OFFICE OF THE BHUTAN POWER SYSTEM OPERATOR (BPSO)

MINISTRY OF ECONOMIC AFFAIRS
ROYAL GOVERNMENT OF BHUTAN

THIMPHU, BHUTAN

TENDER DOCUMENT
FOR

"REVAMP OF SCADA AND TELECOMMUNICATION SYSTEMS"

(International competitive Bidding)

VOLUME – II:
TECHNICAL SPECIFICATIONS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SUMMERY SHEET

VOLUME – I: COMMERCIAL BID

Section – I: Instructions to Bidders

Section – II: Bid Data Sheet

Section – III: Bidding Forms

Section – IV: General Conditions of Contract

Section – V: Special Conditions of Contract

Section – VI: Contract Forms

VOLUME – II: TECHNICAL SPECIFICATIONS

LOT 1: Revamp of SCADA/EMS Systems

LOT 2: Revamp of Telecommunication System

VOLUME – III: PRICE SCHEDULES

LOT 1: Revamp of SCADA/EMS Systems

LOT 2: Revamp of Telecommunication System

Thimphu: Bhutan
Office of the Bhutan Power System Operator

VOLUME – II: TECHNICAL SPECIFICATIONS

LOT 1: REVAMP OF SCADA/EMS SYSTEMS

PART A

Section 1: Introduction and General Information

Section 2: Training

Section 3: Project Management, Testing, and Documentation

Section 4: Maintenance and Support Services

PART B

Section 1: SCADA System Functions

Section 2: EMS System

Section 3: User Interface Requirements

Section 4: System Software Requirements

Section 5: Hardware Requirements

Section 6: Configuration Characteristics

Section 7: Inspection and Testing

Section 8: Web System Functions

Section 9: Auxiliary Power Supply

APPENDIX A-J

LOT 2: REVAMP OF TELECOMMUNICATION SYSTEM

Section 1: Introduction and General Information

Section 2: Network Configuration and Equipment Characteristics

Section 3: Network Management System

Section 4: Environment, EMI, Power supply, Cabling & Earthing Requirements

Section 5: Project Management, Testing, Spares, Maintenance, Training and Documentation

APPENDICES

Thimphu: Bhutan

Office of the Bhutan Power System Operator

VOLUME II

LOT 1
REVAMP OF SCADA/EMS SYSTEMS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 1

INTRODUCTION AND GENERAL INFORMATION

Thimphu: Bhutan
Office of the Bhutan Power System Operator

CONTENTS

List of Figures

SECTION 1
INTRODUCTION AND GENERAL INFORMATION

1.1 Introduction

This part of technical specification details the revamping of the existing Supervisory Control and Data Acquisition System and Energy Management System (SCADA/EMS) for Office of the Bhutan Power System Operator (BPSO), Ministry of Economic Affairs (MoEA), Thimphu. This **Volume II (Part A and Part B)** of the Tender Document describes the Technical specification for the following systems:

Part – A: General Information of the Project

Part – B: Technical specification of SCADA/EMS System

The purpose of this **Section 1 of Part A** of the technical specification is to provide general information about the existing systems, the scope of the proposed project, requirements, responsibilities and obligations of the contractor and Employer, and general bidding requirements.

1.2 Owner

BPSO shall be the "Owner/Employer" for Main and Backup National Load Dispatch Center (NLDC) works.

1.3 Existing NLDC system

Bhutan Power System has all the major generation and transmission substations provided with state-of-art Substation Automation System (SAS) and these substations communicate to the SCADA/EMS system installed at NLDC in Thimphu, as well as Western Load Dispatch Centre (WLDC) at Malbase (also functions as backup NLDC), and Eastern Load Dispatch Center (ELDC) at Tintibi.

The existing SCADA/EMS System is supplied by Areva T&D which works on E-terra platform version 5.1 with dual LAN philosophy at all levels. The RTU and communication equipment are mostly of M/s Alstom make, while some substations have equipment of M/s ABB and M/s Siemens.

The Remote Terminal Units (RTUs) in Eastern Bhutan are reporting to ELDC whereas RTUs in Western Bhutan report to WLDC. The communication protocol used between the control centers is on ICCP. All the RTUs report to the respective control centers on IEC 60870-5-104 protocol.

The major components of the existing BPSO system are:

a) SCADA/EMS Systems at NLDC Thimphu, Backup/WLDC at Malbase, and ELDC at Tintibi;

b) ICCP connectivity with all regional Load dispatch centers and ERLDC, India;

c) Network Equipment;

d) Communication systems; and

e) Auxiliary Power Supply Systems.

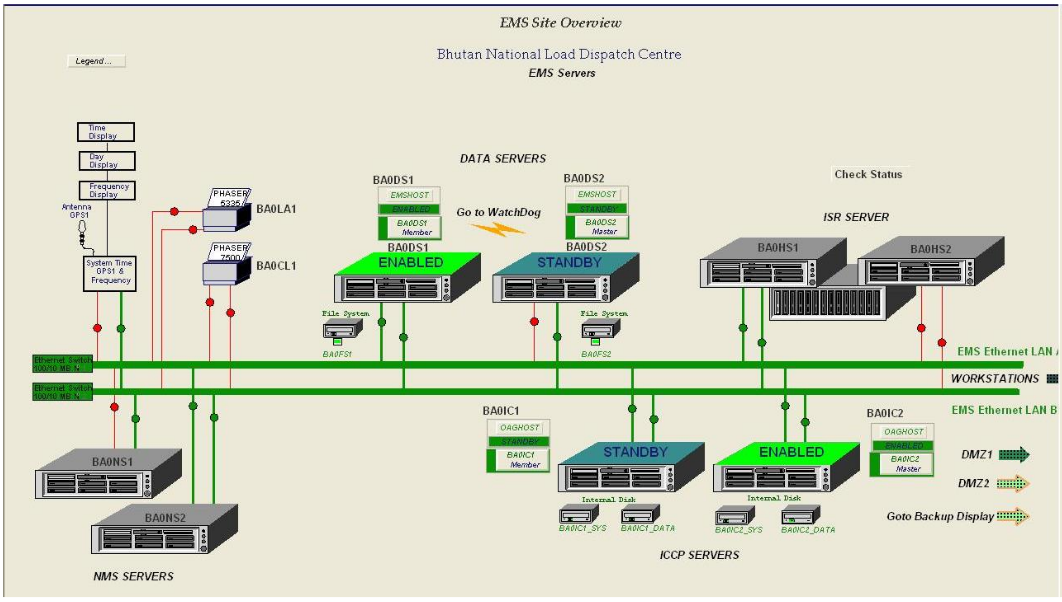

Figure 1 Existing Architecture of NLDC

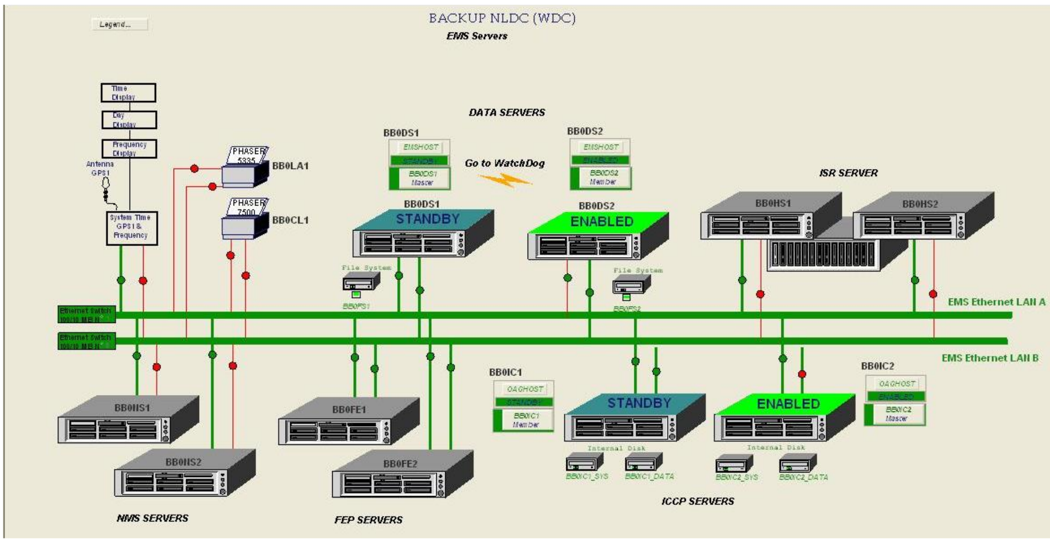

Figure 2 Backup NLDC Architecture at Malbase

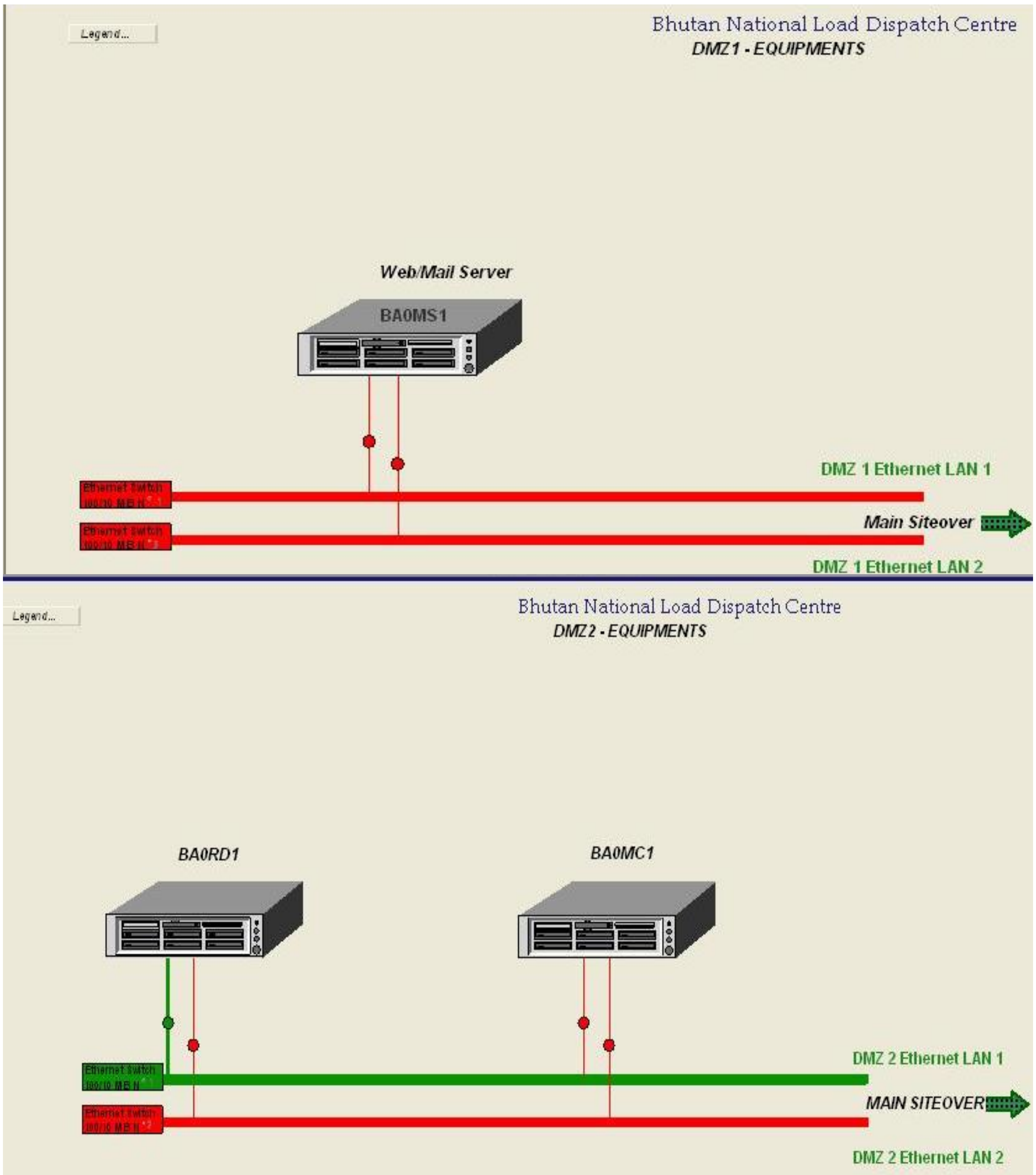

Figure 3 DMZ LAN

1.4 PMU System

In addition to RTU based telemetry system, BPSO has undertaken Phasor Measurement Unit (PMU) based Wide Area Monitoring System (WAMS) independent of the NLDC SCADA/EMS system. The work was executed by M/s SEL India and has provision to integrate on IEC-60870-5-104 protocol.

The architecture of WAMS is similar to the NLDC architecture with western region PMUs reporting to the Phasor Data Concentrator (PDC) at Malbase, the eastern region PMUs reporting to the PDC of Tintibi, and super PDC at the NLDC, Thimphu.

1.5 Overview of the Proposed System

Under this project, the SCADA/EMS system will be established with Main NLDC at Thimphu and Backup NLDC at Jigmeling. The new system shall replace the existing system without affecting the operation of the existing system. The existing and new systems shall be operated in parallel for a period of one month before shifting the entire operation to the new system. The bidder shall submit the migration philosophy document for all Main, backup, and other existing control centers, from the existing system to the new system along with the bid. This document should include the details of the minimum space and logistics requirement at each of the existing control Centers, parallel operation with the existing system, expected downtime in the existing system, shifting the operation to the new system, and dismantling of the existing system.

The Backup Control Centre of Jigmeling should be able to perform all the functions of the Main control Centre of Thimphu. The system shall be designed for meeting the identified expansion requirements in all respects including all hardware, software, and configurations and the successful bidder shall have to demonstrate the same during Factory Acceptance Test.

Each existing RTUs and SAS system shall report to both the main and backup control center at the same time through IEC 60870-5-104 protocol following dual reporting architecture which will be provided by the Employer.

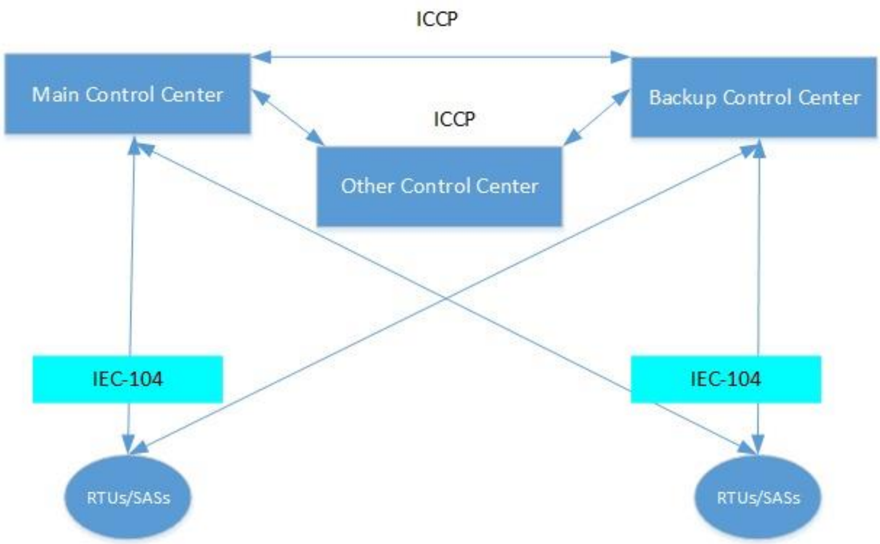

Figure 4 Typical Logical Data Flow between Control Centers

1.6 Scope of Work

The scope of work under this package shall include complete conformity with all the sections of these specifications. This includes overall Project Management having Survey, Planning, Design, Engineering, Documentation, Integration, Supply, Delivery to site, Unloading, Insurance, Storing, Handling, transportation to final locations, Installation, Termination, Testing, Demonstration for acceptance, and Commissioning of following, but not limited to:

a) Supply and Installation of SCADA/EMS System at Main and Backup NLDC including system hardware and software along with associated items at respective control Centers as per **Appendix – G** of **Part – B, Volume – II.** The new system shall be deployed in such a way that the operation of the existing systems should not be disturbed;

b) Integration of Main and Backup Control Centre, Thimphu DMS, and ERLDC India through secure ICCP protocol;

c) Collection & merging of SOE data at Main & Backup NLDC and transfer to Historian System;

d) Installation of IT infrastructure at the control centers;

e) Development of complete Database, displays, and reports from scratch;

f) Import and Adaption of historical data stored in existing Historian for integration in new the system;

g) Supply of Spares identified under AMC along with main items to meet contingency during the installation period and AMC period;

h) All cabling as required, including cable trenches, wiring, and interconnections to the equipment being supplied should be integrated with the communication equipment and from the power supply point provided by the employer;

i) Integration of all the supplied equipment with the existing system;

j) The contractor's scope shall include customization of its ICCP protocol, such as the configuration of the ICCP database for ICCP name, scan period, and all other – database parameters required to integrate existing Control Centers successfully;

k) Shifting of existing system workstations and Installation of new system workstations at a temporary location in parallel for the intervening period;

l) The sequence of system migration work shall be finalized during detailed engineering;

m) The new System and existing system shall run in parallel for at least one month before the dismantling of the existing system. This shall include all the services including cabling and interface modification required for the intervening period before finally shifting to the main control center. The location of disposing of the dismantled materials is to be decided during the detailed engineering;

n) Additional Hardware, software, and services are necessary to ensure compatibility with existing equipment;

o) Training of employer's personnel;

p) Comprehensive Maintenance of the supplied system as per specification including future ICCP Integrations, Database configurations, Maintaining Spare inventory, etc. as deliberated in **Section – 4, Part – A** of this specifications;

q) Integration and exchange of data with Offline Applications: The new SCADA/EMS Systems being supplied shall have provision to exchange data with Web Interface and future market applications of Employer in standard formats like ODBC, OPC & XML that can be configured by the Employer.

r) GI/Aluminum cable trays/trace ways with covers shall be supplied by the bidder for laying cables so that cable can be protected from rodents. These cable trays/trace ways shall be screwed/ fixed on the floor/floor trenches by the Contractor;

s) Contractor AMC's scope shall include the supply of necessary interfaces (hardware and software) for the integration of the number of Control Centers as specified in the **BOQ**. All spares shall have pre-loaded software and required licenses in order to

Thimphu: Bhutan
Office of the Bhutan Power System Operator

make it readily available for use at all times;

t) All the software licenses shall be in the name of the owner and shall be perpetual. The bidder should mention and list all the software that requires licenses and its updates. Also, the employer should have full rights to use the given licenses, even at a later date, should there be need to replace the particular hardware. The detail license condition of the main applications must be submitted along with the bid.

