Terms of Reference (Draft)

For

Feasibility study and detailed design of Arun Hub-Basantapur-Inaruwa and Tingla-Dudhkoshi-Dhalkebar Transmission Lines and substations

1. Background and scope

1.1. Despite tremendous hydropower potential that Nepal is endowed with, country is facing shortages for both Energy and Peak demand. Currently, only about 70 percent of the country's households have access to grid electricity. The Government of Nepal (GoN) has set a target of providing electricity to all of the population in the nation by 2027 (90 percent through the national grid and 10 percent from decentralized generation solutions) and export substantial amount of power.

1.2. For the feasibility study and detail design Nepal Electricity Authority has identified two transmission systems, (i) Arun Hub-Basantapur- Inaruwa 400 kV double circuit transmission line (about 130 km) with the new substation at Arun Hub (Sankhusabha district) and substations expansion at Basantapur (Terhathum) and Inaruwa( Sunsari district) in the region of koshi corridor, and (ii) Tingla-Dudh Koshi-Dhakebar 400 kV double circuit transmission line (about 120 km) with substation expansion at Tingla (Solukhumbu District), Dudhkoshi Hydropower Project and Dhalkebar ( Dhanusha district) in the region of Solu corridor. NEA is currently undertaking the construction of 220 kV and 132 kV transmission line projects in the region of Koshi corridor and Solu corridor respectively. The proposed new lines and substations are envisaged to evacuate planned hydropower projects in the respective corridors. The proposed transmission lines have also been included in the Transmission System Master Plan 2013 of NEA.

1.3. The World Bank under the Power Sector Reforms and Sustainable Hydropower Development Project has provided a credit to the government of Nepal to undertake the feasibility studies and preparation of basic design, route survey, and environmental and social impact assessment and bid documents for the identified Transmission Line Projects as associated substations. Nepal Electricity Authority is the implementing agency for the study. The credit from the World Bank will be used for financing the feasibility studies and project preparation of the transmission lines and substations. The environmental and social impact study will be taken up through separate assignment¹. NEA intends to engage an internationally recognized consulting firm “Consultant” having a competent team of specialist for carrying out the detail feasibility study of above mentioned transmission lines and concomitant substations. The principal activities of the consulting services shall include but not limited to the following;

i. Study of power evacuation through the proposed transmission lines

ii. Fixing of route alignment including desk study, walk over survey and field reconnaissance survey

iii. Detailed survey of the transmission line routes including plan and Profiling, tower schedule, tower spotting and optimization of tower locations using PLS-CADD, verification and demarcation of the tower spots in the site by check survey for actual construction purpose.

iv. Conducting topographical survey of the land for the substations.

v. Identification and preparation of detail land parcel of tower locations and under the Right-

¹ The Consultant and the ESIA consultant need to work closely. NEA would help in coordination of these two consultants.
vi. Geotechnical exploration including electrical resistivity test (ERT) at tower locations and substations.

vii. Electrical design of transmission line including selection of conductor, shield wires, OPGW, insulators and all other line accessories including preparation of specifications.

viii. Tower classifications according to site weather conditions and profile and design of towers including all types of body and leg extensions, tower structures and Foundations Design and drawings.

ix. Reviews of tower designs provided by NEA which is being used for 400 kV transmission lines projects under construction and check the suitability of those designs to be used in the proposed transmission lines.

x. 400 kV substations design complete, sizing and rating of transformers, preparation of single line diagram, layout and sectional drawings, various equipment’s rating and specifications, insulation coordination study, protection, SCADA and communication design, equipment foundation designs and drawing, other necessary civil design, structural designs all complete as may be required.

xi. Preparation of Technical Specifications, Cost Estimates and the Bidding documents (both commercial and technical) of the various procurement packages (to be suggested by the Consultant during the course of assignment) of transmission lines & substations.

xii. To carry out Economic and Financial Analysis of each of the transmission lines including substations.

xiii. Preparation of feasibility study report and procurement packages of the transmission lines and substations.

2. Objective of the Services

The objective of the consultancy service is to prepare a feasibility study and detail design of transmission lines and substations respect including preparation of bidding documents. The secondary objective is to support in the capacity building of NEA staffs.

3. Scope of the Services

The following scope of services is proposed to achieve the objective of the services, which shall include but not be limited to the tasks and assignments, activities outlined below:

Task 1: Inception of the Assignment

a) Collect Data, information, maps etc: Under this task, the Consultant shall collect and review all data required to implement this assignment through review of existing reports/materials and acquisition of additional data where required to execute subsequent tasks. Except where noted, the Consultant shall acquire data through its own means (e.g. purchasing or engaging in primary data through surveys. NEA will facilitate engagements with other domestic stakeholders as required. These data will provide a basis for transmission line/substation design, alignment of transmission line routes and will ultimately be included in the tender. Those data shall be captured in geo-referenced form in an established Geographical Information System (GIS).

The Consultant shall provide/prepare updated topographic maps; recent satellite images, planning maps, etc., for the realization of the consulting tasks. The Consultant is responsible to acquire and prepare all GIS/mapping data necessary for the preparation of accurate maps. The GIS/mapping data shall be stored in a transferable database and shall include all relevant

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2 The tower locations to be re-confirmed after the ESIA team completed the route assessment. Potential high impact areas to be avoided.
metadata, such as source, date of collection, coordinate system and projection, revision information, etc. The Consultant shall use the same metadata convention and GIS management approach for all GIS data necessary for this consultancy. All applicable data for all tasks of this consultancy shall be transferred to the NEA as necessary at the completion of the consultancy.

