Clean Energy Transition through Regional Grid Interconnections

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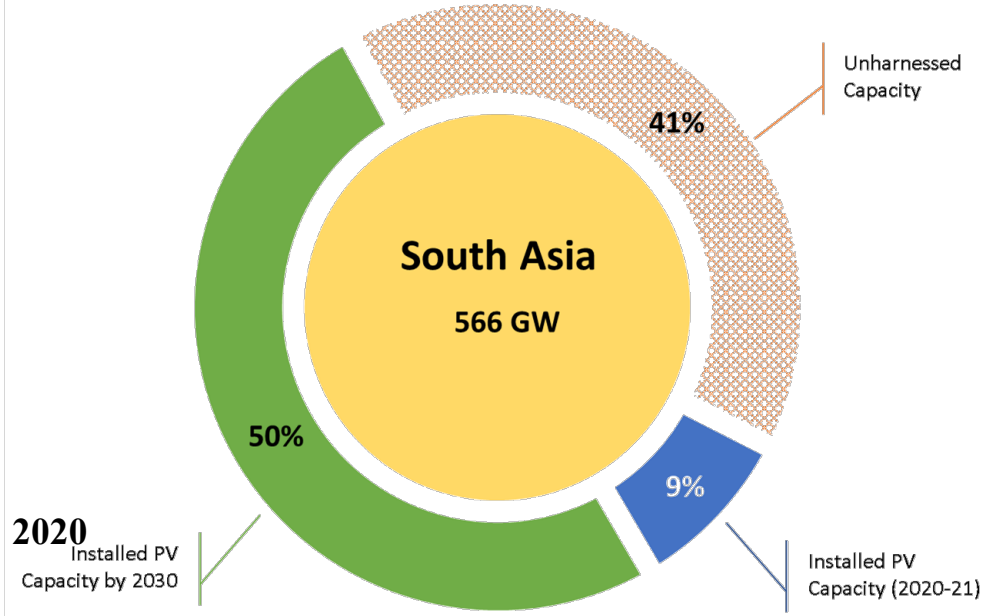
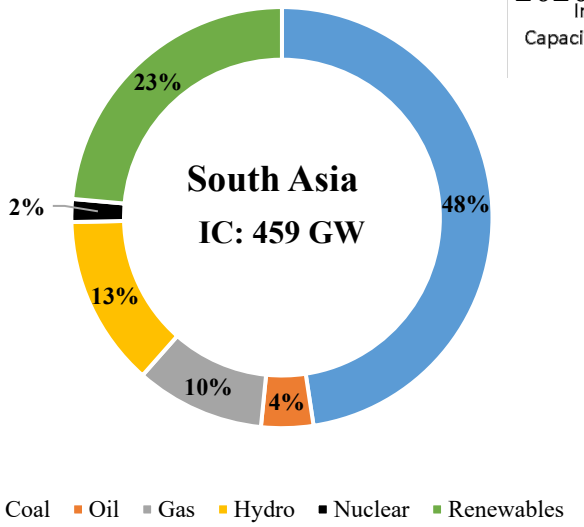
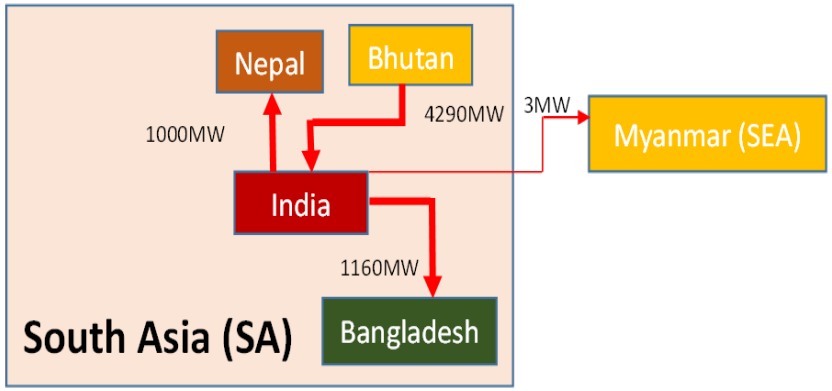
Energy Transition Options

