



CENTRAL ELECTRICITY AUTHORITY

Ministry of Power

Impacts of Climate Change on Hydropower Development and Sustainability: An Overview

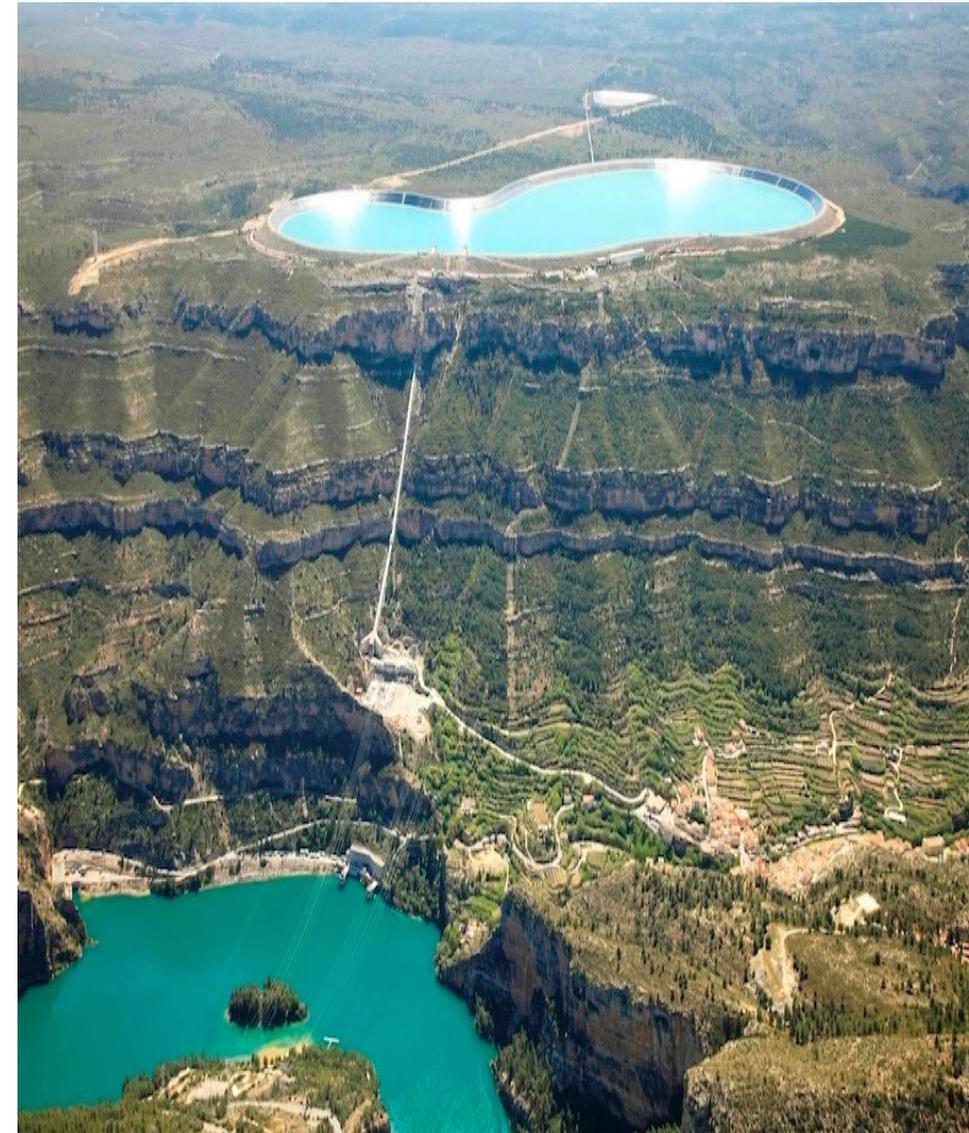
By

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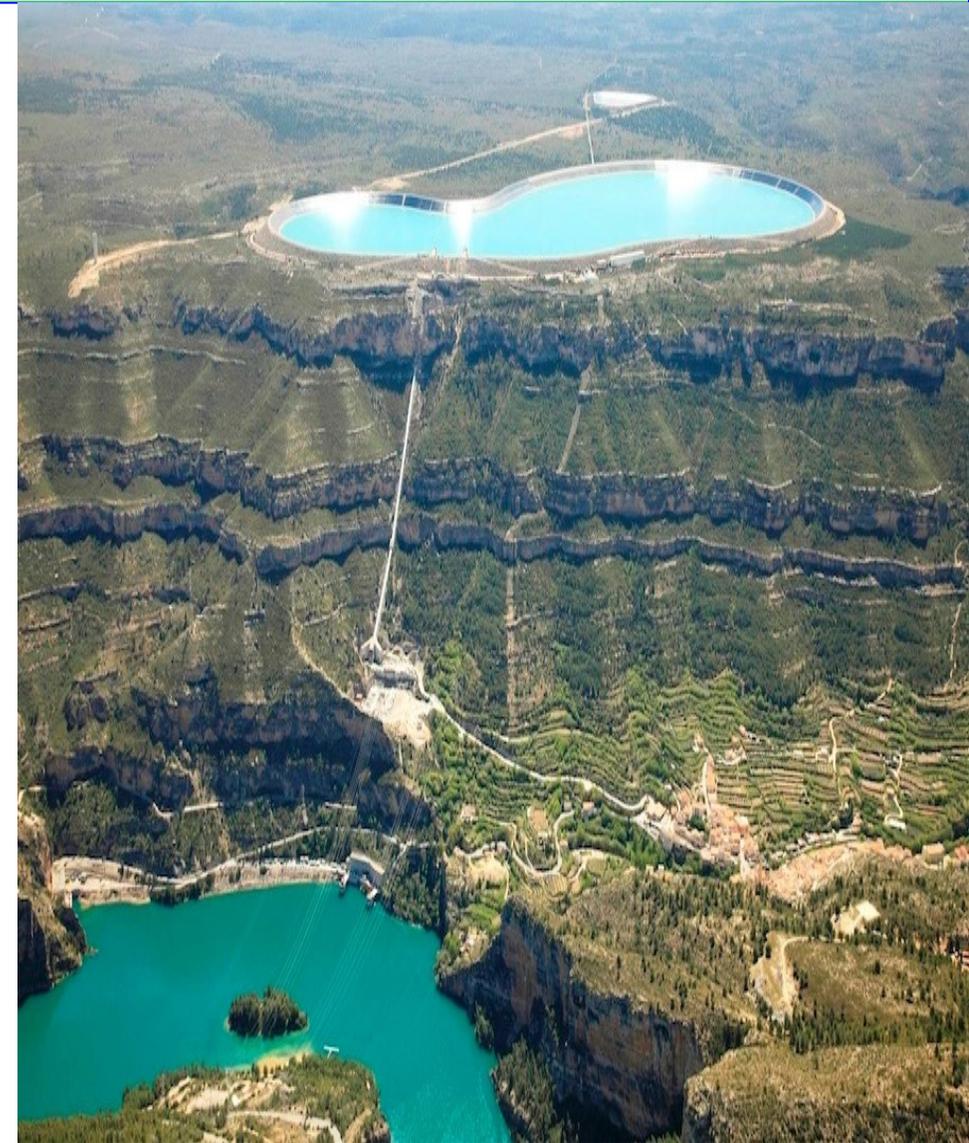
Scheme of Presentation

- Present Power Scenario
- Present and Projected Hydropower Scenario :
National and Global Perspective
- Climate Change
- Extreme weather Events
- Critical elements affecting Hydropower Generation
- Impact of construction of new Dams
- Impact of extreme weather events on Operational, Under Construction Projects

