

Best Practices in Implementation of Planned Transmission Systems in Nepal

Nepal Electricity Authority (NEA)

Online Workshop | 09 June 2026



Presented By

- Kedar Raj Silwal, Director, High Voltage Grid Development Department, NEA
- Shukra Raj Devkota, Manager, Transmission Line and Substation Design Division, NEA



नेपाल विद्युत प्राधिकरण
NEPAL ELECTRICITY AUTHORITY

उद्यमालो नेपालको संवाहक

TOPICS

01 Project Planning, Survey & Detailed Engineering

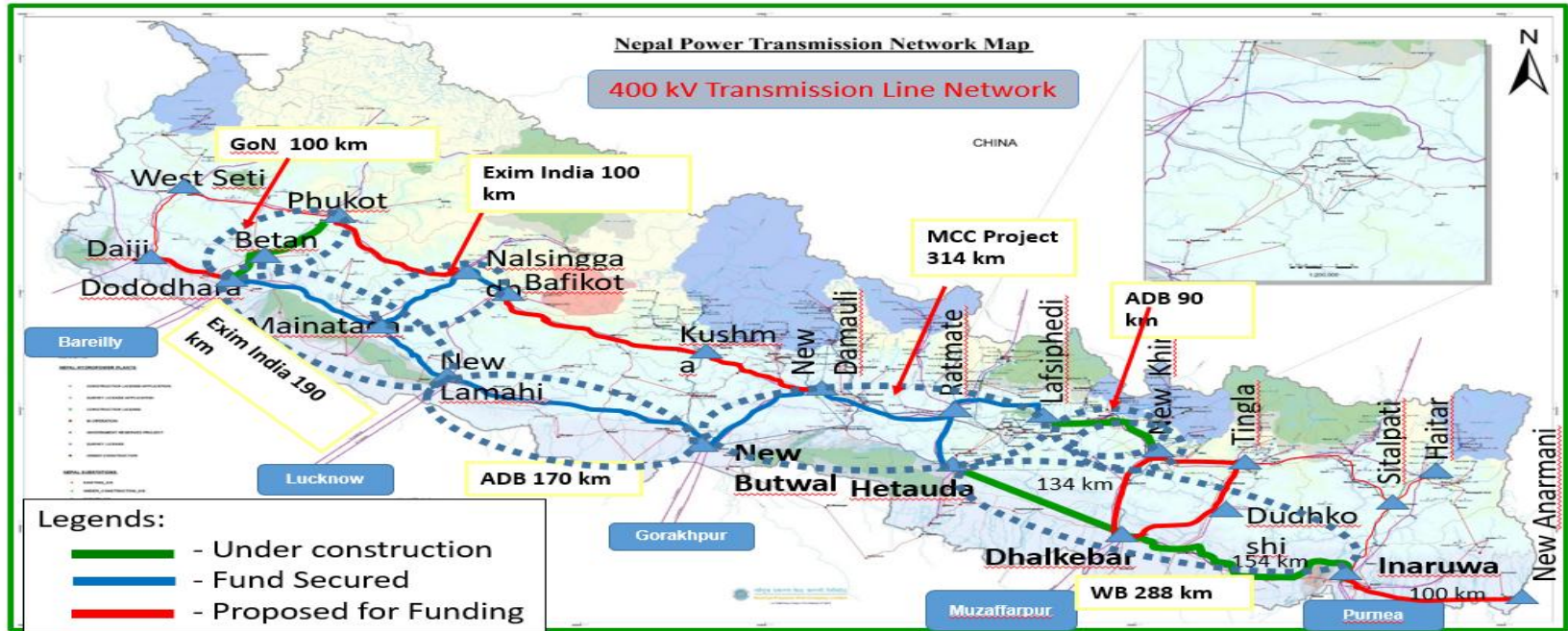
02 Land Acquisition, RoW, Clearances & Stakeholder Coordination