In addition, any subscriptions or renewable fees for the third-party software should be the responsibility of the contractor until the end of the AMC. The contractor should also submit the software alongside the corresponding license details.

u) The contractor will be responsible for dismantling the existing system and transporting it to the nearest employer-designated stores;

v) Any other work which is not identified in the specification but is required for completion of the project within the intent of the specification.

1.7 General Requirements

The Contractor is encouraged to offer standard products and designs. However, the Contractor must conform to the requirements and provide any special or additional equipment or software necessary to meet the requirements stated in the specification.

It should be noted that design information and bill of quantity are provisional only. The contractor shall verify the design data during the site surveys and detail engineering and finalize the BOQ as required for ultimate design and system performance. However, the location/area of execution of works under this project shall not be limited only to the locations indicated in the appendices. The employer reserves the right of execution of works within the stipulated quantity variation provision other than those indicated in the appendices at the same rates, terms, and conditions.

The Bidder's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without the further necessity for inquiries. The Bidder's proposal shall clearly identify all features described in the specifications or in any supporting reference material that will not be implemented; otherwise, those features shall become binding as part of the final contract.

An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items and services are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items and services such that a viable and fully functional SCADA/EMS System is implemented that meets or exceeds the capacity, and performance requirements specified. Such materials and services shall be considered to be within the scope of the contract.

All equipment provided shall be designed to interface with existing equipment and shall be capable of supporting all present requirements and spare capacity requirements identified in this specification.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

The equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation. Adequate measures shall be taken to protect against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration, and electromagnetic interference, etc.

The delivered system should be robust enough to run all the critical functions without any interruption when one machine fails e.g. failure of one SCADA server or failure of a power supply in the server should not interrupt the availability of the functions catered by the server. System Network should be resilient enough to withstand a single fault on network devices. It should be able to monitor multivendor network elements (Server, workstation, Router, switch, etc.).

The diagnostic software shall be provided with the system to perform health monitoring of different components so that timely action can be taken. Server CPU utilization can be monitored so that, before it goes beyond a percentage and system performance deteriorate, action can be taken. The system should be secure against cyber threats. The measures should be taken to harden the system and make multiple levels of defense e.g. firewalls supplied should be from different OEMs in a Control Centre. The entire performance requirements shall be demonstrated for the worst case, if requirements are not explicitly mentioned. All the requirements of the specification are to be met by the delivered system. If there is any conflicting requirement, the applicable requirement shall be decided by the employer and that shall be binding on the Supplier. Backup Control Centre should be considered as independent CC (i.e. users are sitting at Backup CC and operating all the functions delivered even when Main CC is available) for licenses i.e. licenses for Backup CC should not be dependent on Main CC in any way.

It shall be the employer's choice to keep the Furniture color and design differently for each Control Centre or the same for all.

Employer will choose the option wherever either of the options of functionality is given. However, if 'or' is written then Supplier has to provide all the functionality. It can be explained by the following example. Capability to export SCADA data to an external system using ODBC or JDBC or OPC (ODBC/JDBC/OPC). In this case, the Supplier has to deliver all three options to the user. But if it is written that capability to export SCADA data to an external system using either ODBC or JDBC then Supplier has to provide at least one option.

The Contractor shall demonstrate a specified level of performance of the offered items during well-structured factory and site tests.

The bidders are advised to visit sites (at their own expense), prior to the submission of the proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful bidder (Contractor) is required to visit sites. The site visits/routes shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the employer well in advance. The site survey schedule shall be finalized in consultation with the employer. The employer may be associated with the Contractor during their site survey activities.

After the site survey, the Contractor shall submit to the employer a survey report. This report shall include at least the following items:

a) The layout of all equipment (Server, Work Station, Auxiliary Power Supply, ACDB, etc.) in the rooms and buildings as required for final and intermediate positions;

Thimphu: Bhutan
Office of the Bhutan Power System Operator

b) Proposed routing of power, earthing, LAN cable, and signal cables along with trench size at Control Centre locations to be supplied under this project;

c) Availability of space, Air conditioning, and AC/DC Power supply;

d) Proposals for new rooms/buildings/ trench/ facility modifications, if required;

e) Identify all additional items required for integration for each site/location;

f) The AC availability for installation and commissioning of Servers etc.;

g) Details of ACDB panels' locations and dimensions along with dimensions of the gates/entry points: compare with the existing ACDB and check the door size also for entry of fabricated panels. If not possible then split the panel either in two parts at the factory or dismantle it at the site and reassemble it after entry through doors. To take care above ACDB supplier should conduct a survey or accompany the Bidder;

h) Details for Battery placement: Shall include load bearing requirement of the floor. The existing floor can withstand loading or strengthening is required or another location is to be identified so that loading can be borne by the location.

1.8 General Responsibilities and obligations

This sub-section describes the general responsibilities and obligations of the Contractor and the employer.

1.8.1 Responsibilities for the implementation plan

The contractor shall be responsible for the development of a detailed project implementation plan. The implementation plan shall be modeled such that it provides Power Supply for the activation of the SCADA/EMS System before delivering Hardware at the Site, Database development, Commissioning of the new system, shifting of the existing system, parallel operation of systems, shifting of the new system to control room, Dismantling & migration of operations to the new system, etc. The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones such as facilities readiness and clearly identifying the nature of all information and project support expected from the employer. In consultation with the Employer, the Contractor shall finalize the detailed Implementation plan following the award of the contract.

1.8.2 Contractor's Responsibilities and Obligations

The Contractor shall be responsible for all cabling and wiring associated with the equipment provided both inside and outside buildings. The Contractor shall also be responsible for determining the adequacy of the local power source for the equipment and for cabling to it, with adequate circuit protective breakers, if required. In addition, the Contractor shall be responsible for shielding equipment and cabling to eliminate potential interference to or from the equipment and for earthing of all cabinets and shields as required for system. Contractor's responsibilities include, but are not limited to, the following:

a) Provide a working system that meets or exceeds the functional and performance requirements of this specification without affecting the operation of the existing systems.

b) Equipment engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

c) Development of installation guidelines.

d) The overall integration of equipment/subsystems.

e) Integration of existing & new Control Centers

f) Buying and maintaining of spares identified under AMC along with main items to meet the contingency during installation and Maintenance period.

g) Project management, and project scheduling, including periodic project reports documenting progress during the contract period.

h) Engineering and technical assistance during the contract warranty and maintenance period.

i) Provide all additional Equipment and services necessary to ensure compatibility between new and existing equipment.

j) Implement all minor civil works and identify any major civil works i.e. expansion or construction of rooms, and trenches necessary for installation of the proposed equipment and provide the details of such work to the Employer.

k) Define source power requirements for each cabinet/ rack of equipment provided.

l) All hardware, software, and firmware required to satisfy the requirements of this Specification.

m) Factory and site testing of all hardware and software provided.

n) Provide Type Test report to the Employer and if required, conduct type test.

o) Testing for ICCP integration with the Existing system.

p) Provide a Quality Assurance Plan and access to the manufacturing process.

q) Shipment of all equipment to designated locations and/or storing areas.

r) Storing, maintenance of storing area, and security including full responsibility for protection from theft and fire for all the items to be supplied.

s) All documentation and drawings as specified.

t) All required spare parts, maintenance aids, and test equipment.

u) Parallel operation of the existing and new system. However, the maintenance of the existing system will be the responsibility of the owner.

v) Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment as per specifications.

w) Full system backup of all installed software for all machines.

x) Availability of service, spare, and expansion parts for the supplied items for the complete design life i.e. 7 years from the operational acceptance of the system of the project as per details in various parts of this specification.

y) Demonstration of necessary features as indicated in **QUESTIONNAIRES (Volume – II, Part B, Appendix E)**

Thimphu: Bhutan
Office of the Bhutan Power System Operator

1.8.3 Exclusions from the Contractor's Scope

The contractor shall be responsible for providing all the hardware & software, development of the database, and services required for the commissioning of the project except the following:

a) Buildings

b) Firefighting System

c) AC input power supply

d) Communication System

1.8.4 The Employer's Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

a) Overall project management;

b) AC Source power at (nominal) 230 volts, except the power supply, included in the scope of this Project;

c) Review and approval of the Contractor's designs, drawings, and recommendations;

d) Power system network and device data;

e) Communication network;

f) Interconnection drawings for existing equipment;

g) Review and approval of test procedures;

h) Participation in and approval of "Type", factory, and site acceptance tests;

i) Review and approval of training plans;

j) Providing support and access to facilities at the sites;

k) Implement the major civil works such as expansions or construction of rooms as required for the equipment to be provided by the Contractor;

l) Coordination of the Contractor's activities with the Employer's concerned departments;

m) Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned;

n) Arranging appropriate shutdown to facilitate erection testing and commissioning of System; and

o) Any statutory clearance/entry permit as required.

1.9 System Architecture

The typical conceptual system architecture of Main and Backup NLDC, servers, devices, and their interconnection at various Control Centers is provided in **Annexure – I** at the end of this chapter. The bidder can optimize and propose their own system architecture but shall meet the functional requirement as well as future expandability, redundancy, and isolation required for cyber security.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

1.10 Main and Backup Control Centre Operational Philosophy

This specification document states the requirements for the SCADA/EMS systems which the Contractor shall install at the main & backup control centers of NLDC. Apart from the number of workstations/servers associated with each system, the SCADA/EMS configurations shall be identical. The requirements stated in this document for “the SCADA/EMS”, unless expressly indicated otherwise, shall apply equally to the SCADA/EMS Systems. Each SCADA/EMS shall be able to serve as a backup to the other system. In the normal course, Main Control Centre shall be performing all the functions of the Main Control Centre and Backup Control Centre shall be functioning as standby to Main Control Centre. Details of the Main & Backup Control Centre functionality have been specified in **Part B** of this Document.

1.11 Civil Works

This specification document states the requirements for the civil works which the Contractor shall install at the Main & Backup Control Centers. The Civil work under the scope of the contractor is as follows (details can be decided during detailed Engineering):

At Main Control Center:

1. Minor Aluminum Partition work
2. Complete rewiring from the existing ACDB panel
3. Installation of the UPS 20kVA

At Backup Control Center:

1. Aluminum Partition work for the whole Control Center.
2. Installation of appropriate heavy-duty Air Conditioner.
3. Installation of the UPS 20kVA with the installation of ACDB panel with complete wiring.

1.12 General Bidding Requirements

The Bidder shall be responsive to the Employer’s technical requirements as outlined in this specification. To be considered responsive, the Bidder's proposal shall include the following:

a) The Technical Proposal including all the necessary documents

b) A detailed project implementation plan and schedule that is consistent with the Employer’s specified objectives. The plan shall include the activities of both the Contractor and Employer, show all key milestones, and identify the nature of all information and project support to be provided by the Employer.

c) A System Description Document describing the overview of the bidder’s proposed Software and Hardware System.

d) A clearly defined plan to develop a system support organization, based in Bhutan and capable of providing a full range of local services (including software and hardware maintenance and upgrade support) for the life of the delivered SCADA/EMS systems.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

e) The migration plan detailing the minimum space and logistics requirement at the existing control Centre, parallel operation of the existing system without disturbing the operation of the existing system, Expected downtime in the existing system, dismantling of the existing system, and shifting the operation to the new system.

1.13 Table of Compliance

Bidder shall use one copy of **Volume – I** (Commercial Bid) and **Volume – II: Lot 1** (Technical Specifications) to indicate compliance status and Technical Status with those volumes. Within the right-hand margin, Bidder shall indicate compliance status and, technical Status to each paragraph and an index key for any explanation or comment.

In addition, the Bidder shall annotate the Table of Contents of each of the above-stated volumes to provide a high-level summary of compliance status and Technical Status. In both cases, the following symbols, and no others, shall be used:

Compliance Status:

C – Bid complies with all requirements

A – The bid is not compliant with the requirements, but a functional alternative is proposed.

X – Bid takes exception to the requirements and no functional alternative is proposed.

Technical Status:

S – Bidder's Standard product will be used to meet the requirements

D – Bidder will take development work to meet the requirements

Only one symbol of Compliance Status and one symbol of Technical Status shall be assigned for a paragraph and shall indicate the worst-case level of compliance for that paragraph. This annotation may be handwritten.

Bidder shall also underline, on the compliance copy, all requirements to which exceptions have been taken (X) or to which alternatives have been proposed (A).

Each alternative shall be clearly and explicitly described. Such descriptions shall use the same paragraph numbering as the bid document sections addressed by the alternatives. All alternative descriptions shall be in one contiguous section of the Bidder's proposal, preferably in the same volume, and titled "Alternatives". A separate section titled "Exceptions" should be provided containing any discussion or explanation Bidder chooses to provide concerning exceptions taken. Alternatives that do not substantially comply with the intent of the bid documents will be considered exceptions.

The Employer will assess the merits of each alternative and exception and will be the sole judge as to their acceptance.

1.14 Organization of the Volume – II (Lot 1) Document

This **Volume – II (Lot 1)** shall consist of two parts as follows:

A – Project Scope and Summary

B – Technical specifications, requirements, BOQ with System sizing, and Appendices for SCADA/EMS Systems.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

1.15 Applicable Standards

The applicable standards are mentioned in the respective technical section. The offered equipment shall conform to the standards mentioned in the specification except to the extent modified by this specification. In case of any discrepancy between the description given in the specification and the standards, the provisions of the technical specification shall be followed unless specifically agreed to during the bidding process.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the employer.

In the event the Contractor offers to supply material and/or equipment in compliance with any standard other than those listed herein, the Contractor shall provide, salient characteristics of the proposed standard for comparison. The Employer will assess the merit of material/equipment and will be the sole judge as to their acceptance.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Annexure – I: System Architecture

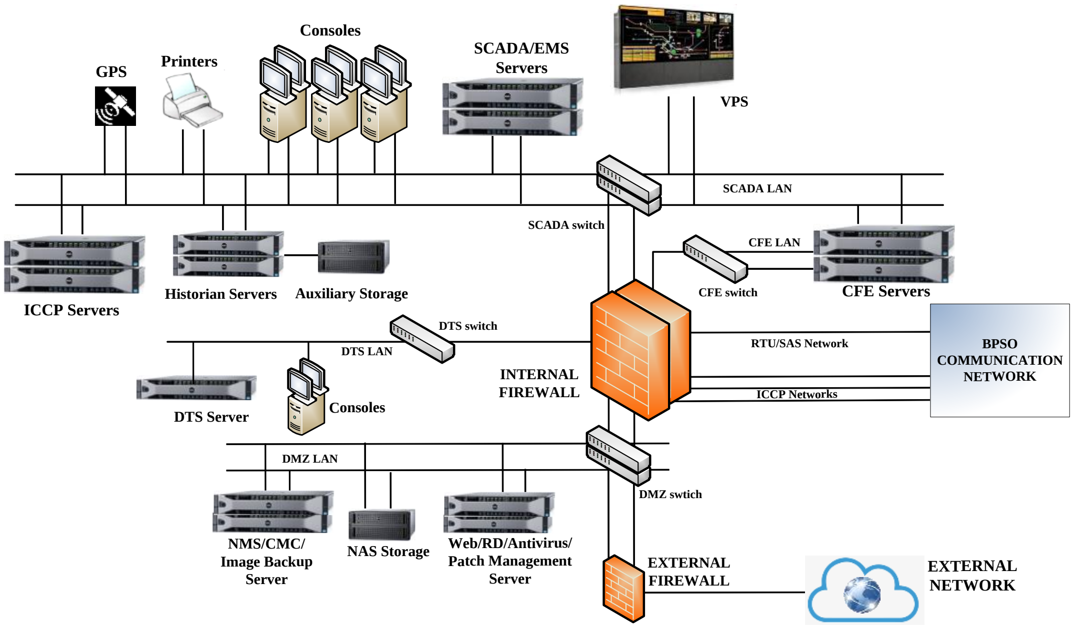

Figure 5 Conceptual architecture for Main Control Center

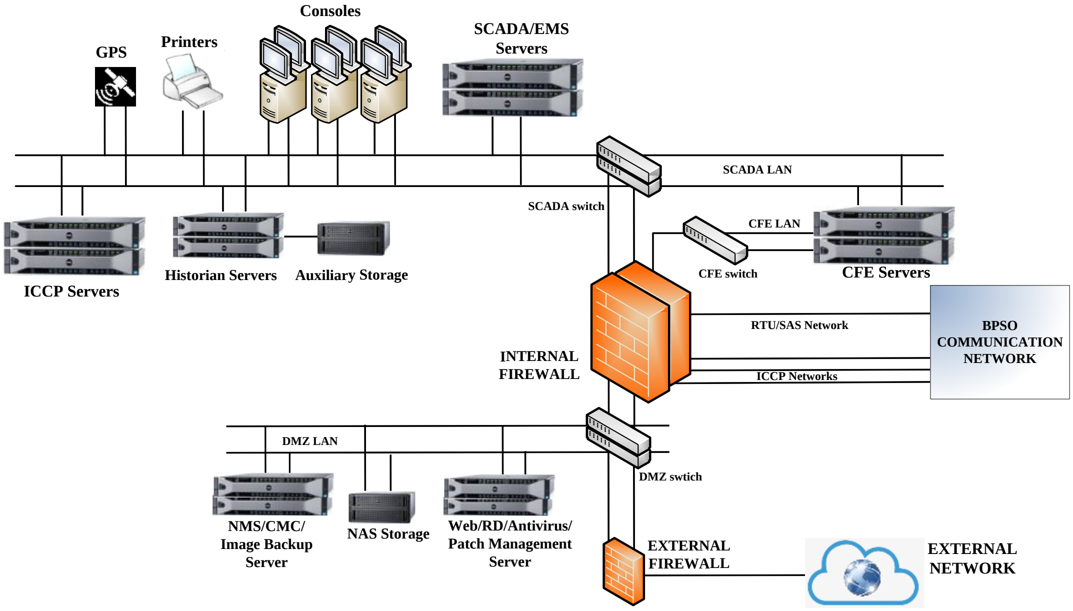

Figure 6 Conceptual architecture for Backup Control Center

SECTION 2
TRAINING

Thimphu: Bhutan
Office of the Bhutan Power System Operator

CONTENTS

List of Tables

SECTION 2
TRAINING

This section describes the project requirements for training employer personnel.

