Bhutan's Transmission System Maintenance

Best Practices for Safety, Reliability & Resilience

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Bhutan

Outline

Reactive → Proactive → Predictive Maintenance

- Foundational Principles
- Planning & Strategy
- Technology
- Field Practices
- Human Resource
- Internal-External linkages
- Expected Outcomes

Line and substation details

Sl No	Voltage Level (KV)	No of Towers	Line Length (Km)
1	66	1,597	409.75
2	132	1,384	502.64
3	220	963	381.6
4	400	1,156	500.86
Total		**5,100**	**1801.57** including 6.72 UG

Sl No	Voltage Level (KV)	No of Substations	Total capacity in MVA
1	66	15	526
2	132	11	201
3	220	8	1751
4	400	2	1000
Total		**36**	

Foundational Principles – *Non-Negotiables*

1. Safety First: ”Accident must be zero" culture. Safety guidelines, Strict PPE, ensure clearances, excellent grounding, and permit-to-work systems.

2. Reliability-focused: Move from Planned maintenance to Condition & Risk-Based Maintenance.

3. Our Perspective : Maintenance is an investment, not an expenditure, as it enhances an asset's entire lifespan.

We care Safety

Planning & Strategy

1. TD Online Portal: Single database for transmission lines, substations, outage records and transformers conditions.

2. Risk Based Maintenance Plan: By identifying and prioritizing vulnerable towers and critical substations

3. Synchronized Annual Maintenance Schedule: Coordinate line shutdown /substation bay maintenance with hydropower generation/export cycles to minimize outage duration.

4. Smart Spare Parts Strategy: Critical spares for obsolete substation equipment & unique line hardware.

Proactive actions

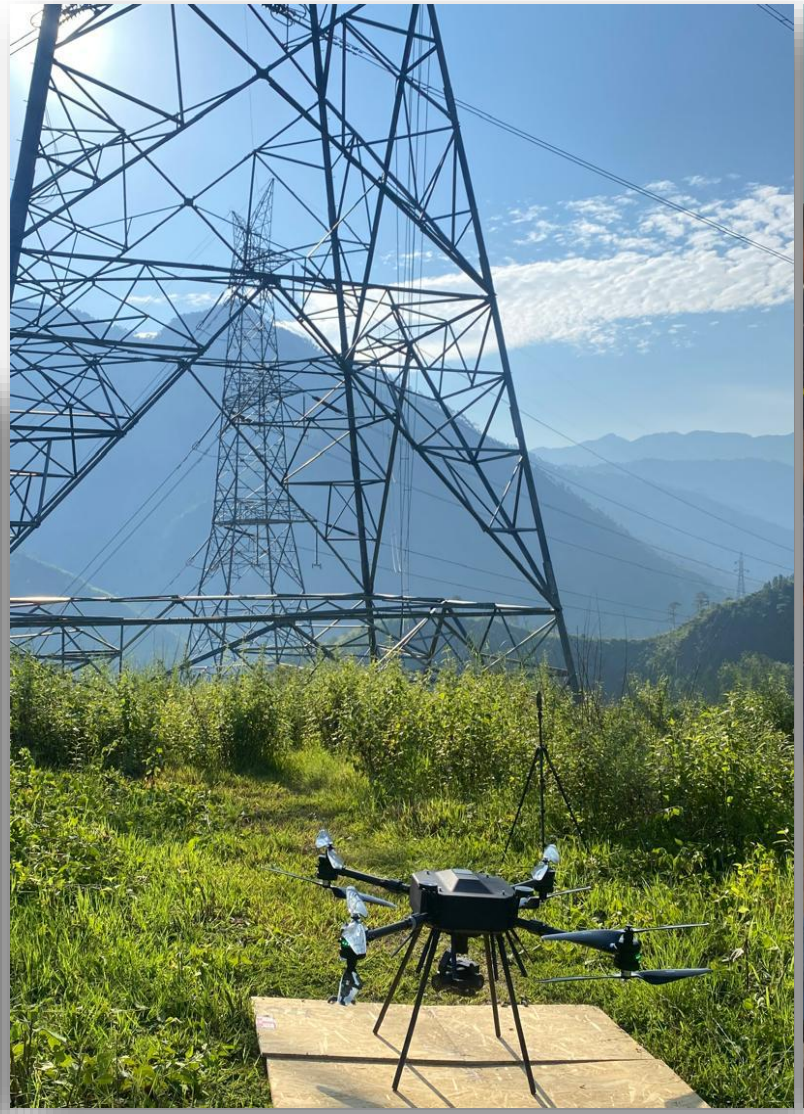
Protection of the tower against landslides, along with the simultaneous installation of an ERS tower for worst-case scenarios.