03 Procurement, Material Management & Construction Methodologies

04 Construction Management, Monitoring & Risk Mitigation

05 Safety, Testing, Commissioning & Operational Readiness

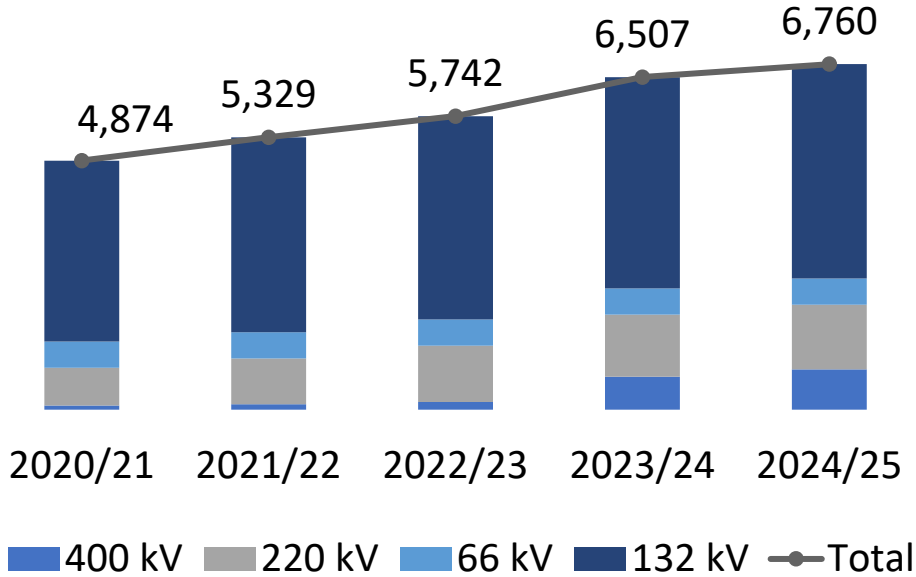
NEPAL TRANSMISSION NETWORK SHOWING MAJOR 400 kV TRANSMISSION LINE



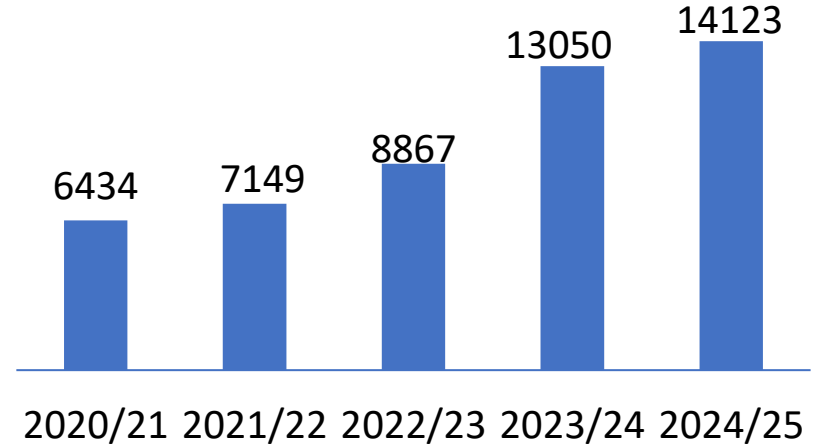
The Transmission Master Plan is approved by Ministry of Energy, Water Resources and Irrigation

TRANSMISSION AND SUBSTATION CAPACITY IN NEPAL

Transmission Line (Ckt. Km)



Sub-stations (MVA)



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Project Planning, Survey & Detailed Engineering

Project Execution Planning & Scheduling

Integrated Project Execution Plan

- Project Selection align with NEA/GoN milestones and financial year targets as per Transmission System Master Plan of Nepal.
- Comprehensive Project Execution Plan covering all phases: survey, design, procurement, construction.
- Critical path and float analysis using Project Management Software
- Monthly updates tracking from top Management

Resource Mobilization Strategy

- Dedicated Project Team responsible for design, procurement, contract management, construction supervision, testing and commissioning to handover.
- Design shall be done inhouse or from the Inhouse NEA subsidiary Consulting Companies
- For Donor Funded Project International Consultant shall be involved as per the guidelines of the Donors like ADB, WB etc.