b) Review of reports and Conduct/review Network modelling and operational standards: The Consultant shall review the most recent Transmission Master Plan of NEA and other reports of planned transmission and generation expansion plans as well as planned generation in the area of project. The Consultant shall then review existing load flow modeling, short circuit calculations, transient stability analysis, insulation coordination studies, etc, for the mentioned transmission lines under the study and determines the extent to which refinements or the extensions of models are necessary to make it sufficient basis for base design. The studies would also determine the reactive power compensation (capacitors, reactors and/or SVCs) for normal and disturbed condition of system. Some of the proposed works involves expanding the substations and this review should also establish load transfer schemes to reconnect the circuits to a newly expanded substation. The Consultant shall carry out all necessary analyses for transformer sizing, overhead primary and secondary conductor sizing, conductor loading limits, short circuit rating of switchgears and operating characteristics etc. The Consultant shall use PSS/E for load flow and other system studies.

c) Finalize Design Standard: The consultant shall finalize the design and operational standards recognized locally and internationally (e.g., IEC, IEEE, IS, BS, DIN, ATMs or other relevant standards) for technical design of transmission networks and substations, including ensuring voltage within the required range, equipments loaded to standard levels, power factor at optimal levels, and minimum design short circuit ratings for the transmission network, etc with due consideration of Grid Code of NEA for planning and operating criteria for voltage, frequency and system overloads.

d) Carry out the desk study (Reconnaissance) and walkover survey of at least three possible routes of each transmission lines as described under task 2 (a).

e) Develop Base Design/Specifications and prepare preliminary cost estimates

For the purposes of this assignment, base design is the design at the starting phase of the study that provides general concepts, key design parameters, design criteria, load tree for tower design and standards based on which the detailed design will be prepared by the Contractor. The base design and technical specifications shall be developed in sufficient detail to allow the prospective bidders to assess the scope and nature of the works, and to estimate the price for preparing the competitive bids. The Consultant shall also prepare the preliminary cost estimate of the transmission lines and substations.

Task 2: Survey of route alignment and its optimization;

These shall include for following details for both the transmission lines

(a) Carrying out the desk study (Reconnaissance) and walkover survey of at least three possible routes of each transmission lines;

Investigate all the three possible routes and fix the optimal route alignment showing the angle points. The final and recommended route shall be so selected as to avoid or mitigate impacts to protected areas, forest areas, wildlife sanctuaries, national parks, biological resources, settlements, cultural heritage etc. The final route should avoid as far as possible earth slip zones, marshy and low lying areas, river beds, civil and military airfields, power/communication line crossings, and major rivers. Route optimization shall be carried out after careful and detail comparison of the alternative routes in regards of environmental impact, number of angle towers, proximity of access roads, magnitude of forest clearance, potential risk of local obstructions, construction difficulties, crossings (LT/HT, communication, river, road etc.) and other relevant aspects including operation & maintenance. The Contractor shall submit the preliminary observation/suggestion along with various information
collected as marked with topo sheets of scale at least 1:25000 (covering features such as road, river, canals, vegetation, forest area, monuments etc).

(b) Carrying out the detail survey of the final route alignment following the modern international practices/standards of detail surveying of High Voltage transmission line route. The survey shall be carried out by using state-of-the-art survey techniques and instruments having error within the standard acceptable limit. Spot Levels- Latitude, Longitude and altitude (X,Y,Z) shall be carried out at a grid of not more than 2m x 2m size at every tower locations so that the leg extensions and corresponding land requirement could be finalized tentatively right after the detailed survey. Survey data shall be taken at every 10 m interval along the center line (longitudinal direction) and 10 m in excess in each direction of RoW of line along transverse direction but wherever there is topographical change/natural or artificial feature; survey point for such shall also be taken. Detail survey shall be carried out in such a way that the surveyed data can be overlaid on Google earth properly. The survey data should be appropriate to be transferred to the software, PLS-CADD, for further usage and results such as plan and profile preparation, tower spotting, etc. As no tree is allowed to cut for carrying out the survey works the consultant is required to employ appropriate technology, if needed, for completing the survey works in forest areas without cutting any tree. The consultant shall, during the course of survey, impart general information regarding the survey works to the local people, if required.

(c) Preparation of plan and profile drawings (in the scales of 1:2000 horizontal and 1:200 vertical) of the recommended route by following the internationally accepted practices. Longitudinal profile shall be prepared based upon field data recorded at the intervals of 10 m. In case ground level is sharp the interval should be reduced appropriately. The recommended route must be accurate enough; and the bill of quantities prepared based on the final route should be compatible with the needs of cost analysis. The three coordinates (latitude, longitude, elevation or Northing, Easting and Elevation) of all tower positions shall be determined. Projection system and datums used for coordinates shall be stated. Further, major features (switch yard, substation, angle and all intermediate points, river crossings, line crossings, houses/sheds/other structures, and any major crossings) shall be determined with latest details/features up to 200 m on both sides of the recommended alignment. The Consultant shall prepare tower spotting data and the towers shall be spotted with PLS software and strength analysis for the line shall be performed. The computerized PLS-CADD output profile shall show the maximum Sag, hot curve, cold curve, ground clearance curve, weight span, wind span, adjacent span, centre peg setting down, if necessary and any other features deemed appropriate.

(d) The Consultant shall prepare final tower schedule including all the body and leg extensions and foundation types and demarcate final tower locations and expected limit of permanent disturbance in the field, including center and all corners. Center Peg shall be established at each Tower location marked with RCC Pillars of 100 x 100 x 500 mm size with embedment of 400mm and projecting 100 mm above the ground and Line pegs (L.P.) shall be established both in backward direction and forward direction no farther than 50 m with a circular RCC Pillar of diameter 100 mm & 300mm length with embedment of 200mm and projecting 100mm above the ground. All pegs shall be named with Readable color mark. Reference for the center point shall be given at least from three (3) permanent structures and reference points shall also be marked with any permanent bright color mark. Way to the Tower spot shall also be shown from the starting point of its access road.