Technology – *Our Eyes in the Mountains & Substations*

Condition Monitoring & Diagnostics:

1. Line Signature Analysis: Line signature analysis are carried out periodically to monitor potential encroachment in RoW and identify other risk factor
2. Thermography: Drones for Transmission line and handheld for substation equipment.
3. Partial Discharge (PD) Detection: Critical for GIS (Gas-Insulated Switchgear), cable terminations, and transformer insulation health.
4. Dissolved Gas Analysis (DGA) on periodic basis: For transformers to predict internal faults and attend the problems immediately, if any.
5. Drone & LiDAR Surveys: For inaccessible towers and substation aerial inspection.
6. Integrate SCADA, test data, inspections into one Transmission Asset Management System.

Thermography, Drone inspection and DGA test



Field Practices – *Tailored to Our Challenges*

For Transmission LINES:

1. Annual Maintenance of transmission line : Field staffs carry out annual maintenance of transmission towers and hardware fittings.
2. Vegetation Management: Scientific clearance cycles for Bhutan's fast-growing forests.
3. Corrosion & Foundation Control: carryout painting, galvanizing, geotechnical checks as an when required.
4. TLSA installation in lightning prone areas.

For SUBSTATIONS:

1. Asset performance Management (APM) on yearly basis, not only check the system healthiness but also helps in procurement planning of the critical items which have high lead times.
2. Earthing values: Regular testing to ensure safety during faults by maintaining 1Ω for all substations. Remedial measures taken for those with higher values. GEE slabs, additional counter poise earthing, Satellite earthing, etc.

Transmission line maintenance

APM testing

Identification of fast growing trees type within ROW.

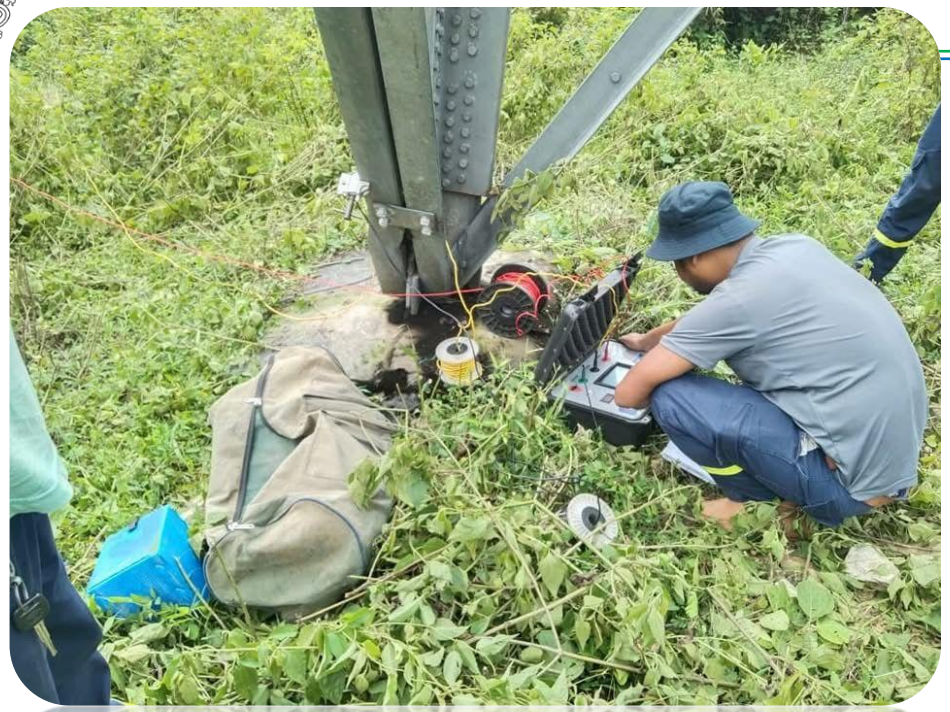
Fast growing tree specics under and near by TG Transmission Line