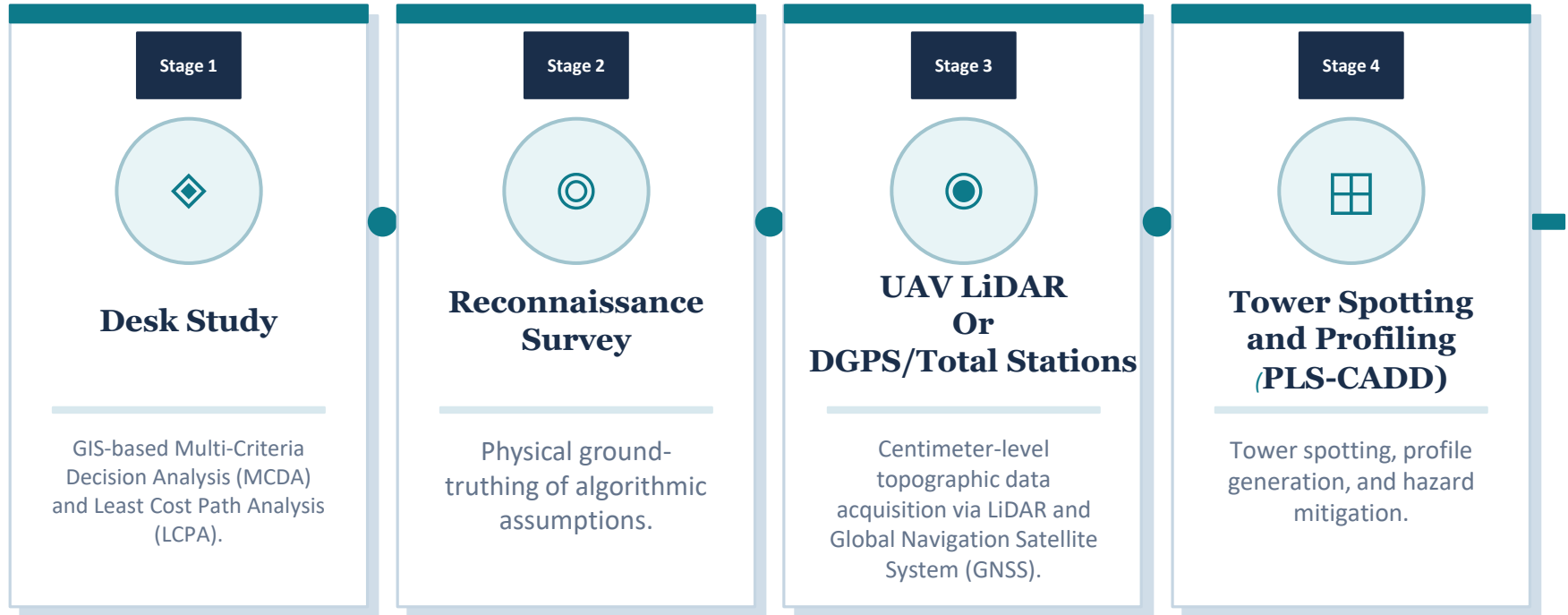
Schedule Risk & Control

- Quantification of Schedule risk matrix associated with project
- Pre-monsoon acceleration plans in order to mitigate seasonal impact
- Monthly project review with NEA senior management

Design Engineering Best Practices

- IEC/IS or international standards-compliant design suitable for Nepal terrain
- Seismic and wind zone compliance as per Nepal Building Code(NBC).
- Foundation design optimization using soil investigation data
- 3D modelling for substation layouts (AutoCAD)
- Adaptation of GIS substation where lands are constraint

Desk Study, Detail Survey & Route Optimization



Route Alignment Optimization – MCDA + LCPA Workflow

Phase	Activity	Key Outputs
1. Desk Study	Collect topographic data of land use and settlement; run MCDA + and LCPA	3 alternative corridors with cost surfaces
2. Reconnaissance	Field verify each corridor; assess access to road, geology, crossings, settlements	D-cards, photographs, refined alignment points, final route selection
3. Detailed Survey	UAV LiDAR (Modern Technology) OR Total station along selected RoW (200m buffer)	Classified point cloud, 1m contour
4. Tower Spotting and Profiling	PLS-CADD optimization using Survey Data	Tower schedule, stacking table, cadastral overlay