(e) The final route alignment along with all the towers spotted shall be overlaid with the cadastral map of area through which line passes. The land plots over which tower shall be erected and under the right of way of lines shall be clearly shown in the cadastral map.
(f) The Consultant shall also carry out Topographic Survey of entire substation area of each transmission line, covering all the features within and outside the Substation boundaries for at least a distance of 100m from the boundaries. Spot Levels - Latitude, Longitude and altitude (X,Y,Z) shall be carried out at a grid of not more than 3m x 3m size and shall be extended to cover the access road for the substation for not less than 150m and cover all natural and man-made features like earthen roads, foot tracks, natural streams, rivers, houses, electric poles, irrigation canal, drains, water body etc. Power line, if any, crossing the proposed site shall be shown clearly including the Voltage level of Power line, Type of structure carrying power line (electric metal pole/cement pole, steel lattice tower etc.) etc. Temporary Bench Mark shall be established at Substation Site and its level from a known Permanent Bench Mark of Survey Department of Nepal with higher precision so that it will be easy during layout of Substation Structures and any other construction work. Temporary Bench Mark shall be established and marked with RCC Pillars of 100 x 100 x 300 mm size with embedment of 200mm and projecting 100 mm above the ground and shall be established no farther by 100 m from each another. Demarcation of boundary of substation sites may be done through RCC concrete pillars of 100 x 100 x 450mm size at all the sites. These pillars should be placed at all corners and at about 50m centre to centre between corners of the plot. These pillars shall be embedded in ground by excavating a pit of 300 x 300 x 300 mm and filled with PCC (1:3:6) all around. Pillars should be embedded in the ground by 300mm and should project 150mm above the ground. Development of Digital Elevation Model (DEM) shall be done based on topographic survey field data using Digital Terrain Modelling software (DTM) viz. Softwell DTM, Civil 3D etc. which shall be compatible with AutoCAD 2014. The Consultant shall prepare Contour maps on 1:1000 scales (or any suitable scale) with contour interval of 0.5m and for very steep topography 1.0 m contour interval may be adopted. Contour map shall include the clear boundary of Substation and possible feasible access road from substation site to nearest Road.

(g) Assess Constructability:

The Consultant shall perform an assessment of the final proposed route and tower locations through the lens of prospective works contractors, identifying the likely equipment needed, access requirements, and corresponding production rates and labor requirements taking into account a reasonable means and methods anticipated during construction (e.g. availability of labor force, Nepali holiday schedules, road conditions, monsoon rains, and other site access issues). This assessment shall feed into all other aspects of this assignment, including the assessment of temporary and permanent impacts, ROW requirements, cost estimates and work packaging and timelines.

Task 3: Conduct geotechnical investigations

The Consultant will carry out geo-technical investigations as well as soil resistance measurement for the transmission towers and substations. This will require field visits along the transmission line route and to substation locations to ensure that an adequate level of technical information is available to establish the viability of proposed tower/substation locations, limiting the potential need for future changes to be proposed by Design-Build contractors in response to unknown soil/foundation conditions.

The Consultant shall also carry out assessment of geological conditions to determine the suitability of site for the tower erection and substation construction. Major geological hazards and constraints will be identified by the Consultant. Taking into account the hazards and constraints, the optimum location for the proposed construction will be selected. At least 100 bore holes with approximate depth of 7 m will be required. This number shall cover both the transmission line route and all four substations. For each substation 2 bore holes will be required. At each substation, a combination of boreholes and geophysical investigation will be used to define the geological/geotechnical model. At least 2 geophysical profiles will be developed. For all sites,
general geological conditions will be determined and construction constraints will be identified. A map showing the surficial and shallow geological conditions will also be prepared.

For carrying out geological investigations, it will be important: (i) to ensure that layers of cemented soils are not mistaken for bedrock by penetrating at least 3 m in bedrock, (ii) in soft, compressible layers and fills, the site investigation need to extend boreholes to the full depth of that layer, (iii) samples/testing every 1.5 m spacing or changes in strata, and (iv) obtain undisturbed samples in clays and carry out SPT tests in granular material.

The Consultant shall also carry out the Electrical resistivity test of soil strata along the transmission line route alignment and conclusion on soil profile drawn from soil resistivity values shall be furnished. The Soil resistivity along the route alignment shall be measured in dry weather by four electrodes method keeping electrode spacing of 50m. Measurement shall be made at every 2 to 3 km along the route. In case, soil characteristics change within 1 to 2 km, the value shall also be measured at intermediate locations. The megger reading and soil characteristics shall also be indicated in the soil resistivity results. The measurement of soil resistivity shall also be carried out in every substations for designing the safety grounding system/earthing mat.

The Consultant will also prepare geo-technical investigation report. This will include:

- Site description: brief overview of site conditions, topography, slopes, regional geology and presence of water bodies;
- Field exploration: details of sub-surface explorations, location of bore holes, depths of investigation, soil types encountered according to United Soil Classification System (USCS);
- Laboratory Testing: index and engineering properties of soil samples according to ASTM;
- Boring Logs: details of information gathered from each borehole according to ASTM in a graphical form which includes the soil types, index properties such as water content, liquid limit, plastic limit, SPT N values, water table location, and accurate surveyed location coordinates;
- Geotechnical Recommendations: design data for shallow and deep foundations, site preparation, excavations, structural fill and other parameters required for structural or electrical design; and
- Earthquake and Seismic design: ground motion values for the area and liquefaction potential evaluation

**Task 4: Preparation of Detail Design of Transmission Line and Substation**

The Consultant shall perform base engineering designs of the transmission line with detailed technical specifications including detailed design calculations for the 400kV transmission lines and substations. All drawings prepared for this solicitation shall have a scale 1:1000 to 1:4000 (for linear components) and 1:100 to 1:1000 (for structures).

