



BIMSTEC
ENERGY CENTRE

Bay of Bengal Initiative for Multi-Sectoral
Technical and Economic Cooperation

Capacity Building Program for BIMSTEC Energy Sector Executives

Bengaluru | 14 - 18 September 2026



**Stronger Together
for a Greener
Tomorrow**

PRESENTATION ON

Advanced Technologies in Power Transmission

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केन्द्रीय विद्युत प्राधिकरण
CEA
Central Electricity Authority



18 September 2026 | Bengaluru



Grid Modernization



HVDC & FACTS



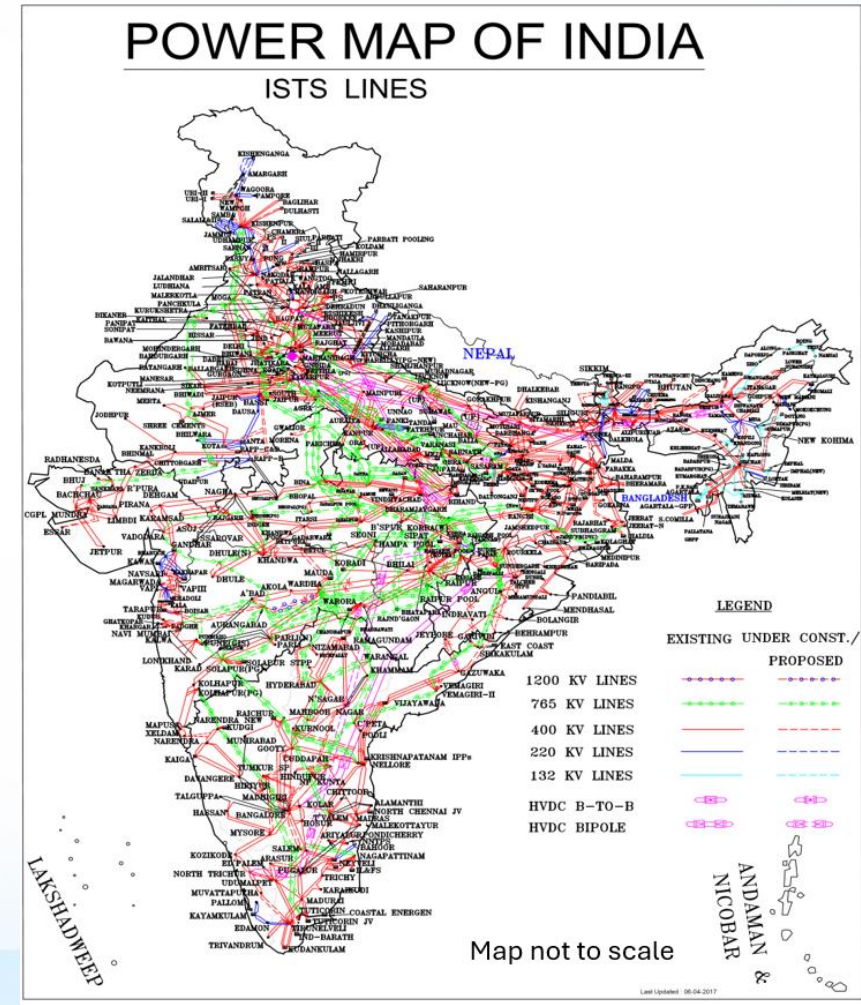
Digitalisation & Smart Grids



Resilient & Sustainable Transmission

Power Transmission

- Vital link in the electricity supply chain
- System provides ‘**service**’ of inter-connection between the source (electrical energy sources) and consumption (load centres) of electricity
- Generally High Voltage system
- System parameters shall be within limits for proper functioning



A strong transmission network is the backbone of a reliable, resilient, economical and renewable-ready power system.

Phases of Transmission System Development

- Planning
- Engineering
- Implementation
- Safety
- Charging
- Operation and Maintenance

Transmission Planning

- Dynamic updation of Rules, Regulations, Policies, Criteria to meet new technologies
 - Planning Criteria Updation
 - Transmission Ahead Generation
 - Potential Based Planning
 - Long term and Rolling Plans
- Generation Resource Adequacy Planning (STELLAR)
- Planning Software
- Coordination among agencies
- Route planning (PM-Gati Shakti)
- LiDAR survey