MCDA Evaluation Criteria

Buildings · Settlements · Slope · Terrain Ruggedness Index (TRI)
Land Use · Waterways · Road Accessibility

Three Priority Scenarios

Building-Priority

Minimizes social impact and RoW conflict

Slope-Priority

Minimizes earthworks and foundation cost

Roads-Priority

Maximizes construction and maintenance access

Modern Survey Technologies & Route Optimization

Drones / UAVs

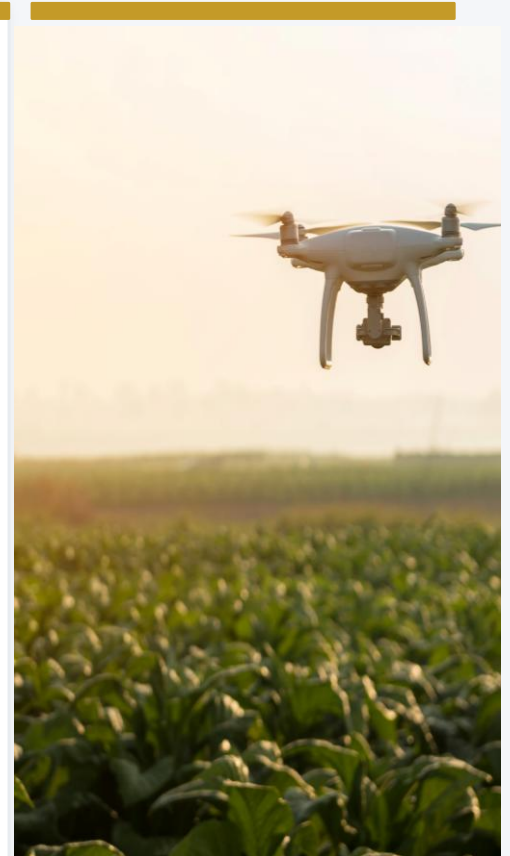
- Aerial corridor survey for route alignment
- Photogrammetry for 3D terrain modelling
- Rapid tower spotting in inaccessible areas
- Inspection of existing lines and structures
- Cost saving: 60–70% vs. manual survey

LiDAR Surveys

- High-accuracy point cloud for sag-clearance analysis
- Vegetation encroachment detection
- Structure-to-structure profile extraction
- Integration with PLS-CADD for design
- Essential for dense forest and urban corridors

GIS / GPS Integration

- Digital RoW mapping and management
- Land parcel identification and ownership records
- Integration with GoN land records databases
- Real-time field data capture on mobile GIS apps
- Environmental sensitivity mapping overlays



Tower Spotting & Foundation Optimization

PLS-CADD Tower Spotting

- Import classified ground DTM and Survey Data
- Apply sag-tension charts (hot/cold conditions) and clearance curves.
- Automatic tower placement with manual adjustment for critical crossings
- RCC pillars at tower centers; reference pegs every Tension Towers.
- D-cards with photos, coordinates, and landowner details

Foundation Optimization by Terrain

- Steep slopes ($>25^\circ$): Step-cut (unequal leg extension) or pile foundations; avoid full benching
- Landslide-prone areas: Deep borehole investigation (SPT), tie-down anchors.
- River / flood zones: Locate towers outside HFL + scour protection measures
- Urban / tight RoW: Narrow base towers (tubular steel poles), reduced swing angle
- Rock anchors, pad & chimney, and direct embedment as per soil investigation

Layout & Technology Selection in Substation

AIS / GIS Selection Guidelines

- **Air Insulated Switchgear (AIS):**
Standard selection where flat, low-cost land is abundant, typically across Nepal's Southern Terai plains.
- **Gas Insulated Switchgear (GIS):**
Mandated in hilly valleys and urban load centers (e.g., Kathmandu Valley). Compact design offers up to a 70% physical footprint reduction.
- **Hybrid Installations:**
Adopted during capacity upgrades in existing brownfield stations to manage extreme physical space boundaries.