a. The Consultant shall perform the following tasks to complement other necessary tasks for both the transmission options:

a1. Collection and analysis of weather/climate data including isokeraunetic data in order to develop weather loadings for design of transmission line. Based on metrological data determine various loading zones for the transmission line, which shall pass through terrains with varying elevation and climate conditions, to optimize design of various transmission line elements/components.

a2. Select design parameters/criteria for the transmission line and preparation of design
manual as per relevant international or local standards and with reference to standards such as IEC or IEE) The Consultant shall perform and document necessary investigations, studies, design, simulation, etc., to support the selection of design parameters and criteria; and

a3. Select optimum conductor and OPGW types; various spans values (basic span, wind span, weight spans); choice of conductors (number in a bundle, type—conventional ACSR or High Capacity Low Sag/High Temperature Low Sag—based upon detail techno-economic considerations), insulators and hardware and all other necessary technical features so as to conduct sag-tension calculations and prepare tower spotting data.

a4. Based on loading zones, line route, ground profile and contours, terrain, spans (ruling, basic and weight span values) and other relevant parameters; develop and design families of self-supporting/standing steel lattice towers and monopoles where applicable and determine their suitability for the project. The tower design shall be done with sufficient detail with identification of all load cases including recommendation of critical load cases. The tower outline drawings and structural drawings for each type of tower including all body and leg extension shall also be developed. The Consultant shall identify innovative tower designs to minimize ROW requirements or address other constraints.

a5 The consultant shall optimally classify the types of foundations to be used according to the soil types and design and develop the foundation drawings for each type of foundation applicable for each type of tower.

a6. **Prepare detail technical specifications:** The Consultant shall prepare detailed technical specifications along with the technical data sheet (TDS) to be included in the bidding document for steel towers and accessories, foundations for all types towers and soils, conductor, shield wires, optical ground wire (OPGW), dampers, disc insulators and hardware, line hardware and all other line accessories including the construction materials to be used for foundation works based upon the internationally recognized standards. The design shall also include the calculations of electromagnetic/electrostatic fields of transmission along with corona/RI. The Consultant shall carry out technical analysis to determine and demonstrate that the specifications of technical parameters chosen are realistic, optimal and suitable for Nepal-specific conditions.

a7. Consultant will be provided the tower and foundation design that are being used in the existing under construction 400 kV Transmission lines in NEA. Consultant shall review the design and check for suitability of that design to be used in the transmission lines under the scope.

a6. The Consultant shall carry out sag-tension calculations using PLS-CADD software, and prepare sag template in the scale of plan and profile drawings. The Consultant shall carry out tower spotting including optimization of tower locations on the prepared plan and profile drawings optimally and provide demarcation on-site as specified below. The Consultant shall prepare sag curves using PLS-CADD software. The sag curves shall be for both hot and cold conditions and shall also include ground clearance curve and tower footing curve with all other necessary details prescribed by international standards, as well conforming to applicable local and regional standards.

b. The Consultant shall perform the following tasks with regard to detail design of all substations:

- perform base engineering to develop substation designs;
- Develop design criteria for Air Insulated Substations (AIS) and Gas Insulated Substations (GIS), calculations and technical specifications and data sheet of substations equipment
(electrical, mechanical, protection and communication and control equipment) and related accessories;
• design of gantry structures, equipment structures, structure foundations, control building, staff quarter, boundary wall, approach and internal roads, cable trench and associated civil works taking into consideration applicable seismic factors and preparation of all drawings;
• Prepare single line diagrams, layout and calculations, specifications and technical data sheet for HV, MV and LV equipment,
• Prepare base designs, specifications, technical data sheet, drawings and calculations of complete protection and control system including earthing system;
• Prepare base designs, specifications and drawings of substation lay outs, access roads, earthing and lightning protection systems; and
• Prepare base designs, specifications, technical data sheet and drawings of SCADA, substation automation and communication and control systems and all other related activities to complete the intended jobs.
• Any other tasks as may be required

Task 5: Prepare procurement packages, Cost Estimates and Bills of Quantities and bidding documents:

• The Consultant shall develop a plan for project packaging and sequencing for procurement, and shall confirm the appropriate contract type for each package along with the technical specifications, schedules and drawings for bidding of the project on a Plant-Design basis and submit documents with incorporation of suggestions from approving agencies until approved. The Consultant shall provide recommendations covering the implementation schedule, right-of-way acquisition, permitting, procurement of works (and supply and installation) services, contractor mobilization, construction, commissioning/testing, handover, Defect liability and warranty periods, and contract close out for each contract. The Quality Assurance Plan for implementation during the construction shall also be prepared.

• The Consultant shall prepare cost estimates based on quantities taken from the design and realistic unit prices derived from ongoing or recently completed similar works in Nepal and in the region by international and local contractors. Project costs shall also include accommodations for personnel involved in construction supervision such as offices, transportation, etc., a physical contingency sum based on perceived risk, and a price contingency sum, taking into account appropriate cost escalation factors and the period of time over which the works will be designed, procured, and constructed. The preparation of the cost estimates shall also take into account the costs for all access roads and other road/bridge improvements as may be necessary to deliver equipment to site. The Consultant shall develop a confidential Unit Price Analysis for each work item and a Confidential Cost Estimate, for each work item, work category, section as may be defined and contract package as a whole. Unit prices shall be classified into direct costs (labour, materials and equipment), indirect costs (mobilization, on-site and general overheads, contractor’s contingencies and profit). The Consultant shall also provide following information:
  - Reference price level of estimates
  - Currency and Exchange rates and their referenced period
  - Level of Contingencies
  - Level of inventories of materials, spares, etc
  - Scaling factors used for scaling up/down cost of any major equipment/item
  - Status of engineering and design on the basis of which the estimates have been framed
  - Rates and quantity of the items on the basis of value analysis.
  - Insurance, Transportation, Custom Duty and Taxes, etc
The Consultant shall prepare Bills of Quantities (“BoQs”) based on the various items of work to be executed in accordance with the drawings and the technical specifications. The items in the BoQs shall correspond to the work (pay) items specified in the technical specifications.