Transmission Planning Criteria by CEA

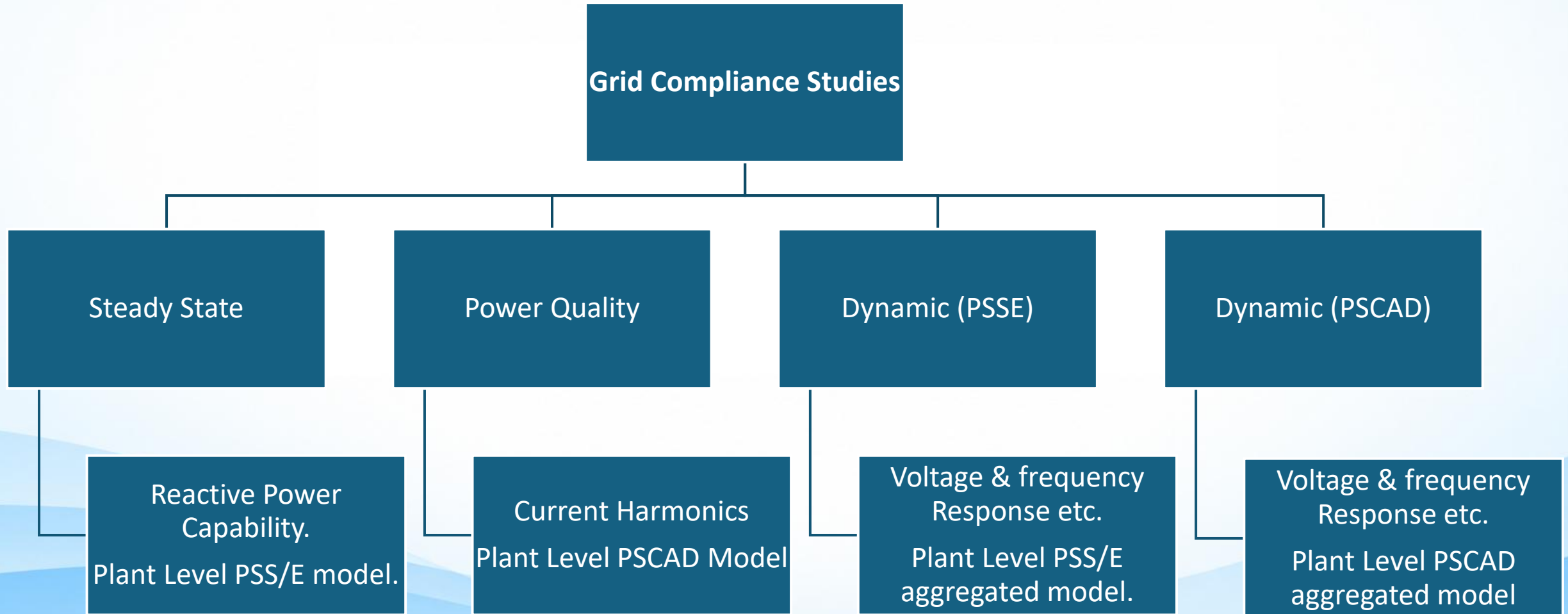
❖ Guideline document for Transmission Planning purpose for Indian Grid
The manual on transmission planning criteria published by CEA covers the planning philosophy, the information required from various entities, permissible limits, reliability criteria, broad scope of system studies, modelling and analysis and gives guidelines for transmission planning.

❖ System studies for Transmission Planning

1. Power flow studies
2. Short circuit studies
3. Stability studies
4. TTC/ATC calculations

Updation of Criteria based on learnings and New Technologies. Latest update will be released shortly.

Studies & Tools



PM GATISHAKTI NATIONAL MASTER PLAN

Spatial GIS Integration:

Single-window planning using over 1,400+ spatial data layers to map ISTS lines against land, forest, rail, and highway networks.

Proactive Avoidance Mapping:

Identifies restricted zones early (e.g., reserve forests, GIB habitats in Rajasthan, coal seams) to minimize line rerouting.

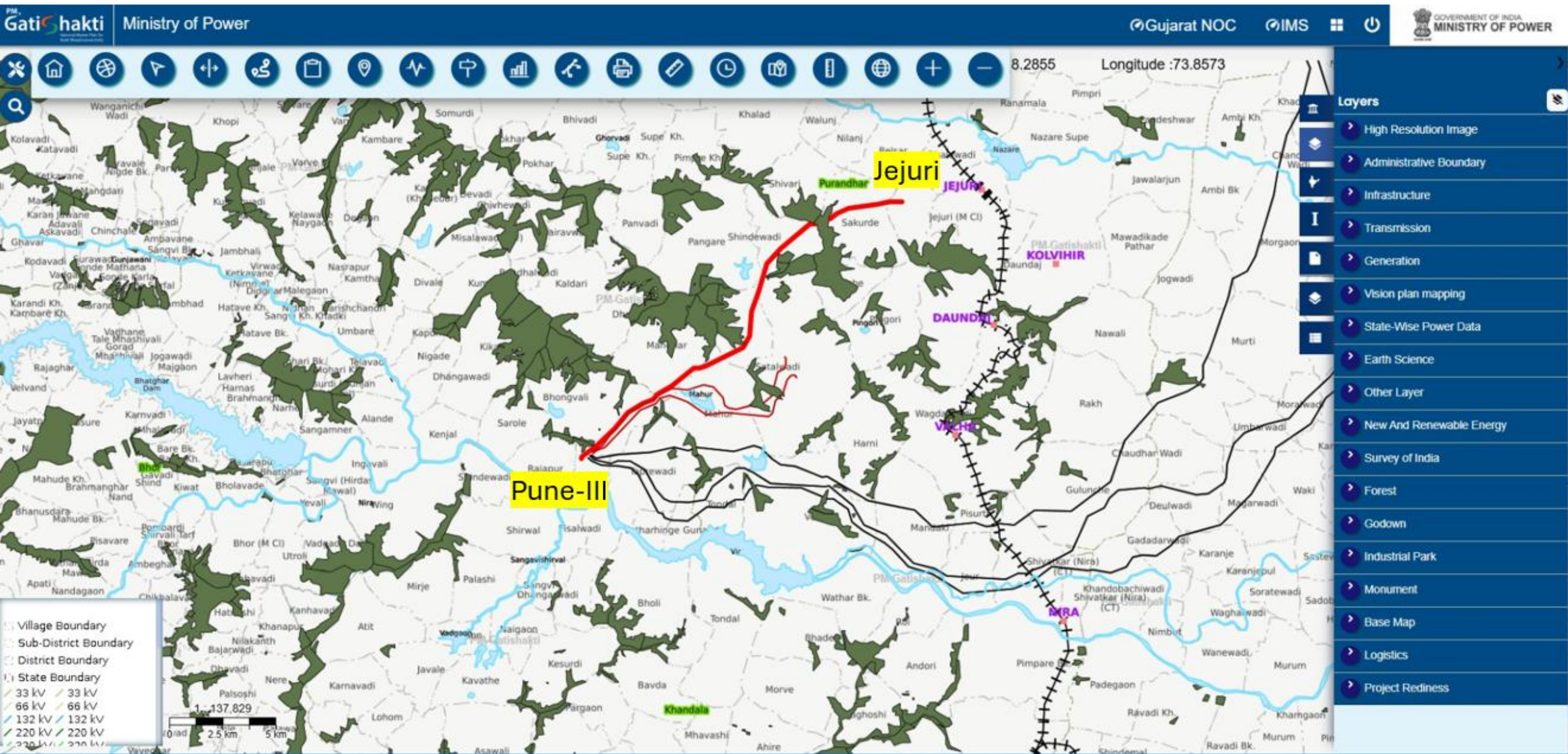
Coordinated Infrastructure Corridors:

Synchronizes transmission line alignment with upcoming expressways and freight corridors to reduce Right-of-Way (RoW) fragmentation.

NPG & TBCB Streamlining:

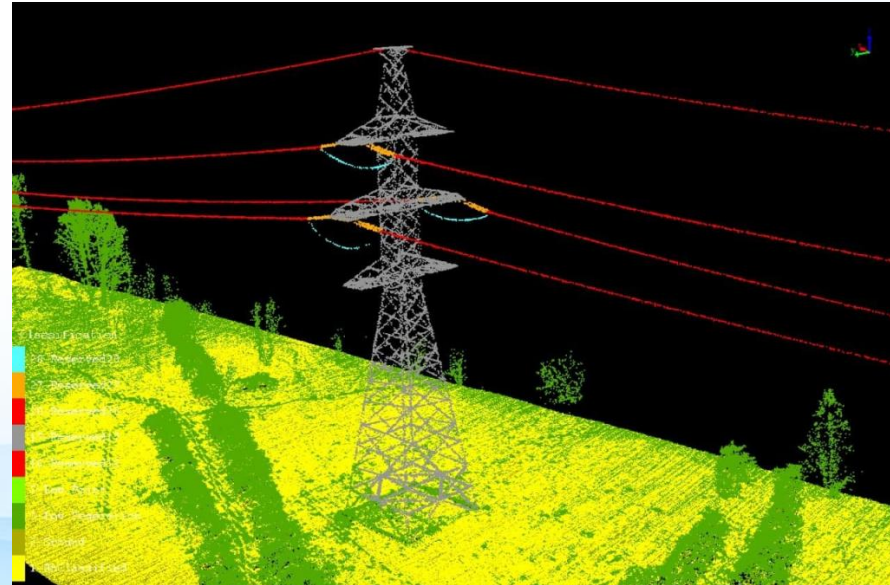
Speeds up Network Planning Group (NPG) clearances and DPR preparation, ensuring faster project execution under Tariff-Based Competitive Bidding.

PM GATISHAKTI NATIONAL MASTER PLAN



LiDAR Survey

- Drone-mounted or airborne laser scanners to map corridors in 3D, capturing true ground elevations, vegetation, and conductor wires quickly and accurately



Engineering and Technological Advancements

- Monopole, Narrow base towers, Insulated Cross Arms (RoW optimization)
- Gas-Insulated Substations (Footprint Compression)
- STATCOM, SVC (High speed Dynamic Reactive Compensation)
- Synchronous Condensers
- HVDC (LCC/VSC)
- UHVAC (1150 kV)
- High capacity conductors (HTLS)
- Grid forming inverters
- DLR (Capacity unlocking)