2.0 Introduction

a. Training shall be conducted by Contractor personnel who are experienced instructors and speak understandable English.
b. All necessary training materials shall be provided by the Contractor. Each trainee shall receive individual copies of all technical manuals (hardcopy as well as pdf) and all other documents used for training.
c. Class materials, including the documents provided to the trainees as well as class handouts, shall become the property of the Owner/Employer. Employer/Owner reserves the right to copy such materials, but for in-house training and use only.
d. Hands-on training shall utilize equipment similar to that being supplied under the contract. In general training, the duration shall be 50% for hands-on except for database and dispatcher which could go up to 80% for hands-on training.
e. For all training courses, the travel (e.g., airfare) and daily expenses will be borne by the Owner. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangements.
f. The Contractor shall quote training prices individually for each of the courses as per **Table-1**.
g. The schedule, location, detailed contents, and batches for training for each course shall be finalized during detailed engineering. The number of participants in the training program may change.
h. Employers will have the option to cancel any or all training courses. In the case of cancellation, the rate quoted against the respective course will not be paid to the Contractor.

The training courses, their duration, and the number of Owner personnel to be trained in each course are identified in **Table-1.**

2.0.1 SCADA/EMS System

Owner training course requirements are described below in terms of the contents of each course to be provided. Training shall be provided on supplied system database for the application software course, database and display building, dispatcher training course, and associate training courses.

- **Database and Display Building**

The database and display building course shall be the first course to be given in the overall training sequence. It shall be primarily a hands-on course. The course shall be designed to train personnel in how to develop the databases, displays, reports, and configure alarms, events, logs, etc. for the supplied system.
Course objectives shall include but not be limited to:

a. How to identify database fields, entries, records, tables, and contents.
b. How to build tables, arrays, and report formats.
c. How to build displays.
d. How to perform database maintenance.
e. How to generate the database from source information.

Thimphu Bhutan
Office of the Bhutan Power System Operator

f. How to maintain symbol libraries, display color groups, and display string lists.
g. How to Track and reverse database changes
h. How to do Online editing of Databases and Displays
i. How to generate reports using database queries and web services.

On top of that, this training module also should contain the following:

a. Concepts and techniques for creating, modifying, and saving databases, displays, and reports
b. Creation and modification of database, display, and reports for Channel monitoring of the ICCP Communications

On course completion, all participants shall be able to prepare the necessary input data to define the system operating environment, build the system database and displays and prepare the database administrator to maintain and modify the database and its structures. This will include database modeling and also populate data for neighboring systems.

- **Application Software**

The Contractor shall provide comprehensive application software courses covering all applications as per BOQ. The training shall include:

a. Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
b. Application Functions: Functional capabilities, Configuration, Associated maintenance, and expansion techniques.
c. Software and Protocol Administration: Techniques and conventions to be used for the preparation and integration of new software functions including Application Program Interface (API) interfaces and Web services. This shall also include the configuration of the system for IEC 60870-5-101, IEC 60870-5-104, ICCP, Security (IEC 62351), CIM (IEC 61970), Web services, OPC and other Standards specified in the Specification.
d. Software Documentation: Orientation in the organization and use of functional and detailed design documentation and programmer and user manuals.

- **Historian System**

The Historian System training course and documentation shall impart comprehensive training and information on the structure of the Historian Database, details of all database tables and their fields, procedures, and sub-routines being called to populate the database tables, etc. On completion of the course, the trainees shall be able to customize the Historian Database, create their own database tables, and shall be able to create new procedures/sub-routines and call pre-written procedures/sub-routines to automatically populate the new tables with SCADA data.

The Course shall also provide comprehensive training on the forms, reports, displays, etc., provided by the contractor in the Historian System. The training shall also cover tools being supplied by the contractor to generate database forms, reports, displays, etc. On completion of the training, the trainees shall be able to manage the existing forms, reports, and displays as well as generate new forms, reports & displays, etc., as per their own requirements using the data stored in Historian System.

- **Dispatcher Training Simulator**

This training course shall provide SCADA/EMS training for Dispatcher Training Simulator (DTS) instructors. At the end of the training, these instructors should be able to create scenarios in DTS so that they can train other Dispatcher/ System Operators. The course shall focus on hands-on training on the system and the trainees shall be able to perform expected outcome with the help of the detailed procedure/documentation submitted.

2.0.2 Computer System Software and Hardware

The training course shall be designed to give personnel sufficient knowledge of the overall design and operation of the system so that they can correct the problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects, but not limited to, shall be covered:

a. **System Hardware Overview:** Configuration of the system hardware. Preventive maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, New Generation Firewalls, IPS, IDS, and printers.
b. **System Expansion:** Techniques and procedures to expand and additional equipment such as memory in the server, printer, communication channels, router ports, workstations, and control centers. This shall also include adding New Control Centers.
c. **System Configuration:** Procedures of configuring Router ports, VLANs, Firewall policy definitions, and Interfacing web services.
d. **System Maintenance:** Basics of operation and maintenance of the redundant hardware configuration fail-over hardware, failure of control centers configuration, control panels, and fail-over switches. Maintenance of protective devices and power supplies.
e. **Subsystem Maintenance:** Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of supplied systems. All interfaces to the computing equipment shall be covered in detail.
f. **Operational Training:** Practical training on preventive and corrective maintenance of all equipment, including the use of special tools and instruments. This training shall be provided on the supplied equipment.
g. **System Programming:** An introduction to software architecture, the Effect of tuning/configuration parameters (OS software, Application Software, Network software, database software, firewall, IPS antivirus, etc.) on the performance of the system, Administration of Database (both real-time and RDBMS, security),
h. **System Initialization and Failover:** Cold Setup, Warm setup Including design, theory of operation, and practice.
i. **Operation and Maintenance:** O&M of Main & Backup Control Centers
j. **Diagnostics:** Including the execution of diagnostic procedures and the interpretation of diagnostic outputs
k. **Software Patch management/update:** Deploying of software patches for Operating system, various applications, anti-virus update etc.
l. **Software Documentation:** Orientation in the organization and use of system software documentation.
m. **Cyber security:** Cyber security system administration and log analysis

Thimphu: Bhutan
Office of the Bhutan Power System Operator

2.0.3 NMS and Cyber Security

The NMS training shall familiarize the Employer's maintenance personnel with the concepts and techniques for configuring, programming, maintaining, and troubleshooting the Contractor supplied NMS and its associated database.

The minimal NMS Training requirements are:

a) Features of the software being supplied
b) System configuration procedures, including operating system & database parameterization and buffer sizes
c) Operating system concepts, including resource allocation, priority level processing, performance monitoring, diagnostic messages, and restoration procedures.
d) Concepts and techniques for creating, modifying, and saving database, displays, and reports

The Contractor shall also provide comprehensive training on 'Cyber Security to the system administrators of the Owner. The training shall familiarize the Owner's personnel with the basic understanding of network architecture, cyber security concepts, possible threats & vulnerabilities of the system, the effective configuration of the network control elements, and recovery management. The training on Cyber Security shall cover the following concepts:

- Access controls
- Device configuration
- Anti-virus/patch management
- Password management
- Knowledge of remote administration
- Incidence response
- Disaster recovery
- Awareness of Cyber security standards
- Monitoring for Critical Infrastructure Protection
- Compliance manager for Critical Infrastructure Protection

2.0.4 Operator Applications Trainings

This training course shall provide application part of SCADA/EMS, Historian, etc. training for dispatchers. Emphasis shall be placed on the overall usage of all system applications defined in these specifications to operate, monitor, and control the power system. The Operators shall be also trained to interact with the system and control actual power system devices through the DTS.

The Training shall include a System Overview, General Operating Procedures, System Applications, Handling of Equipment, Dispatcher Documentation, etc. The course shall focus on hands-on training on the system. The trainees shall perform instructor-defined procedures with the help of the dispatcher documentation.

2.0.5 *Auxiliary Power Supply System familiarization course*

This course shall familiarize the operators with the supplied UPS system. The course shall include at least the following:

a) The sequence of starting the UPS operation
b) Procedure for changing UPS to parallel operation and isolated operation
c) Procedure to isolate the loads

Thimphu: Bhutan
Office of the Bhutan Power System Operator

d) Maintain the Batteries
e) Understand the Alarms and indications on the UPS at local as well as from remote through UPS monitoring software
f) Remedial actions to be taken on alarms

2.0.6 Attachment for engineers during the project design phase

A maximum of three engineers from BPSO shall be attached to the Contractor during the project design phase. They shall be deputed at the equipment manufacturer's premises/factory for a period mutually agreed period after the award of the contract. All the expenses including travel and daily expenses shall be borne by the employer. However, the contractor shall extend all necessary assistance for making appropriate logistics. It shall be the obligation of the contractor to keep the engineers informed of the design and operational philosophy of the project.

2.0.7 Annual Training

The employer's personnel shall be given a short-term training/refresher course annually after the completion of the one-year defect liability period until the end of AMC. This training shall be mainly focused on Sl. No. 1 and Sl. No. 4 (one week each) of **Table-1**.

This training shall be conductedd at the employer's premises by the Contractor personnel who are experienced instructors. The associated cost for the contractor personnel must be clubbed with the AMC cost.

Table-1 Training Requirements

Sl. No.	Category	Total No. of Trainees	Duration in Weeks	
			Bhutan	Contractor's facility
1	SCADA/EMS Systems (Database & Display, Applications Software, Historian, and DTS)	5	5	4
2	Computer System Software and Hardware	5	3	0
3	NMS and Cyber Security	5	1	1
4	Operator Applications Trainings	20	3	2
5	Auxiliary Power Supply Systems	3	1	0
		38	**13**	**7**

* The training may need to be conducted in two batches/sessions and the same shall also be applicable for Training during AMC).

SECTION 3

PROJECT MANAGEMENT, TESTING, AND DOCUMENTATION

CONTENTS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 3

PROJECT MANAGEMENT, TESTING, AND DOCUMENTATION

This section describes the project management, schedule, quality assurance, and documentation requirements for the project.

3.1 Project Management

The Contractor shall assign a Project Manager with the authority to make commitments and decisions that are binding on the Contractor. Employer will designate a Project Manager to coordinate all Employer project activities. All communications between Employer and the Contractor shall be coordinated through the project managers. The project managers shall also be responsible for all communications between other members of the project staffs including sub-contractor, if any.

3.2 Project Schedule

The project implementation schedule is given in **Annexure – II**, at the end of this chapter. Based upon this the bidder shall submit a preliminary project implementation schedule along with the bid. The detail project implementation schedule shall be submitted by the Contractor after award for Employer's approval, which shall include at least the following activities:

a) Site Survey

b) Testing at Site for interface with existing Control centres

c) Migration Plan from existing to new Control Centre

d) Documents, DRS, Drawing submission and approval

e) Database, Display and Report development

f) Type Testing

g) Hardware purchases, development/manufacturing and integration

h) Dispatch

i) Receipt, Storage, Installation & Site update

j) Factory & Site Testing

k) Training

The project implementation schedule shall include the estimated period for completion and its linkage with other activities. The Project implementation schedule shall also contain Employer activities required for the Contractor to complete the system.

3.3 Progress Report

A progress report shall be prepared by the Contractor each month against the activities listed in the project schedule. The report shall be made available to Employer on a monthly basis, e.g., the 10th of each month. The progress report shall include all the completed, ongoing and scheduled activities and transmittals issued and received for the month.

Thimphu Bhutan
Office of the Bhutan Power System Operator

3.4 Transmittals

Every document, letter, progress report, change order, and any other written transmissions exchanged between the Contractor and Employer shall be assigned a unique transmittal number. The Contractor shall maintain a correspondence index and assign transmittal numbers consecutively for all Contractor documents. Employer will maintain a similar correspondence numbering scheme identifying documents and correspondence that Employer initiates.

3.5 Review Meetings

Progress meetings shall be scheduled by the Project Manager and attended by the Contractor and Employer to review progress of the project. Progress meetings shall be used to review the progress report, written correspondence exchanged since the last meeting, and open action items.

The Contractor shall also attend technical meetings as required to discuss technical aspects of the project and to review Employer comments on approval documents. When appropriate, these technical meetings shall be conducted as extensions to the progress meetings.

3.6 Testing

This section describes general requirement applicable to all type of equipment being supplied under the project. For System and Equipment specific requirements are given in respective parts of the specifications.

3.6.1 Quality Assurance & Testing

All materials and parts of the system/sub-system to be supplied under the project shall be of current manufacture from a supplier regularly engaged in the production of such equipment.

3.6.2 Quality Assurance and Quality Control Program

The Contractor shall maintain a Quality Assurance/Quality Control (QA/QC) program that provides that equipment, materials and services under this specification whether manufactured, designed or performed within the Contractor's plant, in the site, or at any sub-contractor source shall be controlled at all points necessary to assure conformance to contractual requirements. The program shall provide for prevention and ready detection of discrepancies and for timely and positive corrective action. The Contractor shall make objective evidence of quality conformance readily available to the Employer. Instructions and records for quality assurance shall be controlled and maintained at the system levels. The Contractor shall describe his QA/QC program in the Technical Proposal, (along with samples from his QA/QC manual) and shall submit his QA/QC Manual for review and acceptance by the Employer.

Such QA/QC program shall be outlined by the Contractor and shall be finally accepted by Employer after discussions before the award of Contract. A Quality Assurance Program of the Contractor shall generally cover but not be limited to the following:

a) The organization structure for the management and implementation of the proposed Quality Assurance Program.

b) Documentation control system.

c) Qualification data for key personnel.

d) The procedure for purchase of materials, parts/components and selection of sub-

Thimphu Bhutan
Office of the Bhutan Power System Operator

contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases, etc.

e) System for shop manufacturing including process controls.

f) Control of non-conforming items and system for corrective action.

g) Control of calibration and testing of measuring and testing equipment.

h) Inspection and test procedure for manufacture.

i) System for indication and appraisal of inspection status.

j) System for quality audits.

k) System for maintenance of records.

l) System for handling, storage and delivery.

m) A Quality Plan detailing out the specific quality control procedure adopted for controlling the quality characteristics of the product.

The Quality Plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

Neither the enforcement of QA/QC procedures nor the correction of work mandated by those procedures shall be cause for an excusable delay. An effective Quality Assurance and Quality Control organization shall be maintained by the Contractor for at least the duration of this Contract. The personnel performing QA/QC functions shall have well-defined responsibility, authority, and organizational freedom to identify and evaluate quality problems and to initiate, recommend, or provide solutions during all phases of the Contract. The QA/QC organization of the Contractor shall be an independent administrative and functional structure reporting via its manager to the Contractor's top management. The QA/QC manager(s) shall have the authority within the delegated areas of responsibility to resolve all matters pertaining to quality to the satisfaction of Employer when actual quality deviates from that stated in the Work Statement.

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of equipment/materials. The scope of the duties of the Employer, pursuant to the Contract, will include but not be limited to the following:

a) Review of all the Contractor's drawings, engineering data etc.

b) Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the Contract.

c) Inspect, accept or reject any equipment, material and work under the Contract in accordance with the specifications.

d) Issue certificate of acceptance and/or progressive payment and final payment certificate

e) Review and suggest modification and improvement in completion schedules from time to time; and

f) Monitor the Quality Assurance program implementation at all stages of the works.

Thimphu: Bhutan

Office of the Bhutan Power System Operator

The Employer or his duly authorized representative reserves the right to carry out Quality Audit and Quality Surveillance of the systems and procedures of the Contractor's/his vendor's Quality Management and Control Activities.

3.6.3 Inspection Certificate

The Contractor shall give the Employer two weeks in case of domestic supplies and six weeks in case of foreign supplies written notice of any material being ready for testing. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Employer, unless witnessing of the tests is waived, will attend such tests on the scheduled date for which Employer has been so notified or on a mutually agreed alternative date. If Employer fails to attend the testing on the mutually agreed date, Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and Contractor shall forthwith forward to the Inspector, duly certified copies of the test results in triplicate.

