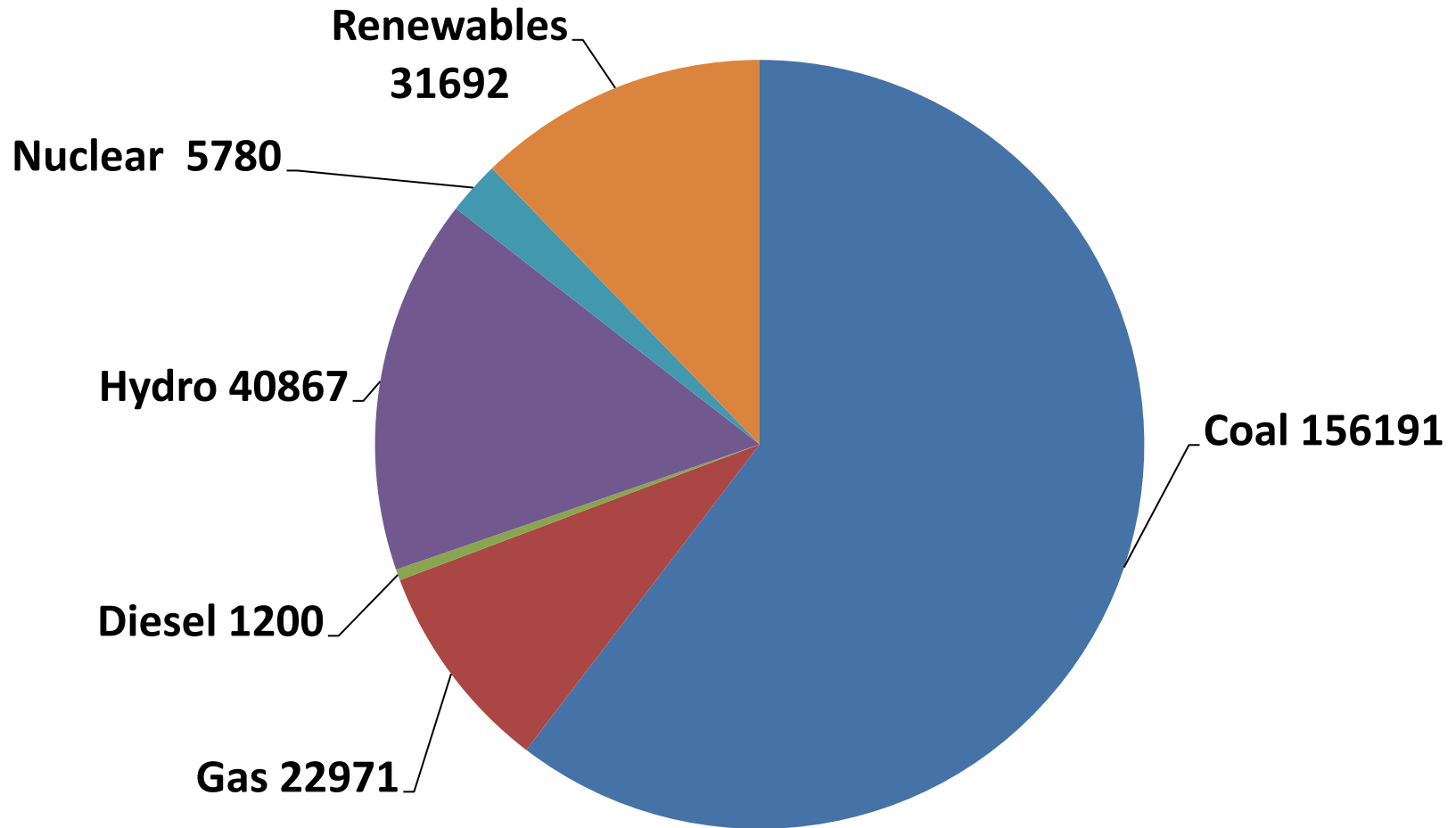


India's Nuclear Development Programme

THE 48th JAIF ANNUAL CONFERENCE
April 13-14, 2015, Tokyo

S A Bhardwaj
DAE Homi Bhabha Chair
Former Director(Technical), NPCIL
INDIA

Installed Capacity (MW)



as on January 31, 2015, 258701 MW

India's immediate target:

Nuclear power capacity addition in next two decades

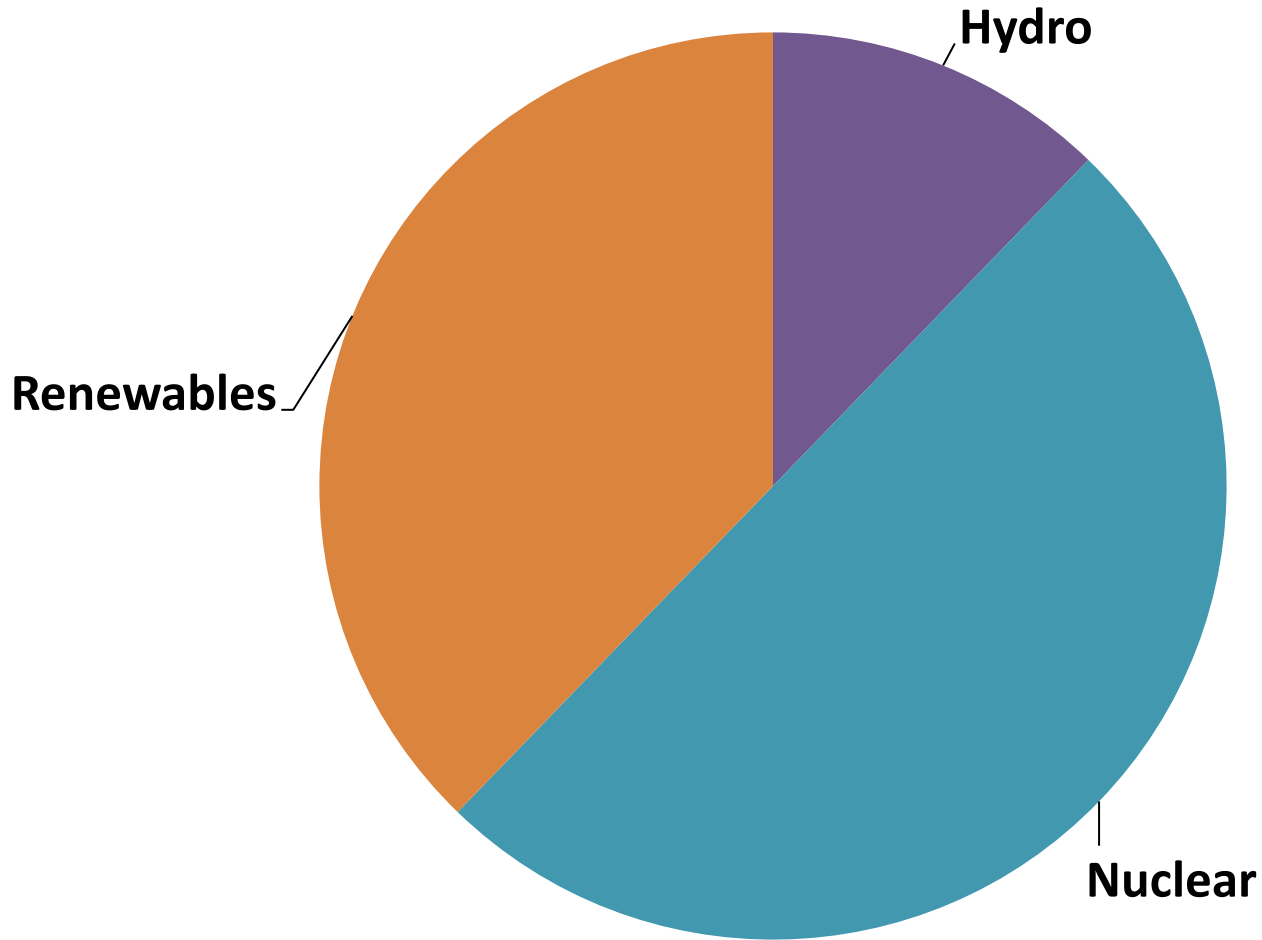
- To increase share of nuclear energy to about 10% of total electricity in next two decades (closer to the current world average)
- To create a fissile inventory base from where rapid growth is achievable through implementation of the Three stage programme
 - ultimately attaining long term energy security.

Why Nuclear

Nuclear Power

- *offers* a potential system for energy security lasting a few hundred years, without generating green house gases.
- is a proven and dependable base-load option.
- ***requires highest priority to be given to safety in all stages of its life cycle from design to decommissioning.***

Could be on January 31, 2051



Objective of Indian Nuclear Power Programme

- Utilisation of both fissile & fertile components of Uranium
- Thorium utilisation
- Sustainability

Fuel cycle & sustainability

Important considerations for sustainability:

Environment

Clean energy

Resources

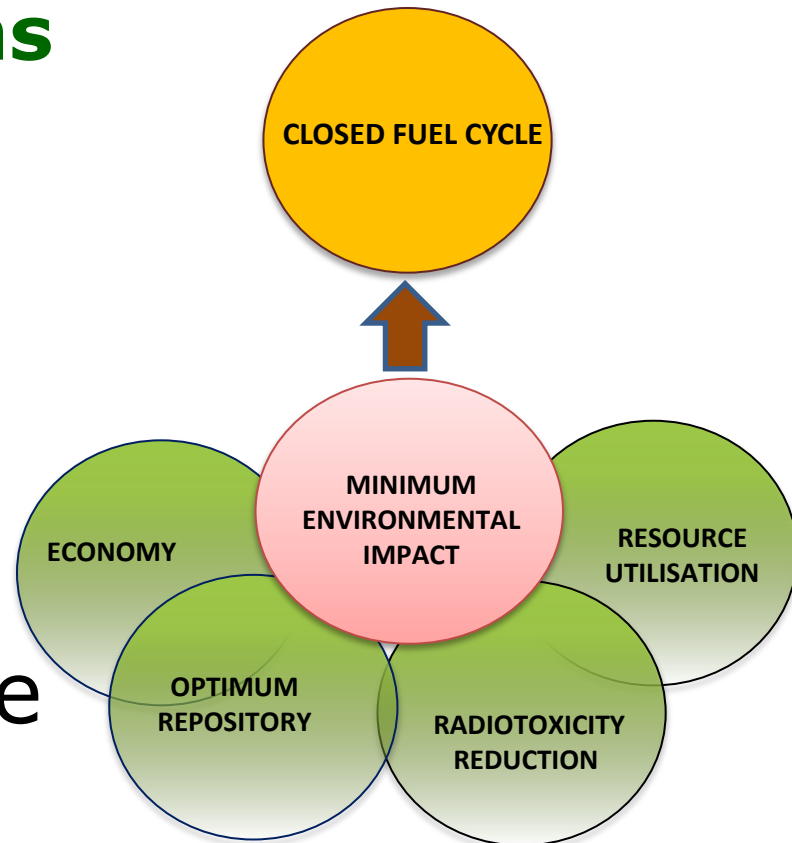
Fissile material

Fertile material

Long lived nuclear waste reduction

Safety and security

Economy



Homi Bhabha's vision

The three stage nuclear power programme of India

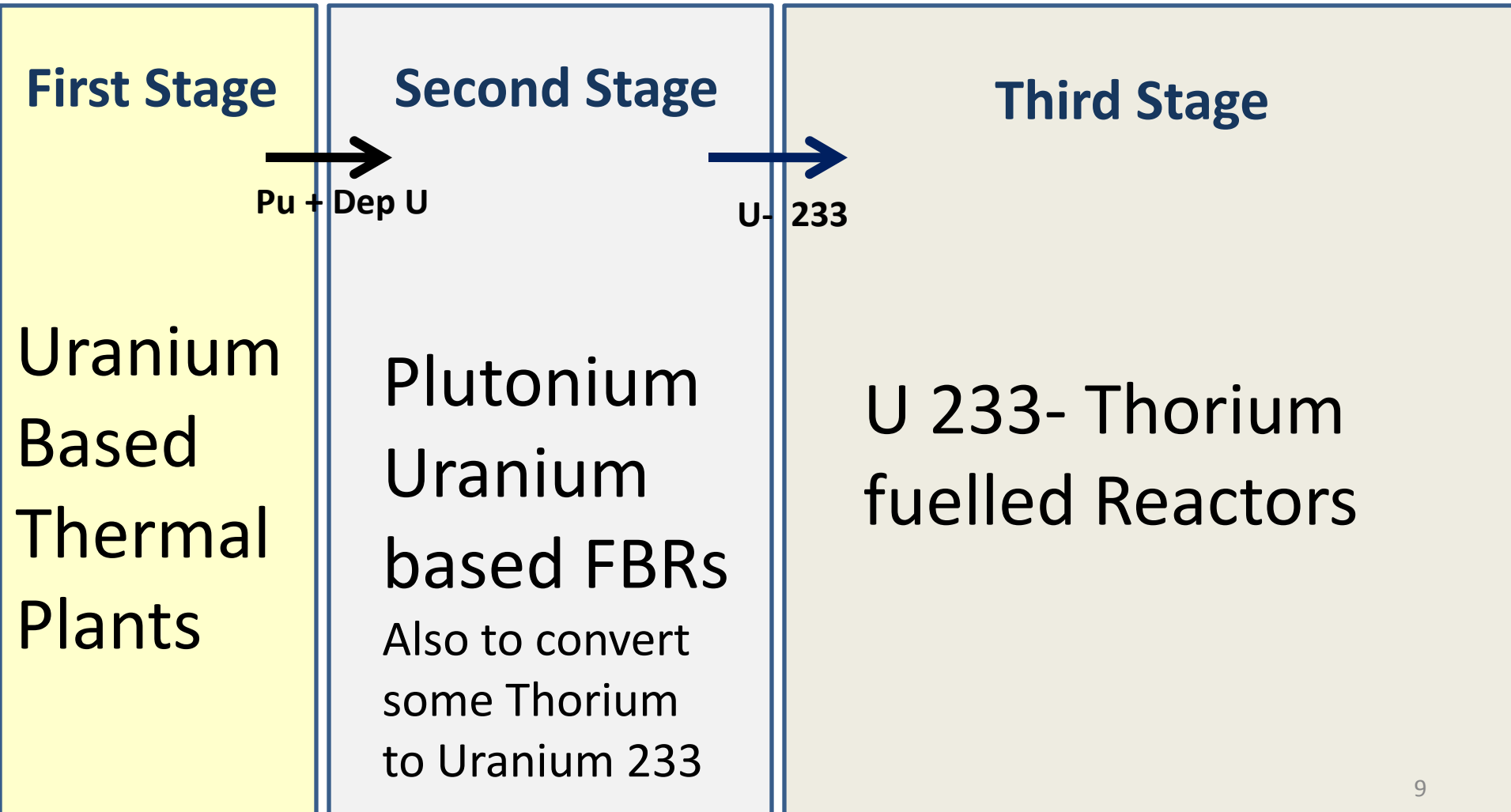
First stage : burning U^{235} and generating Pu^{239}