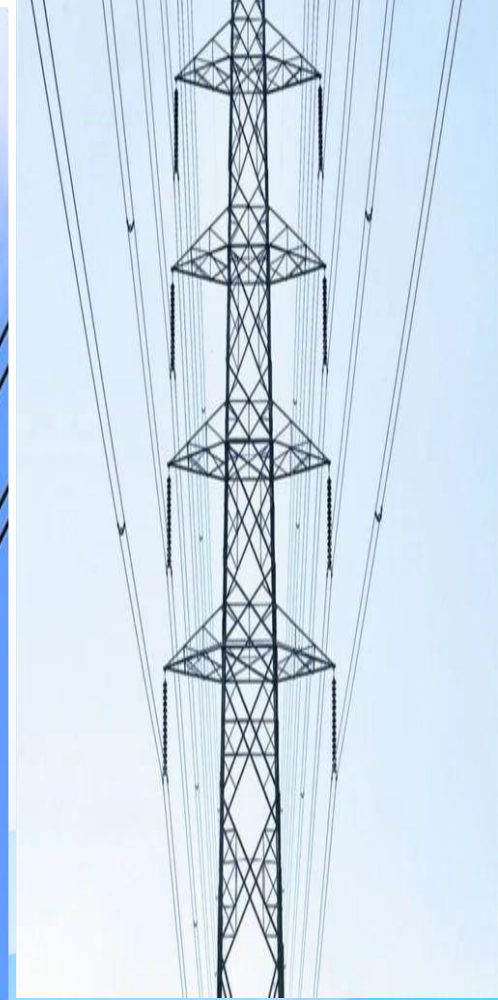
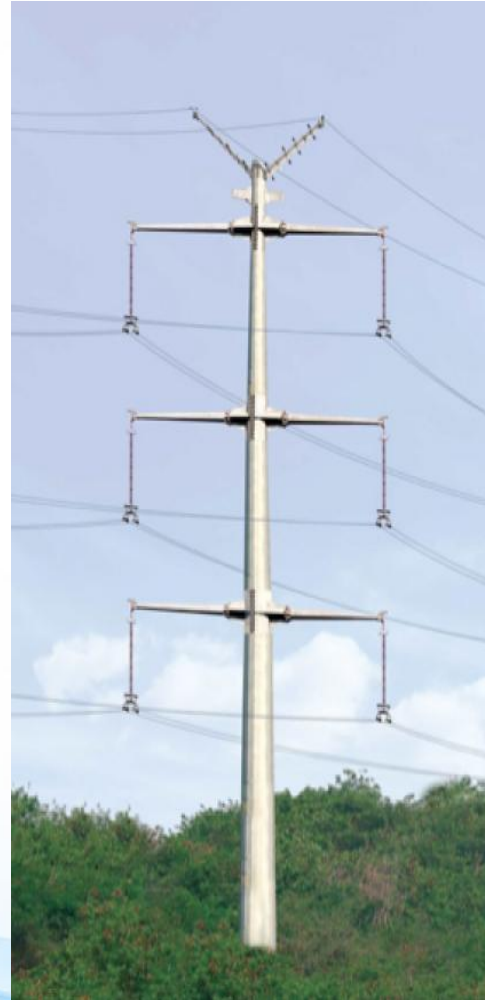
Monopole, Narrow base and Insulated Cross-Arm

Compact Foundation Footprint: Steel monopoles reduce ground land requirement by **70–80%** compared to broad-base 4-legged lattice towers.

Insulation-Integrated Cross-Arms (ICA): Replaces hanging insulator strings to eliminate conductor swing under high wind conditions, cutting tower top width by **30–40%**.

RoW Mitigation in Severely Constrained Areas: Solves acquisition deadlocks in congested urban fringes, high-density forest patches, and steep hilly terrains.

Corridor Upgrading: Enables voltage upgrading (e.g., 220 kV to 400 kV) within the exact same existing line corridor without fresh land acquisition.

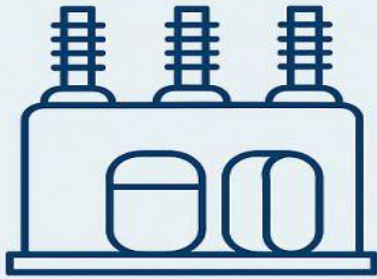


Gas Insulated Substation (GIS)

GIS vs AIS Substation

GIS

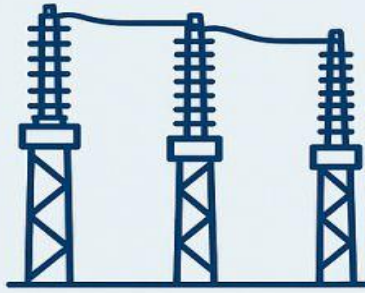
(Gas Insulated Substation)



- Compact footprint
- High reliability & low maintenance
- Higher cost
- Enclosed design