The Employer shall, within fourteen (14) days from the date of inspection as defined herein, give notice in writing to the Contractor of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet said objections. When the factory tests have been completed successfully at the Contractor's or Sub-contractor's works, the Employer shall issue a certificate to this effect within fourteen (14) days after completion of tests but if the tests are not witnessed by the Employer, the certificate shall be issued within fourteen (14) days of receipt of the Contractor's Test Certificate by the Employer. The completion of these tests or the issue of the certificates shall not bind the Employer to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.

In cases where the Contract provides for tests, whether at the premises or works of the Contractor or of any Sub-contractor, the Contractor except where otherwise specified shall provide free of charge items such as labor, materials, electricity, fuel, water stores, apparatus and instruments, as may be reasonably demanded by the Employer or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall provide facilities to the Employer or his authorized representative to accomplish testing.

The inspection by Employer and issue of Inspection Certificate thereon, shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Program forming a part of the Contract.

The Contractor shall keep the Employer informed in advance of the time of starting of the progress of manufacture of material in its various stages so that arrangements can be made for inspection.

Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.

Certificates of manufacturing tests shall be maintained by the Contractor and produced for verification as and when desired by the Employer. No material shall be dispatched from its point of manufacture until it has been satisfactorily inspected and tested. Testing shall always be carried out while the inspection may be waived off by the Employer in writing only.

Thimphu Bhutan
Office of the Bhutan Power System Operator

However, such inspection by the Employer's representative(s) shall not relieve the Contractor from the responsibility for furnishing material, software, and equipment to conform to the requirements of the Contract; nor invalidate any claim which the Employer may make because of defective or unsatisfactory material, software or equipment.

3.6.4 Inspection and Test

All materials furnished and all work performed under this Specification shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, all deficiencies have been corrected to Employer's satisfaction, and the equipment has been approved for shipment by Employer.

Should any inspections or tests indicate that specific hardware, software or documentation does not meet the Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The test shall be considered complete when (a) when all variances have been resolved (b) all the test records have been submitted (c) Employer acknowledges in writing the successful completion of the test.

3.6.4.1 Inspection

Access to the Contractor's facilities while manufacturing and testing are taking place, and to any facility where hardware/software is being produced for Employer shall be available to Employer representatives. The Contractor shall provide to Employer representatives sufficient facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification. Inspection rights shall apply to the Contractor's facilities and to subcontractor facilities where equipment is being manufactured.

Inspections will be performed by Employer, which will include visual examination of hardware, enclosure cable dressings, and equipment and cable labeling. Contractor documentation will also be examined to verify that it adequately identifies and describes all wiring, hardware and spare parts. Access to inspect the Contractor's hardware quality assurance standards, procedures, and records that are applicable to the facilities shall be provided to Employer.

3.6.4.2 Test Plans & Procedures

Test plans for both factory and site tests shall be provided by the Contractor to ensure that each test is comprehensive and verifies all the features of the equipment are tested. The test plans for factory and site tests shall be submitted for Employer approval before the start of testing.

The contractor shall prepare detail testing procedure in line to specification and submit for Employer's approval. The procedure shall be modular to the extent possible, which shall facilitate the completion of the testing in the least possible time.

The test procedures shall include the following items:

a) Objective of each test.

Thimphu Bhutan
Office of the Bhutan Power System Operator

b) Parameter(s)/function(s) to be tested.

c) List of reference standards/ codes of practice.

d) Set-up and conditions for testing, including block diagrams of the test configuration and a list of test equipment.

e) Sequence of tests to be followed

f) Procedures to be followed

g) All inputs and outputs for each test segment

h) Expected results

i) Acceptance criteria for each test sequence.

j) Copies of any certified test data, if applicable.

3.6.4.3 Test Records

The complete record of all factory and site acceptance tests results shall be maintained by the Contractor. The records shall be maintained in a logical form and shall contain all the relevant information. The test reports shall be signed by the testing engineer and the engineer witnessing the tests.

3.6.4.4 Reporting of variances

A variance report shall be prepared by either Employer or Contractor personnel each time a deviation from specification requirements is detected during inspection or testing. All such variances shall be closed in mutually agreed manner.

However, at any stage if Employer feels that quality of variances calls for suspension of the testing the testing shall be halted till satisfactory resolution of variances, which may also involve re-testing.

3.6.5 Factory Test

The factory tests shall be conducted on all the equipment and shall include, but not be limited to the following, appropriate to the equipment being tested:

a. Verification of all functional characteristics and requirements specified

b. Inspection and verification of all construction, wiring, labeling, documentation and completeness of the hardware

Before the start of factory testing, the Contractor shall verify that all changes applicable to the equipment have been implemented. As a part of the factory tests, unstructured testing shall be performed to allow Employer representatives to verify proper operation of the equipment under conditions not specifically tested in the above structured performance test. The Contractor's test representative shall be present and the Contractor's technical staff members shall be available for consultation with Employer personnel during unstructured test periods. All special test facilities used during the structured performance test shall be made available for Employer's use during unstructured testing.

Thimphu Bhutan
Office of the Bhutan Power System Operator

3.6.6 Site Performance Test / Site Acceptance Test

After the equipment (product supplied) has been installed, the Contractor shall start up and check the performance of the equipment of site locations. All hardware shall be aligned and adjusted, interfaces to all inputs and outputs installed, operation verified, and all test readings recorded in accordance with the Contractor's recommended procedures. The site performance test shall exhibit generally all functions of the equipment and duplicate factory test. All variances must be corrected prior to the start of the site performance test. The list of final tests to be carried out in the site shall be listed in the site-testing document.

3.6.7 Type Testing

Type Tests shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

a) The Contractor shall submit, within 30 days of Contract Award, copies of test reports and certificates for all of the Type Tests that are specified in the specifications and that have previously been performed. These certificates may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at nationally/Internationally accredited labs and witnessed by third party / customer's representatives

b) Type Tests shall be performed at no cost to the employer for all equipment types for which certification is not provided as required in (a) above, or if it is determined by the Employer that the certification provided is not acceptable. If any of the type tests are required to be carried out, the same shall be carried out by the Contractor.

c) Type Tests shall be certified or performed by nationally/internationally reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as in the specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

d) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

e) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

f) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type tests at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

g) No type test report shall be older than 5 years at the time of bid submission.

Thimphu Bhutan
Office of the Bhutan Power System Operator

3.7 Documentation

To ensure that the proposed systems conform to the specific provisions and general intent of the Specification, the Contractor shall submit documentation describing the systems to Employer for review and approval. Further the Contractor shall also submit the drawings/documents for all the hardware & software required for site installation, testing and commissioning and thereafter operation of the system. The Contractor shall obtain approval of Employer for the relevant document at each stage before proceeding for purchase, manufacturing, system development, factory testing, erection, site testing, training etc.

Each document shall be identified by a Contractor document number, the Employer document number, and the Employer purchase order number. Where a document is revised for any reason, each revision shall be indicated by a number, date, and description in a revision block along with an indication of official approval by the Contractor's Project Manager. Each revision of a document shall highlight all changes made since the previous revision.

The Contractor shall submit one hard copy of each document/drawing for Employer's review and approval along with soft copy with each submission. After approval, one set of all the documents shall be submitted as final documentation and shall be provided for each site. Any changes observed during site implementation shall be incorporated in the As-built drawing and required sets of same shall be submitted to Employer. Other than above hard copy documents, all other documentation should be used in electronic form in searchable, printable formats (preferably pdf). In case any documentation requirement is specified in the relevant section the same shall apply for the equipment /system defined in that section. The following document shall be submitted as applicable for the subsystem.

a) Document Identification Plan
b) System Description Documents (Overview)
c) Functional Description Document (FDS)
d) Functional Cross Reference Document
e) Data Requirement sheets
f) Software Design Document
g) Data base Documents
h) Drawings/Documents for manufacturing/Assembly of the equipment/system
i) Drawings/Documents for installation of the equipment/system at site
j) Software description/design documents for each module
k) Factory Test report
l) Manuals for each equipment
m) System Configuration Parameter Details and procedure for configuration of all supplied equipment
n) Site Testing documents
o) Training documents

Thimphu: Bhutan
Office of the Bhutan Power System Operator

p) System Administrator Documents

q) User guide for Despatcher

r) Software Licences

s) Type test reports

t) Cable sizing calculations

u) Panel General and Internal Arrangement drawing indicating modules, components location etc.

v) Installation drawing.

w) Schematic drawing.

x) External cable laying & termination schedule details

y) Communication Channel Plan

z) Firewall and security setup check list

The Contractor shall also supply one set of User manuals, guides & O&M manuals and manufacturer's catalogues for all the Hardware & Software supplied under the contract one set each of which shall be at the locations where the System has been installed. The user manual shall at minimum include the principle of operation, block diagrams, troubleshooting and diagnostic and maintenance procedures.

Considering all the components of the project briefly the following documents/drawings shall be required under the project. It is not acceptable to supply user manuals of systems, functions and applications as it exists. The user manuals shall be oriented towards system users and system deployed.

The documentation pertaining to third party or OEM products may be supplied in the format as available from the third party/OEM. The documents to be submitted shall include the following information:

3.7.1 Software Inventory

An inventory of all software shall be maintained by the Contractor. The Contractor shall submit the following inventory lists: the preliminary inventory list at the time of the FDS approval, an updated inventory list immediately prior to the start of the FAT, and the final inventory list at the time of system commissioning. The inventory shall include the name of each program, a cross reference to pertinent Contractor documents, language and libraries used, and an indication of whether the program is to be standard, modified, or custom.

3.7.2 Functional Description

Functional description documentation shall be provided for each function described in Part B. It shall include the following information for each function:

a) Introduction describing the purpose of the function with references to other documentation to aid the reader's understanding of the functions performed.

b) Performance requirements that describe the execution periodicity and the tuning parameters that control or limit the capabilities of the software.

Thimphu Bhutan
Office of the Bhutan Power System Operator

c) Complete description of the operation, data and logic interfaces with other functions.

d) Sample displays where applicable.

3.7.3 Software Design

Software design documentation shall be provided for each function, at least three months before the Factory Acceptance Test. It shall include detailed descriptions of the following items:

a) The overall organization and structure of the software logic such as a breakout of the software into software modules.

b) Mathematical algorithms and formulae.

c) Complete description of the algorithms, operation and the data and logic interfaces with other functions.

d) Data dictionary in which the following (as applicable) information for each data item in tables, file, and array is provided: (1) Name (2) Purpose, (3) Location, (4) Length of data item, and (5) Initialization.

e) Databases internal and external to the software, along with a description of all inputs required and the output produced by the software modules.

f) Interfaces with other software modules.

g) Design limitations such as field length and the maximum quantity of data items that can be processed.

h) Processor loading and memory size used.

3.7.4 Database Documentation

Database documentation shall describe the structure of the database. The documentation shall define the individual elements (files, records, fields, and tables) and their interrelationships. Portions of the database developed specifically for Employer's systems shall be identified.

Documentation shall also be provided that instructs the user in the preparation of data to be used for the databases, including:

(a) The overall organization of input records

(b) The format of each data record.

(c) Each data field and the valid entries pertaining to the fields

Sufficient database documentation shall be provided to enable the database to be updated or regenerated when inputs are changed and added, programs are modified, and new programs are added. The documentations of all database scripts and sub-routines developed by the vendor shall also be provided to enable owner to modify the same later. Database access documentation shall be supplied such that software developed by Employer may use the same access tools used by the Contractor-supplied software.

3.7.5 User Documentation for Dispatchers

User documentation for dispatchers shall contain detailed operating instructions and procedures. Information in the documentation shall be presented in terms that are meaningful to dispatchers.

Thimphu Bhutan
Office of the Bhutan Power System Operator

Each system function of this Specification and all other functions designed for dispatcher use shall be included in this documentation.

Instructions and procedures shall be explained step-by-step with an explanation of how each step is performed, which parameters can be adjusted, and the effects obtained by varying each parameter. Additionally, the user documentation shall describe:

a) All user guidance and error messages, along with the steps necessary to recover from errors

b) The user interface including displays and keyboard operations used to control and review input to and output produced by the function. All displays relevant to the function shall be included along with a description of each dynamic display field.

c) Alarms and messages issued by the function and the conditions under which they are generated

d) Procedures to be followed as a result of computer system restarts, failures, and failovers.

e) Main & backup control Centre Switch Over

Dispatcher documentation shall be customized separately for Owner's system of main and Backup and shall be based on the delivered systems. It is not acceptable to describe the Contractor's standard system and then identify differences between the standard and delivered systems. The documentation shall not include standard or other descriptions that do not apply to the delivered systems.

3.7.6 System Administration Documentation

System administration documentation shall be provided to guide Employer personnel in the operation and procedures required to generate and update the systems, including system software, database, application software, and other elements of the systems. System administration documents shall be provided for the following items:

a) Software management

b) Network communications management

c) Programming language compilers, assemblers, linkers, and loaders.

d) Processor configuration

e) System performance monitoring

f) System restart/failover management and diagnostic procedures

g) System generation and management

h) Database generation and management

i) Display generation and management

j) Report generation and management

k) Diagnostic programs

l) Software utilities

m) Software maintenance

n) Application software parameters and tuning guides

o) Other Contractor-supplied system software not included above.

p) Switch Over from Main to backup

3.7.7 Test Documentation

Documentation for all factory, site, and availability tests that apply to Owner's system shall be provided in accordance with the requirements defined in **Volume – II, Part B**.

3.7.8 Training Documentation

Training documentation shall be provided for all courses in accordance with the requirements defined in **Volume – II, Part A**.

The Contractor shall submit a comprehensive list of the document as applicable for the offered system for Employer's approval immediately after signing of the contract and the documents shall be finalized as per the approved list. The schedule for submission/approval of documents shall be in line with the overall project schedule.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Annexure – II: Project Schedule

Sl. No.	Project Implementation Schedule (in months)								
	Task Name	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Site Survey and Detailed Engineering								
2	Database Development								
3	FAT of equipment								
4	Supply of equipment & delivery at sites								
5	Installation and Commissioning								
6	Site Acceptance Test								
7	System Availability Test and taking over								

SECTION 4
MAINTENANCE AND SUPPORT SERVICES

Thimphu: Bhutan
Office of the Bhutan Power System Operator

CONTENTS

List of Tables

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 4
MAINTENANCE AND SUPPORT SERVICES

4.1 Introduction

The scope of work shall include a comprehensive maintenance of all the software and hardware provided by the contractor for the various systems namely SCADA/EMS with the future integration and support services for meeting the expansion requirement envisaged. The maintenance practices to be followed shall be as per ISO 20000 Standard. The essence of the maintenance and support services is to provide maintenance support for the designated hardware and software, with the goal of meeting the availability as set forth herein.

4.2 Maintenance Support

The period of maintenance support shall be the one year Warranty period or Defect Liability period commencing from Operational Acceptance and **Five** year Maintenance period thereafter. The nature of maintenance support required for the different type of systems and components are described in the **Table 4.2.1** below:

Table 4.2.1 Maintentenace support and availability requirements

Sl. no.	System	Scope	System Availability requirements
1.	All Systems such as (SCADA,EMS, ICCP, Web, Historian, & NMS Supplied with this project including Cyber security system)	Hardware and software in Control centers	99.99%

The system availability shall be measured control center wise, for example the availability of Main & Backup Control Centre shall be considered separately. For all third party equipment (Hardware & Software) Contractor shall have back to back support along with supply of spare with appropriate response time from OEM or OEM Authorized representatives. Contractor shall be responsible for coordination with the OEM for all matter related to that equipment. The Contractor shall also be responsible for meeting the overall response times and availability requirements specified in the Specification.

The maintenance of the System shall be comprehensive and shall comprise of the following category of works which is further elaborated for each of the different subsystems:

- Preventive Maintenance Activity (performance monitoring, system backup, patch management, updates, emergency response and troubleshooting).
- Maintaining a minimum no. of specified spares.
- Integration of new equipment (Workstations, Printers, Switch, Router, ICCP connection etc.) with Main and Backup Control Centre System.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.3 Preventive Maintenance Activity

The preventive maintenance activity would involve activities to be performed by the Contractor to keep the system running at optimum level by diagnosis and rectification of all hardware and software failures and would broadly include:

- Repair / replacement of defective equipment. The Contractor shall be responsible for repair/replacement of all the hardware including consumables required for the various systems. Only replacement of printer cartridge and paper rim shall be excluded from the scope of the Contractor.
- Configuration of the replaced hardware and software, periodic routine checking as part of a preventive maintenance program (as described in further detail in this document) which would include checking of functionality of hardware and software.
- Monitoring of the performance of the system and doing necessary tuning for optimum performance to accommodate any changes such as addition of new components.
- Providing all necessary assistance to Owner for addition and modification of database and displays.
- Database sizing activities including Backup and restore of the system. Any replacement or upgrade of hardware and/or software to meet the power system sizing as per table in **Appendix F** would be the responsibility of the contractor at its own cost.
- Restoration of the systems upon its failure and to restore the functioning of the various systems at the different Control Centers.

Routine works like database building, addition of analog and status points and other such day-to-day operational activity would primarily be the responsibility of Owner and in case of any difficulty in this regard the same shall be referred to the contractor for support.

4.3.1 Hours of Cover

The Contractor shall provide engineers who have desired experience and skill to maintain the SCADA/EMS system to the desired level of availability. The contractor's on-site support for Main Control Centre shall be standard hours of service i.e. Monday to Friday- 9:00 am to 5:00 pm local time (BST), excluding Public and Owner Company holidays, throughout a year. At least one Software Engineer and One Hardware Engineer having expertise in SCADA/EMS system shall be available during the standard hours of service at each Main Control Centre. The timings for Emergency Support would be 24 hours a day, 7 days a week throughout the year.