Second stage : burning Pu^{239} and capacity enhancement, generating U^{233}

Third stage : operating U^{233} -Th cycle

Second United Nations Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958

The Three Stages of the Indian Nuclear Programme



The First Stage of the Indian Nuclear Programme- operation

First Stage

21 reactor units are in operation

Comprising of

of PHWRs 16 Units 220 MWe

2 Units 540 Mwe

BWRs 2 Units 160 Mwe

VVER 1 1000MWe

Uranium
Based
Thermal
Plants

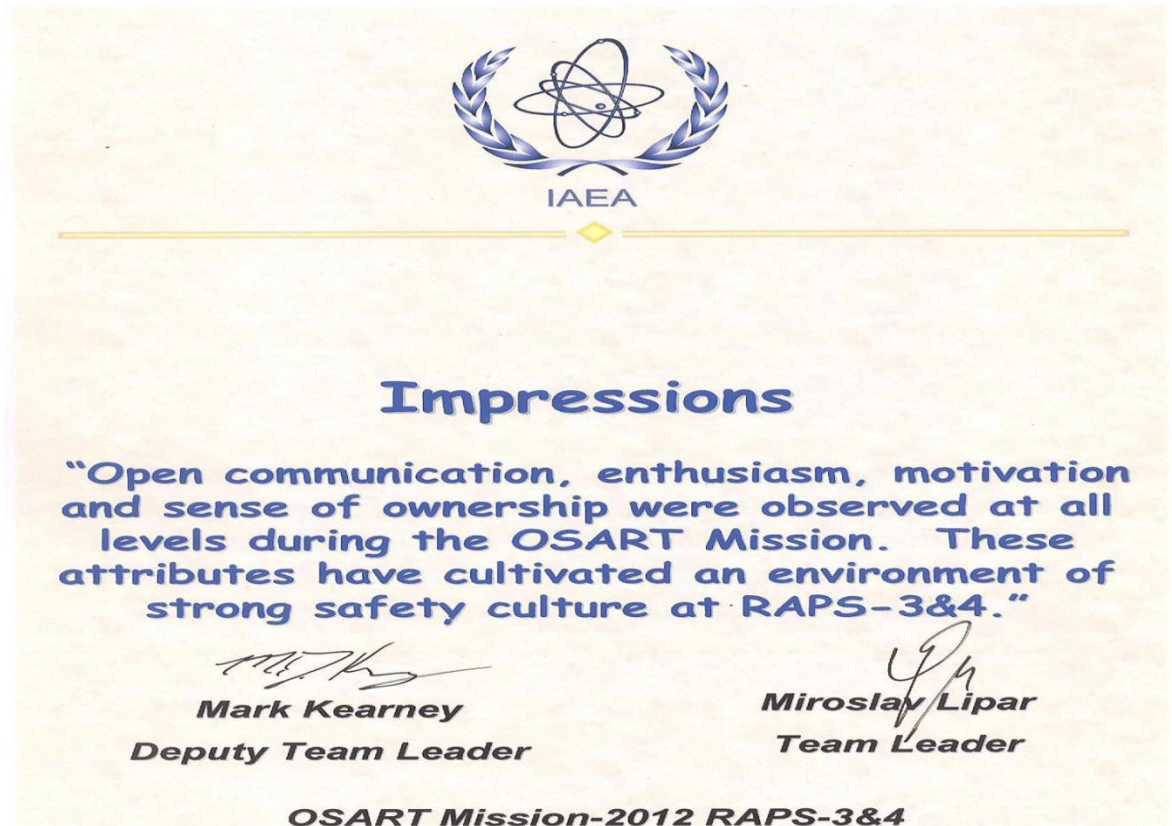
Post-Fukushima: Major actions taken in India