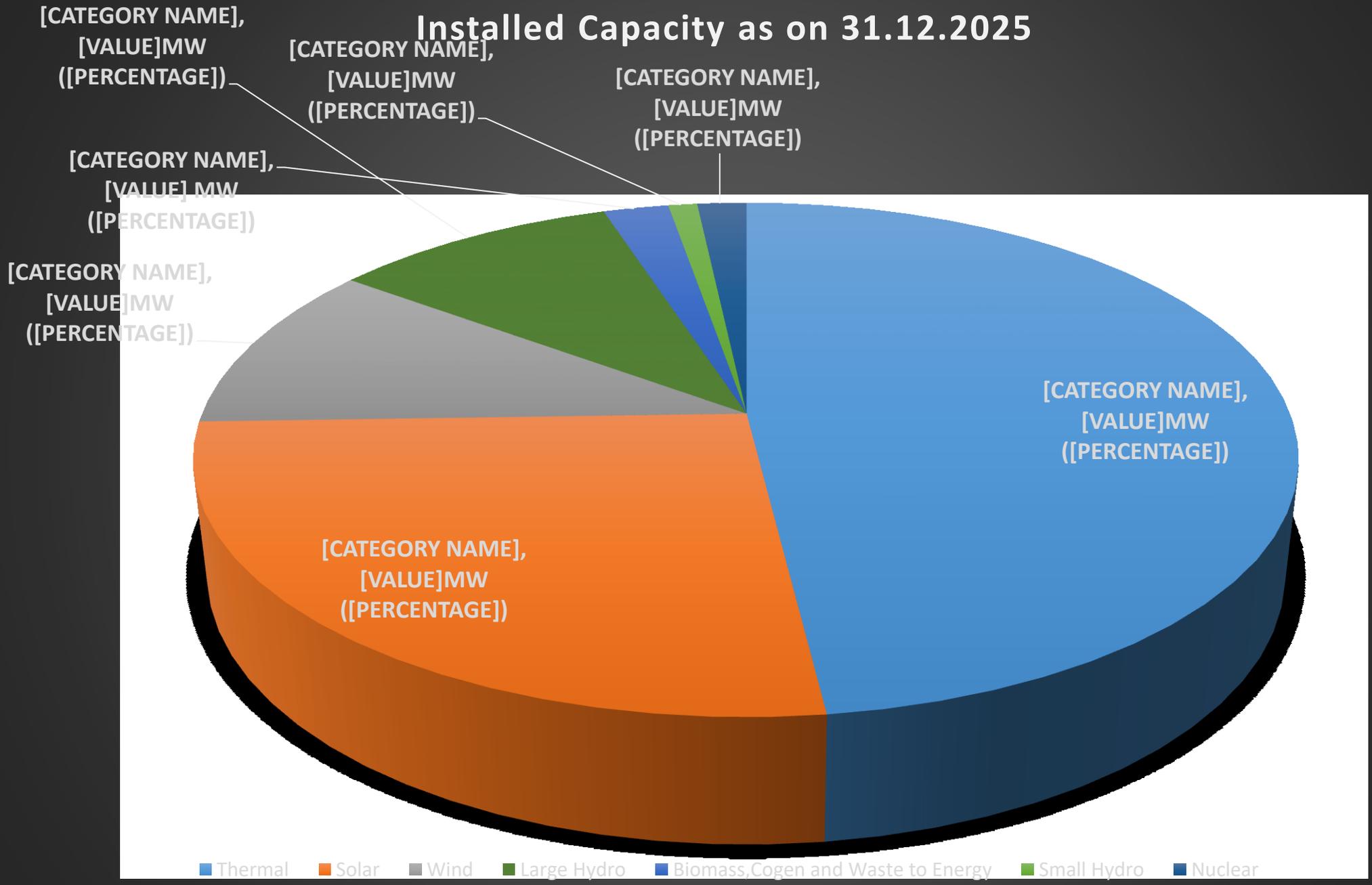


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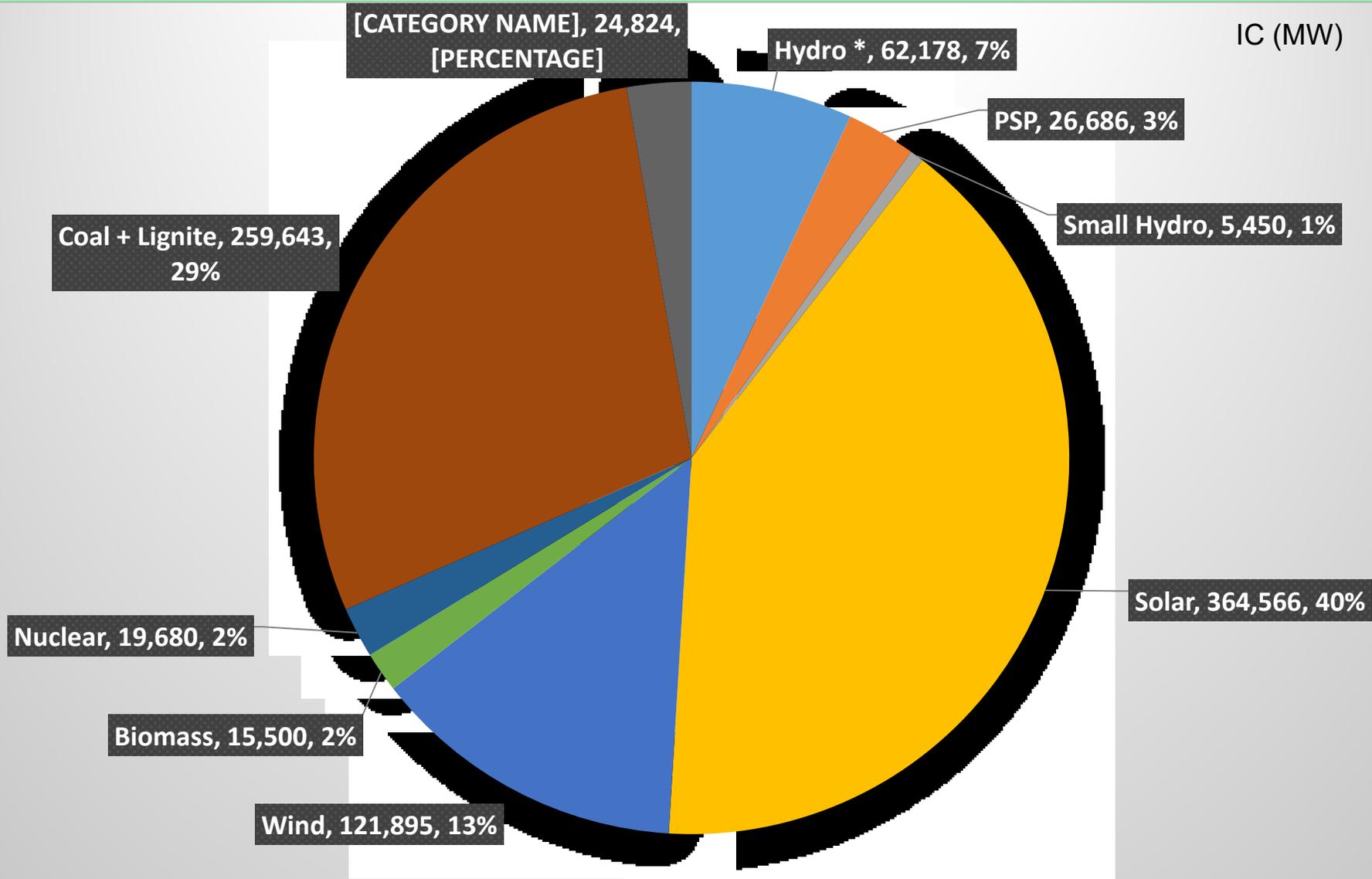
- Measures for Sustainable Management
- Risk Mitigation measures during Planning, Implementation and Operation
- Conclusion



Installed Capacity as on 31.12.2025



Projected Installed Capacity by Mar 2032



Total IC: 900 GW as on 31.03.2032

(Fossil: 34% Non-Fossil: 66%)