The tender documents for the construction of the Works shall be prepared using the World Bank’s Standard Bidding Documents for plant-design in the version current at the time of preparation of the bid packages (SBDs can be found at http://www.worldbank.org). The Consultant shall work closely with NEA in the preparation of final tender documents. Preparation of these documents shall include preparation of the Bid Data Sheet, Evaluation and Qualification Criteria, Bidding Forms, recommended modifications to the Conditions of Particular Applications (if appropriate); Specifications; Drawings; Schedule of Rates (BoQs); Schedules of guaranteed equipment data sheet (TDS). The tender documents shall include clearly worded and contractually enforceable clauses.

Task 6: Economic and Financial Analysis of the Project

The Consultant shall analyze the economic and financial viability of the project as per International standard and norms. The consultant shall in particular perform the following major activities:

- Analyze the economic viability of the project. Identify all economic costs and benefits with sensitivity analyses and evaluate economic internal rates of return.

Assess and analyze the financial viability of the project. Identify all risks for revenues and costs with sensitivity analyses, and evaluate financial internal rates of return. Include risk mitigation and risk transfer plans as necessary. Economic and financial analysis shall cover the life of the project.

Task 7: Capacity building of client’s staffs

One of the objectives of the consulting services is the transfer of technology in this field to the NEA’s engineers. This will be achieved by involving the NEA engineers with the Consultant’s experts as much as possible in various activities of the project implementation. The Consultant shall propose appropriate knowledge transfer methodologies to enhance the capacities of the relevant counterparts in all aspects of the planning, design, and financial analysis of the project. Skill development and knowledge transfer will primarily be achieved through field visit, on-job-training as well as short-term internal courses, trainings on analysis, design and software, and presentations on relevant subjects to the study. The capacity building program shall include but not limited to:

a) Transmission line Design: Introduction to evolution of HV transmission technology and latest available schemes; selection of AC or DC scheme; selection of voltage; selection of conductors (ACSR/HTLS composite type, determination of number of bundles etc.), OPGW, hardwares and insulators; selection of family of towers; selection of various items such as basic/wind/weight spans and their significance; highlights of international standards with regard to important and significant design parameters such as wind speed, governing temperatures, conductor/earthwire’s limiting loading, broken wire conditions, etc; development of tower spotting data; Sag and Tension calculations using PLS-CADD program; calculations of electrostatic and electromagnetic fields of EHV lines; design exercises of sample 400 kV transmission lines. Introduction to latest IEC/other internationally accepted standards for transmission line components (tower, insulator, hardwares, OPGW/ground wire, and conductors).

Tentative Duration: at least 2 weeks
Number of Trainee: 4
Place of training: Consultant’s home office
b) **Substation Design**: Trends in high voltage substations designs. Design of switchyard and control room layouts; Bus-bar schemes and their selection; selection of bus-bar capacity, selection of switchyard equipment (DS,CB,CT,PT,CVT,LA etc); substation grounding design; introductory approach to protection scheme, practices and adoption of distance and differential schemes for transmission line; adoption of bus-bar protection; selection of auxiliary supply (battery, battery charger and substation supply scheme); introduction to cable schedules; requirement and selection of HV cables; introduction to GIS system and comparison with AIS. Introduction to hybrid (GIS and AIS combined) substation designs. Introduction and application of SCADA system and terminal equipment. Introduction to application of standard software in substation designs. Differences between HV and EHV substation designs. Design exercise of a 400 kV substation. Introduction to latest IEC/other internationally accepted standards for substation components/substation design.

*Tentative duration*: at least 2 weeks

**Number of trainees**: 4

**Place of training**: Consultant’s home office

c) **Transmission Line Routing and Profiling**, tower spotting, 3D analysis of transmission line Structural Analysis of Transmission Line tower, Tower design and Foundation design using appropriate software preferably using PLS-CADD.

*Tentative duration*: at least 2 weeks

**Number of trainees**: 4

**Place of training**: Consultant’s home office

The Consultant shall include in its price proposal all the cost for the training except the cost for traveling air tickets and boarding & lodging of NEA Engineers, which shall be borne by the NEA.

4. **Implementation Arrangement**

   The Consultant will work closely with the office of NEA and relevant ministries & agencies. The Consultant’s team leader will be the principal contact and will be expected to be readily available at the Project office with a notice of seven days from the Project during the assignment period. The Consultant will be responsible for all aspects of performance of services set forth in the TOR. The Client will be responsible for providing the existing data and information and supporting arrangement for the necessary field investigations.

**Design Progress Meetings**: The Consultant shall hold periodic progress meetings with the Client at least once a month. Additional meetings shall be scheduled as required by the Consultant's design. The intent of these meetings will be for the Client to provide input and to discuss options for addressing the Client's comments. The Consultant shall fully cooperate with the Client in scheduling and attending such meetings as requested by the Client. These meetings shall be held at NEA office in Kathmandu/NEA training centre. The Client will be responsible to prepare meeting minutes during each of these meetings. Minutes will be distributed to participants for review and comment.