- Review of Safety of existing reactors by six task Forces for each technology by utility (NPCIL) and a committee constituted by regulator in India (AERB) - found sufficient margins & design provisions in Indian NPPs to withstand extreme natural events. Improvements suggested. Reports in public domain.
- Accord of statutory (*de jure* independence) status to the regulators - NSRA Bill introduced in Parliament
- Review of Regulatory Codes and Guides post Fukushima is ongoing. An important AERB Safety code revised recently is 'Site Evaluation Of Nuclear Facilities' . A Safety code 'Design of Light Water Reactor Based Nuclear Power Plants', has been issued.
- Further strengthening of Emergency Preparedness - underway.
- Instituted massive Public Outreach Programme

OSART Review of RAPS 3&4

Noted series of good safety practices at the station to be shared by IAEA with global nuclear industry. Examples:

- Safety culture that cultivates constructive work environment, sense of accountability and opportunities for skill enhancement
- Public Awareness Programme
- Management of Training and Authorisation
- Testing facilities and use of mock-ups to improve quality



The First Stage of the Indian Nuclear Programme- Projects

First Stage

4 reactor units of 700 MWe capacity each under construction.

1 unit of VVER under final steps to fuel loading

Construction of 2 units of 700 MWe PHWRs and

2 Units of 1000MWe VVERs to start this year.

Uranium Based Thermal Plants

Important priorities

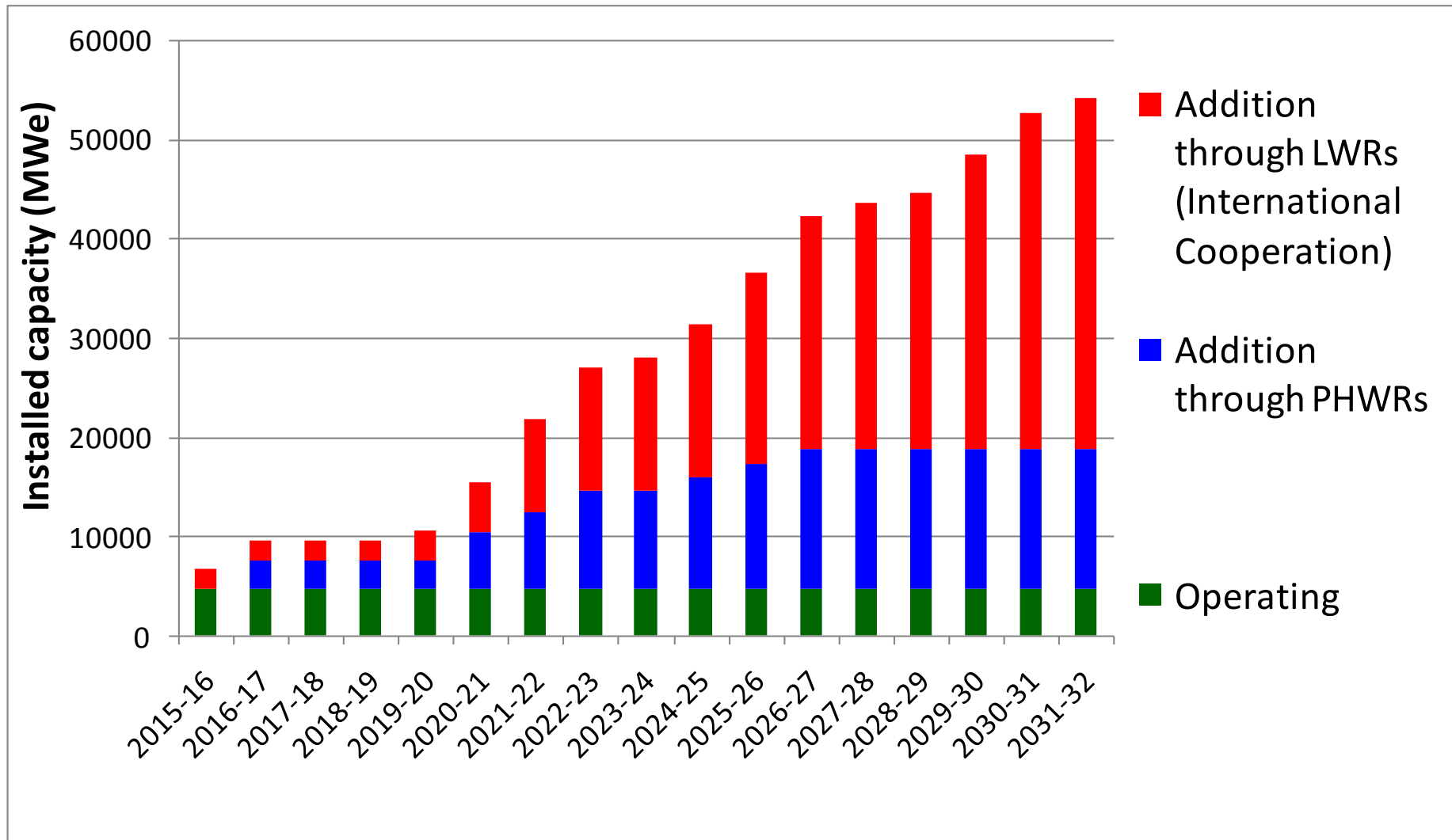
- Continue PHWR programme
 - More installation sites