CLIMATE CHANGE

- Long term shift in temperature and weather patterns
- Burning Fossil fuels(Coal, Oil and Gas)
- Green House Gases like CO₂ and CH₄
- Average temperature of Earth has increased by 1.42⁰C with base as 1800 AD

The Result is :

- Intense droughts
- Water crisis
- Rising sea levels and salt water intrusion
- Flooding



- Melting Glaciers
- Storms
- Rising evaporation losses from reservoirs
- Impact on Health
- Risk of Water and Food Security
- Impact on existing Infrastructure
- Impact on Bio diversity

Impact on People & Economy

Extreme Weather Events & other Impacts

- GLOF
- LLOF
- Cloud Burst
- Inundation due to sea level rise
- Wide spread Floods
- Intense droughts



Extreme Weather Events & other Impacts

- Extreme cold and summer
- Salt water intrusion in fresh water resources
- Melting Glacier
- Frequent Storms
- Wild Fires



Critical elements affecting Hydropower Generation

- Quantum of water available
- Change in availability of water in comparison to Historic data effect of snow fall, snow melt, increment in global temperature
- Increase of inflow in high discharge season and reduction in low discharge season
- Soil erosion and increased Silt load
- Reduction of live storage
- Stoppage of Powerhouse frequently due to high silt load

Critical elements affecting Hydropower Generation

- Rise of River bed level downstream of Dam/Barrage
- Filling of TRC by debris, slush/silt and rise of TRC Level

Reduction in Net Head available to Turbine

- Increase in Head Loss
- Higher Maintenance Costs



Impact of Construction of Dams

Negative

- Natural flow of River gets disturbed
- Quality of water to an extent gets affected during Construction
- Fish Migration
- Slope disturbance due to huge excavation
- Creation of Reservoirs results in submergence
- Creation of reservoirs may affect local economy as River rafting may not be possible
- Sudden release of water affects downstream area
- Methane generation due to decomposition of organic matter in reservoir

Positive

Controlled release of water downstream during high discharge /Flood Protection

- Water security
- Irrigation
- Boost to State economy due to free energy
- Local Area development due to LADF, local contracts
- Creation of new Infrastructure like Schools, Hospitals , Community Buildings etc under CSR
- Roads, Communication facilities

Operational Assets :

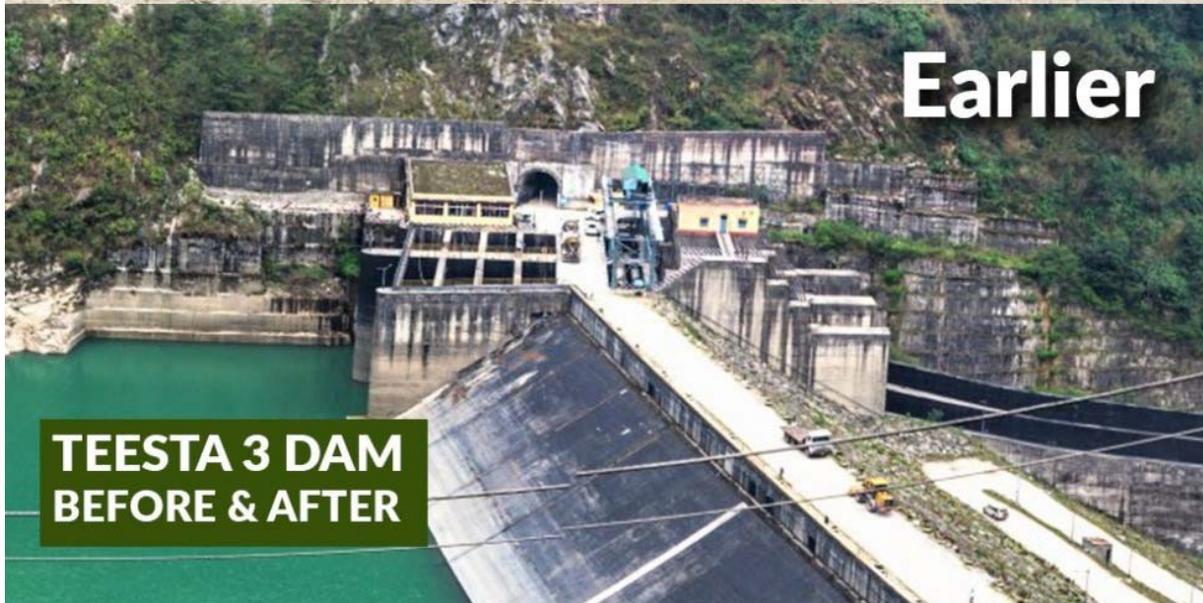
- Loss of asset as in Teesta-III CFRD
- Loss of partial asset as in Teesta-V (Radial Gates)
- Loss of Generation for long time thus affecting Organization, Banking System and GRID
- Reduction of Generation affecting viability of Projects
- Destruction of existing infrastructure like Roads, Bridges, Drinking water systems, Canals, Transmission Towers
- Inundation of downstream area and resultant catastrophe including cascade effect
- Inundation of Hydropower stations and risk to Human Safety

Impact of extreme weather events on operational and under construction Assets

- Hydro being perceived as Risky Asset by Insurance Companies and resultant increase in Insurance costs
- Severe damage to Wind and Solar Installation due to Storms
- Change in Wind flow patterns and reduction of Generation