Bus Bar Scheme Standards

- **Low Voltage Distribution (33 kV & below):**
Deploys single or sectionalized busbar layouts for cost-effective localized distribution grids.
- **Sub-Transmission (132 kV):**
Standardized on Double Busbar with bypass layout configurations to guarantee safe maintenance bypass options.
- **High-Voltage Backbone (220 kV & 400 kV):**
In 220 kV utilizes the Double Busbar with bypass layout or Double main and transfer bus scheme to meet system requirements. However, in 400 kV strictly utilizes the One-and-a-Half Breaker scheme for critical bulk transmission systems to meet strict contingency rules.

Terrain & Geological Adaptation in Substation

Stepped Hilly Terrain Design

- **Multi-Step Terracing:**
Switchyards are terraced into stepped platforms along steep corridors (e.g., Trishuli, Marsyangdi) where flat land is non-existent.
- **Excavation Mitigation:**
Saves critical civil expenditure by avoiding massive slope deep-cutting, directly reducing severe local landslide triggers.
- **Runoff Control Management:**
Integrated with specialized retaining walls, gabions, and deep surface drainage structures to reroute monsoonal water streams.



Dadakhet Substation

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Land Acquisition, RoW, Clearances & Stakeholder Coordination

Cadastral Survey

01

Coordination with District Land Administration Office

Formal coordination with Survey Department to obtain cadastral base maps and parcel data along the transmission line corridor.

02

Collection of Trace Maps

Collect trace maps showing tower locations along the transmission line alignment from project documents and field surveys.

03

GIS Plotting & RoW Corridor

Plot tower locations and trace maps in GIS. Generate the Right-of-Way (RoW) corridor boundary as a spatial layer.

04

Land Parcel Identification

Overlay RoW corridor on cadastral maps in GIS to identify all land parcels — tower pad footprints and RoW-affected plots.

05

Land Owners Identification

Collect land ownership records, parcel numbers (sheet & parcel), and ownership details from the District Land Administrations Office.

06

Landowner Details — Tower Pad & RoW

Compile verified ownership data for each affected parcel owner name with three-generation details, contact, land area impacted (tower pad + RoW).

Output:

Cadastral Survey Report listing all affected land parcels with owner name, citizenship no., parcel no. (sheet/plot), land type, total parcel area, area under tower pad, and area within RoW corridor — submitted to NEA for Land Acquisition and Compensation proceedings.

Land Acquisition Framework

- Early stakeholder mapping: identify all land parcels along RoW
- GIS-based RoW management: digital parcel mapping linked to revenue records
- For Tower Pad: Land acquisitions as per Land Acquisition Act
- For ROW : Compensation as per Electricity Regulations (Maximum given 20% of the Land Cost fixed by the Committed head of CDO of concerned District)
- Dedicated Grievance Redressal Mechanism (GRM) cell for any complains
- RoW Taken
 - 400 kV D/C Vertical Tower Configurations: 46m
 - 220 kV D/C Vertical Tower Configurations: 30m
 - 132 & 66 kV D/C Vertical Tower Configurations: 18m

Forest Clearance for Transmission Lines

1 PHASE 1 — Environmental Assessment

IEE (Initial Environmental Examination)

- For all TLs NOT through reserved/national forest
- Includes TOR, public hearings, full report
- Approval: Ministry of Energy | ~6–12 months

EIA (Environmental Impact Assessment)

- Mandatory for TLs passing through NATIONAL/RESERVED FOREST
- Includes Scoping, TOR, public hearings, full report
- Approval: Ministry of Forests & Env. | ~12–18 months



2 PHASE 2 — Land Use Permission Request

Project Proponent

Submits land use permission request after IEE/EIA approval



Ministry of Forests

Reviews application; forwards file to District Forest Office through Department of Forest



