Regulatory Challenges in the Interaction of Individuals, Technology and Organizations in the Management of Safety Subsequent to Fukushima Accident

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Overview of the Presentation

- Indian nuclear power program
- Structure and functions of AERB
- Fukushima Accident - an Eye Opener
- Approach followed by India in identifying actions w.r.to Fukushima accident
- Human and Organizational aspects in handling beyond design basis events

Indian Nuclear Power Program

Details of Reactor Units

Operating Reactors	: 20	Units generating 4760 Mwe
Reactors Under Construction	: 7	Units of capacity 5300 Mwe
Planned (PHWRs, LWRs)	: 38	Units ~ 39000 Mwe

Additional : FBRs, AHWR

Reactor Years of Operation: Around 360 years

Research Reactor experience- Additional

Operating Plants & On-going Projects

NARORA (UP)

2x 220 MW

RAWATBHATA (RAJ)

1x 200 MW

2x 220 MW

2x 220 MW

1×100 MW

2× 700MW

KAKRAPAR (GUJ)

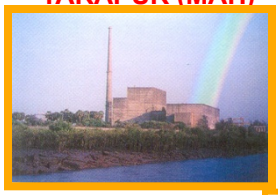
2x 220 MW

2 x 700MW

TARAPUR (MAH)

2x 160 MW

2x 540 MW



KAIGA (KAR)

4x 220 MW

KALPAKKAM (TN)

2x 220 MW

500 MW (PFBR)

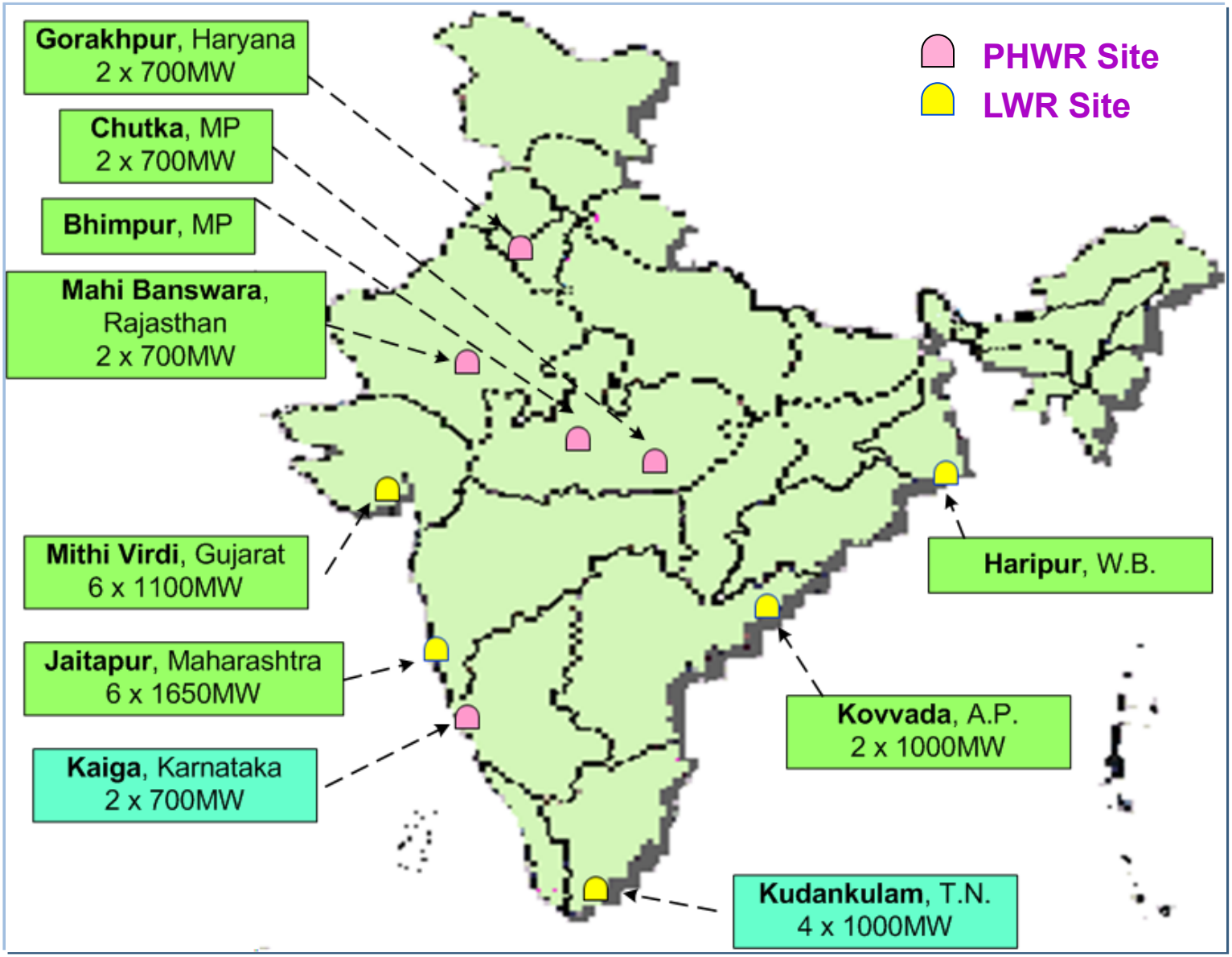
KUDANKULAM (TN)