Impact of extreme weather events on operational and under construction Assets



Teesta- III HEP CFRD
Sikkim Flash Floods October 2023

**View of Dam Upstream during pre-disaster and post-disaster
Teesta-V PS Sikkim Floods 2023**



Before



After Flash Flood

Views of Radial Gates at Dam of Teesta-V PS

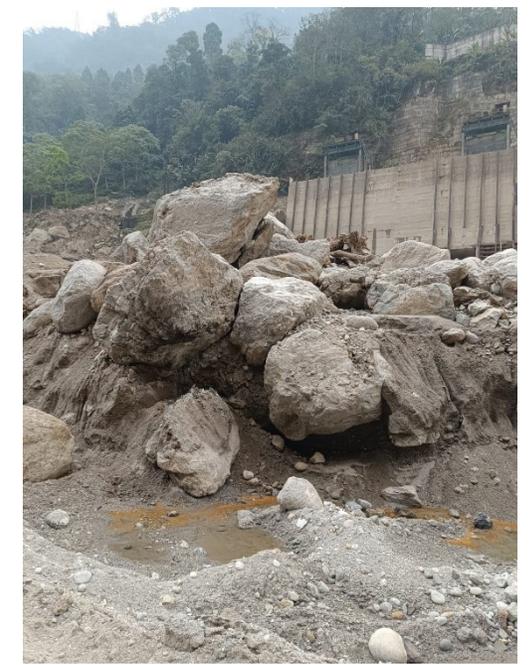
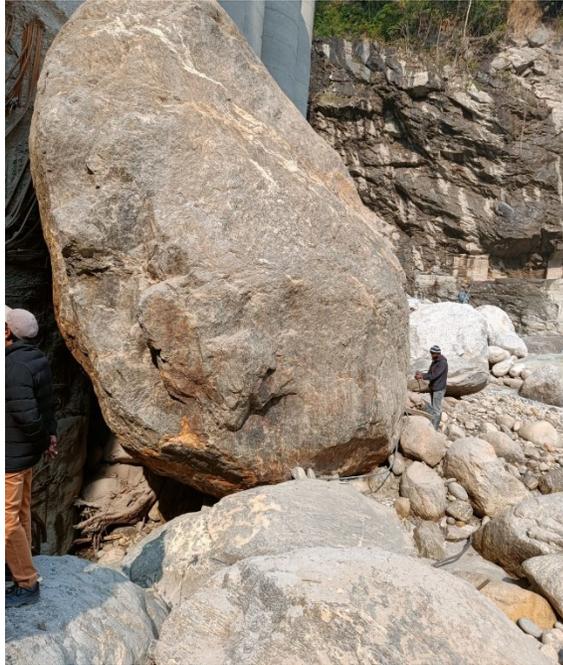


Before



After Flash Flood

Views of Boulder deposition upstream of Dam of Teesta-V PS



Views of Boulder deposition upstream of Dam which might have obstructed spillway openings during the flash flood occurred on 4th October 2023 and eventually resulted into choking of approx. 40% of Spillway openings.

Impact of extreme weather events on operational and under construction Assets



TLDP-III HEP : D/s view of power House. Silt and slush deposit on TRC during Sikkim floods 2023

Under construction Asset

- Loss of Cofferdams
- Damage to under construction Civil work resulting in re-work
- Damage to Electromechanical & Hydromechanical equipment in Store/Site
- Substantial increment in Insurance cost
- Time overrun of Projects and resultant Cost overrun
- Viability of Project

Breaching of U/s Cofferdam of Kwar HE Project – 26.08.2025



Before



After

Measures for Sustainable Development

- Less dependence on Fossil fuels
- Energy Transition
- Target for 50% Energy contribution from Non fossil fuel resources
- 1000 GW Capacity from Non-fossil fuel resources by 2040
- Limiting Earth temperature rise to by 1.5⁰C with base as 1800 AD
- Nuclear Capacity of 100 GW by 2047
- Focus on Power Generation, Transport and Energy Guzzler Industries
- Construction of Large Dams with BCM Level storage for Water and Food Security
- To support large scale RE integration, addition of PSP capacity at a large scale

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Measures for Sustainable Development

- Check Dams
- E-flow
- Fish Passes
- Focus on Energy Efficient Equipment
- Carbon Capture Utilization & Storage (CCUS)
- Green Hydrogen Mission
- Use of Floating Solar Projects on Reservoirs, Canals
- Off shore Wind Project
- Bio fuels