The support personnel so deployed shall be qualified personnel having at least 5 years of experience in the delivered SCADA/EMS system. Official deputed shall be a permanent employee on the direct pay roll of the vendor. The contractor shall submit the CV's to Owner/Employer for approval before deployment at site. The Owner can ask the Contractor to replace the personnel deployed for maintenance support if his performance is not found to be satisfactory.

4.3.2 Service Response Requirements

The severity levels are defined in coming sections and the requirement of response time for various severity levels is defined below:

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Emergency Support for Severity 1 issues are to be provided 24 hours a day, seven days a week. The on-call support team shall include all key technical competencies so that any aspect of a system failure can be attended. The team shall comprise of experienced technical staff that are skilled in troubleshooting of the various systems covered under AMC. Severity 1 problems shall be reported by telephone for rapid response; target response times are defined in **4.7** of this section. The bidder shall submit the process details to meet the above requirements along with the offer. For **Severity 1** problems, the key objective is to restore the system to an operational state as quickly as possible, including by a temporary workaround. Resolution of problems shall also be provided by an individual fix that will be installed by the contractor at no extra cost to Owner. The **Severity 2, 3, and 4** problems shall be reported by Owner through a call tracking system to be provided by the contractor.

The operation and performance of the various systems under AMC shall be monitored on a fortnightly basis (After every two weeks), the contractor personnel shall review the following, analyze the results, and communicate to Owner. Non-compliance to Monitoring of Log, Patch Management, Annual Security audit and implementation of the remedial actions suggested by the auditor will be treated as Severity 2. The contractor shall conduct at least the following monitoring, for the Control Centers.

4.3.2.1 Log Monitoring

- System logs for a selected day
- System history log
- Aggregate data collection
- Events Collection
- Configuration change to core application/OS.

Log monitoring and report generation for Non-availability period of ICCP links and other communication links shall be done. Compiled report shall be generated based on the requirements. During monitoring if any defect/ abnormality is found, the contractor shall undertake corrective maintenance for the same. The bidder shall **submit the process details** to meet the above requirements with the bid.

4.3.2.2 Resource Monitoring

Resource Monitoring services comprises checking the system's major node resources, gather log data, analyze results, and advise Owner on the appropriate actions to be taken and undertake any agreed upon actions to maintain system performance. The NMS system shall be used to continuously collect the following information:

- loading (Peak and Average)
- Memory utilization (Peak and Average)
- Disk utilization (Peak and Average)
- LAN utilization (Peak and Average)
- Operating system resource utilization reports
- System error log

The bidder shall submit the procedures details to meet the above along with the offer.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.3.2.3 Cyber Security system Monitoring and Compliance manager

The Contractor shall also be responsible for monitoring of the cyber security system with cyber security perspective and implementing the monitoring and compliance manager for Critical Infrastructure Protection. The logs of the system shall be analyzed for exceptions and the possible incident of intrusion/trespass shall be informed to the Employer.

The monitoring shall encompass the various cyber security devices installed at Control Centers such as firewalls, Intrusion prevention system (both network based and host based), etc. The Centralized Monitoring Console (CMC) shall monitor and continuously collect the above logs.

The contractor shall carry out the Annual Security Audit from certified Auditors at its own cost (deemed to have included in AMC) for the complete systems under this project until the end of AMC period and submit to the employer. Subsequently, the contractor is needed to implement the recommendation given by auditor in consultation with the owner.

4.3.3 Patch Management

The contractor shall also be responsible for providing updates/patches for the software products supplied under the project. All other patches of third party product like Operating System and Anti-virus shall be tested by the Contractor prior to installing in the supplied system. Subsystems/ Devices like IPS, Network IPS, Host based IPS, Firewalls shall also be provided with secure patch management. A secure patch management and deployment system is to be established which shall be provided with single point of Internet connectivity. All the patches shall be downloaded through this single point of connection. Limited Internet access shall be provided as shown in System Architecture diagram at **Appendix I of Part A.**

The Contractor shall provide a mechanism for patch management so that it is known that what patches have been applied and what all patches are pending but available with System.

The contractor shall upgrade the various applications delivered under the project through patch management and version upgrade to make it compliant with IEC standards as envisaged under the specification throughout the AMC period.

4.4 Spare Management

The Contractor shall maintain a spares inventory at his own cost to meet the spare availability requirements of the system. The spares shall be used as and when required and no separate charges are payable except the maintenance charges. All spare shall have pre-loaded software and required licenses in order to make it readily available for use at all times. The Contractor shall decide the items and components to be maintained as spare but a minimum number of spares as listed in **BoQ** shall be kept at the respective control centers. This shall be periodically verified by the Owner and unavailability of spares shall be treated as non-availability as per severity 2. If spares has been used in the system then the replenishment of the spare should be completed within 45 calendar days, otherwise it will be considered as non-availability as per **Severity- 2.**

4.4.1 Spares for Defect Liability Period and Maintenance Period

The list of mandatory spares to be supplied by the contractor, as a minimum requirement, under the contract is enclosed. The contractor shall maintain an inventory of spares, which may be required during the guaranteed availability period and maintenance period to meet

Thimphu: Bhutan
Office of the Bhutan Power System Operator

the availability requirements. However, the bidder may include any further spares (in addition to those specified) in the bid, which may be required for ensuring the guaranteed availability. The list of such spares shall be discussed and finalized. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the maintenance period, the spare parts supplied by the contractor shall be made available to the contractor for usage subject to replenishment within a month. Further additional items (not mentioned in the contract) of spares shall be supplied as and when required.

If any of the spare parts become obsolete by redesign or modification, the contractor shall be obliged to replenish the parts made obsolete by the redesigned or modified parts in the same quantity as the spare parts made obsolete at no additional cost to the employer. If the redesign parts use in the system warrants change in the software delivered as part of project the same shall be modified to enable the system to accept the redesigned/modified spare part.

4.4.2 Services

The contractor shall ensure the availability of service, spare and expansion parts for SCADA/EMS hardware for a period of 10 years from Operational Acceptance by the Employer. In case supplied hardware declared end of life/sale/service the Contractor shall ensure that functionally equivalent hardware is available which is compatible with all software delivered with the system. If Employer chooses to purchase said functionally equivalent hardware, any software modifications necessary to maintain complete functional compatibility with all software delivered by Contractor shall be made at no cost to Employer. In the event the modified software is not found compatible with functional equivalent hardware, the Contractor shall make suitable corrections to this modified software & install this corrected software at no cost to Employer.

Further, the Contractor shall provide advance notification to Employer of the pending termination of production of spare parts in sufficient time (not less than one year prior to such termination) to permit Employer to procure needed requirements.

4.5 Integration of new equipment and or control center

All future services, protocol emulations and configuration support for integration of Control Centre on ICCP, Clients for OPC services, Web Services & CIM import & export utility for offline applications shall be the responsibility of contractor during maintenance period. The integration services to be provided by the bidder will include the addition of New ICCP connection & its integration and addition of interface for off-line Applications, OPC clients. Non-availability of these services at Control Centre for these integration shall be treated as severity-3 support.

4.6 Problem/Defect Reporting

The bidder shall submit an appropriate problem/defect reporting procedure to meet the requirement of all severity level cases to get the approval of the same from Employer/Owner.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Table 4.6.1:Severity Levels

Category	Definition
Severity 1 – Urgent	Complete system failure, severe system instability, loss or failure of any major subsystem or system component such as to cause a significant adverse impact to system availability, performance, or operational capability (as described in 4.6.1.1)
Severity 2 – Serious	Online Editing of SCADA, Network and ICCP Database without failover and re-start, Non- availability of offline database modeling tool, Degradation of services or critical functions such as to negatively impact system operation. Failure of any redundantsystem component such that the normal redundancy is lost (as described in 4.6.1.2) Non-availability of Man-power at control center during working hours, non-availability of spares
Severity 3 – Minor	Any other system defect, failure, or unexpected operation (as described in 4.6.1.3)
Severity 4 – General/ Technical Help	Request for information, technical configuration assistance, “how to” guidance, and enhancement requests (as described in 4.6.1.4)

The problems will be categorized as follows:

4.6.1 Severity Levels

The detail of the systems under different severity levels is as below:

4.6.1.1 Severity 1 (Urgent support)

This support is required when there is a complete system failure, severe system instability, the loss/ failure of any major sub-system / system or its components, which may significantly impact the system availability, performance, or operational capability at Control Centre. Following outages/disruptions will be considered under Serverity-1:

- Loss of Critical functionality as envisaged in specification due to any problem software/Hardware-related in SCADA-EMS system.
- Cyber Security issues and Outage of complete Web system.
- Outage of both NGFW and LAN Switches.
- Loss of data exchange with other computer systems or other control centers.

Initially, the Owner’s Engineers shall attempt to restore the system. In case the system does not come up and/or the problem is not resolved then the Owner’s Engineer shall intimate the problem to the contractor. Upon receiving intimation, the representative of the contractor would immediately attend to the problem. The problem shall be attended by the contractor at the earliest, and it shall arrange all resources and take all steps to restore the data availability and functionality at the earliest.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.6.1.2 Severity 2

The support services not defined under Severity-1 are included under this category. Coverage under this severity would be outages that do not immediately cause on line data loss but subsequently could result into Severity-1 category outage, loss of an important subsystem that may affect the day-to-day works and loss of archived data.
Following outages/disruptions will be considered under Serverity-2:

- Failure of one Data Server/ICCP server, stoppage of data collections for archiving and outage of other applications not covered under severity-1 are included in this category. However the critical functionality loss due to loss of only one component as defined here shall be treated as Severity-1.
- Failure of any redundant system component affecting the critical redundancy like loss of any one Application Processor, Router also be included in this category.
- Non-availability of designated contractor's Man-power at control center as well as required inventory of spares specified here.
- Non-compliance of Monitoring functions as specified in 4.3.2.3.
- Non-availability of any of the database modeling tools.
- Online Editing of SCADA, Network and ICCP Database.

4.6.1.3 Severity 3 (Standard Support)

The support services included under this category are when the outage or loss of functionality is neither of an emergency nor priority functionalities as indicated in severity level 1 or 2 above. Problems like database reworking, failure of any one workstation, printers and integration services as defined in section 4.5 would be covered under this Severity.

4.6.1.4 Severity 4

Request for information, technical configuration assistance, "how to" guidance, and enhancement requests are included under this category.

4.7 Response and Resolution Time

This section describes the target times within which the contractor should respond to support requests for each category of severity. The *Initial Response Time* is defined as the period from the initial receipt of the support request (through approved communications channels) and the acknowledgment of the contractor subject to the Maximum time defined in **Table 4.7.1.** The *Action Resolution Time* is from the acknowledgement of support request to the contractor delivering a solution subject to the Maximum time defined in **Table 4.7.1.**This period includes investigation time and consideration of alternative courses of action to remedy the situation. The *Action* is defined as a direct solution or a workaround.
Except for Severity Level 1 all response and resolution times (hours and days) specified below are working hours only.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Table 4.7.1 Emergency Support Response/ Resolution Time

Severity	Initial Response Time	Action Resolution Time	Action
1	30 minutes	2 hours	An urgent or emergency situation requiring continuous attention from necessary support staff until system operation is restored – may be by workaround.
2	2 Hours	12 Hours	Attempt to find a solution acceptable to Owner (dependent on reproducibility) as quickly as practical.
3	1 day	2 days	Evaluation and action plan. Resolution time is dependent on reproducibility, ability to gather data, and Owner's prioritization. Resolution may be by workaround.
4	2 days	5 days	Report on the problem/query is to be furnished.

The bidder shall submit the detailed format and procedure for all the activities such as Reporting time, Resolution time, Downtime etc. along with the bid proposal**.**

4.8 Availability and Payment Charges Calculation

It is the endeavor of both the contractor and Owner to maximize system availability to the extent possible. The contractor shall provide guaranteed availability for various types of Systems as specified in **Table 4.2.1.**

The non-availability hours for availability calculation shall be counted from the end of the allowed Action Resolution time. A standardized register shall be maintained at each site containing full details of each outages, actions taken by Owner to correct the problem, applicable Severity level, time of reporting to the contractor support engineer/support centers pursuant to the appropriate methods in the Agreement, allowed Response time as per the Response times defined in above section, actual Resolution time and signature of Engineer-in-charge as well as the contractor's support engineer of the site.

Duration of outages over and above the Action Resolution time, as defined in **Table 4.7.1** in each of the Severity levels shall be counted for the non- availability computation and shall be clearly brought out in the register. The resolution may be accomplished by a work around, and such solution shall mark the end of non- availability.

In the event of frequent failures at a site, due to a common cause, the first FPR (Field Problem Report) logged shall be used for the purpose of availability calculation. However, simultaneous multiple outages due to unrelated cause would be counted separately.

4.8.1 Availability Computation for SCADA/ EMS

Availability would be on per quarter per site basis. The formula to be used for availability computation would be as under

Availability per quarter yearly (per site) = <u>THQ- (S1 x 1+S2 x0.8+S3 x 0.5)</u> x 100%

Thimphu: Bhutan
Office of the Bhutan Power System Operator

THQ

Where,
THQ is total hours in the quarter
S1 is the total non-available hours in Severity Level-1 in the quarter. S2 is the total non-available hours in Severity Level-2 in the quarter. S3 is the total non-available hours in Severity Level -3 in the quarter.
The above calculations shall be same for the Auxiliary Power supply system.

4.8.2 Payment of Annual Maintenance Charges

The payment of maintenance charges will be based on SCADA/EMS system availability. In the event of availability below a certain level, the maintenance charges would be proportionately reduced as follows:

Availability for each control center per quarter	Deduction as % of the apportioned price of total AMC for SCADA-EMS portion of the contract applicable for that site (AMC price)
Software Availability ≥99.99%	NIL
Less than 99.99%	Deduction of 2% of the apportioned price of the apportioned quarterly AMC for every 0.5% or part there of decrease in availability under 99.99%.
Manpower availability for each control center per quarter	Deduction as % of the apportioned price of total AMC for SCADA-EMS portion of the contract applicable for that site (AMC Price)
Hardware Availability ≥ 95.00 %	NIL
Less than 95.00%	Deduction of 2% of the apportioned price of the apportioned quarterly AMC for every 0.5% or part there of decrease in availability under 95.00%.

4.8.3 Computation of Availability/ Non-availability

The computation of Availability / Non-availability would be rounded up to 2 decimal places at each Control Centre on quarterly basis and any deduction in the maintenance charges thereof would be calculated as stated above in **Section 4.8.2** on pro-rata basis.
Planned & scheduled Equipment shutdown during preventive maintenance shall be deemed as available.

4.9 Contractor's Obligations

The contractor shall guarantee continuous availability of the system as indicated in **Table 4.2.1** for the defect liability period of one year from the date of operational acceptance. The system availability shall be calculated as indicated above on monthly basis. During this period, the contractor shall take continuous actions to ensure the guaranteed availability. In case the actual availability falls short of the guaranteed availability, it would be considered as contractors default and defect liability period shall be extended by a period equal to the period / months during which the availability is less than the guaranteed availability.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

In order to optimize and improve the response of the system, the contractor may re-install the program modules after making the Owner engineer aware of the consequence (like data loss, database rebuild etc.).

Any modification of software/Operating System required to restore functionality due to hardware upgrades, patches, or arising out of a necessity to fix FPRs (Field problem reports), would be done by the contractor at no extra cost to Owner.

The contractor will submit FSR (Field Service Report) and the steps taken to solve the problem, along with details of code changes.

4.10 Responsibilities of Owner

The responsibilities of the owner during the maintenance period are as follows:

a. Owner shall ensure that proper Environmental conditions are maintained for the system.

b. Owner shall ensure that the System is kept and operated in a proper and prudent manner as described in the system documentation provided by the Contractor and only trained Owner representatives (or persons under their supervision) are allowed to operate the system.

c. Owner shall provide access to the sites of installation for purposes of providing Support Services.

d. Owner shall provide the contractor with Space for Office and storage space for their maintenance staff and spares.

4.11 Responsibility Matrix

The table in this section provides a summary definition of the roles and responsibilities of the contractor and Owner.

Legend:	☐	This indicates who has primary responsibility to perform this function.
	A	This indicates who will provide assistance.

Item	Task	Owner	Contractor
1.0	**PROBLEM IDENTIFICATION**		
1.1	Root cause analysis to determine whether the fault is attributable to Hardware or Software.	☐	A
1.2	Resolution of problems involving third party maintainer where there is uncertainty whether the root cause is hardware or software.	☐	A
2.0	**SOFTWARE PROBLEM RESOLUTION**		
2.1	Report problem and assist with the problem identification	☐	A
2.2	Provide or recommend corrections, temporary patches, workarounds or other fixes to system problems	☐	A

Thimphu: Bhutan
Office of the Bhutan Power System Operator

2.3	Install and test corrections, temporary patches, workarounds or other fixes to system problems	☐	A
3.0	**ROUTINE SOFTWARE SUPPORT**		
3.1	Build and maintain database, displays and reports	☐	A
3.2	Perform system back-ups	☐	A
3.3	Restore or reinstall software from back-ups	☐	A
3.4	Monitor system logs (part of remote monitoring service)	☐	A
3.5	Maintain system logs	☐	A
3.6	Maintain user accounts	☐	A
4.0	HARDWARE PROBLEM RESOLUTION		
4.1	Report problem and assist with defining problem	☐	A
4.2	Troubleshoot problem to diagnose if it is software-related or hardware-related	☐	A
4.3	Identify failed component, Replace failed components in online system using parts from spares inventory	☐	A
4.4	Restore operation of repaired/replaced equipment	☐	A
5.0	HARDWARE SPARE PARTS		
5.1	Manage local spares inventory	☐	----
5.2	Replenish local spares inventory	☐	----
6.0	INTEGRATION AND DATABASE WORK AT CONTROL CENTRE END		
6.1	ICCP Integration	☐	A
8.0	CYBER SECURITY MONITORING UNTIL THE AMC PERIOD		
8.1	Patch Updates	----	☐
8.2	Cyber Security Monitoring	☐	☐
8.3	Annual Audits	----	☐
8.4	Implementation of Recommendations during Audit	----	☐
8.5	Implementation of Monitoring and compliance manager for Critical Infrastructure Protection	☐	☐

PART B

TECHNICAL SPECIFICATIONS

A. Introduction

This **Part B of Volume-II** describes the technical specifications for SCADA/EMS System to be procured as a part of the revamping of existing NLDC. The description includes requirements in respect to Control Center computer hardware and software, SCADA/EMS functions, user interface, testing, maintenance, etc. The supplier of the system shall ensure that support services for maintenance are also available even after the maintenance period.