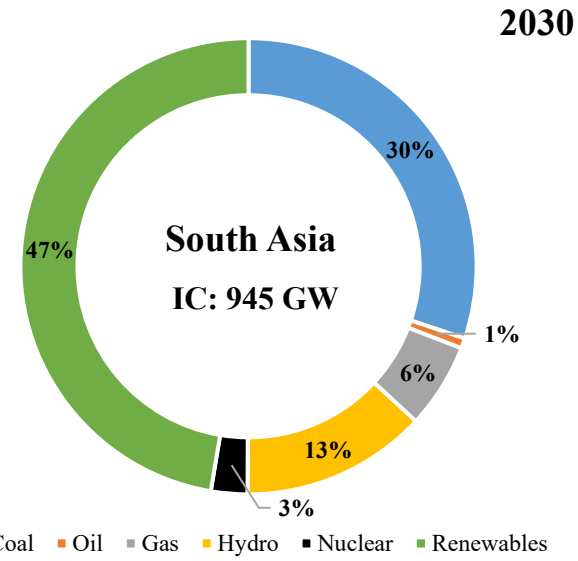
I	Optimal Utilization of Clean Energy Resources	Robust Cross Border Interconnection for accessing Clean Energy and Sustainable development
II	Utilization of Local Energy Resources	Harness Locally Available Energy Resources

South Asia Region – Overview









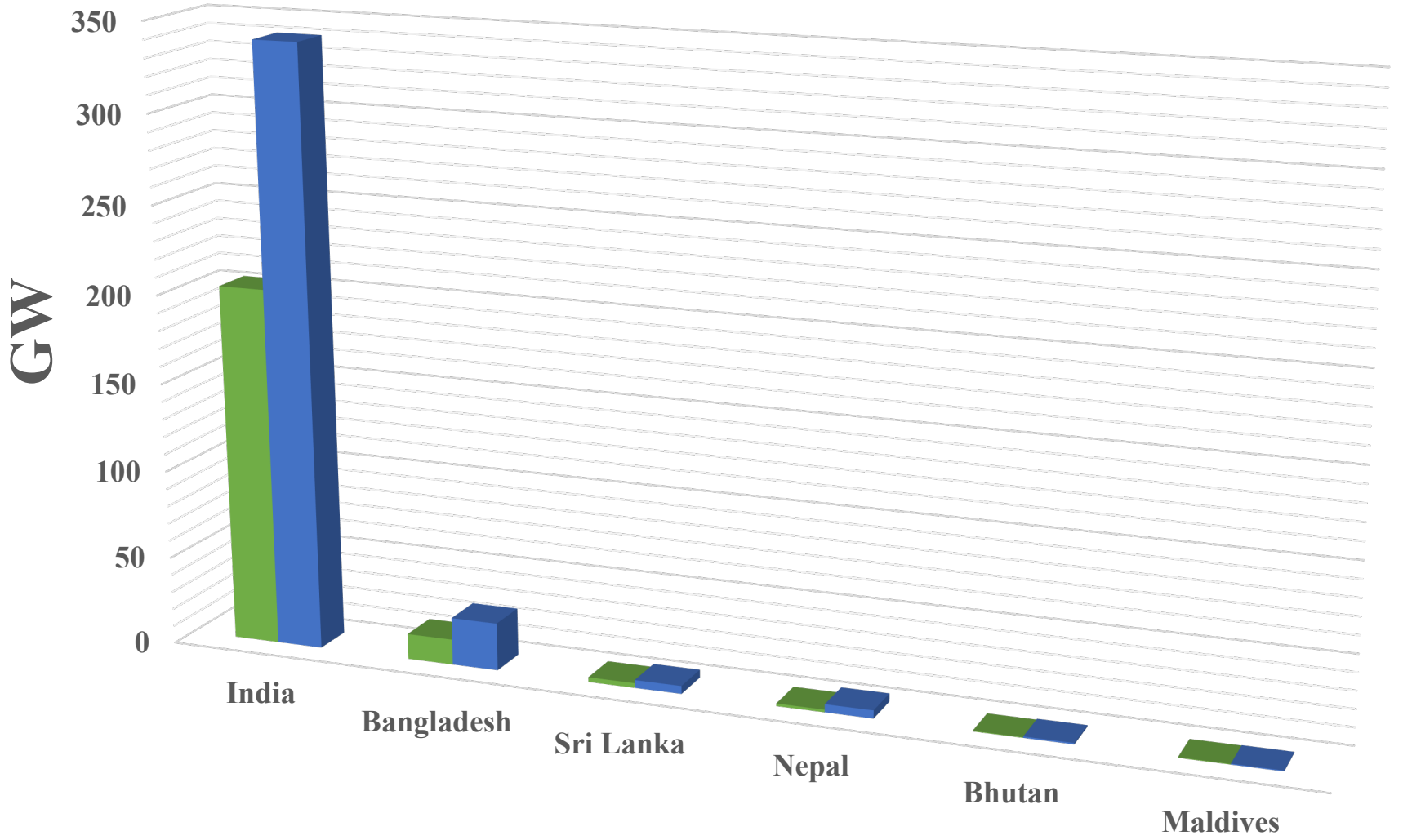
RE Penetration (Capacity) :