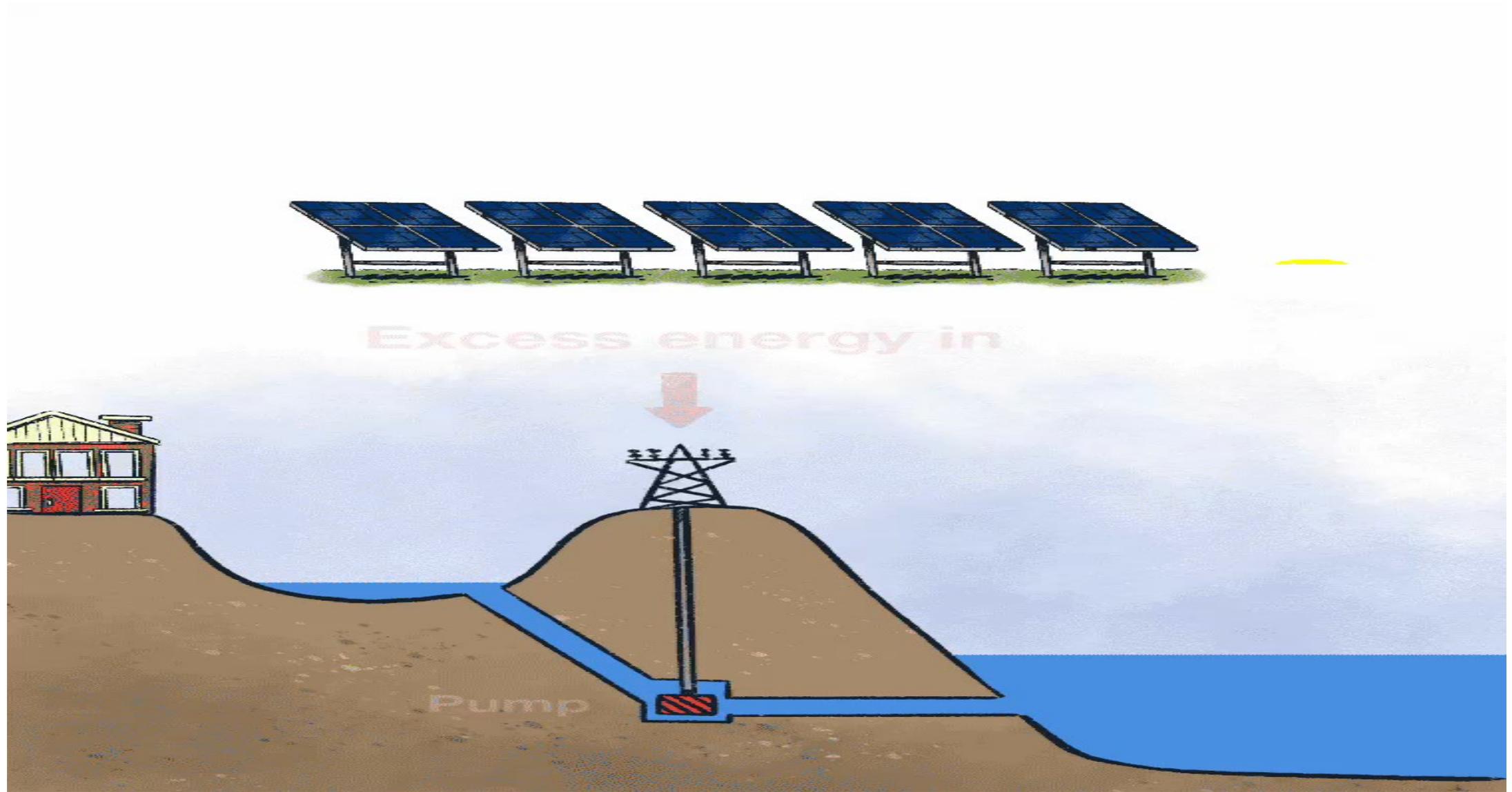
Risk Mitigation Measures

- Mapping Glacial Lakes
- Design Dams taking in to consideration GLOF aspects (GLOF+SPF)
- Early Warning Systems
- First Project nearest to Glacial lake invariably Concrete Gravity Dam
- Sufficient measures for sediment management
- Use of Colcrete coffer Dams instead of Conventional Dykes with clay core
- Additional surface spillway to remove debris, wooden logs

Risk Mitigation Measures

- Protecting Reservoir Rim
- Protecting Downstream Erosion and Protecting River Banks
- Additional cushion in Dam height for absorbing Flood
- Use of Steel liner downstream of sil beam in spillway Gates
- Recouping Live Storage
- Well planned Flushing & Sluicing operations
- Effective use of weather data and satellite data

Prototype of a PSP



Conclusion

- Core issue is Net zero@2070
(preferably earlier without compromising development needs of Country)
- Focus on Energy Transition with increasing share of Non-fossil fuel based resources
- To facilitate Energy Transition , emphasis on Energy Storage Systems(Preferably PSP)
- Large scale addition of Storage Dams for Water Security , Flood Control and Hydro Generation
- Evaluation of Risk, Adaptation Strategy and Operational Resilience
- Winning Strategy is one which can successfully navigate: People, Planet and Profit



THANK YOU

Advantages of PSP over Battery Storage

	PSP	Battery Storage
Life	Civil structures: 100 years E&M: 40 years, extended upto 100 years with R&M	6000- 8000 cycles (12 years)
Replacement	No replacement required during project life	Requires replacement every 10-12 years with current technology.
Resource availability	Natural resource, abundantly available in India	To be imported Key minerals concentrated in South America, China, Congo
Critical equipment dependence	Manufacturing - based in India	Manufacturing concentrated in China, Japan, Korea
Commodity Price Risk	Minimal – mature and well-developed supply chain	High, multiple competing uses
Storage/ Discharge duration	6-12 Hrs No technology limitation	~3 Hrs
Environmental hazard	Negligible	High
Bankability	Matured technology	Developing technology

- Energy Transition -
 - 50% installed capacity from non-fossil fuel sources by 2030(already achieved in July 2025)
 - Net Zero Emission target by Year 2070
- Serving as a clean, green, and domestically sustainable energy solution.
- Integration of vREs for Grid Stability & Security
- Offering large amount of energy during off-peak hours and providing additional capacity to meet the peak loads
- Ramping support, faster start-up and shutdown, spinning reserves- similar to Hydro projects
- Ensuring grid stability with a lifecycle of about 100 years
- Imparting mech needed Inertia to the Grid with rotating Mass

PSP Capacity addition plan till 2031-32

Year	Total (MW)
2025-26	2680
2026-27	2920
2027-28	1600
2028-29	6350
2029-30	13500
2030-31	21190
2031-32	8800
Total	57040

Ambitious Plan is to have 100 GW PSP Capacity by 2036.