District Forest Office

Receives file; schedules field inspection & tree count



3 PHASE 3 — DFO Tree Count & 15% Threshold Decision

Supplementary IEE/EIA → re-assess

← NO

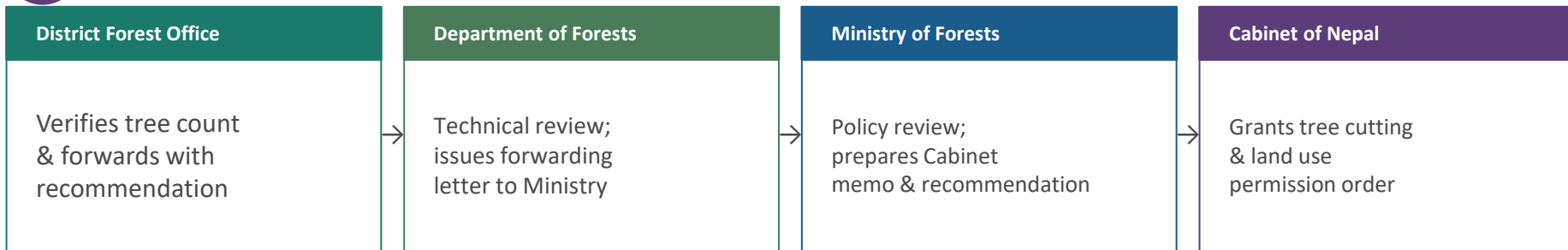
Trees within 10% limit?

YES →

Direct to Cabinet approval

Forest Clearance for Transmission Lines

4 PHASE 4 — Approval Chain & Cabinet Decision



5 PHASE 5 — Statutory Record Keeping (as per Forest Rules)

Tree Felling Register

DFO maintains register with species, diameter, volume. Updated immediately after each tree is felled.

Compensatory Plantation and Compensation

Mandatory afforestation at prescribed ratio (typically 1:5). Site identified, planted within timeframe.
10% Compensation of Tower Pad land use deposited in the Forest Development Fund.

Compliance Report

Report to DoF & Ministry confirming all Cabinet conditions met. Pre-requisite for project completion.

Key rules: Supplementary IEE/EIA required if trees exceed 10% of total forest area | Cabinet approval mandatory for all tree cutting | All obligations must be fulfilled before project completion

Social Issues in Right of Way in Urban and Semi Urban Area



The 20-Year Deadlock: Right-of-Way (ROW) issues halting progress on the Thankot-Chapagaun 132 kV Transmission Line in Kathmandu Valley



Work done in 400 kV Hetauda Dhalkbar Line with help of Security Personnel where ROW problem not resolved

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Procurement, Material Management & Construction Methodologies

Procurement Strategy & Modalities

Contracting frameworks and risk management standards

EPC Turnkey Modality

- All major transmission lines and substation construction works are executed via EPC Turnkey contracts to shift execution risk to contractor.

National Competitive Bidding (NCB)

- Utilized for lower-voltage packages, substation extensions, and civil works falling under international threshold limits, promoting local capacity. (Single Stage Two Envelope Procedure)

PPMO Bidding Documents

- Framework contracts formatted in full compliance with Nepal Public Procurement Monitoring Office (PPMO) master documents.

Risk Management in International Competitive Bidding (ICB)

- Mandatory front-end procurement planning to outline environmental, RoW, and other risks prior to bid floating.

ICB Threshold & Prequalification

- Compulsory ICB for high-value packages meeting threshold limits.
- Multi-stage evaluation for global bidders' terrain experience and financial solvency.

Early Risk Identification

- Mandatory pre-procurement planning to identify environmental, right-of-way, and geographic risks before bid floatation.

Donor-Funded Project Framework

Multilateral development bank guidelines and compliance standards

MDB Guideline Precedence

- Procurements financed by ADB, World Bank, JICA, or AIIB adopt the respective donor's guidelines, overriding local PPMO rules where conflicts exist.

Standard Bidding Documents (SBDs)

- Donor-specific international master templates used for EPC contracts, protecting legal and financial safeguards.