AIS

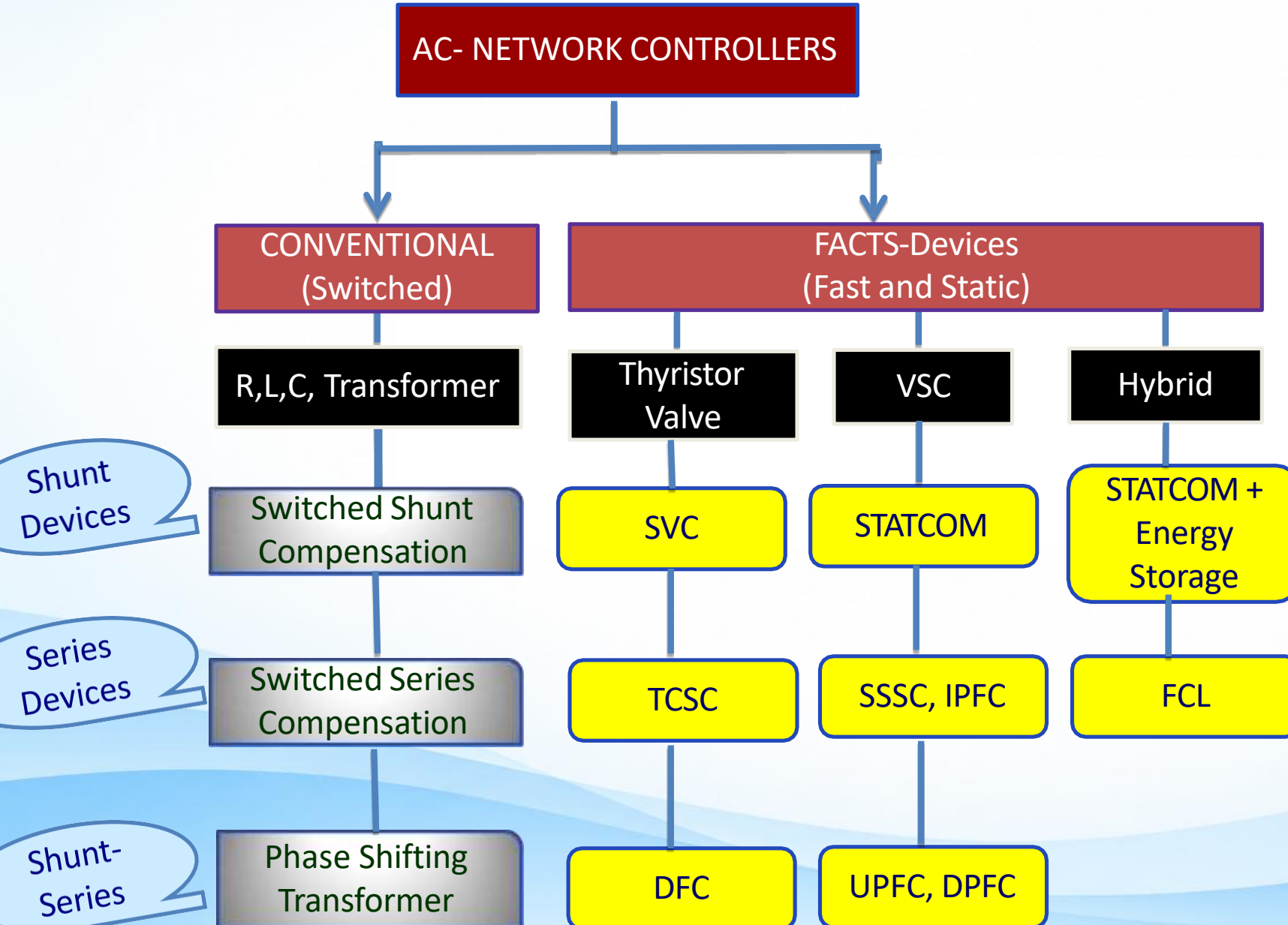
(Air Insulated Substation)



- Economical
- Easier to maintain and upgrade
- Requires more land
- More exposure to environmental elements



Flexible AC Transmission System



FACTS controllers are classified as

- Series Controllers
- Shunt Controllers
- Combined Series-Series Controllers
- Combined Series-Shunt Controllers

SVC: Static VAr Compensator
TCSC: Thyristor Controlled Series Capacitor
DFC: Dynamic Flow Controller
SSSC: Static Synchronous Series Compensator
IPFC: Interline Power Flow Controller
UPFC: Unified Power Flow Controller
DPFC: Distributed Power Flow Controller
FCL: Fault Current Limiter

Dynamic Line Rating (DLR)

Key Function: Replaces static thermal limits by monitoring actual line conditions using physical IoT sensors and weather telemetry.

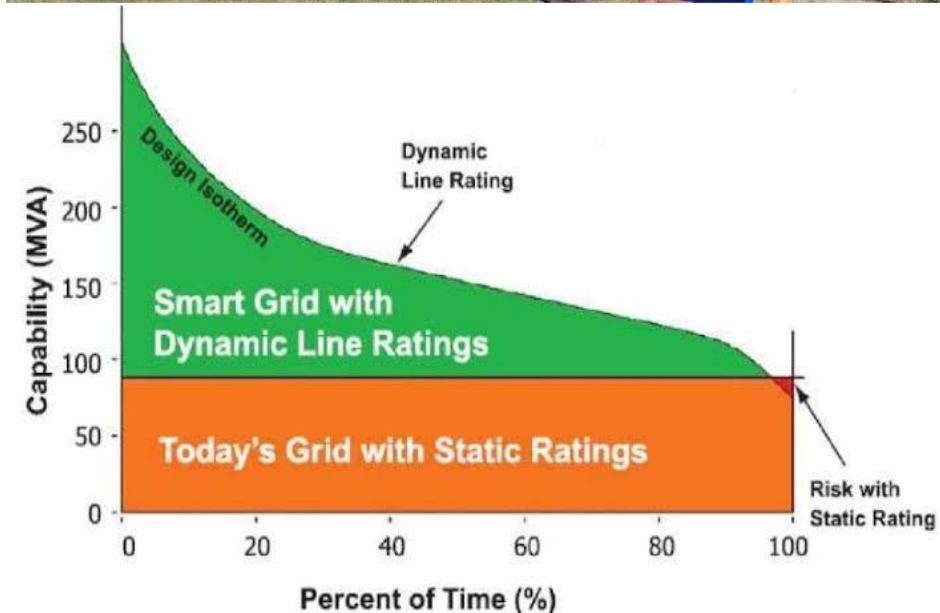
Unlocks Latent Capacity: Increases transmission line capacity by 20–40%, particularly along wind-heavy generation corridors.