Environment Clearance Process

- **Category 'A' Projects** - EC from MoEF&CC on the recommendations of an Expert Appraisal Committee (EAC) - **Hydro Power Projects with capacity \geq 100 MW**
- **Category 'B' Projects** - EC from the SEIAA based on the recommendations of a State/ Union Territory Level Expert Appraisal Committee (SEAC) - **Hydro Power Projects with capacity \geq 25 MW & $<$ 100 MW**
- Category 'B' river valley projects falling in more than one State/projects in/ in vicinity of Protected Area/ ESZ/ State boundary /International boundary shall be appraised at the Central Level.

Environment Clearance Process.....

- EIA Notification stipulates four stages in the process of obtaining Environmental Clearance.

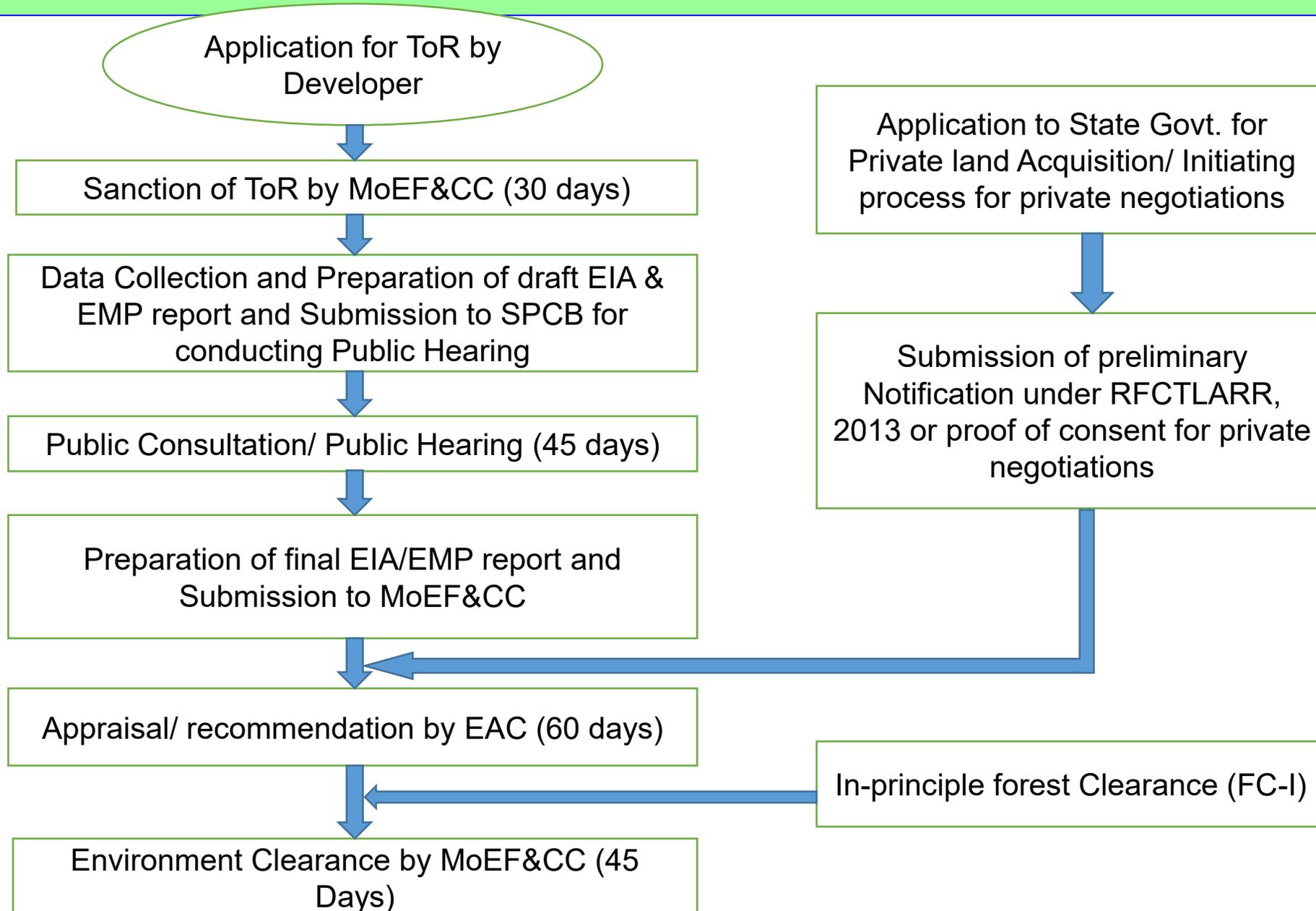
Stage (1) – Screening: For Category ‘B’ Projects, SEAC takes the decision whether or not the project or activity requires further environmental studies for EIA report for its appraisal prior to grant of environmental clearance – Two Categories – B1 (requires EIA report) & B2 (doesn’t require EIA report)

Stage (2) – Scoping: wherein the EAC/ SEAC determines Terms of Reference (ToR) addressing all relevant environmental concern for the preparation of an EIA Report in respect of the proposed project.