Region	2020	2030
SA	23%	47%

RE + Hydro Penetration (Capacity) :

Region	2020	2030
SA	23% +13%=36%	47% +12%=59%

Peak Demand

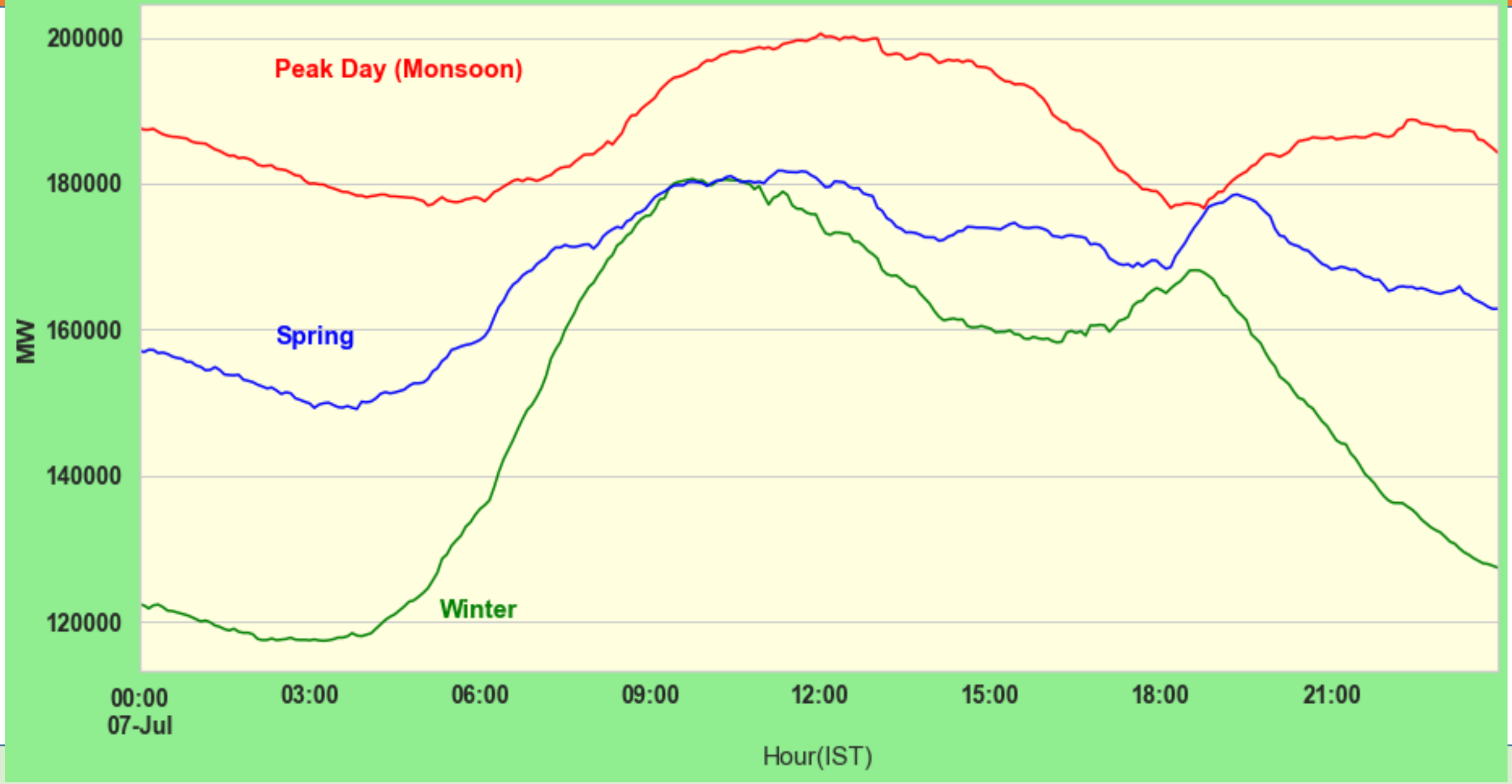


	India	Bangladesh	Sri Lanka	Nepal	Bhutan	Maldives
Peak Demand (GW) -2020	203	14.5	2.7	1.5	0.3	0.3
Peak Demand (GW)-2030	340	27.01	4.5	4.6	0.8	0.5

Key Learnings From Existing Cross Border Links - South Asia

- **Planning** : By planning agencies of the respective countries for either Import or Export of Power
- **Type of Interconnections** : Either HVDC or AC network or Radial Connection
  - HVDC- 01 no.
  - AC- 10 no.
- **Investment and Ownership**:
  - By Utility of the Respective Country
  - Part of Generation Project
  - Combination of Utility in the importing country and Part of generation project in the exporting country
  - JV between utility of respective country
  - Grant by Govt. and ownership by utilities in the respective country
- Recovery of investment through payment of monthly Transmission charges / Generation Tariff by the importing country
- Power transfer through Bilateral Long Term Contracts.

Typical All India Daily Load Profile



Source: POSOCO

Cross- Border Link Planning Considering Various Aspects of Regional Interconnection

Regional Interconnection: Technical Aspects

- **Type of Interconnection :**
  - Synchronous (AC) or Asynchronous (DC)
  - DC
    - Monopolar or Bipolar
    - Back-to-Back
  - Overhead Line or Underground Cable or Undersea cable
- **Transmission Voltage**
  - 765kV /400 kV /220 kV /230 kV /132 kV AC
  - ±800kV DC / ± 500kV DC / ± 320kV DC
- **Frequency**
  - 50 Hz or 60 Hz
- Length of the Interconnection
- Quantum of Power (MW) and direction of power flow
- Terrain, Geology and land use, Temperature Zone, Wind Zone
- Reliability Criteria
  - N-1, N-1-1
- Transformers - Transformation Capacity (MVA)

Regional Interconnection: Operational Aspects

- Real Time Data:
  - Interconnection control center - Load Dispatch Center