Low Initial CAPEX: Significantly cheaper and faster to deploy compared to building new transmission towers or re-conductoring lines.

Avoids Right-of-Way Issues: Requires no additional land permits or civil construction.

Prevents Thermal Overloads: Delivers real-time conductor sag and temperature monitoring, improving overall line safety and grid reliability.

Implemented in 400 kV Tuticorin-Madurai D/C line



Implementation and Monitoring

- Modalities
 - TBCB
 - RTM
- Technologies in construction like Helicrane
- Project Monitoring Unit (PMU portal)



Operation and Maintenance

- Emergency Response System (ERS)
- Mobile Substations
- Digital Twin
 - Asset level
 - System level

ERS and Mobile sub-station

ERS



Mobile Sub-station



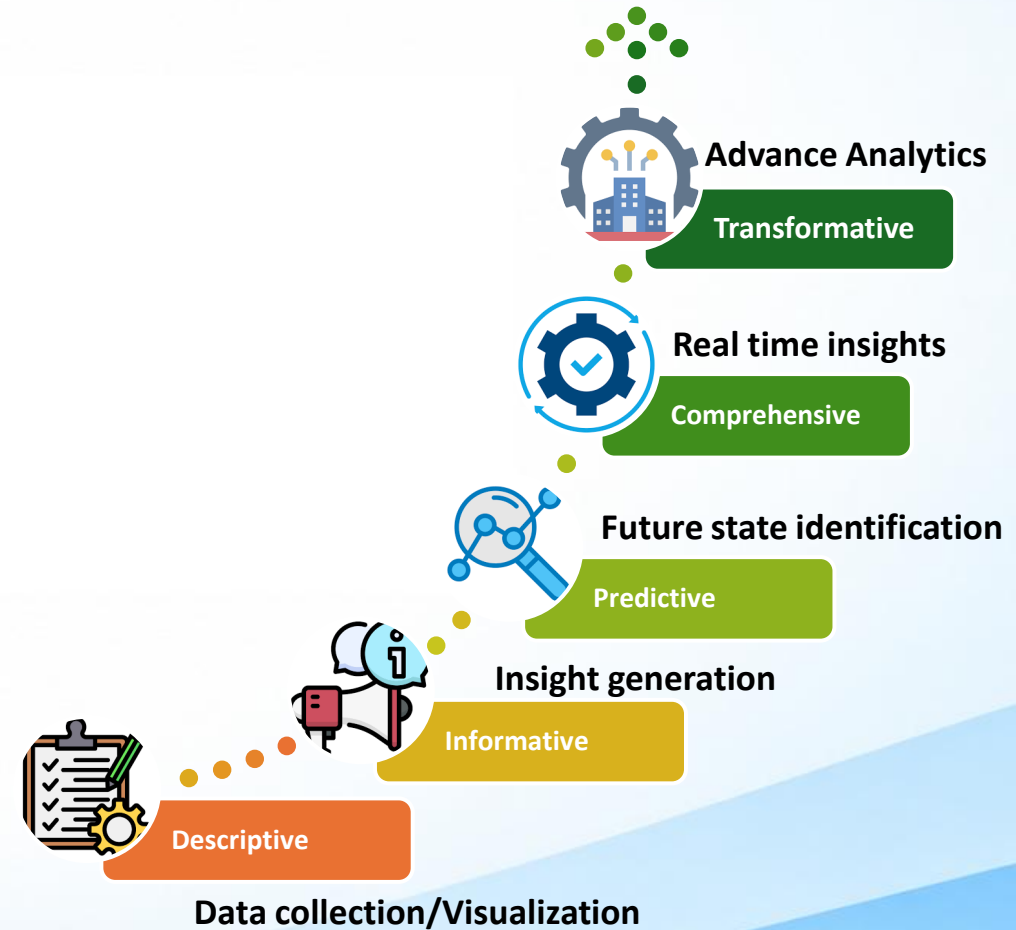
Digital Twin

Digital twin is a:

“Dynamic, synchronized virtual replicas that integrate physics based and data driven models with real-time sensor data to enable continuous situational awareness, predictive analysis and informed decision making”.