2x 1000 MW

4780 MW - 18 PHWR & 2 BWR

5300 MW - 2 LWR, 1 PFBR, 4 PHWR

Sites for Future Projects



Age of the operating reactors

Age			Induction of Reactors	
More than 30 years	:	4	After 2002:	6
Between 20 and 30 years	:	5	Between 1992-2002:	5
Between 10 and 20 years	:	5	Between 1982-1992:	5
Less than 10 years	:	6	Between 1972-1982:	1
			Between 1962-1972:	3

Atomic Energy Regulatory Board

- Established in 1983, Under Atomic Energy Act 1962
  - ✓ Control of Radioactive Substances
  - ✓ Safety in Nuclear and Radiation Installations
  - ✓ Industrial Safety in DAE Installations

- The Board: Chairman + 4 Members
- Eight Technical Divisions including SRI
- Staff Strength >400 (Scientific & Technical)
- ISO 9001:2008 Certification for areas:
  - ✓ Consenting Process
  - ✓ Preparation of Regulatory Documents
  - ✓ Regulatory Inspections

- **Autonomous Nuclear Safety Regulatory Authority is on the anvil**

Mission of AERB

To ensure the use of ionizing radiation and nuclear energy in India does not cause unacceptable impact on health of workers and the members of the public and on the environment

Compliance/ Enforcement through:

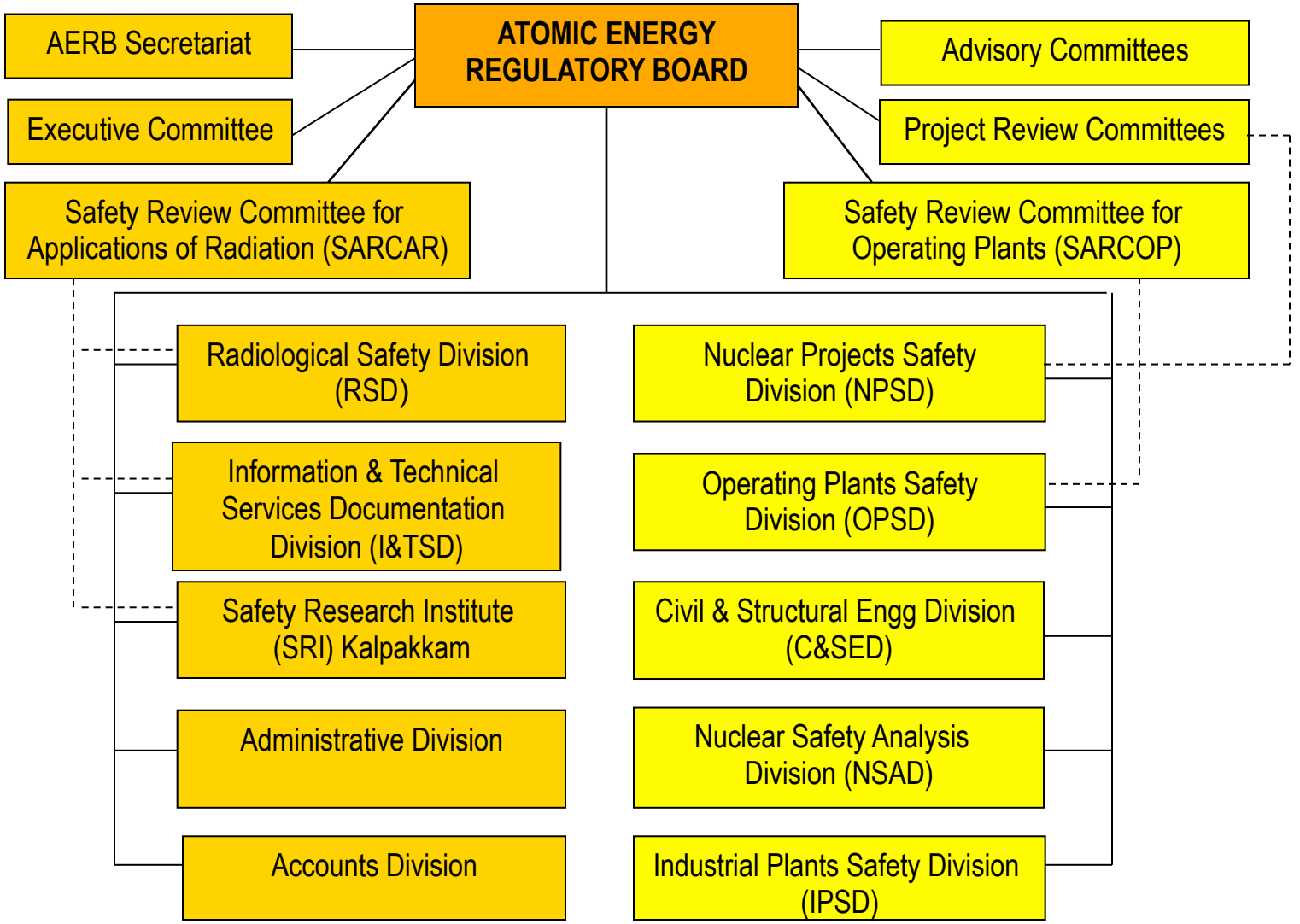
- Codes and Guides
- Regulatory processes (Inspections, PSRs, Safety review etc.)

Granting of Licenses:

- Siting, Construction, Commissioning and Operation
- Decommissioning design provisions requirement at the initial approval of the project.

Extension of license for operation based on Periodic Safety Reviews

Organization



Functions

- Safety Review of Nuclear & Radiation Facilities
- Issue of Authorizations
- Regulatory Inspections, PSR
- Review Emergency Preparedness Plans and Procedures
- Development of Safety Documents
- Safety Research (SRI at Kalpakkam)
- Sponsors Research Projects
- Public Information

Technical Support Agencies for Safety Review

In-house expertise is complemented by

- Bhabha Atomic Research Centre, Mumbai
- Indira Gandhi Centre for Atomic Research, Kalpakkam
- Academic Institutions
- Government Research Organizations
- Experts in the field

International Interactions

- Nuclear Technology cannot remain in isolation
- More so for Regulatory body that controls it
- Interaction with
  - US NRC, ASN(France), ROSTENKHANDZOR(Russia)
  - Nuclear Energy Agency (NEA), OECD
  - MDEP (Multi National Design Evaluation Program)
  - CNS
  - OSART
  - IRRS (Gearing up)

Vital Aspects of Effective Regulation

- Independence in Decision Making
- Competence
- Transparency in regulatory process
- Public Confidence

Regulatory Body earns respect by technical competence (technical and regulatory) and in taking just decisions.

Decision Making Process

- Rule Based and Science based. Both have merits and de-merits.
- Judicious mixture in taking decision has helped.
- Independence of expertise
- Conflict of interest?

  - Designers (from the same TSO)may also become a part of the review process

  Better understanding in problem solving and improvement in design

- Balanced review process to have regulatory perspective

Expertise

- A regulator cannot be expected to possess expertise in all the fields.
- Experts from various fields as per requirement are involved in the regulatory reviews (IITs, BARC, IGCAR, Seismology, Oceanography etc.)
- Development of in-house expertise is an on going process. Various safety research projects are underway.