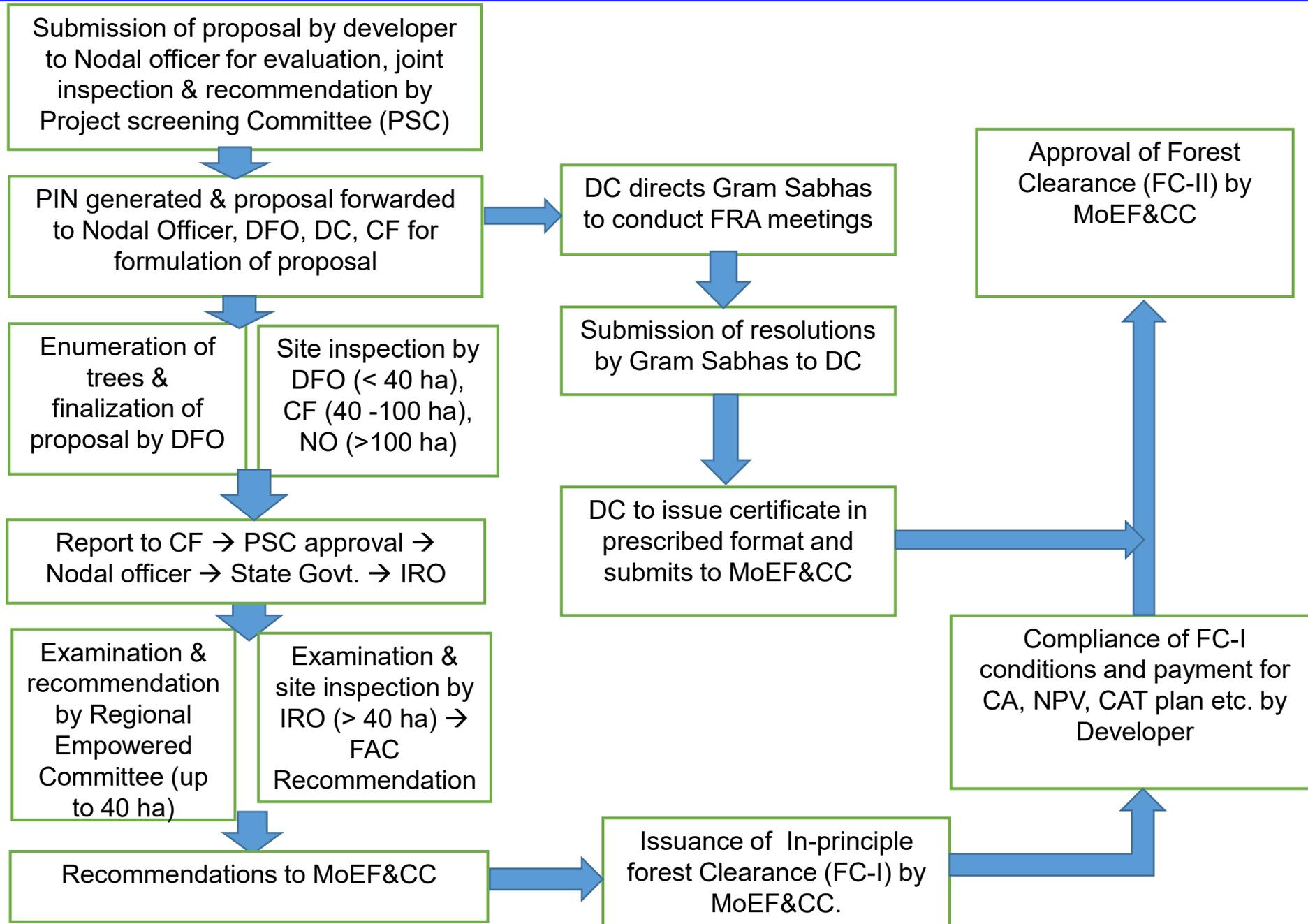
Stage (3) – Public Consultation: Two components- i) Public Hearing at the site or in its close proximity - district wise, to be carried out for ascertaining concerns of local affected persons; ii) Obtaining responses in writing from other concerned persons having a plausible stake in the environmental aspects of the project or activity.

Stage (4) – Appraisal: Detailed scrutiny by EAC or SEAC of the application, the Final EIA Report, outcome of public consultations including public hearing proceedings and recommendations for grant of environment clearance.

Environment Clearance Process.....



Forest Clearance Process



Timelines for DPR preparation and concurrence

- For PSPs awarded under section 63 of EA, 2003 or part of Integrated Renewable Energy projects and captive PSPs

S. No.	Description of Clearance	Time limit as per revised guidelines (Version 2.0)
1.	Survey & Investigation stage (pre-DPR clearances)	690 days
2.	Concurrence	50 days (30 days.....)

- For other PSPs

S. No.	Description of Clearance	Time limit as per revised guidelines (Version 2.0)
1.	Survey & Investigation stage (pre-DPR clearances)	690 days
2.	Concurrence	90 days