- Addition through deployment of LWRs
 - LWRs of 1000+ MW capacity based on foreign technical cooperation
 - Developing indigenous LWR

Nuclear Capacity Buildup

- **Present Capacity** : **5780 MW**
- **By 2017 on completion of reactors under construction** : **10080 MW**
- **On completion of new launches planned by 2021-22** : **27080 MW**
- **By 2032** : **48000 MW - 63000 MW**
(By a mix of indigenous PHWRs & FBRs and LWRs based on foreign technical cooperation)
- **Beyond 2032, capacity addition based on FBRs and thorium based reactors**

Capacity addition through PHWRs and LWRs: 2000-2500 MWe per year during period 2020-2032



Constraints Experienced in Recent Time

- Public perception following Fukushima.
- Process of acquiring land for new projects.
- Civil liability for nuclear damage act.

The Second Stage of the Indian Nuclear Programme

First Stage


Pu + Dep U

Second Stage

Plutonium
Uranium
based
FBRs

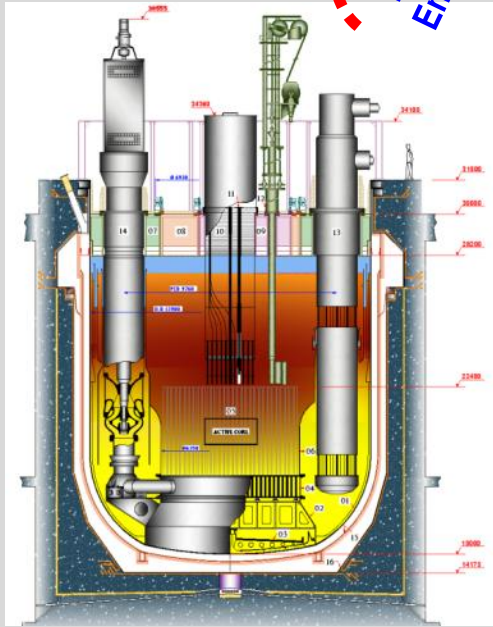
Also to convert
some Thorium
to Uranium 233

- *FBRs permit Effective Utilization of Uranium Resources*
- *High thermodynamic efficiency (high steam temperature).*
- *A fast reactor is “flexible” in the sense that, it can be used as breeder or burner or sustainable reactor.*
- *It is possible to transmute MA in to short lived isotopes in a FBR, For a reduced burden on a deep geological storage*