Challenges

- Various Designs of reactors
  - BWR, PHWRs, PWRs, FBTR, PFBR, AHWR
- Ageing management of older reactors
- Improvement in safety goals
- Stringent requirements
- Keeping abreast of the technological and in the use of state of the art analytical models / methods
- Keeping in step with the international developments & technology

Safety culture Evaluation

- Safety Culture assessment is done during periodic inspections, periodic safety reviews (PSRs) and during interaction with the operating organisation managers.
- The codes and guides concerning the quality management/ assurance set the requirements
- Valuable information regarding the safety culture is attainable from prevailing practices. However, based on the developments in this field it is recognised that it is an expertise subject and more needs to be done.
- A system for reviewing the human and organisational factors is under evaluation by the regulatory body.

In the aftermath of Fukushima Accident

Fukushima Accident - an Eye Opener

- Beyond Design Basis states are possible due to effect of external events
- Enormity of Cliff Edge Effects were seen
- The external events can knock off safety and safety support systems and hamper recovery actions
- Extended black out conditions are possible and may have to be considered as design basis conditions
- Handling of Accidents in multiple units site need to be considered and addressed
- Communication and Decision making play vital role
- Dissemination of information to Public to be enhanced
- **Human Organizational factors play an important role in all the above. The dependence on operator in such scenarios where set procedures are not there is highlighted.**

Consideration of Extreme External events in the design of an NPP – Lessons learnt from Fukushima Accident

- External events (EE) are considered in the design as per site characteristics
- Conservative Margins are built in; revised based on experience and improvements in modeling
- Predicting Magnitude of EE and arriving at a safe margin is a challenge
- It is learnt that(in FA) Systems built to withstand seismic event survived
- Flooding due to tsunami had devastating effect. Safety systems wererendered ineffective
- Limitations of passive systems along with their mission time needs review
- Combination of external events and failure of safety systems need in-depth study

Approach Followed

- Individual Review of the safety of the NPPs by the operating organisation and the regulatory body (Stress Tests)
- Different Working Groups formed under an Apex Committee to review:

  - External Events (Max possible value)

  - Review of different type of reactors

  - Electrical and C&I aspects

  - Waste Management aspects

  -Severe Accident Analysis

  - Station Black out conditions etc.

The Apex Committee report and the recommendations are being reviewed/ followed up.

Approach Followed by India (1/2)

- Review of magnitude of EE for different sites and arriving at numbers

  - Difficult task, quite involved

  - National and international Experts involved in the study

- As an interim measure, some enhanced margin is considered and the NPPs are assessed for their withstand capability – stress test
- Identify the short term and long term measures to upgrade/ guard the SSCs against EEs
- Core and Hydrogen management measures
- Containment protective measures
- Review of Nuclear Emergency handling mechanism
- **Review of regulatory requirements, codes & guides**

Approach Followed by India (2/2)

- Engineering provisions as a preventive measure for 3Cs
  - Raising the elevation of Equipment, Water tight Sealing gates
  - Water injection to core, Isolation Condensers, SFSBs
  - Mobile / Temporary power sources
  - Reactor condition monitoring
  - Alternate heat sink provisions (air, cooling tower etc.)
  -Containment protection and hydrogen handling
  - Recovery action plan (power and system restoration)
- Examination of Human aspects involved in the proposals
  - The measures suggested should be easy to enforce – time to act
  - Dry sites preferred to wet provisions
  - Cliff edge effects should be taken in consideration
  - Access problems to be considered

Human Organizational Aspects in handling the accident at NPP and at Public Domain

- Normal Plant Operation and while facing accidental situations at plant level
- Emergency handling at the NPP site
- Radiological Emergency handling at the national level
- The role of the Regulator in the above

Human Aspects during plant operation and while facing accidents -Requirements (1/2)

- Normal Operations & Design Basis Incidents / Accidents
  - Well analyzed.
  - Required Operator Action -Adherence to procedure
- Beyond Design Basis Events/ conditions:
  - Unchartered territory
  - Normal & Safety Engineered features may not be available
  - Operator on uncertain grounds not trained adequately

Concern:

Operator action should not deteriorate the situation

Human Aspects during plant operation and while facing accidents -Requirements (2/2)

Measures Taken:

- Stress Tests
- Engineering provisions for preventive measures

  -Feed water, Power supply, Core condition monitoring, A

  -Alternate heat sink
- Containment protection, hydrogen handling

  (Venting/PARs etc.)
- Severe accident analysis

Review includes human and organizational aspects w.r.to design of the provisions and carrying out the actions

