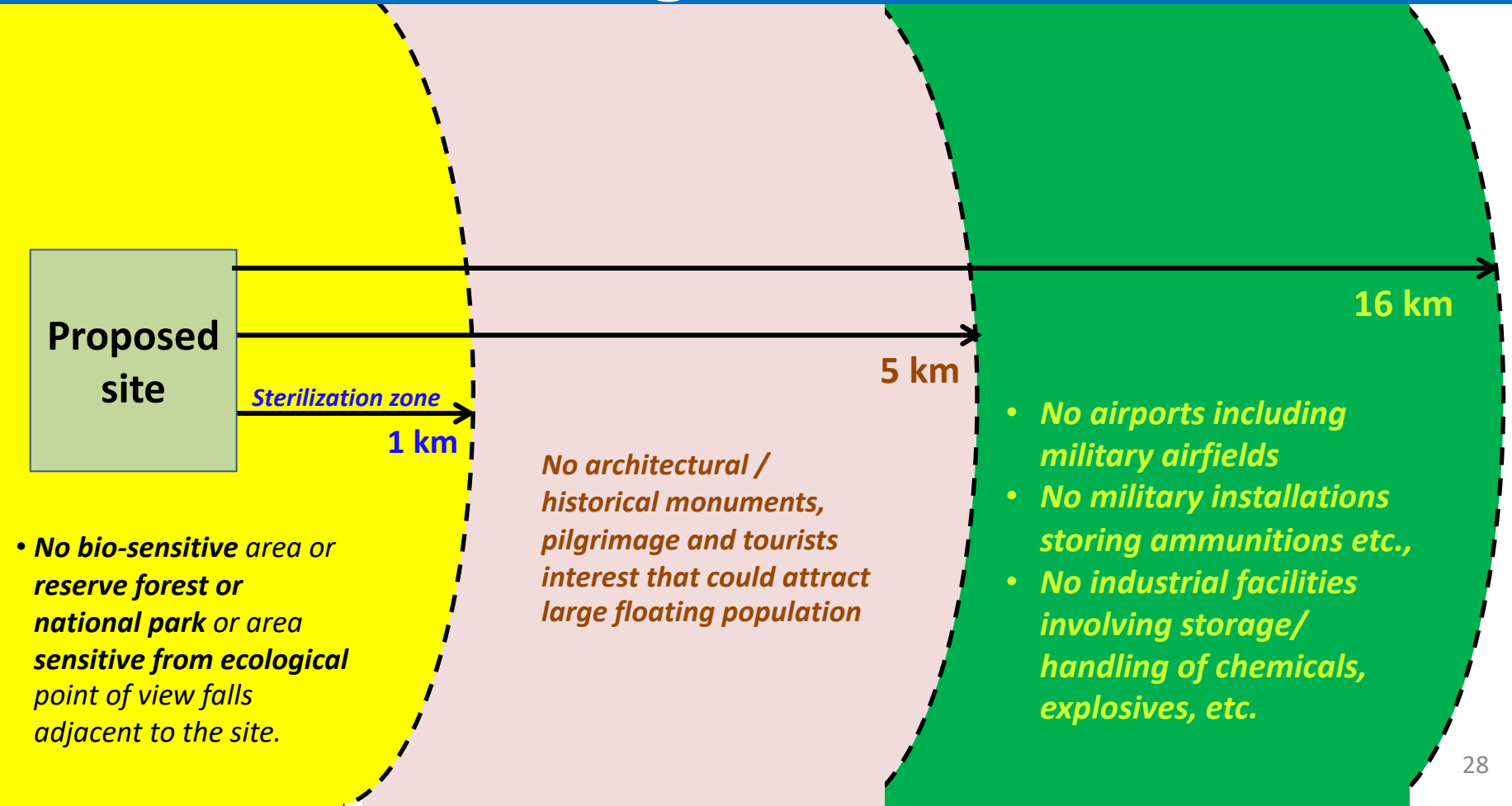
FBR-5&6 (500 MWe)