IEEE Task force categorises it into five stages:

- a. Descriptive twin (level 1)
- b. Informative twin (level 2)
- c. Predictive twin (level 3)
- d. Comprehensive twin (level 4)
- e. Transformative twin (level 5)



Different Levels of Digital Twin

Digital Twin vs Simulation

Aspect	Digital Twin	Simulation
Definition	A real-time virtual replica of a physical system continuously updated with live data	A model used to study system behavior under specific conditions (mostly static or offline)
Data Integration	Continuous data feed from IoT/SCADA/PMUs	Typically uses historical or static data for scenarios
Scope	Covers the entire lifecycle of assets (design, operation, maintenance)	Focused on specific cases or events
Interactivity	For power system; advisory in nature	One-way: results do not affect the physical system
Update Frequency	Continuous	Performed as needed
Use Cases	Predictive maintenance, equipment health monitoring, grid optimization	Planning, design validation, contingency analysis
Technology Level	Requires IoT sensors, data ingestion, representative asset model, analytics, cybersecurity	Can work with simpler computational models

Use cases

Equipment Level

- i. Distribution Power Transformers – Primarily for health monitoring and preventive maintenance
- ii. DLR Gas turbine
- iii. Wind Turbine
- iv. Substation
- v. HVDC
- vi. BESS
- vii. Vegetation Management

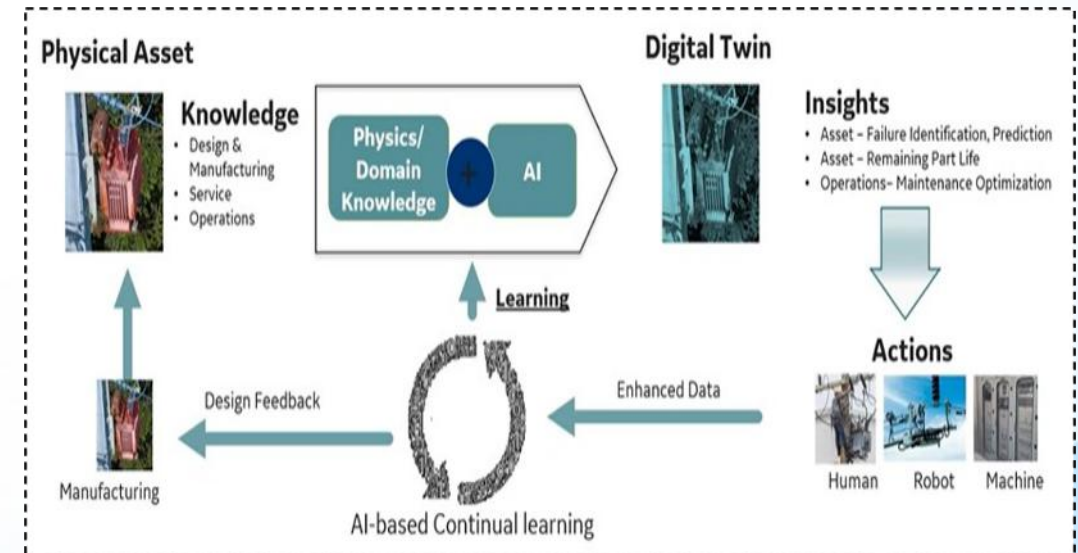
Network level : In some areas, mostly upto Level-2