B. Proposed System

The SCADA/EMS system shall establish modern computer and control system at all control centers. The technical requirements for various functions of SCADA/EMS system are described in subsequent sections. The supply of source code under this project is not envisaged. However, Source codes of following applications shall be provided to the owner/employer but not limited to:

- APIs (Application Programming Interface) specified in the Specification.
- Applications specifically developed for this project such as web applications.
- Source codes for creating new tables, reports, etc. to meet the user's requirement in Historian System.

The Bidders are encouraged to offer their standard products that meet or exceed the specification requirements. However, the proposal will be judged by its conformance to the Specification. These products may be provided from their in-house baseline offerings, the computer manufacturer and established third-party software suppliers. The proposal shall clearly identify all deviations from the Specification to help Employer evaluate the degree of conformance of the Bidder's offering.

The System Design Parameters and Performance requirements for SCADA/EMS systems are specified in **Part B, Appendices C & D**.

All the variable parameters of SCADA/EMS System, which require adjustment from time-to-time, shall be defined in the database and shall be adjustable by system users through graphic user interface displays. All periodicities and time intervals contained in the Specification that define these parameters shall be considered as initial values to be used for performance purposes. The adjustments made to parameters by the dispatcher or the programmer shall become effective without having to re-assemble or recompile programs.

The specific requirements for output results are described along with the other requirements of each function. However, all results shall be stored in a form accessible for display and printing, whether or not explicitly specified in the particular subsection. The application result storage details shall be submitted during detail design stage. The system shall be designed such that failure of single server or single peripheral device shall not render the system unavailable.

C. Critical & Non Critical functions

SCADA/EMS System functions are classified as Critical or Non-critical function. At Control Centre every critical function must be supported by sufficient hardware and software

Thimphu: Bhutan
Office of the Bhutan Power System Operator

redundancy to ensure that no single hardware failure will interrupt the availability of the functions for a period exceeding the automatic transfer time defined in the specification.

Non-critical function may not be supported by hardware redundancy and can be suspended in case of non-availability of corresponding hardware.

i) The following functions are classified as Critical functions:

a) All SCADA functions

b) All EMS functions

c) Historian System

d) User Interface Requirements

e) Network Management system

f) Web Applications

ii) The following functions are classified as Non-Critical functions:

a) Database modification and generation.

b) Display modification and generation.

c) Report modification and creation.

d) Software configuration and system generation.

D. Organization of PART-B of the specification

Sections 1 through 8 and appendices provide the requirements for SCADA/EMS system to be procured for this project as follows:

E. Sections

- Section 1: SCADA Functions
- Section 2: EMS Functions
- Section 3: User Interface Requirements
- Section 4: System Software Requirements
- Section 5: Hardware Requirements
- Section 6: Configuration Characteristics
- Section 7: Inspection and Testing
- Section 8: Web Systems Functions
- Section 9: Auxiliary Power Supply

F. Appendices

- Appendix A : Glossary
- Appendix B : Sample Report
- Appendix C : System Design Parameters

Thimphu: Bhutan
Office of the Bhutan Power System Operator

- Appendix D : Performance Requirements
- Appendix E : Questionnaire
- Appendix F : Power System Sizing
- Appendix G : Bill of Quantity for SCADA/EMS system
- Appendix H : Hardware Specifications
- Appendix I : Data Structure for Historian system
- Appendix J : Interoperability profile IEC 62351

SECTION 1

SCADA SYSTEM FUNCTIONS

CONTENTS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 1
SCADA SYSTEM FUNCTIONS

1.0 Introduction

This section describes the functions to be performed by the SCADA/EMS system being procured. The applications of SCADA system are broadly grouped into the followings:

a. SCADA Applications

b. Network Management System (NMS)

c. Historian System

The proposal shall clearly mention the platform and product limitation, if any, for the mentioned functionalities.

1.1 SCADA Functions

The following SCADA functions are envisaged under this specification:

1.1.1 Data Acquisition

Real-time data shall be collected from Field Devices located at various Substations and Power Plants on IEC 60870-5-104. In general the data acquisition shall support standard SCADA.

1.1.2 Data Exchange

1.1.2.1 Data Exchange with Control Centers

The SCADA/EMS system shall acquire Real-time data like analog, status, calculated, and manually entered data from connected control center over secure Inter Control Centre Protocol (ICCP).

As per the information provided in **Part A: Section – 1** of this technical specification document, the details of the Control Center systems to be integrated with NLDC Main & Backup has been given.

The ICCP Interoperability profile used at the Control Centers (CC) has been enclosed in **Appendix J of Part B** of this specifications. The ICCP protocol at NLDCs shall be suitably implemented as per these details including Block 4 to enable message Transfer.

The communication links provided by Employer for data exchange among control centers shall allow configuration of each channel transmission rate of 2 Mbps or more. Communication links shall be configured as Main & Backup links. The backup ICCP communications channel shall be tested periodically, without manual intervention, to determine its readiness to take over upon failure of the main communication. An alarm shall be generated for any backup channel that is not ready to take over.

Status data (Value, Quality Code, and Time Stamp having Millisecond resolution) shall be reported periodically and also “by exception” from respective Control Centers and shall be updated in the database and displayed at the operator consoles within 1 seconds of receipt at ICCP servers. A complete scan of all status data shall also be made every 10 minutes as an Integrity Check and any discrepancies between data of Control Centers shall be reported by an alarm message to the operator.

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Analog data (Value and Quality Code) shall be periodically exchanged at a periodicity of 5 seconds. This periodicity shall be set by the ICCP client as per the ICCP protocol. This analog data shall be updated in database & displayed at the operator consoles within 2 seconds of receipt at ICCP servers. All scans shall be monitored and any failure to shall be alarmed. The computer systems at Control Centre shall be able to exchange various types of data within the delivery times and response times listed in **Appendix C & D.**

The ICCP communication application shall have detailed logging of all the activities on a communication link. The logs shall be organized in multiple levels such as operator controls, error messages, warning messages, event messages and low level tracing. These logs shall also be transferred to Historian system. ICCP logs should also be available preferably area-wise & station-wise.

The SCADA system shall also maintain the communication statistics for Telemetered data for a period of one month on hourly basis for all Control Centers. The communication statistics shall also be transferred to Historian System.

Statistical Analysis for Availability of data: Communication Monitoring, Recording and Statistics – The availability of telemetered data shall be recorded such as Period of availability/non-availability, number/percent of successful data updates, for a set of data source of individual data source and its reporting based on various filters such as station-wise, region-wise, voltage level-wise, element-wise, etc.

The SCADA system shall be capable of monitoring and recording the data exchange that is occurring between the systems across Control Centers without affecting the normal data acquisition process.

Based on this statistics, operator should be able to generate the reports of availability of data in percentage terms station wise as well as region wise. Sample report is attached in **Appendix – B**.

1.1.2.2 Data Exchange with Historian System

The SCADA system shall be able to exchange data with Historian system for all type of data envisaged in the specification.

1.1.2.3 Data Exchange with Other Systems

The Control Center computer systems shall be able to have bidirectional exchange of various types of data within the Employer-specified delivery times and response times using the assigned priorities specified in this section. Data exchange shall allow information to be transferred periodically or on demand between control center computer systems.

The Data exchange with Other Systems include:

- Data exchange between Main NLDC, Thimphu and Distribution Management System (DMS), Thimphu
- Data exchange between Main NLDC, Thimphu and NLDC, India
- Data exchange between Backup NLDC, Jigmeling and NLDC, India

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Office of the Bhutan Power System Operator

1.1.2.4 Data Exchange with other Applications

The SCADA system shall provide web services on SOAP and REST that allow multiple applications to exchange any data points & vice-versa including alarms and events. Some of the functionality to be served through Web Services is explained in **Section 8** in detail. SCADA System shall have inbuilt OPC-UA Server functionality also so that OPC Client shall be able to interact with SCADA system using a defined OPC-UA interface.

The SCADA system shall have the facility to integrate the data from spread sheet applications or .CSV files into real-time database & vice-versa. The time stamp, value and the quality code of the real-time data shall be accessible through this interface.

1.1.3 Data Exchange with Market Applications and Open Access

The SCADA system shall have the provision to acquire data from Market applications and put in SCADA database for visualization, archival in Historian, trending, playback and all other purposes. The data to be integrated is as follows –

- Short term transactions in trade (Bilateral and Power exchange)
- Scheduling data
- ATC (Available Transmission Capacity) and TTC (Total Transmission Capacity)
- Market Clearing Price (area-wise)
- Market Clearing volume (area-wise)
- Deviation Settlement Mechanism Price (DSM)

All data mentioned in the above bulleted points would be available in one or more of the following formats shall be finalized during detail engineering–

- .CSV format
- .TXT format
- .XML format

1.1.4 Data Processing

The SCADA system shall prepare all the acquired data for use by the power system applications. The SCADA system shall have capability to accept data from the following sources:

a) Real-time (also referred as telemetered) data received from control centers (ICCP data)
b) Calculation
c) Manual entry
d) Sequence of events data from connected control centers,
e) EMS applications
f) Stored data
g) Any Other External Sources

The data processing requirements shall apply to data collected from all specified sources. All input data and parameters, whether collected automatically or entered by a user, shall be checked for reasonability and shall be flagged/ rejected if they are unreasonable. All intermediate and final results shall be checked to prevent unreasonable data from being

Thimphu: Bhutan
Office of the Bhutan Power System Operator

propagated or displayed to the user. All programs and all computer systems shall continue to operate with the old data or manually replaced data in the presence of unreasonable data.

1.1.4.1 Analog Data Processing

Analog data shall be stored in engineering values in SCADA database & processing shall be performed according to the requirements listed below.

a) Reasonability Limit Check

The reasonability limits shall represent the extremes of valid measurements for the point's value. All analog values shall be compared against defined high and low reasonability limits. The comparisons shall be performed at the scan rates of the analog values. An alarm shall be generated the first time a reasonability limit violation is detected. The last valid value of the variable shall be maintained in the database and marked with a quality code indicating the **'reasonability limit violation'**. When data returns to a reasonable value, the new value shall be accepted and return-to-normal message/events shall be generated. Reasonability limits shall be adjustable.

b) Limit Monitoring

For bi-directional quantities (positive or negative) there shall be a set of three limits for each direction. For unidirectional quantities there shall be a set of three limits in one direction. These limits will represent increasing levels of concern and shall be named as "Operational", "Alarm" and "Emergency" limits. These three limits shall be set within the boundaries of reasonability limit.

All acquired and calculated analog point shall also be compared against rate of change limits as well as above sets of high and low limits each time the value is scanned or calculated. In case of limit violation alarm message shall be generated. The alarm message shall include:

i. Time of limit violation detection
ii. Station name
iii. Point name
iv. Point value
v. Name of limit crossed
vi. Value of limit crossed

Whenever a monitored point crosses a limit in the desirable direction, an exit alarm/event message shall be generated. The exit alarm message shall contain the same information as a limit alarm message except that it indicates that the alarm region bounded by the limit that was crossed has been exited. If multiple limits have been crossed since the last check, highest limit crossed shall be reported.

All limit monitoring shall preclude annunciation of multiple alarms when a value oscillates about an alarm limit by utilizing adjustable alarm dead-band for each point.

The user shall be able to temporarily override any of the above limits (which are in use).

Any change in alarm states resulting from a change in limit value shall be reported/ alarmed.

c) Sign Conventions

The following sign conventions for the display, data entry and reporting of active and reactive power flow shall be used universally by all SCADA/EMS functions:

Equipment	Flow convention
Bus	Real power into bus : Negative Reactive power : same as real power
Generator Transformer	Real power low to high side : Positive Reactive power : same as real power
Substation Transformer (Measurement on HV side)	Real power high to low side : Positive Reactive power : same as real power
Substation Transformer (Measurement on LV side)	Real power high to low side : Negative Reactive power : same as real power
Generator	Real power out of generator: positive Reactive power out of generator: Positive
Reactors/Capacitors	Reactive power into equipment: Positive
Loads	Real power into load : Positive Reactive power into equipment: Positive

d) Data Validity Tests

Data validity tests shall be performed and shall generate an alarm when data changes from valid to invalid. A return-to-normal message shall be generated when the data again becomes valid. The tests shall be performed as follows:

- The algebraic sums of telemetered, calculated, and/or manually entered MW and MVAR values for devices connected to a bus shall be compared to a tolerance, provided values are available for all such devices.
- The MW and MVAR flows for switching devices that are open shall be compared to a tolerance.
- Redundant branch MW and MVAR flows shall be compared for differences greater than a tolerance.
- Redundant bus voltages shall be compared for differences greater than a tolerance.
- Redundant frequency values (for the same electrical island) shall be compared for differences greater than a tolerance.

The system-wide tolerances shall be configurable by operator through a display. When invalid data is detected it shall be marked in the database with a quality code to denote the data is questionable. A data validity summary display shall be provided that lists all the invalid/ questionable data.

1.1.4.2 Digital Status input data processing

Each state of a digital input point represents the state of an actual device. The following digital input data types shall be accommodated as a minimum:

(a) Single Point Information

(b) Double Point Information

Thimphu: Bhutan

Office of the Bhutan Power System Operator

1.1.4.3 Calculated data processing

SCADA/EMS system shall be capable of performing the following calculations at the indicated rates and storing the result in the database as calculated data available for display. The database variables to be used for arguments and the mathematical, statistical and logical functions to be used as operations shall be definable interactively at a workstation by dispatcher as well as by the programmer using database creation and maintenance procedures. Suitable API shall also be provided to define Real time Calculations and for estimated Data along with SCADA Data.

Features of user defined real-time calculation shall be available for Estimated Data along with SCADA data. There shall be no limitation on number of calculations and arguments involved in each calculation which shall be defined in the real-time calculations.

Calculated analog values shall use database points as the arguments and combined mathematical, logical and statistical functions as the operators. Functions such as addition, subtraction, multiplication, division, maximum value, minimum value, average value, count, square root, exponentiation, trigonometric functions, logarithms and other statistical functions, logical & comparative operators such as AND, OR, exclusive OR, NOT, Less Than, Greater Than, Less Than or Equal To, Greater Than or Equal To, and Equal To, etc. and nesting of these operators shall be provided.

Calculated status values shall use database points as arguments and combinational logical functions as operators that include the logical & comparative operators AND, inclusive OR, exclusive OR, NOT, Less Than, Greater Than, Less Than or Equal To, Greater Than or Equal To, and Equal To.

Suitable rules or operators (such as multi-level parentheses) shall be provided to indicate the sequence of operations in the calculation. Some of the calculations on telemetered and calculated analog points are defined below.

1.1.4.3.1 MVA Calculation

MVA values for all lines/loads and transformers shall be calculated as per the formula

MVA = SQRT (MW^2 + $MVAR^2$). The calculation shall be performed at the fastest scan rate of the component data.

1.1.4.3.2 MW and MVAR Integration

MW & MVAR values for all lines/loads, transformers and generators shall be individually integrated at their scan rates over each quarter of an hour for 96 blocks of the day to calculate active & reactive energy. The quarter-hourly energy values shall be summed for each hour to compute hourly energy quantities which shall be further summed up to calculate daily energy.

1.1.4.3.3 Rate of Change

The rate of change of variables shall be calculated using the following formula that filters the rate of change via exponential smoothing:

NewRate = A * OldRate + (1 - A) (NewValue - OldValue)/TimeInterval

Thimphu: Bhutan
Office of the Bhutan Power System Operator

New Value and Old Value refer to the selected variable, A is a user-specified constant between 0 and 1, and Time Interval is the applicable scan rate. The rate of change of variables tag shall be automatically associated with every data (analog values) field. Separate limits (in percentage and value) shall be associated for rate of change values associated with analogs and rate of change shall be user configurable (individual and bulk).

1.1.4.3.4 Max and Min Value Calculations

For calculation of the max/min value of an analog point (all lines, loads, generators and transformers) , the time period (duration) of interest shall be defined by the user and max/min value shall be identified/calculated from all samples collected during the duration of interest.

The duration of interest shall be configurable on a system wide basis from 5 to 60 minutes in steps of 5 minutes. Corresponding tags should be archived with time stamp and dumped. The results shall bear the time tag of the time at which the Maxima and Minima occurred. These calculations shall use the real-time clock and initially shall be performed for 15 minute intervals and it should be available to operator for last 24 hours.

The ability to calculate and display the Maxima and Minima values of user-selected telemetered and calculated analog points shall be provided. The user shall be able to enter the point names and the duration (period) of interest.

1.1.4.3.5 Average Value Calculations

For calculation of the average value of an analog points (all lines, loads, generators and transformers), the sampling frequencies of the point shall be same as scan rate and the time periods duration of interest shall be defined by the user.