  - SCADA/EMS
  - PMU - WAMS
- Data sharing mechanism
- Communication
  - Fiber Optic / PLCC/ Microwave/ GPS
- Scheduling and despatch mechanism
- Energy Meter
  - Metering Interval
  - Online/ off-line
- Energy Accounting and settlement
- Deviation settlement mechanism
- Protection
  - Overvoltage/ Under voltage
  - Defense mechanism: Rate of Change of Frequency (df/dt), Under frequency, System Protection Schemes
  - Fault Clearance time (Zone-1, Zone-2, Zone-3, etc.)

Regional Interconnection: Commercial Aspects

- Mode of Transaction:
  - Bilateral/ Trilateral/ Multi lateral
- Owning and operation of line: Utility consortium / Territorial utility / Private player under Regulated / Merchant model
- Financing for construction and Repayment
- Contractual frameworks for recovery of CAPEX and OPEX through tariffs
- Bulk Power Transmission Agreements
- Power Purchase Agreements – Bilateral / Multilateral
- Markets – Long Term / Day ahead / Intraday
- Physical Transmission Rights / Financial Transmission Rights / Contracts for difference
- Transmission tariff determination and aproval
- Network Access
  - Pricing
  - Sharing of charges (Cost of Transmission) – Postage stamp / Point-of-Connection
  - Sharing of transmission losses
  - Maintenance cost
  - Payment security mechanism
  - Taxes & duties

Regional Interconnection: Regulatory & Legal Aspects

- Cross Border Trade of Electricity mechanism (Connectivity & Access):
  - Regulation
  - Procedure
- Dispute Resolution
- Regulator
- Grid codes
  - Connection code
  - Operational philosophy
  - Scheduling and dispatch code
  - Market operation
- Harmonization of technical standards
- Legal framework for :
  - Co-operation and collaboration for formation of the interconnected grid between participating nations
  - Long / Medium / Short term agreements with rights and duties of each parties
  - Power purchase and pricing – Scheduled and Unscheduled exchanges
  - Defaults management and termination