**Monthly Progress Reports**: The Consultant shall furnish the Client with a written Monthly Progress Report that summarizes all aspects of the completed monthly and cumulative work progress. The objectives of the Monthly Progress Report are to:

   a) Provide a reliable and readily accessible summary record of the project activities with daily activities performed by each individual at the site and progress of work during last month with verification of daily task in the site signed by the project's representative.
   
   b) Provide a detailed description of all work actually completed up to the date and revision to the project schedule required, which shall reflect changes in the critical path since the date of the last revision.
   
   c) Identify issues and problems requiring action by the Client or the Consultant, including issues of conflicting priorities.
   
   d) Provide a forecast of the work to be accomplished in the next month.
   
   e) Provide information to help substantiate the Consultant’s pay request
Submittal Protocol. No later than thirty (30) days after the Commencement Date, the Consultant shall submit a submittal protocol for the Consulting Services. The submittal protocol shall identify the submittal packages to be prepared by the Consultant including but not limited to detailed listing of the content, the expected dates of the submittals, number of copies, and distribution of the submittals by the Consultant based on distribution information provided by the Client.

Consultant’s Obligations. The Consultant shall provide submittals for review consistent with the submittal dates. The Consultant acknowledges that the Client’s review will often involve input from, or consultation with, a number of individuals. Therefore, should submittal dates to the Client be delayed, the Consultant shall provide prompt notice to the Client of the delay. In no case shall this notice be given less than ten (10) calendar days prior to the scheduled submittal date for that submittal. The submittals shall identify any proposed change to the requirements, or the design concept, project delivery approach, or the project schedule provided in the Consultant’s proposal, accompanied by the rationale behind the proposed change. No changes shall be implemented without the Client’s acceptance. Such acceptance shall not, however, relieve the Consultant of any of its obligations under the contract.

Form of Submittals. Each submittal shall be transmitted electronically and in hard copy, unless otherwise required by other sections of the TOR, with a cover letter to the Client at the office of NEA. Unless otherwise specified in the contract, the Consultant shall prepare up to eight (08) hard copies of each submittal for distribution. The Client is responsible for distribution of submittals to reviewers. Electronic submittals shall be in the original file format. The Consultant is responsible for the accuracy and completeness of the information submitted.

The Consultant shall make submittals far enough in advance of subsequent activities to allow time for reviews, consultations with other entities, for securing necessary acceptance, for possible revisions and re-submittals. The Client intends to process Consultant’s submittals as quickly as practical.

Client’s Review. The Client will review submittals for consistency with the design concept presented in the Consultant’s proposal. The primary purpose of the Client’s review is to satisfy itself that the submittals generally conform to the intent of the contract. The Client’s review shall not relieve the Consultant of the sole risk and responsibility for all defects, errors or omissions, or of sole responsibility for meeting all requirements of the contract. The Consultant shall not proceed with implementation of any work affected by a submittal until review by the Client is complete and the submittal is returned with review comments as below: The Services under this assignment are expected to be conducted for a period of approximately 18 calendar months.

5. Staffing and Key personnel

It is expected that about 50 person-months of international key experts and 60 person months of national non-key experts will be needed from a firm specializing in HV transmission line and substations.

Consultant shall assemble a team of both key and non-key experts as per the table below. List of Experts (LOE) and estimates are notional and Consultants are free to propose their own LOE to match their methodology and staffing plans, noting any deviations from the notional LOE as well as the reasons behind them. Additional staff and staffing requirements may be proposed by the Consultant as necessary and based on the Consultant’s proposed methodology and approach that will achieve the objectives of the assignment. Consultant shall provide and maintain all Key Personnel. Any changes are subject to prior approvals by NEA in accordance with the terms of the contract.
The Consultant shall plan its activities and deliverables in such a way that most of the works will be done in Kathmandu office so that NEA Engineers may attach with the Consultant's expert.

The Qualification and Experience of the Key and Non-Key Experts shall be as follows:

<table>
<thead>
<tr>
<th>Role</th>
<th>Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. International Key Experts</strong></td>
<td></td>
</tr>
<tr>
<td>Team Leader/TL expert (or equivalent Title)</td>
<td>He/She shall be an independent professional with strong organizational skills, with a preferably Master degree in electrical engineering. He/she shall have extensive knowledge of international best practices in power system planning and infrastructure design, contract procedures and project follow-up. He/she shall also have a proven track record of successfully managing and coordinating as team leader a diverse group of professionals in accomplishing projects of similar nature and complexity to this assignment. A minimum of 15 years of working experience in implementation of electricity transmission projects is required. The Team Leader shall have in the last ten years, specific experience of managing consultancy teams working on feasibility study and detail design of at least one transmission line projects of 345 kV or above in a similar terrain condition and in countries other than Expert's home country.</td>
</tr>
<tr>
<td>Lead Civil Engineer-Civil works &amp; structural</td>
<td>He/she shall have at least Bachelor degree (preferably Master's Degree) In civil Engineering with at least 10 years’ experience in transmission line tower designs of 345 kV or above voltage class and civil works associated with HV transmission projects, related to the design of civil structures, Gantry structure tower/and equipments foundations of 345 kV or above transmission lines, and substations and buildings, ideally in similar terrain conditions to the proposed project.</td>
</tr>
<tr>
<td>Lead Electrical Engineer-TL &amp;SS</td>
<td>He/She shall have at least Bachelor Degree (preferably Master Degree) in electrical engineering or relevant fields, coupled with at least 15 years of relevant experience. Experience in transmission network of 345 kV or above design and operations are required. He/She shall have specific experience of working on at least one transmission line design projects of similar nature and in similar terrain conditions to the proposed projects. Extensive knowledge of international best practices in electric transmission system planning, line routing processes, maintenance, and transmission system design is critical.</td>
</tr>
<tr>
<td>Lead Survey Engineer</td>
<td>He/She shall have at least Bachelor's Degree in Survey/Civil Engineering or other relevant discipline and over 15 years of consulting experience, with previous experience in detail survey of 345 kV or above transmission lines in countries other than the expert's home country. Experience shall include route definition, detail survey, profiling, contouring and tower spotting in mountainous/hilly terrain. The expert shall have an understanding of line clearances and safety considerations. He/she shall also have an extensive knowledge on handling and operation of PLS-CADD, AutoCAD and other similar software.</td>
</tr>
<tr>
<td>Lead Power System Analyst</td>
<td>He/She must have at least 10 years’ experience in electrical system modeling and analysis, and be familiar with system analysis software such as PSS/E. He/she should be well-versed in load flow, stability and short-circuit analysis as well as international best practices in power system planning</td>
</tr>
<tr>
<td>Role</td>
<td>Requirements</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lead Protection, Control and SCADA Engineer</td>
<td>He/She shall have at least Bachelor Degree (preferably Master’s Degree) in Electrical/Electronics/Communications coupled with at least 10 years of relevant experience in designing/planning of Control and Protection system for interconnected/integrated power grid system. He/She shall have specific experience of working on at least one substation projects of 345 kV or above.</td>
</tr>
<tr>
<td>Lead Telecommunication Engineer</td>
<td>He/She shall have at least Bachelor Degree (Preferably Master Degree) in Electrical/Electronics/communication Engineering with at least 10 years’ experience in telecommunication systems associated with transmission system projects (345 kV or above), including experience with fiber optic and OPGW based tele-protection systems and equipment.</td>
</tr>
<tr>
<td>Lead Procurement Expert</td>
<td>He/She shall have at least Bachelor’s degree in engineering or management with minimum 10 years of procurement specialization/experience in high voltage transmission systems projects. He/She shall have an knowledge on World Bank’s procurement Guidelines and Standard Bidding Documents.</td>
</tr>
<tr>
<td>Lead Geotechnical Engineer</td>
<td>He/She shall have preferably Master’s Degree in Geotechnical/Civil Engineering and preferably 10 years of experience, with previous experience in countries other than the expert’s home country. The experience shall be in geotechnical investigation, test and design of tower foundations of 345 kV or above voltage level transmission lines and substation.</td>
</tr>
<tr>
<td>Economist/Financial Analyst</td>
<td>He/She shall have preferably Master’s Degree in Economics, Business Administration, Finance or related studies with minimum 10 years of consulting experience. The experience shall be in Financial/Economic analysis of high voltage level transmission lines and substation projects.</td>
</tr>
</tbody>
</table>