Socio-Environmental Safeguards

- Pre-requisite approval of ESIA and detailed Resettlement Plans before bid awards.
- Donor-guided compensation for land acquisition and tree-cutting along transmission routes.

Supervision & Auditing

- Execution supervised by an international Project Management Consultant (PMC).
- Frequent inspections and financial audits by donor-delegated review missions.

Independent Consultant

- International PMC approves physical milestones and payment bills.
- Periodic oversight audits guarantee zero deviation from donor mandates.

Fair Compensation

- Donor frameworks govern land acquisition, compensation, and right-of-way permissions along all transmission routes.

Quality Assurance & Inspection

Factory acceptance testing, field testing, and pre-commissioning standards

Type Test and Routines Requirement

- Type Test conducted in the independent third-Party Laboratory
- Complete Routine Test before carry out Factory Acceptance Tests (FAT)

Mandatory FAT Clearance

- Factory Acceptance Tests (FAT) verified by NEA engineers at international production sites before material shipping is authorized.

Third-Party Inspections (TPI)

- Independent TPI agencies engaged at the global manufacturing phase for critical items — Transformers, Reactors, and GIS equipment.

On-Site Material Testing Labs

- Functional material labs established at construction sites to test concrete, structural steel, and foundational fillers.

Construction Materials Approvals

- Systematic sampling of cement grades and steel reinforcement strength to verify structural load capacity as per standards.

Field Quality Plan (FQP)

- Quality assurances via FQP.

Pre-commissioning (SAT)

- Mandatory site acceptance tests for all equipments and materials as per international standards.

Procurement, Quality Assurance & Supply Chain Management

Procurement Strategy

- Early procurement Plan identify the all risks associated with.
- International Competitive Bidding (ICB) for major packages with and above 6 Arab Nepalese Rupees estimate
- Framework contracts format as per PPMO Standard Bidding Documents

Quality Assurance & Inspection

- Third-party inspection (TPI) at manufacturing stage for transformers/Reactors and others as necessary
- Factory Acceptance Tests (FAT) mandatory for all equipments including but not limited to GIS, power transformers, protection panels
- Material Testing Lab at project site for civil works materials

Logistics & Supply Chain

- Material tracking using RFID/barcode from manufacturing to site
- Customs clearance coordinator at Nepal border (Birgunj/Biratnagar)
- Helicopter lifting for inaccessible mountain terrain
- Regional warehousing at Butwal, Hetauda, Pokhara, Dhalkebar
- Seasonal stock pre-positioning before monsoon season

Construction — TL & Substation

- Tower erection: gin pole / crane / helicopter per terrain requirements
- Conductor stringing: tension method to avoid conductor damage
- Foundation types: direct embedment, pad & chimney, pile, rock anchor per soil
- GIS/AIS substations: strict erection sequence per manufacturer specifications
- Urban areas: compaction towers, undergrounding for sensitive zones



Construction Management, Monitoring & Risk Mitigation

Field Supervision & Quality Matrix

Field Engineering Presence

- **Active Front Supervision:**
Dedicated Resident Engineers (RE) and structural site inspectors deployed across all active line routes (stub setting, foundation casting, tower erection, stringing).
- **Resource Performance Logs:**
Enforcement of daily contractor progress reports tracking active workforce count, specialized machinery availability, and critical material usage.
- **Escalation Mechanism:**
High-level monthly project evaluation sessions directly with NEA management to instantly clear bureaucratic and site bottlenecks.

Quality Governance Systems

- **Inspection & Verification:**
Weekly field inspection reports supported by mandatory geotagged photos to cross-verify physical curing, clearance, and safety profiles.
- **Field Quality Plan(FQP) Protocol:**
Systematic implementation of field quality plan to ensure quality of works done
- **Civil Material Testing:**
Continuous on-site testing labs checking concrete core compression, aggregate purity, and rebar structural profiles across complex alpine terrains.