Average of value over duration of interest = Sum of values/No. of samples

The duration of interest shall be configurable on a system wide basis from 5 to 24 hours in steps of 5 minutes. Corresponding tags should be archived with time stamp and dumped. The results shall bear the time-tag of the time at the start of the interval. These calculations shall use the real-time clock. Initial setting for capacity and performance shall be 5 minutes and it should be available to operator for last 24 hours.

1.1.4.4 System Load and Interchange data

The MW & MVAR flow and net interchange (both import and export) for each entity/area/licenses shall be calculated, at prevailing scan rates. Calculation of these parameters shall be defined based on area and company.

1.1.5 Quality Codes

Quality codes indicate the presence of one or more factors that affect the validity of a data value. All quality codes that apply to a data value shall be maintained in the database for that data value.

For calculated data, the presence of a quality code on any of the component data values shall not disrupt the calculation using that value. The quality of the calculated value shall be the quality of its "poorest" component. Results of calculations that are manually overridden by the user shall be denoted with a quality code that can be differentiated from the propagation of a manual entry quality code from one of its component values.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

The following are the data quality codes that have been defined in this Specification and the quality code should propagate to the result of a calculation.

Quality Code	Propagate	Details
Telemetry Failure	Yes	Telemetry has failed
Delete From Scan	Yes	User has disabled the update of data from database
Reasonability Limit Exceeded	Yes	Reasonability limit violated
Questionable/In valid	Yes	When the data is not valid
Manual Entry	Yes	Values entered Manually
Manual entry at remote end	Yes	Values entered Manually at remote end
Alarm Inhibit	No	Alarm processing has been prohibited
Not in service	Yes	Point is temporarily removed from service
State Estimator replaced	Yes	Replaced by corresponding State Estimator output
Alarm Limit flags	Yes	Which Alarm limit is exceeded (out of 3 or more defined)
Suspect data	Yes	Data is “suspect” quality by probable reason
Uninitialized	Yes	Data has not been initialized even once
Good	Yes	Data is available with “Good” quality

1.1.6 Real-time data storage and playback

All real-time data (Analog and status) shall be continuously stored on-line for at least 3 months. It shall be possible to playback above stored data on Single Line Diagram and Network Diagram for a configurable time window (configurable from 1 second to 48 hours) by defining Start time & Date, End time & date for faster and/ or slower playing. It shall be possible to have tabular and graphical trends from the stored data. Trend shall be available historically with time-stamp of that period.

The user shall be able to view the stored data on SCADA/EMS system displays such as on Single Line diagram, Network Diagram & Trend display by placing a workstation console monitor in a history mode for a specified time and date. Any system display subsequently called up on that monitor shall display the data that existed at the specified time and date, or the closest previous time available. The history mode and the historical time and date shall be prominently indicated on each display. The display during playback should confirm with all the facility of Network Status Processor as applicable in real time displays i.e. de-energized portion of the network, Alarm based Visual (e.g. thickening of Lines) appearances, connectivity shall be shown accordingly.

The users shall be able to select the time window of interest for archival of above important data in the Historian System for future retrieval and playback in SCADA system. This archived data shall be transferable in database of Historian system for generation of reports. The Snap-shot archived data may be used by EMS applications in study mode.

Thimphu: Bhutan

1.1.7 Redundant data Source processing

Some data in the SCADA/ EMS database may be obtained from more than one source. Typically, the "best available" source of the data shall be chosen for use in displays, reports, and other functions. This feature of choosing the best available source is "redundant data source processing" function. The inputs to redundant data processing function shall be called "arguments", and the chosen source is called the "resultant best value." The arguments may be values form Field devices and ICCP telemetered values. The resultant best value shall be stored in the SCADA/EMS database with Quality Code.

1.2 SCADA based Network Status Processor

The SCADA systems shall be provided with a power system network status processing function. This function shall be capable of analyzing the open/closed status of switching devices, such as Circuit breakers and Isolators, in order to define the configuration of the substation for display. The energization of all power system elements such as lines, transformers, bus-bars and generating units shall be determined so that the associated displays may correctly show the status of these power system elements. The configuration shall be re-evaluated and updated whenever a switching device status change is detected by the system.

1.3 Sequence-of-Events (SOE) Recording

SOE data is the time stamped chronological/reverse chronological listing of status change/events collected from the Generating plants/Substations. The SOE have time tag with one millisecond resolution. SOE data shall be collected by the NLDC Main/Backup system and shall be made available for review by NLDC user. SOE data shall be acquired periodically or on demand. All necessary processing required on the SOE data like filtering, sorting, merging, mapping is to be done at Control Centre.

SOE data acquisition shall not interfere with periodic data acquisition between two Control Centers. The description of each event shall include the device name (Alias Name), in addition to database description name, device state, the date, and the time (to the nearest millisecond) of each event. Events shall be displayed and logged in chronological order. The user shall be able to select the display of events by RTU station, or the entire power system covered by the NLDC. SOE data shall also be stored in Historian system.

Integration tool with user interface should be provided for real-time SoE integration at NLDC Main and Backup. NLDC SoE file size shall be as per incoming SOE file size considering possible chattering and or noise. Logs should be made regarding all the points not merged and entered into the database. SoE should be visualized in a UI with filter and sorting.

1.4 Network Management System (NMS)

Network management system software functions are described in **Section – 4**.

1.5 Historian System

The Historian System shall capture raw production data in real-time, at its original scan rate from the SCADA system and also from other specified sources. This includes storing of data such as SOE, Analog values, Status Values, calculated Values, Energy Values, external inserted values, etc. The raw data can be captured either by exception or

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Office of the Bhutan Power System Operator

periodically. The Historian System shall be a COTS (Commercial off the Shelf) product and shall provide user-configurable graphical visualization, reporting, analysis, and web application/access tools. It shall display current and past operating conditions on desktops anywhere and anytime throughout the enterprise and beyond. It shall store the information online for at least five years at its original resolution, making it instantly available for deep and broad analysis, trending, and benchmarking for continuous process improvement.

The Historian System shall provide operators, engineers, and management with direct access to one integrated source of information.

1.5.1 Configuration of the Historian System

The Historian System shall communicate to the SCADA servers and sample the real-time values as configured by the User. The real-time values shall be stored at the same resolution as available from the SCADA server.

The addition, deletion, or modification of data to be collected and processed shall not result in loss of any previously stored data during the transition of data collection and processing to the revised database.

The Historian System should support High Availability and automatic failover, interface data buffering to guarantee no data loss, and no impact to clients or applications in case of communication loss or data server shut down for maintenance or security patch installations, etc.

Software utilities shall be provided in the Historian System to back-up the Historian data to an auxiliary memory available on network. This software shall have the feature of automatic as well as the manual backup of data. This utility shall also provide the feature of retrieval of data for selected period to be used in generation of reports through user friendly pull down menu and drag and drop facilities.

The typical types of data and its periodicity to be stored in Historian system shall be finalized during the detailed engineering Stage.

1.5.2 Features required with the Historian System

The following features shall be provided along with the Historian System application

a) Interface with SCADA software for acquiring the real-time data

The Historian System shall exchange data with the SCADA system and ensure high performance for real-time data exchange. The data value as well as quality codes shall be received from the SCADA system. Data must be time stamped according to the sending system and not on receipt by the Historian System unless no other time stamp is available. The Historian System must store all the time series data in its original time-resolution and associated quality code in a real-time database.

b) Organization of data and configuration

The asset or power system topology model hierarchical structure shall be stored in Historian System with versioning/archiving capability, and with roll-ups to aggregate data on real-time basis. The Historian System must be able to link data points held within the Historian to the process model defined in SCADA System.

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Office of the Bhutan Power System Operator

c) Real-time data interfaces

The Historian System shall provide real-time, fault-tolerant, high-speed links from any industrial automated real-time data sources through an industry standard interfaces such as OPC, UA/, OPC DA and OPC HDA, connector. Also it shall have interfaces compatible with DAS (1.0 AND 2.0) COMPILANT SERVERS, SQL, and ODBC.

The Historian System shall provide the trace logs for audit trails and audit purpose.

d) Calculated values

The Historian System must be able to perform any mathematical calculations on raw data values (analog and digital values) before being displayed. The Historian System shall also have data summary function for defining calculations such as totals, averages, and other aggregates from real-time data inputs. The equations of these calculations shall be able to use mathematical functions, logical operators, conditional operators and trigonometrically functions. Calculations shall be started and reset based on time. The Historian System must be able to save calculated values as separate data points. The Historian system shall perform the calculations in real time and allow results to be trended and archived with the raw data without affecting the operations of the source systems.

The historian shall provide functions such as derivative and double derivative to compute the “ramp rate” and “rate of change of ramp rate”. Historian system shall provide moving average on a variable interval.

The calculation engine shall be able to define aggregations based on asset type, totalizers (accumulators), and performance equations formulas and shall support periodic or time-based or event-based triggers. The calculation expression shall allow the users to implement complex calculations without any formal programming and coding. The calculations shall be able to be done by asset- based/group-based, instead of per-point bases. All calculations shall provide the re-calculation functionality to automatically or on-demand to re-calculate the historical data.

The calculation tool shall also have:

i. Ability to define static variables.

ii. Ability to define logic based expressions.

iii. Standard math library.

iv. Configurable calculation frequency.

v. Adding new calculation without affecting the existing calculation service.

vi. Ability to define calculations with return error codes.

vii. Graphical user interface

The graphical user interface shall be provided. The User interface shall facilitate contextual organization of information for decisions making. The GUI shall create and display real-time and historical data, including customizable equipment schematics and trends, for faster evaluation by all the users.

The UI shall have following feature:

Thimphu: Bhutan

Office of the Bhutan Power System Operator

- Drawing tools
- Ability to incorporate trends
- Easy to zoom-in/zoom-out capability.
- Drilldown
- To solve production issues quickly. Ability to produce ad-hoc and formal reports on data held within the Historian and any linked databases.
- Reports shall be configurable for different time/region/substation ranges by simply changing the report time/region/substation cells.
- Ability for report to carry some manual entry.
- Excel based add-in Reports.
- To generate dynamic reports in tabular format. Scheduling options to generate reports time-of-day scheduling, natural scheduling (when an input tags changes), event-based scheduling. End-users tool to build, modify and manage displays SLD (Single-Line-Diagrams) and multiple build-in analytics from amongst graphs, bar-charts (horizontal or vertical), XY plots (can be rotated in any direction), pie-charts, scatter plot, box-plot .
- Major and minor axis of plots shall be user configurable.
- Viewing rights for SLDs and other data analytics rights.
- Trending Displays configurable refresh rate.

It shall allow users to create interactive, configurable displays for publishing on the operator workstations as well as on the web. It shall be possible to extract the data for a user configured parameters and selected time period. User interface for drag and drop functionality shall also available. It shall be possible to search for a data point by defining search criterion in the system.

viii. Interface with office applications

The Historian System shall allow retrieval of data into Microsoft Excel. It shall provide menus to extract data into spreadsheet. Extraction shall include current value, archive value, aggregation calculation (average, min, max, total, standard deviation) for specified period, tag-based calculation and calculations with filters.

ix. Manual data entry

The Historian System shall also have the capability to accept manual data. This information shall be used to complete the picture of operations and required for problem diagnosis or reporting in conjunction with the data collected automatically. Manual data entry shall be allowed from defined clients with audit trail.

The Historian system shall have feature of the manual correction of the archived data with a unique flag. This shall be limited to only to the authorized users. All such changes shall be logged to the audit file for future reference.

x. Interface with Business Applications

Thimphu: Bhutan
Office of the Bhutan Power System Operator

A well-documented API shall be provided to exchange data with third party software. The API must be able to query data and models held within the Historian System. The Historian System must offer connectivity to third party systems using multiple protocols (at least two) e.g.; OPC/ ODBC/ OLEDB/ JDBC and web services. The Historian System must be able to control the authorization of data extracted through API.

xi. Data migration requirement

The Historian System shall provide means of migration of data by importing and exporting old data in a predefined format such as .csv files or through APIs so that the data can be migrated to another system.

xii. Interface with External System

The Historian system shall provide web services on Simple Object Access Protocol (SOAP) and REST to publish data into the database through multiple applications.

Historian System shall have inbuilt OPC-UA Server functionality so that OPC Client shall be able to take the data from Historian system using a defined OPC interface.

The Historian system shall also have an ODBC (Open Database Connectivity) interface which shall allow all the historical data to be accessible by Personal Computers (PCs) running Microsoft-Windows based applications. A dynamic link between the Historian system and the spreadsheet shall enable an automatic update of the spreadsheet whenever data point change.

xiii. Mass storage of files and Data

The Historian system shall also be used for mass storage of data and files such as EMS application save-cases, Output results of EMS applications, Outage Schedules and Continuous real-time data of selected time window. External file (i.e. monthly compiled data) shall also be stored for archiving and retrieving purposes.

xiv. Sequence of event (SOE) data interface

Historian system shall store the sequence of event (SOE) data available from either SCADA system or in file format. It shall be possible to import ID as well as detailed name of the imported parameter (which will be used during reporting). Proper log generation system shall be in place in case data available for archiving and not stored in historian due to some reason. SOE transfer in historian shall be either automatic or on demand by operator. All stored data shall be accessible from any time period regardless of changes made to the database after storage of that data. Report generation of SOE shall be possible with sorting facility of parameter.

1.5.3 Reports

A Business Tool shall be provided with user friendly configurable with (preferably drag and Drop) query builder, report builder and trend builder facility. Reports can be generated on user demand, on a preset timed interval, or be driven by specific events. The contractor shall be required to generate the Daily, Weekly, Monthly & Annual reports formats. The user shall be able to schedule periodic generation of reports, direct report to display, print report, and

Thimphu: Bhutan
Office of the Bhutan Power System Operator

archive report using report scheduling display. The report scheduling display shall enable entry of the following parameters, with default values provided where appropriate:

(a) Report name

(b) Time the system shall produce the report.

The user shall be able to examine and modify the contents of reports for the current period and for previous report periods using displays. Any calculation associated with the revision of data in a report shall be performed automatically after data entry has been completed.

The report shall also contain the following:

(a) Operator entered fields of Text, Symbols, Images, etc.

(b) Trends and charts (2D and 3D).

The details shall be finalized during the engineering Stage.

1.5.4 Historical Trending

The Historical trending facility should have feature/facility to

a) Rescale and Re-label axis.

b) 3 dimensional display.

c) Zoom in and Zoom out on data.

d) Selections of points through pointing device preferably drag and drop features.

e) Display the timestamp and value of all the trends for any point on the trend while hovering over it with the mouse.

f) Save the configuration (trend point, sampled interval, trending period, etc.) for viewing at later stage.

g) Configure up to 6 points in a single trend window.

h) Plot raw, average, interpolated, and min and max over a user defined sampled time.

i) On any displayed trend it shall be possible to display its Max., Min, and Average value simultaneously on the trend itself.

j) Compare up to 4 different time periods on the same plot simultaneously.

k) Compare (trend) of two different days for the same parameter.

l) Customize trend properties such as Foreground and Background color, scaling, line color, thickness, font size, plot style, type of data marker.

m) Overlay alarm thresholds on the trend display.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 2

EMS SYSTEM FUNCTIONS

CONTENTS

SECTION 2
EMS SYSTEM FUNCTIONS

2.1 Introduction

This section describes the functions to be performed by the EMS Application being procured.

2.2 Design Requirements

The Bidders are encouraged to offer their standard products that meet or exceed the specification requirements. However, the proposal will be judged by its conformance to the Specification. These products may be provided from their in- house baseline offerings, the computer manufacturer and established third-party software suppliers. The proposal shall clearly identify all deviations from the Specification to help Employer evaluate the degree of conformance of the Bidder's offering.

The System Design Parameters and Performance requirements for SCADA/EMS system are specified in **Part-B Appendices C & D**.

All the variable parameters of SCADA/EMS System, which require adjustment from time-to-time, shall be defined in the database and shall be adjustable by system users through graphic user interface displays. All periodicities and time intervals contained in the Specification that define these parameters shall be considered as initial values to be used for performance purposes. The adjustments made to parameters by the dispatcher or the programmer shall become effective without having to reassemble or recompile programs.

The user shall be able to combine group of areas in a new area for the purpose of interchange monitoring and control.

The specific requirements for output results are described along with the other requirements of each function. However, all results shall be stored in a form accessible for display and printing, whether or not explicitly specified in the particular subsection. The application result storage details shall be submitted during detail design stage. The system shall be designed such that failure of single server or single peripheral device shall not render the system unavailable.

2.3 Power System Analysis

The Power System Analysis (PSA) functions shall be used at Control Centre computer system to: (1) monitor power system operations, (2) analyze power system security problems, and (3) determine corrective and preventive controls that may be used by operating personnel to minimize the impact of security problems on reliable and economic power system operation.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

The principle PSA activities of Control Centre are summarized as follows:

(a) Facility is to be provided to run PSA on Separate Network Model (National/ Individual Control Area / Combined network).

(b) Maintain a detailed device-oriented model of the national power system and model equivalents of connected systems in other countries which has interconnection with Bhutan. The National Model shall be maintained at NLDC.

(c) Import, Export and Maintain a detailed Common Information Model (CIM) based model of the power system covering Bhutan and nearby Indian Power system network consisting of all the network elements at 66kV and above.

(d) Execute State Estimation using the National power system model and all telemetry obtained from field devices. Replace missing telemetry data with pseudo measurements.

(e) Replace all Circuit Breaker and Isolator closed in case the telemetered value is more than the threshold limit.

(f) Execute other real-time PSA functions (e.g., OPF) using the base case obtained from National State Estimation.

2.3.1 PSA Execution and Model Requirements

2.3.1.1 Real-Time Mode

SE shall execute upon the occurrence of any of the following triggers:

(a) Periodic (selectable between 5 minutes and 60 minutes, initially 5 minutes)

(b) User demand

(c) Event resulting in power system topology change.