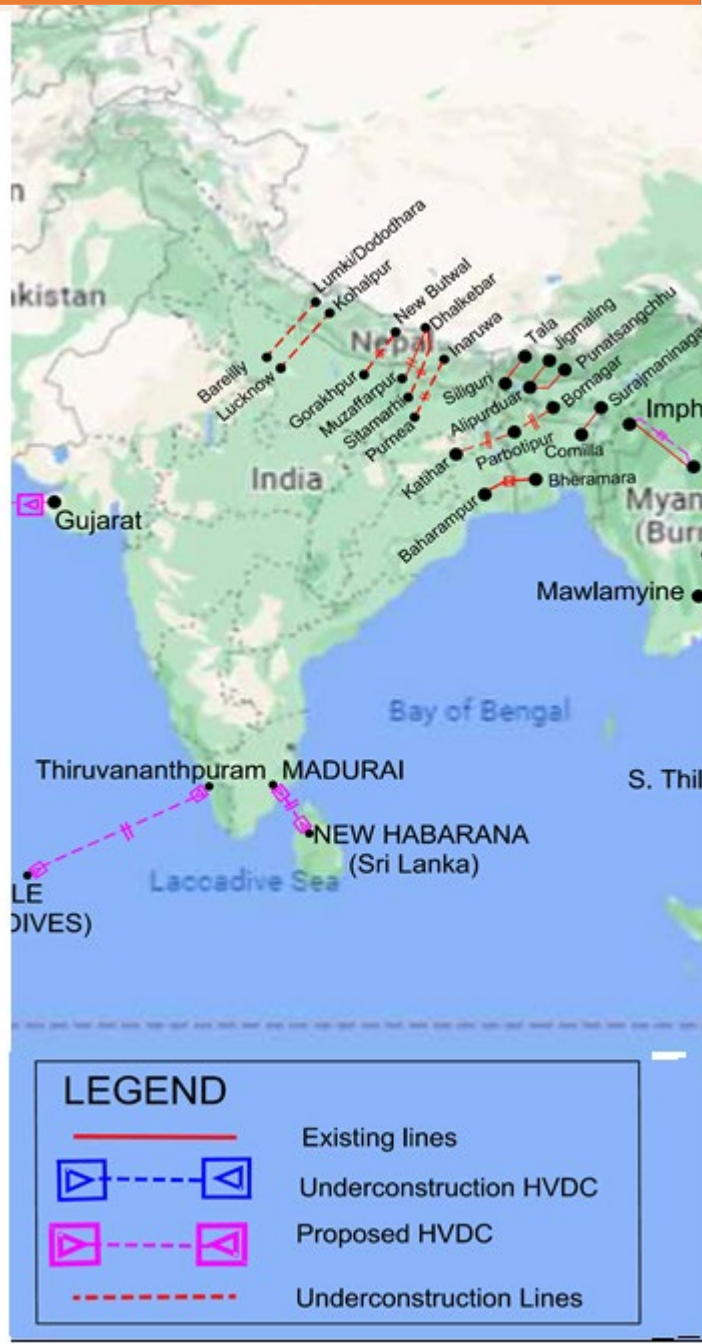
Regional Interconnection: Institutional Aspects

- Governing body of Govt. representatives – to adopt policy, legal and regulatory framework (JSC/JWG)
- Scheme approving agency - Intergovernmental forum(CEA)
- Planning agency for Cross Border links (JTT)
- Regulator for international links

- Utility / Consortium to own and operate links
- System Operator (JOC)
- Different bodies with TSO / ISO representatives for:
  - Overall coordination
  - System operation and security
  - Regulatory oversight
  - Market operations etc.

Cross Border Interconnections in South Asia

- Cross-Border Interconnection in South Asia Under Consideration
  - Augmentation of India- Nepal Links
  - Augmentation of India- Bangladesh Links
  - Augmentation of India- Bhutan Links
  - India-Myanmar
  - India- Sri Lanka
  - India- Maldives



Summary & Way Forward

- Inter Governmental Agreement for Establishment of new links & Strengthening of existing interconnections
- Steering Committee/Working group for coordination related to Technical, Operational, Commercial, Regulatory matters.
- Country Specific Outline for energy transition, Clean Development

Thank You