Some applications of Digital Twin

Vegetation Management



Transformer Health Monitoring

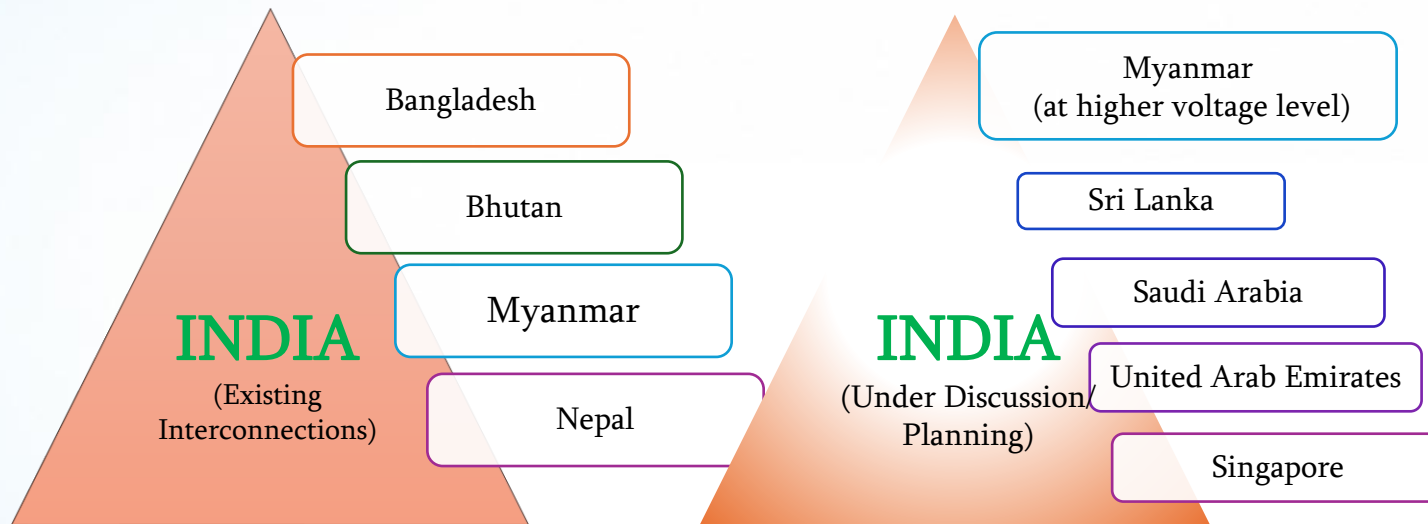


Challenges in System level Implementation

- Availability of mathematical models (both RMS and EMT) of system equipments and their validation
- Load modeling (Data Centre, bulk consumer models etc. missing)
- Non-availability of data telemetry of lower voltage network (132 kV and below) and topology status (isolator, breaker even at 220 kV level)
- Time synchronization and integration of such data reporting through multiple measurement devices (SCADA, PMU, AMI etc.) reporting at different sampling rate.
- Data interfacing with multivendor supplied SCADA/EMS system
- High performance real-time dynamic simulation infrastructure
- Handling of cyber security related challenges for data transfer from OT to IT Platform

While equipment-level applications have seen limited deployment, system-level digital twins for power systems are presently being explored globally through research and pilot implementations.

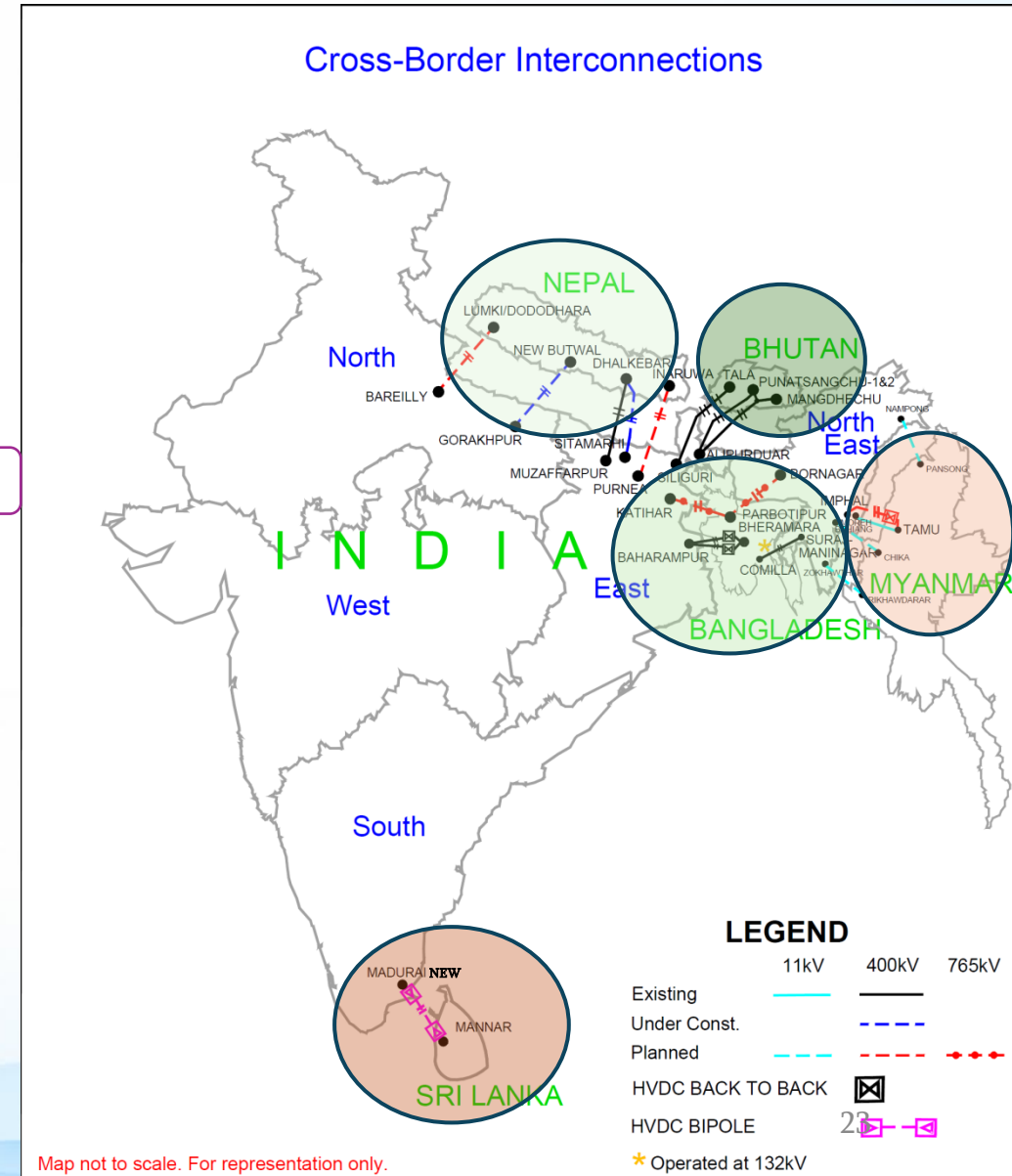
Cross Border Interconnections: Indian Grid



Cross Border interconnection under discussion with:

1. Saudi Arabia
2. United Arab Emirates
3. Singapore

Interconnections with Sri Lanka, Saudi Arabia, UAE and Singapore require Under Sea Cable



Thank You