Requirement: Training, Strong Technical Knowledge

and Certain amount of innovativeness

Human Aspects during plant operation and while facing accidents -Regulatory Measures

- Strengthening operating experience feed back mechanism
- Inclusion of selected beyond design basis conditions in simulator training
- Training in severe accident management
- Field training in handling upgrades and new provisions
- Training in radiological emergency handling
- Training in Communication
- Unambiguous chain of responsibility (defined actions)

<u>Verification During:</u>

Regulatory inspections, Surveillance schedules, Licensing interviews, Periodic Safety Reviews

Human Aspects during plant operation and while facing accidents –Strengths and Challenges

Strengths: Qualified Engineers, Sound Training in nuclear technology.

Reactor operators are graduates in Engineering and trained in nuclear sciences and technology before undergoing rigorous licensing procedures

High Stress Factors:

Psychological stress due to unknown condition of his family etc. due to external events

- A special evaluation program required?

Human & Organizational Aspects of Emergency handling at site

Requirement:

Hardened emergency control (shielded) centers – Infrastructure for condition monitoring,

protective gear, long term occupancy ,

Training of operator and management in recovery actions and, communication,

Clear Command and control

Strengths:

-Dedicated fire stations for nuclear installations

-Public awareness program and close interaction

-Presence of regulator as an observer during emergency drills

Human & Organizational Aspects of Emergency handling at site

Proposal:

Establishing hardened control centers

Challenges:

Emergency plans to cover

Increase in population around the sites

Development of Industrial Areas, Hospitals, Educational institutes etc. around the site

Integration of emergency measures with local population centers

Emergency action plan for events from industrial units.

NPP Recovery actions to expect accidents in industrial units

Nuclear Emergency Handling at National Level (1)

- <u>Nuclear Emergency Handling:</u>

  Review of Emergency Plans

  Training

  - Measuring Instruments, Prophylactics, contamination control

  Infrastructure for sheltering and evacuation etc.

  Clear Command and control

- <u>Revamping of the System:</u>

  National Disaster Management Authority under the chairmanship of Prime Minister

  Swift Action National Disaster Reactor Force

Nuclear Emergency Handling at National Level (2)

- Training by BARC, NPCIL and AERB in nuclear emergency handling
- Decision Support System:

  Indian Real Time Online Decision Support System (IRODOS), Geographic Information based Decision Support Systems (GIS-DSS)
- Strengths:

  Tested system through frequent exercises (limited measures)

  Close interaction and sensitization of people around

  Experience in handling natural disasters
- Challenges: Psychological trauma in case of relocation, land recovery etc.

Role of Regulator (1)

- Review the Assessment of magnitude of EEs:

  - Exhaustive models being looked into through National and international interactions. Higher return periods considered

  - Safety margin assessment

- Review of different aspects of nuclear installation w.r.t Fukushima accident. Strengths and Weaknesses assessed, recommendations made.

- Preparation for facing extreme external events:

  Review of Proposals based on Individual plant examination, plant system upgrades, engineering provisions – human aspect also taken into consideration

  Effectiveness monitoring through surveillance, drills, PSRs

Role of Regulator (2)

- Severe Accident Management Program: Analysis of extended station blackout and hydrogen management - Helps in understanding accident progression, available time scales, forming preventive and mitigative measures, decision making in public domain
- Independent analysis by by Utility (NPCIL), TSO (BARC), AERB (some part) - Helps in validation and Training
- Training Module for Plant Operators and Management, Simulator Training exploration
- Challenges: Technology development of mitigative measures like filtered venting (when designed system not available), PARs etc. Impossible to foresee all the scenarios, Encompassing Operator knowledge, training of operator in ateral thinking, innovative methods, Technical Support

Review of Emergency Preparedness and management of nuclear emergencies

- Review of emergency preparedness plans, improvements in facilities and infrastructre, review of regulatory guides, event based emergency declaration criteria –accident states of reactor
- Formation of Nuclear and Radiological emergency monitoring cell in AERB.
- Training of regulatory staff in the oversight process:

  -Seminars, Lectures etc. Training in severe accident analyses and recovery actions

  - Most of the regulatory staff connected with the operating power stations review undergone rigors of operator licensing program for regular operators – first hand knowledge available

Need of the hour

- To allay the fears and anxiety caused by nuclear accident by transparent communication between nuclear community and public
- Ensuring all the relevant measures are taken to make the nuclear power safe
- Measures should not only be taken but seem to be taken
- Close interaction between nuclear community in reviews, exchanging notes on developments in ITO etc.