**B. National Experts- Non Key**

<table>
<thead>
<tr>
<th>Role</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Engineers-TL &amp; SS (2 Nos)</td>
<td>He/she Shall have at least Bachelor’s Degree in Electrical Engineering/High Voltage Engineering or other relevant discipline and 5 years of experience in transmission line and substation design, specification preparation, construction/operation of 132 kV or above voltage class.</td>
</tr>
<tr>
<td>Civil Engineers- TL&amp;SS (2 Nos)</td>
<td>He/she shall have at least Bachelor’s Degree in Structure/Civil Engineering or other relevant discipline with preferably over 5 years of experience in project preparation of transmission line and substation of 132 kV and above voltage level. He/she shall also have knowledge of the design of foundations for transmission line towers and substation structures for 132 kV and above voltage level. The expert shall have knowledge on AutoCAD or similar software.</td>
</tr>
<tr>
<td>Survey Engineer/Surveyor (2 Nos)</td>
<td>He/she shall have at least Bachelor’s Degree in Survey/Civil Engineering or other relevant discipline and 5 years of experience in detail survey of 132 kV or above transmission lines. Experience shall include route definition, detail survey profiling and contouring in mountainous/hilly terrain. The expert shall have an understanding of line clearances and safety considerations and knowledge on AutoCAD or similar software.</td>
</tr>
<tr>
<td>Geologist/Geomorphologist (2 Nos)</td>
<td>He/She shall preferably Master’s Degree in geology and at least 10 years of field experience in Nepal or other parts of the Himalayas. He/She shall have a knowledge and understanding of the Churia zone, and of the various fault zones. A thorough understanding of down wasting and</td>
</tr>
</tbody>
</table>
landslide mechanisms is also essential.

<table>
<thead>
<tr>
<th>Role</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geotechnical Engineer</td>
<td>shall have preferably Master’s Degree in Geotechnical/Civil Engineering and preferably 10 years of experience. The experience shall be in geotechnical investigation, test and design of tower foundations of 132 kV or above voltage level transmission lines and substation structures</td>
</tr>
<tr>
<td>Environmental and social safeguard experts</td>
<td>He/She shall have preferably Master's Degree in Environmental Science/Environment Management/Environmental Engineering or closely related discipline with more than ten (10) years of professional experience in the related field. The experts shall have experience in conducting environmental impact analysis (EIA), initial environmental examinations (IEE) of transmission line projects as per national laws relating to EIA and IEE</td>
</tr>
</tbody>
</table>

6. Reporting Requirements

Following the signing of the Contract and issuance of the contract commencement, the consultancy shall be launched with a formal kick-off meeting at a location to be determined by NEA (in Kathmandu, Nepal). The Consultant shall be represented by at least the Project Manager and Key Technical Personnel. The purpose of the kick-off meeting is to address any questions about the Contract or scope of work and to clarify expectations regarding the services.

The services under this contract are expected to be conducted for a period of approximately Fifteen (15) calendar months. The Consultant may propose adjustments to the timing and schedule of deliverables outlined below, provided that any alternative schedule will meet the completion period of NEA’s requirements.

The Consultant shall be expected to be available during the period of performance and shall be responsible for management of the services. This includes supervision and management of the consultancy, liaison with NEA and other parties, office management, and ensuring quality control of services. As part of project management, a number of meetings between NEA and the Consultant may be scheduled at any point in time. The Consultant shall produce minutes of all such proceedings.