Sl#	Local Name	Scientifice Name	English Name	Growth habit	Altitude range	photo
1	Luma Dagay Shing	Broussonetia papyrifera	Paper mulberry	3-4 meter in 6month	1000m above	
2	Choka Shing	Rhus Chinensis	Rhus	15-20 cm in 6 months	915-2740m	
3	Gama Shing	Alnus nepalensis	Birch	25-35cm in 6 months	500-3000m	
4	Baashing	Chimonabambusa	Wild bamboo	4-8meter in 6 months	1400-2200m	
5	Regagi Ngala	Muse sikkimensis	wild banana	60cm or more in 6 months	1320-1920m	

TLSA Installation at 400kV lines





Checking the tower footing resistance and improving it through the installation of a GEE slab.

Human Resource Development – *Building Our Future*

Specialized Trainings: for Substation Protection Engineers and Technicians in critical skills.

Cross-Training: Ensure understanding of how line conditions affect substation operations.

Technology Certification: Drone pilots, GIS specialists and HV test Kit specialists underway.

Knowledge Management: Document SOPs, proper reporting and documentations containing challenges and recommendations.

Completion and Analysis reports

Transmission Department
Transmission Operation & Maintenance Division
Transmission Operation & Maintenance Section
Lobesa: Punakha: Bhutan

Completion report on Installation of Transmission Line Surge Arrestor at 400kV Puna I to Lhamoizingkha Transmission line

December 9, 2025

TRIPPING REPORT AND ANALYSIS FOR FIRST QUARTER, 2024

Transmission Operation & Maintenance Section,
LOBESA

January-March 2024

Internal-External linkages- *for Coordination & Resilience*

1. Stakeholder Engagement : Forests Department for RoW, Local Governments &communities for hazard reporting near lines/substations.

2. Operation coordination committee: A committee consisting of stakeholders from all energy sectors, meeting every 2 months to discuss and resolve the issues for the improvement of national gird resilience.

3. Learning from Peers: Engage with POWERGRID, India and EGAT, Thailand on substation automation & line maintenance.

4. Preparedness for worst case: Tested and certified black-start capabilities for all powerplants.


Training and Experience Sharing Program
Power System Protection
and
Fault Analysis
EGAT
BPC
Sep 29 – Oct 3, 2025


EGAT
Fault Calculation

Performance Measurement – *Data-Driven Decisions*

Track These KPIs

1. Transmission Availability: Maintain >98%, achieved 98.74 % on 2025.
2. Transmission line loss: To maintain Below 2% as per O&M Manual, however mandated to bring down below 1.49% in compact Target 2025 and further down to 1.44% for this year.
3. Vigorous asset health management: Negative points in KPI for lines & substation equipment failure.
4. Mandatory target: All Substation Earthing to maintain earthing below 1Ω and improve earthing for at least 80 towers by maintaining below 10Ω.

Expected outcomes – *The Value Proposition*

1. Increased System Availability: Reliable power for domestic growth and export revenue.
2. Reduced Lifecycle Costs: Predict and prevent costly failures with minimal outages.
3. Enhanced Safety: Protect our employee and the public.
4. Informed Capital Planning: Data-driven decisions for augmentation, refurbishment and replacement.

The ultimate goal is to build a future-ready, resilient grid capable of overcoming climate and geological challenges and keep up to date with new technologies.

THANK YOU!