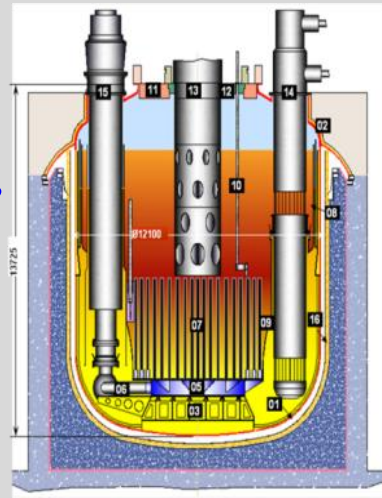
Development Plan for FBRs

Proven Prototype
 Concepts
 Design, Mfg. and
 Safety review
 Experience

Improved
 Economics and
 Enhanced Safety

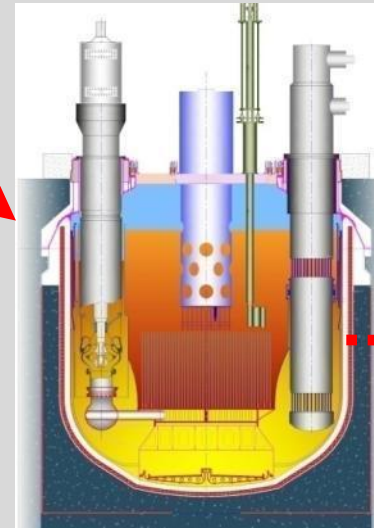


FBR - 500 MWe
 MOX , Pool type, Indigenous
 First 500 MWe unit final
 stages of Commissioning
 Expected criticality End 2015



FBR-600 MWe
 MOX, Pool, Twin
 units, Indigenous

Adopting
 Innovative
 Features



MFBR
 1000 MWe

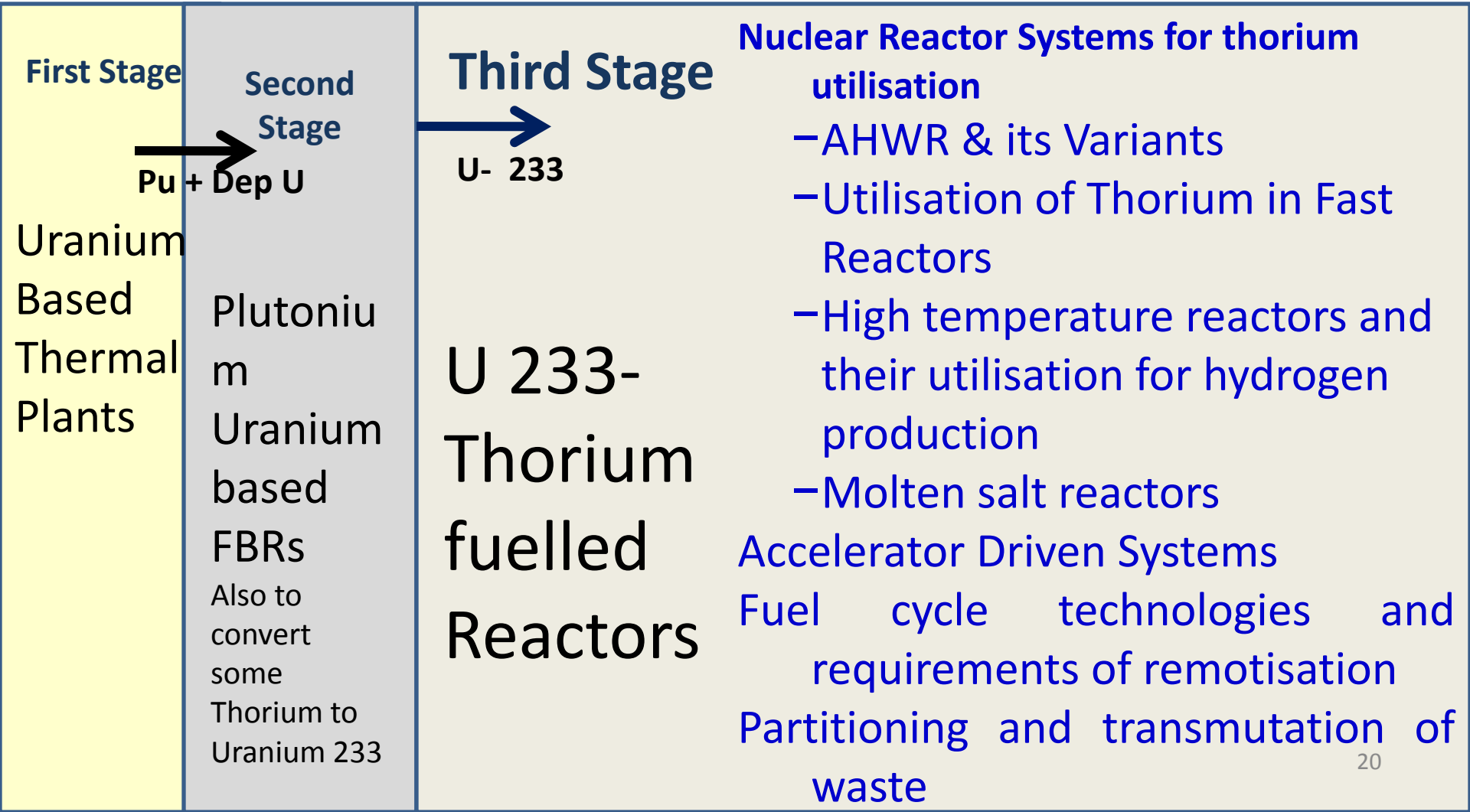
**Metal fuel Demonstration
 Fast Reactor – 500 MWe**
 Same reactor concepts,
 Indigenous