The Consultant shall prepare the various reports and maintain records documenting decisions made at meetings, progress on project preparation, financial records and changes to the contract plans. The reporting shall, in general, comprise including but not limited to the following:

**Task 1;**

1. Report on Power Evacuation study
2. Report on review of all reports, drawings and plans prepared by or for NEA.
3. Desk study survey report
4. Report on base design including base drawings, Single line diagram and preliminary cost estimates of transmission line and substations
5. Consolidated Inception report

**Task 2;**

1. Route alignment survey report with all the feasible alternatives alignments (at least three) for approval from NEA to carry out the detailed survey.
2. Report on line routing and tower spotting plans and survey information using PLS-CADD including profiling, tower spotting, tower schedules and staking table with demarcation of tower spot in the field
3. Report on check survey of transmission lines with contouring of tower locations and determination of all types of leg extensions.
4. Report on topographical survey of substation lands
5. Report on Cadastral survey of tower plots and under the Right of Way
vi. Consolidated report of the detail survey of transmission lines and substations

Task 3:

Report on Geotechnical investigation and geological stability slope stability studies for tower locations including Electrical Resistivity Test as specified in Scope of Services

Task 4;

i. Report on definition of transmission line and substation design technical parameters, conductor configurations, insulator and special tower types, taking account of NEA’s requirements and Nepal-specific conditions including wind velocity, terrain type and altitude, single line diagram

ii. Report on design of various types towers including all outline and structural drawings

iii. Report on design of various types of tower foundation with all necessary drawings Manual for checking drawings of towers and foundations

iv. Design report on detailed engineering design of AIS or/and GIS substations including design of gantry structure & their foundations, equipment structure and their foundation, equipment foundation, earthing design, SCADA, communication design, protection design, control building & cable trenches etc and all associated single line and schematic drawings with incorporation of suggestions from approving agencies.

v. Report on reviews of tower designs provided by NEA which is being used for 400 kV transmission lines projects under construction and check the suitability of those designs to be used in the proposed transmission lines

vi.

Task 5;

i. Report on recommendation on various procurement packages as required.

ii. Detail cost estimate of the transmission lines and substations

iii. Bidding documents for each procurement packages including technical specifications, performance specifications, schedules and drawings

Task 6:

iv. Detail feasibility Report for each transmission system including economic and financial analysis acceptable to NEA.

Task 7:

i. Report on need assessment of training.

ii. Completion Report of each of the training separately with feedback from the participant and training material for the client’s record.

All documents and reports would be made available on hard copy as well as electronic format. Electronic submission/reports shall be in the original file format. Consultant must submit Design Drawings/Construction Drawings in editable format. All reports will be in English language. The above reporting requirements or deliverables are minimum requirement and NEA may ask consultant to submit any other intermediate reports as deemed necessary and as transpired during the period of contract in connection with the service rendered as per the Scope of Services. However, should the Consultant find better idea on above reporting requirement (deliverables) , the same may be suggested in the technical proposal. However, the acceptance of which shall be NEA’s prerogative.
The Consultant is also required to make presentation in front of NEA management upon the completion of each category of task except task no 7. NEA shall intimate the consultant about the date, time and venue of such presentations in at least 2 weeks prior to the presentation date.

7. Deliverables and Payment Schedule

This consulting assignment will be based on Lump Sum contract and consulting Firm will be paid upon completion of the Deliverables (Milestones). The following table summarizes the deliverables and associated payments, which are described more fully below, and their due dates:

**Advanced Payment**- 10% of the contract amount against unconditional Bank Guarantee. Advance will be deducted proportionately from each payment until same is fully repaid.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Milestones (submission and acceptance of reports under the various tasks of Scope of Services)</th>
<th>Due date</th>
<th>Payment (% of Contract Price)</th>
<th>Cumulative (% of Contract price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reports under Task 1</td>
<td>Within 4 weeks of Contract Commencement</td>
<td>10.0%</td>
<td>10.0%</td>
</tr>
<tr>
<td>2</td>
<td>Reports under Task 2</td>
<td>Within 20 weeks of Contract Commencement</td>
<td>30.0%</td>
<td>40.0%</td>
</tr>
<tr>
<td>3</td>
<td>Reports under task 3</td>
<td>Within 30 weeks of Contract Commencement</td>
<td>5%</td>
<td>45%</td>
</tr>
<tr>
<td>4</td>
<td>Reports under Task 4</td>
<td>Within 40 weeks of Contract Commencement</td>
<td>20%</td>
<td>65%</td>
</tr>
<tr>
<td>5</td>
<td>Reports under Task 5</td>
<td>Within 50 weeks of Contract Commencement</td>
<td>15%</td>
<td>80%</td>
</tr>
<tr>
<td>6</td>
<td>Reports under task 6</td>
<td>Within 64 weeks of Contract Commencement</td>
<td>10%</td>
<td>90%</td>
</tr>
<tr>
<td>7</td>
<td>Reports under task 7</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; training: within 10 weeks 2&lt;sup&gt;nd&lt;/sup&gt; training: within 35 weeks 3&lt;sup&gt;rd&lt;/sup&gt; training: within 60 weeks</td>
<td>10% (proportionate payment for each training)</td>
<td>100%</td>
</tr>
</tbody>
</table>
8. **Counterpart Support and Inputs Provided by NEA**

NEA shall work in close collaboration with the consultant’s team and provide necessary support in all aspects of the consulting services. Both NEA and Consultant's teams shall work together as one single team in all matters related to the Project. If required by local regulations, NEA will provide Consultant with necessary support letters for obtaining visas and permits for its experts. The cost and timing of obtaining the above is entirely the responsibility of the Consultant.

9. The prospective consulting firm expressing their interest under this Terms of References shall consider the necessary support staffs such as semi-skilled and unskilled field manpower, office assistants, computer operator, secretary, draftsmen, data enumerator, Tools and Equipments, transportation and all other necessary amenities required to render the services as per this Terms of reference.