Timeline of project

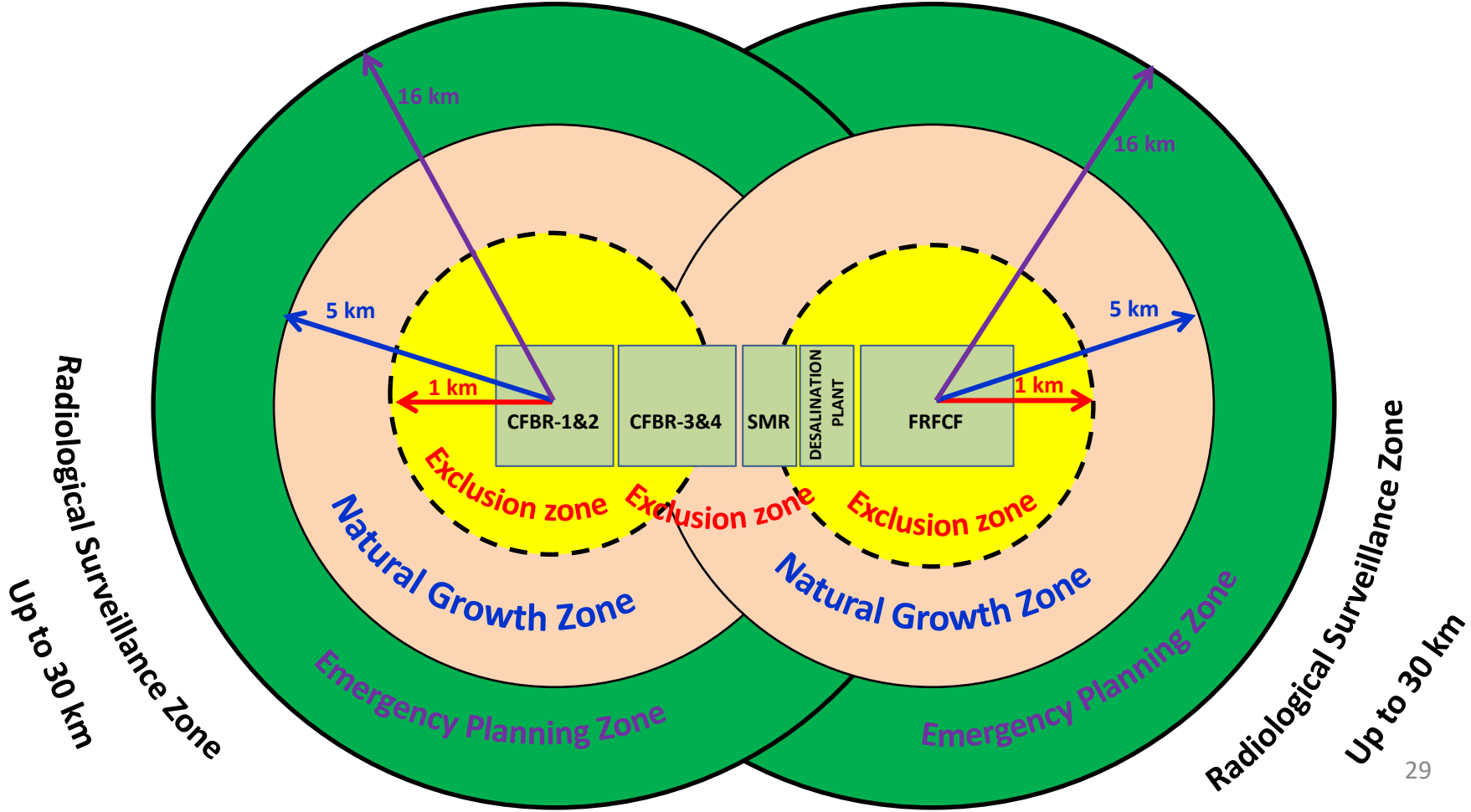


Site selection criteria

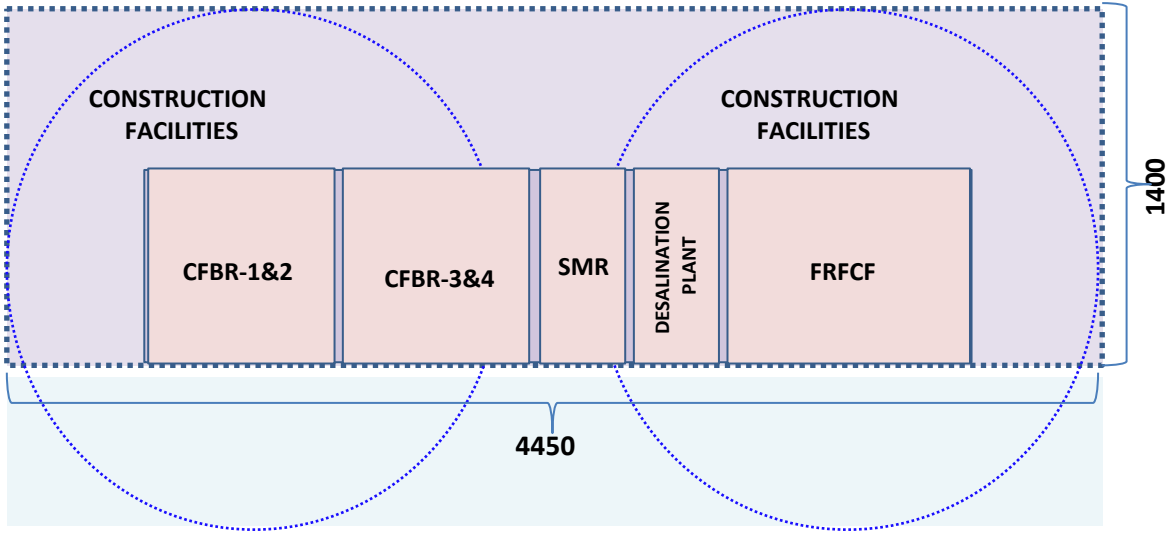
Screening Distance Value

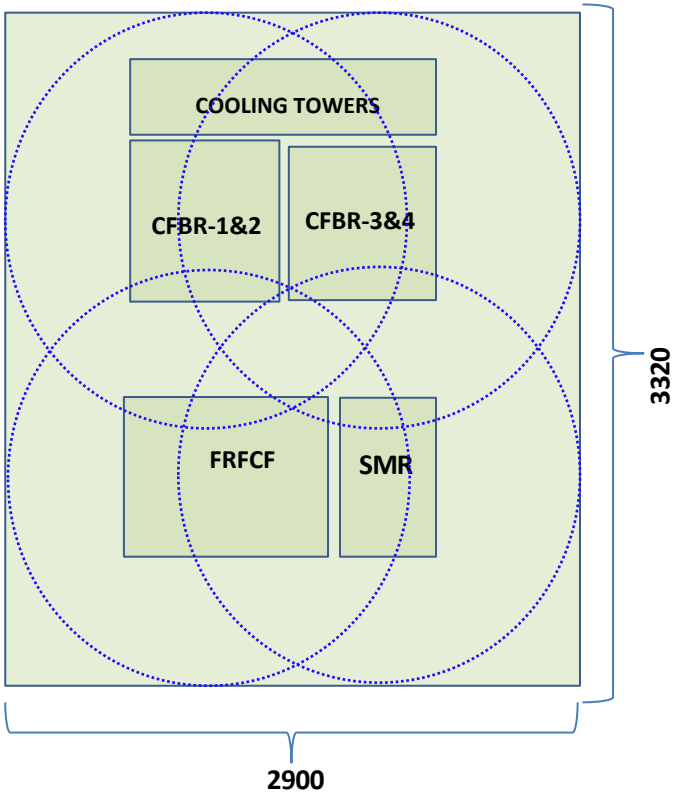


Zonal requirement as per AERB code



Land requirement layout





Coastal site : 625 hectare

Inland site : 960 hectare

INLAND SITE – KAIGA GENERATING STATION, KARWAR,UTTAR KANNADA

COASTAL SITE – PROTOTYPE FAST BREEDER REACTOR, KALPAKKAM, TAMILNADU

Land strata

- Barren land with reasonably flat terrain
- Free from soil liquefaction, slope instability, subsidence, uplift, ground collapse which cannot be mitigated by engineering measures
- Free from possibility of occurrence of landslides, rock fall, rock avalanche and debris flows, sand dunes etc.
- Preferably to have rock foundation

Township – Land requirement - 125 hectares approx. 5 km away from site

Site connectivity & infrastructure

Site connectivity:

- Rail, road, barge if coastal - for transportation of ODC

Infrastructure and construction facilities:

- Construction material (quarry, blue metal, sand)
- Construction power

Water:

- Coastal Site – Sea water - 4,50,000 m^3 /hr
- Inland Site – Raw water – 10,000 -12,000 m^3 /hr
- Raw/Potable water for Residential Colony - 55 m^3 /hr

Transportation of ODC Component

Benefits and outcome of the project

Major benefits of the project

- On completion of the project with installed capacity of 4 X 500 MWe (total 2000 MWe), initially it will produce annual energy of about 13140 Million Units at 75% capacity factor.
- Direct Employment Opportunities
- Employment of locals in skilled, semi-skilled and un-skilled categories through contracts
- Growth of small scale industries/MSMEs
- Development of infrastructures in neighbourhood such as schools, hospitals and roads
- Socio-economic activity near Township

THANK YOU