Conclusion

- Credibility of nuclear regulator would be an important factor in assuaging the public feeling and allaying their fears.
- Competency, Expertise, Transparency in regulatory enforcements should live up to instill confidence in the minds of all
- Human and Oraganizational aspects play an important role and should be properly addressed.

Thank You For Your Attention

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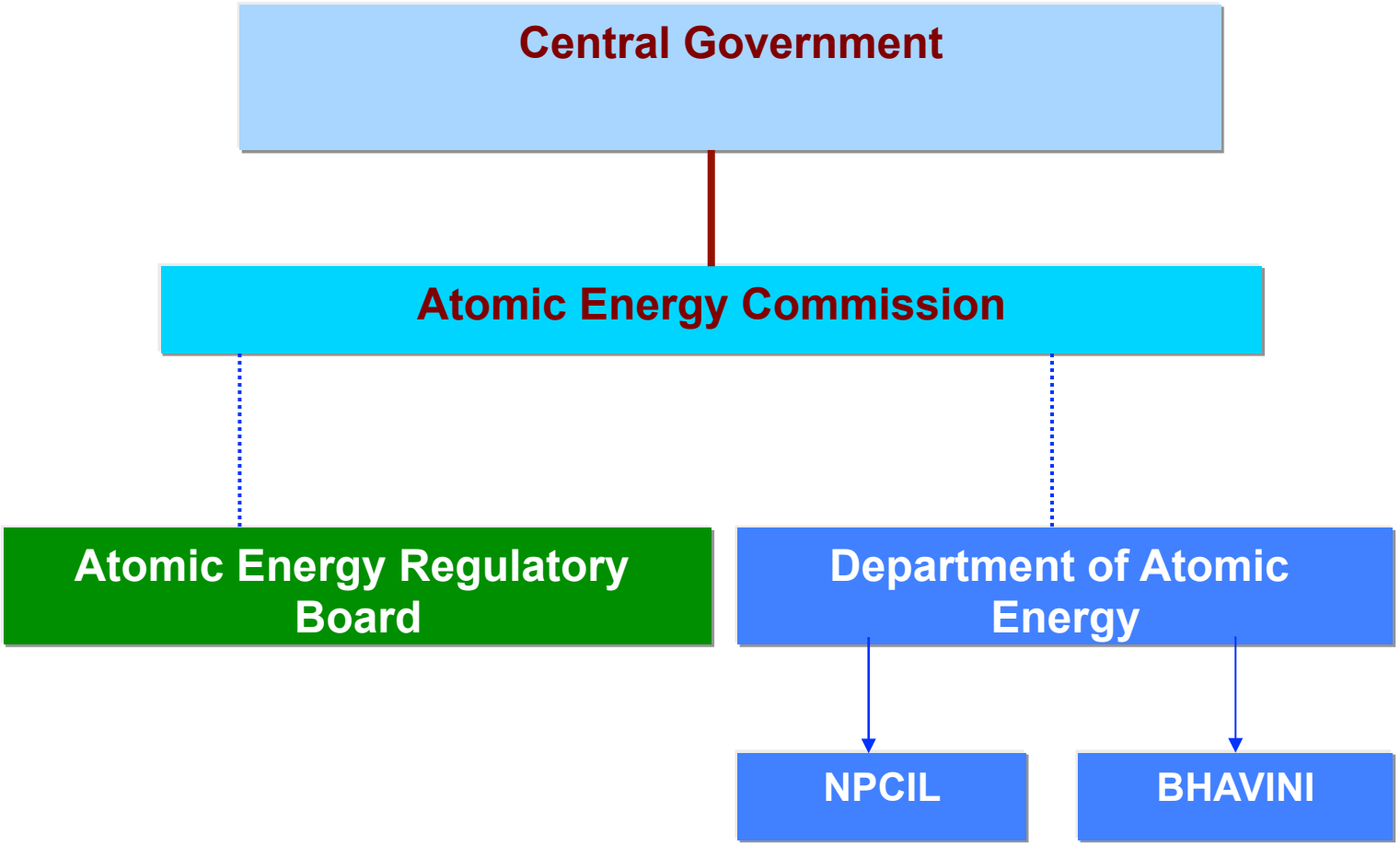
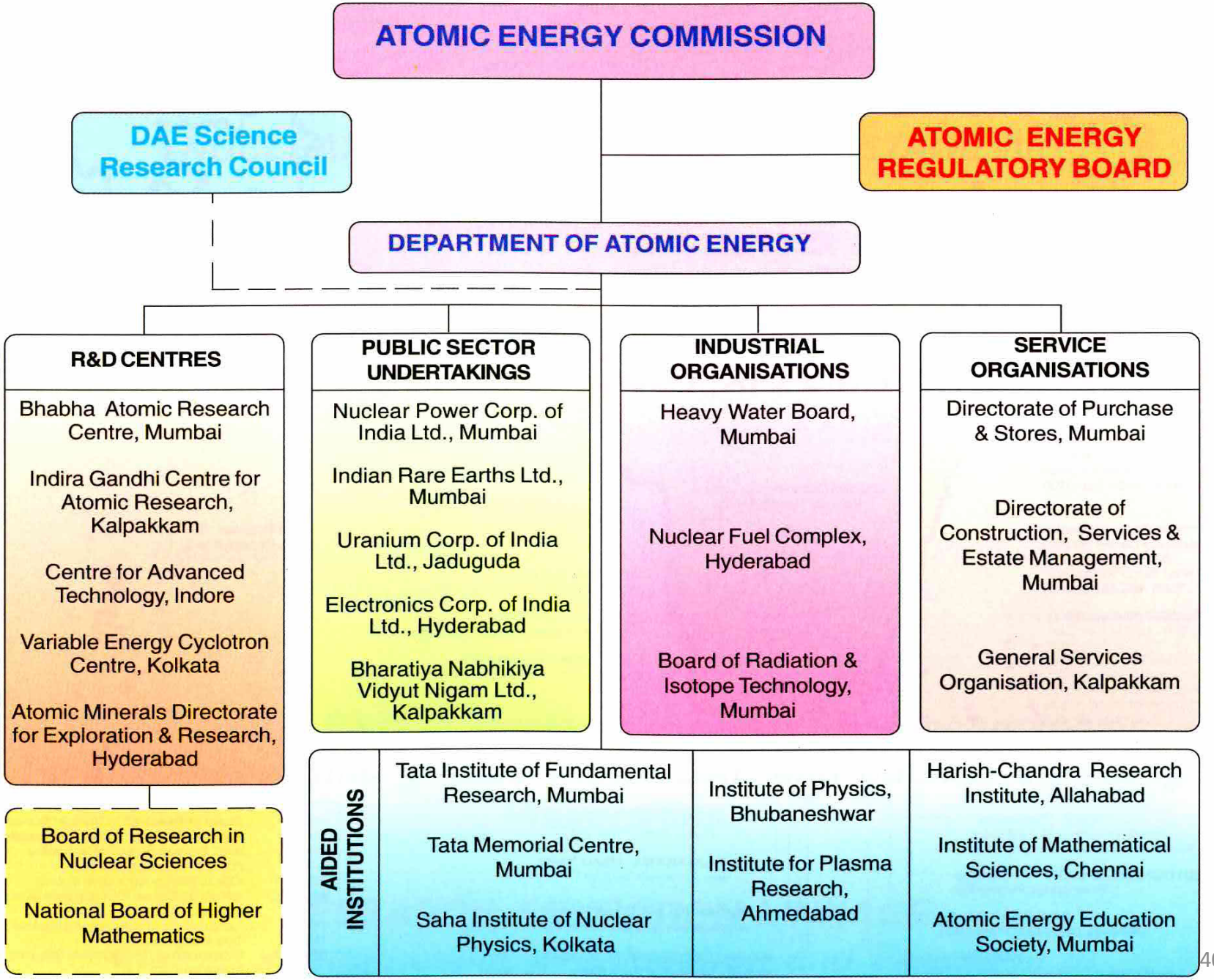
Regulatory Framework

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