Operational
 Experience



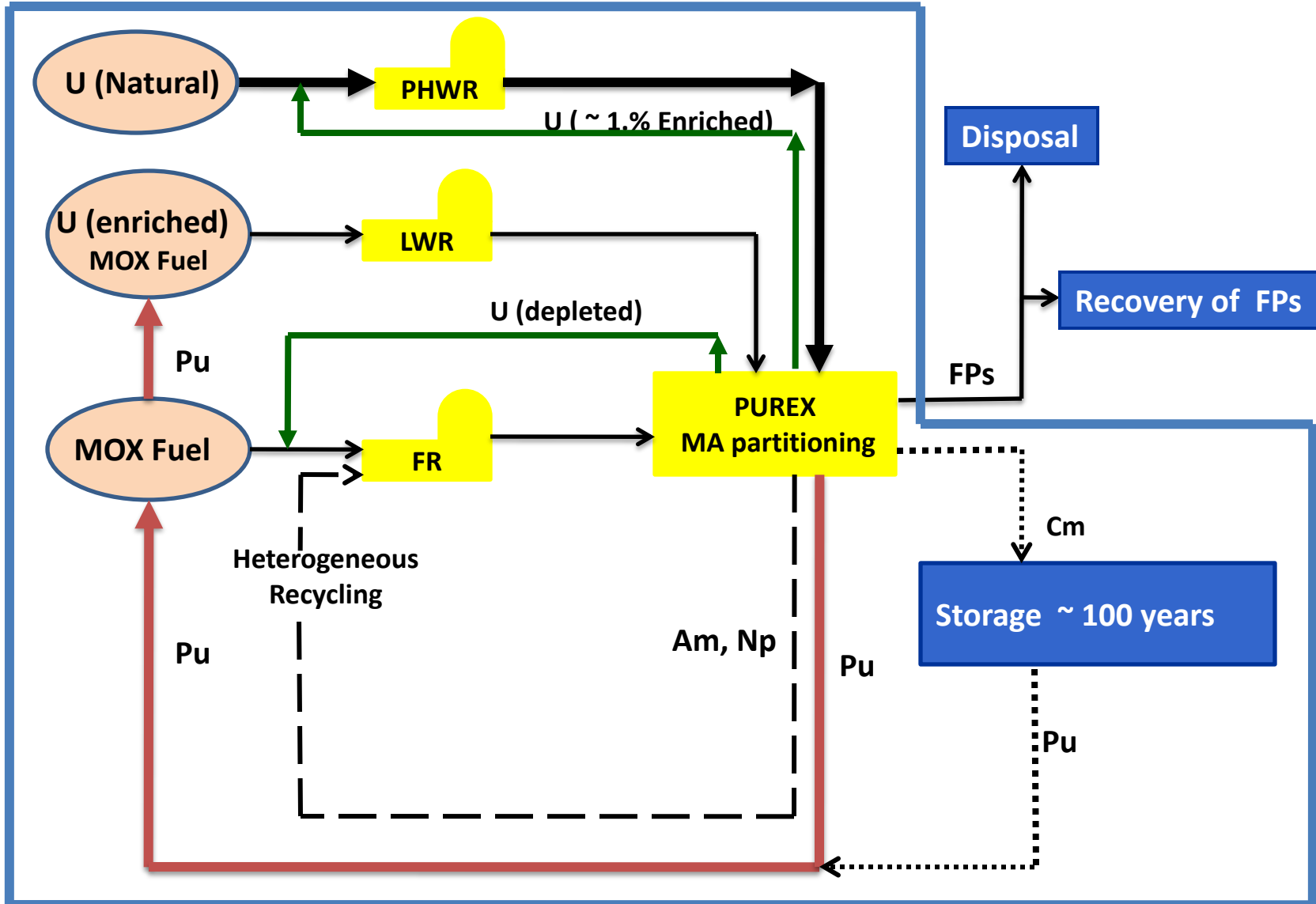
FBTR, 40 MWt, 13.5 MWe,
 Loop type (Pu-U) Cfuel, in
 operation since 1985

The Third Stage of the Indian Nuclear Programme



Evolving Fuel Cycle

(Partitioning and transmutation of waste)



Why Nuclear

- *The climate issue is global.*
- *it calls urgently for united action.*

Nuclear, a proven base-load power source, is part of solution to mitigate global warming concerns.

A united action by all to provide safe and secure nuclear technologies is necessary.

Thank you for your kind attention