Construction Management, Digital Monitoring & Risk Mitigation

The screenshot shows the user interface of the Nepal Electricity Authority (NEA) system. At the top left, there is a hamburger menu icon and the NEA logo with the text 'नेपाल विद्युत प्राधिकरण' and 'NEPAL ELECTRICITY AUTHORITY'. Below this is a navigation sidebar with the following items: 'Dashboard' (highlighted with a dark background), 'Analytics', 'Admin Menus' (with a plus icon), 'User Management', 'Settings', 'Menus' (with a blue header), 'Budgets' (with a dropdown arrow), 'Pre Budget', 'Budgets', 'Projects' (with a right arrow), 'Contracts', 'Schedules', 'Tasks', and 'Files'. The main content area is currently blank.

Digital Monitoring Tools

- Project Management Dashboard (Project Management Software)
- Track Schedule of the project and give alert if any missing
- Track the project activities with its physical and financial progress with respect to baseline target

Risk Mitigation & Lessons Learnt

- Risk Register with probability-impact matrix; quarterly review
- Seasonal risk management: monsoon, winter access, festival shutdowns
- Community risk: advance engagement to prevent disruptions
- Common challenges: access roads, RoW, material supply, skilled labour
- Lessons Learnt register maintained and shared across NEA projects
- Post-project review

Socio-Environmental Safeguards

Donor funded project Community Safeguards

- **Multilateral Safeguard Sync:**

Execution in strict compliance with World Bank, ADB, and JICA environmental/social standards, ensuring detailed Resettlement Action Plans (RAP) are met.

- **Right-of-Way Resolution:**

Proactive local community engagement structures designed to settle land easement acquisitions and compensation transparently, avoiding costly legal delays.

- **Grievance Redressal (GRM):**

Active field-level grievance mechanisms to record and address community issues regarding infrastructure placement and environmental restoration.

Safety, Testing, Commissioning & Operational Readiness

Safety Management, Testing, Commissioning & Operational Readiness

Safety Policies & Work Permit System

- Comprehensive Health, Safety, and Environment (HSE) Plan compliant with NEA/ILO standards
- Permit-to-Work (PTW): Confined Space, Height Work, Electrical permits
- Monthly safety audits by Project Management Consultant (PMC)
- Daily toolbox talks; PPE mandatory for all site workers
- Mock drills (fire, electrical accident, fall from height) — **quarterly**

Pre-Commissioning & Testing

- Transmission Line: As per Technical Specification/international standard and best industry practices
- Substations: As per Technical Specification/international standard and best industry practices

Protection Coordination & Energization

- Started Protection coordination study using DigSilent PowerFactory
- All protection settings shall be reviewed by System Operation Department (SOD)
- 72-hour trial operation before commercial declaration
- Energization checklist: joint inspection by NEA Grid Operation Department, PMC, contractor
- Punch list clearance mandatory before issuance of the Operational Acceptance Certificate

Key Challenges & Lessons Learnt in Nepal's Transmission Projects

Difficult Terrain

Proactive helicopter logistics planning; design access roads as project component; pre-construct helipads for critical tower locations.

RoW Delays

Begin RoW acquisition 2 years before construction; establish dedicated RoW cell; digital GIS-based tracking; community liaison officers in every Rural Municipality/ Municipality.

Monsoon Disruptions

Front-load critical-path activities before monsoon; pre-stock materials at intermediate points; utilize monsoon productively for substation civil works.

Material Supply Chain

Multi-source procurement; maintain 3-month buffer stock at site; establish contingency contracts with alternate suppliers.

Forest Clearance Delays

Parallel processing of FC with survey; engage MoFE at DPR stage; propose viable compensatory afforestation plans early.

Skilled Labour Shortage

Partner with Vocational Training Institutions for conducting trainings like stringing, erection, welding trades; incentive-based retention; establish project training centers.

CONCLUSION & WAY FORWARD



Adopt modern survey technologies (LiDAR/UAV/GIS) to cut survey time by 40–50% and improve design accuracy



Parallel processing of clearances, RoW acquisition, and design is non-negotiable to meet project timelines



Digital project monitoring dashboards and Early Warning Systems enable proactive course corrections



Safety-first culture with robust Permit to Work (PTW) and emergency response systems



Knowledge sharing cultures among the Project Specific Challenges