Necessary Features of Real-time mode are listed as follows:

(i) Event triggers shall take highest priority, with demand triggers higher in priority than periodic triggers. SE shall ensure that the input data represents a quiescent state of the power system which can be defined as no status changes have occurred for a programmer-adjustable period (initially 5 seconds)

(ii) The other PSA functions shall execute following the successful completion of SE and individually on demand. A separate count shall be specified for each of these functions for each trigger type, and each function shall be executed after SE has executed the number of times that the count is used to indicate.

(iii) OPF shall be initiated whenever an actual security violation (e.g., voltage violation or branch overload) is detected by SE. It shall then continue to execute after each execution of SE as long as the security violation exists or the output of one or more generators is being constrained to correct or prevent a security violation.

(iv) A record of the time shall be kept when each PSA function previously executed successfully and when the input data for such was last changed.

2.3.1.2 Multi-User Study Mode

(a) SE, CA, and OPF shall be executable at the Control Centre in a multi-user study mode environment, there shall be provision for a minimum of 3 concurrent user studies.

(b) It shall be possible to compare output (i.e. Branch flows, bus voltages & angles) of multiple study cases (minimum 10 scenarios) of SE, CA & OPF by a single user. Further it shall also be possible to take any of the 10 scenarios as a reference scenario and compare the balance 9 with this reference scenario of SE, CA & OPF.

(c) Input for SE in the study mode shall be SCADA data saved by Real-Time Database Snapshot or from the current real-time SE solution.

(d) Input for the other functions shall be from stored SE or power flow solutions.

(e) All solution and tuning parameters shall be separately specifiable for the real-time and study modes.

(f) Users shall be able to validate and scale input case data and examine & compare the output data from different solutions. Any user shall be able to suspend preparation of an input case and to prepare and execute a second case without losing any data previously entered for the first case.

(g) All PSA functions shall be capable of solving networks with at least ten electrical islands. The model parameters shall be in per unit (p.u.) on a 100 MVA base.

2.3.1.3 Alternating Current Model

The Common Information Model (CIM) is a standard way of representing power system resources as object classes and attributes along with their relationships.

The CIM facilitates the integration of EMS developed independently by different vendors.

The EMS-CIM should be able to do conversion of third party network model formats to CIM compliant model and vice versa.

It should be possible to export data model in CIM format and web-based XML schemes as well as import from same. The CIM shall be used as the foundation to maintain, distribute and exchange the static data. This data exchange would include all models and model files. The minimum requirements of the Alternating Current (AC) model shall be as per the CIM standard IEC 61970-301. The offered model shall include:

(a) Shunt capacitors and shunt reactors

(b) It shall represent variable series capacitor.

(c) There shall be no restriction on the magnitude or sign of the active and reactive components of the branch impedances.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

(d) Branches and shunt elements shall be identified by names and by their connected bus names.

(e) Limits for non-telemetered quantities shall be user- enterable.

(f) Nominal ratios and step sizes for off load tap transformers shall be user enterable.

(g) OLTC (On Load Tap Changer) transformer voltage ranges and step sizes shall be specified for each transformer. OLTC transformer impedances shall be adjusted as a function of tap position.

(h) Phase-shifter angle ranges and step sizes shall be enterable by the programmer. Phase-shifter impedance adjustments with step change shall be automatic.

(i) Transformers shall have low voltage and high voltage tap settings, one side with tap changing and the other side without tap changing.

(j) Generator reactive power limits shall be modelled as a function of the active power output of the generator. Programmer-definable and user-selectable multiple curves shall be provided for each generator (including synchronous condensers). A single user action shall enable/disable generator reactive power limiting on all user-identifiable units.

(k) Loads shall be generally modelled as: (1) constant active and reactive powers, (2) constant impedance, (3) mixed

(l) When there are several transmission lines between two buses and/or when the line(s) between the buses consists of several segments, a common name shall be used for each line with a separate individual line and/or line segment identifier.

(m) Open-ended branches shall be modelled and the solution shall include: (1) the voltage magnitude and angle at the open end and (2) the voltage and angle difference between the open end and the bus to which the branch is normally connected.

(n) Designated generating units shall be capable of operating as synchronous condensers and/or pumps.

(o) Static Var Compensator (SVC) models that recognize both voltage and susceptance control modes shall be provided.

(p) It shall be possible to model a continuous controlled variable reactor such as to represent variation from zero value to Rated value as a function of voltage control.

(q) It shall model Renewable energy sources such as Wind generator and solar model.

2.3.2 Power System Model Update

The power system model to be used by SE and other power flow calculations shall reflect present conditions as reported by Telemetry, ICCP data Exchange from connected Control Centers and as entered by the users. The Power System Model Update (PSMU) function shall include the following features.

2.3.2.1 Network Topology

The prevailing network topology shall be determined from the status of all switching devices that affect the topology of the network modelled, e.g., a utility's internal power system network. This topology and the associated model parameters shall be based on: (1) Telemetered switching device statuses, (2) manually entered switching device statuses, (3) manually entered in-service or out-of-service designations for bus-oriented model elements (e.g., branches) where switches are not represented, (4) modelled element statuses from the Outage Scheduler.

Switching status of a device shall be treated as closed in case MW and MVAR flow on a device is more than threshold limit as defined by the programmer. A specific display to show the list of switching devices closed by such action shall be available.

2.3.2.2 Bus Loads

Bus loads shall be calculated for the unobservable regions of the power system model by the Bus Load Forecast function described in 2.3.5.

2.3.2.3 National Power System Model

The Vendor shall develop national power system model using CIM compliant models (IEEE power system model) and additional data (Paper copy of single line diagrams and parameters in excel sheet) provided by owner. The National Model shall in general include the following:

(a) 400 KV, 220 KV, 132 KV and 66kV Stations.

(b) All the Lines for the defined stations as above.

(c) Equivalent networks as required to adequately represent the effect of the external networks.

(d) Other Grid elements as identified during detail engineering.

All load and generation that is connected to 66 kV and higher shall be represented. Non-telemetered substation load and generation shall be calculated.

Employer shall be able to use the NLDC computer System to develop the external equivalents and to build and test the National model.

2.3.3 External Equivalent

Employer shall be able to use the SCADA/EMS System to develop and export & import the equivalents in standard CIM model as well as in format of PSS/E and IEEE. The format for PSS/E and IEEE shall be in the latest version with backward compatibility. It should be possible to make external equivalent around the tie lines so that the network is reduced but the tie lines are kept as it is. All boundary buses shall be retained of other utility while making the external equivalent so that no fictitious lines shall come in parallel to original tie flow. It shall be possible to create the external equivalent of the own network in same manner to pass it on to other external agencies. The solution (Voltage, Angle & Power flow) of equivalent system shall not have major variation with the full network's solution.

It shall be possible to merge the imported equivalent model in the defined network model. The supplier shall provide software as required to establish the methods equivalent in terms of equivalent impedance and equivalent generation/Load of the network being reduced.

The user shall have flexibility to define the network for making equivalent based on the chosen nodes, lines, voltage levels or operating areas.

Network equivalence and Truncation shall be supported. It could be based on Station, voltage level and any class such as Area, region, etc. An example of truncation is given below:

While truncating the network at 220kV and above level, all the switching devices at 66kV and below level are opened in Network database and Modeled Loads are connected at the secondary side of 220/66kV ICTs. These modeled loads shall take the Real-time data on associated ICTs as its load measurements.

2.3.4 State Estimation (SE)

State Estimation shall provide a complete and reliable power system model solution containing information for use by other PSA functions and for display. The State Estimator measurements will consist of telemetered data from all the field devices.

It may be necessary to convert field devices measurements suitable for input to the State Estimator function at NLDC. The Contractor shall provide functionality for merging/conversion measurements received. The vendor shall provide necessary measures to take care of the time skew of the SCADA measurements among field devices measurements so that the solution accuracy or convergence of State Estimator running at NLDC shall not be degraded.

The State Estimator measurements will consist of telemetered data from majority of modelled stations.

2.3.4.1 SE Measurement Set

The measurement set for State Estimation will not always include sufficient measurements to estimate the state of the entire model. Therefore, the model estimated must be dynamically reduced to the limit of observability due to lack of measurements, loss of measurements and detection of anomalies. The portion of the model that is unobservable shall be solved either in conjunction with the observable portion or by a subsequent execution of the State Estimation algorithm based on the complete model.

The solution of the unobservable portions of the network shall be based on pseudo measurements for load and generation which shall be calculated internally from the system.

The following is the preferred method for calculating these pseudo measurements:

(a) The unobservable portions of the model shall be divided into areas, each of which represents a Region or the unobservable portion of a Region.

(b) For each Region, the load, generation, and net interchange shall be determined. Provision shall be made for these values to be telemetered. Alternatively, the Regional load shall be calculated based on the total National load and a predefined Regional load ratio, the net interchange shall be enterable by the user and the generation shall be calculated from the load and net interchange.

(c) Pseudo measurements for the load at each bus shall be calculated based on the Regional load and pre-stored bus load distribution factors. Provision shall be included to use several sets of busload distribution factors based on time-of-day, day type, and month.

(d) Pseudo measurement for the generation at each bus shall be calculated based on the status of each generator and dispatch based on a merit/priority order, in the event that the generator status if different from the Current Operating Plan. Otherwise, the generator status shall be as per the Current Operating Plan.

(e) Pseudo measurements for unobservable regulated bus voltages shall be based on either a function of the load of the Region where the bus is located, or a function of time of day. Provision shall be made for a linear function of up to three segments of voltage versus load at each regulated bus.

(f) When unmetered tap loads exist on transmission lines where the flows are known at both ends, pseudo measurements shall be based on the net flow into the line and bus load distribution factors. The bus load distribution factors shall be those maintained by BLF, normalized for all unmetered tap loads on the line.

(g) When needed, pseudo measurements for regulated bus voltages shall be calculated as the mid-point between the high and low bus voltage limits from Limit Monitoring.

(h) It shall be possible to substitute telemetry data for any pseudo measurement if telemetry is available.

2.3.4.2 State Estimation Characteristics

The State Estimation function shall:

(a) Solve all islands when islanding occurs in the solutions due to either real electrical separation in the network or observability islanding. The solutions from the islands shall be integrated into a single network solution containing as many islands as exist in the electrical network.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

(b) Determine line and transformer overloads, voltage violations, and violations of generator and synchronous condenser VAr limits. Generator VAr limits shall be according to unit capability curves. Limits for non-telemetered quantities shall be user-enterable. It should be possible to sort the results based on line flows and or losses.

(c) Use injection measurements.

(d) Support pre-filtering of input data via data validity tests as defined in SCADA section, including the ability to recognize quality codes attached to the input data and to adjust the variances (sigma) or reject the data as appropriate.

(e) Detect bad data and measurement bias errors and cause a quality code to be set in the real-time database. Bad data detection shall be able to resolve multiple and interactive errors. It shall be possible for the programmer to disable and enable the setting of the quality code in the real-time data base on a global basis.

(f) Maintain bus voltages within high and low voltage limits on regulated buses in the unobservable portions of the network to the extent possible given the VAr resources available.

(g) Maintain generator and synchronous condenser VArs within high and low limits in the unobservable portions of the network.

(h) Accept injection, branch flow and voltage measurements in the unobservable portions of the network.

(i) Minimize observable-unobservable boundary flow mismatches without interference with the observable network solution.

(j) Assign generation, load and voltage values to any buses in the network.

(k) Estimate telemetered and un-telemetered tap positions for voltage transformers and phase-shifters.

(l) Calculate load power factor.

(m) Calculate and display a confidence factor based on the covariance of the residual of each measured quantity. Confidence factors shall be calculated each time the network topology or measurement set changes and shall be available for display.

(n) Allow operator control of the SE execution control parameters such as convergence tolerance and maximum number of iterations. A UI (User Interface) to automatically re-initialize the various parameters (operator selected) associated with State Estimation process after running a specified number of times by the operator

(o) Allow the operator to enable-disable the use of telemetered values by the SE on an individual basis.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

2.3.4.3 SE Output Requirements

State Estimation output shall be for both the observable and unobservable portions of the National power system and external nearby power systems. State Estimation output for the entire network model shall be as follows:

(a) Vector voltage solution

(b) Branch flows

(c) Injections

(d) Transmission loss for each bus and Area

(e) The results of the State Estimation function shall be available for display in tabular form and also on SLD and Network diagrams in the same formats as those used to display real-time data.

(f) The Network diagrams shall clearly identify the makeup of any islands that exist and show the status of all branches.

(g) The user shall be able to save State Estimation solutions for use as base cases by the other PSA functions.

(h) The user shall be able to save solutions in the latest version (with backward compatibility) of IEEE format and PSS/E.

(i) The user shall be able to get the trend / profile of selected state estimated value on a curve and in a table.

2.3.5 Bus Load Forecast

The Bus Load Forecast (BLF) function shall calculate bus loads for the unobservable regions of the power system model using bus load distribution factors. The bus load distribution factors shall be applied to the total National load. Unobservability may be due to loss of telemetry or data exchange or insufficient telemetry.

Bus load distribution factors shall be maintained for every bus in the network model so that BLF can generate the bus loads used for line flow calculations by OPF (for example) and for pseudo measurement calculations by SE.

BLF shall calculate the busload distribution factors for all buses in the observable portion of the network and exponentially smooth them with previously calculated distribution factors to provide adaptive bus load distribution factors. Users shall be able to:

(1) Initialize and reset the dynamic factors from default or manually entered values and (2) change the filter parameters used by the smoothing process.

Each bus load distribution factor shall express each conforming load as a function of the total Regional conforming load. Total Regional conforming load shall be the difference between total Regional load and total Regional non-conforming load.

Provision shall be made for multiple sets of busload distribution factors. Sets shall be provided to cover:

(a) up to twelve individual calendar months of the year,

(b) up to three different periods of the day, and

(c) up to seven different day types; resulting in up to 252 sets.

It shall be possible to group or regroup calendar months later on. These sets shall be stored in in Historian system.

2.3.6 Contingency Analysis

The transmission system shall be periodically analyzed by the Contingency Analysis (CA) function to predict potential problems if selected elements of the power system were to be out of service.

The CA function shall use the State Estimation results as a base case and check specified contingency cases to determine if potential overloads or voltage problems exist.

2.3.6.1 Contingency Cases

Each contingency case shall consist of combinations of elements, including:

(a) Branch outages

(b) Reactor or capacitor switching

(c) Generating unit outages

(d) Load element outages

(e) Switching device changes (open or close).

Following features are to be provided in contingency analysis:

(a) Each case shall consist of the outage of multiple elements defined by the user interactively via display entry. It shall be possible for operator to select an element from single line/Network diagram (by clicking on it) for inclusion in a contingency case definition.

(b) Each case shall be given a case number and be assigned to one of eight priority levels by the user. The user shall be able to designate the priority levels to be studied during each execution of CA.

(c) The user shall be able to enable or inhibit the modelling of closed-loop control of transformer (voltage and phase-shifter) tap changers, reactor/capacitor switching and generating unit reactive power limiting.

(d) In the event of generating unit outages or outages that cause a loss of load the change in generation/load shall be assigned to all remaining generating units in the affected electrical island.

(e) A complete solution shall be produced for outages that result in a change in network topology (such as the creation of new system buses or the merging of buses) or result in a group of buses being isolated from the rest of the system.

(f) A complete solution shall be produced for each viable island (i.e. for each island in which there is a generation-load match within a predefined amount).

(g) The operation of relay load changeover schemes shall be properly modelled. Such schemes automatically switch loads from a bus that is de-energized as a result of an outage to another predefined bus that remains energized.

(h) The operation of SPS relay schemes shall be modelled. Such schemes automatically switch loads/elements based on events to enhance system security.

(i) Cascading outages shall be modelled. Operator will define selected branches as secondary outage devices. Each secondary outage device shall be associated with a secondary outage monitoring point. The programmer shall be able to specify that a unique limit be used as the MVA limit for a monitoring point. If a secondary outage device's monitoring point violates an associated limit during evaluation of a contingency case, the device shall be added to the outage elements.

(j) There shall be up to 10 secondary outage devices. In those situations in which secondary outage devices are added to the case, the output shall clearly describe the power system elements added.

(k) The CA function shall study up to 15 contingency cases, including dynamically created cases. Dynamically created cases shall each consist of a single element taken in order of decreasing severity from the set of overloaded branches, if any, determined by State Estimation.

2.3.6.2 Contingency Screening

The contingency cases shall be screened so that only those representing the most severe security problems need to be studied using full AC power flow techniques. Screening shall identify active and reactive power and voltage problems. The user shall be able to bypass the screening process by manually selecting specific cases for detailed analysis.

2.3.6.3 Full AC Analysis

After screening all contingency cases, full AC studies shall be performed on a user- chosen number of the most severe cases (up to 5).

CA shall contain violation checks for a user-specified set of branch flows and bus voltages, potentially all branch flows and bus voltages. Limits for non-telemetered quantities shall be the same as those specified for non-telemetered quantities in SCADA section. In addition, for bus voltages, there shall be a set of limits on the deviation between the pre-contingency voltage and the post-contingency voltage at user specified buses.

Office of the Bhutan Power System Operator Thimphu: Bhutan

2.3.6.4 CA Output

CA shall notify the user of each new contingency violation discovered. Overload conditions that exist in the base case shall not be alarmed unless they exceed the degree of overload in the base case by a programmer-enterable amount. CA output shall consist of the following:

(a) For each element in violation, the output shall identify its name, the value of the parameter and its associated limit, and the value of the parameter in the base case.

(b) CA output shall also include the base conditions of the outaged equipment. Violations resulting from CA shall be ranked according to their severity. An output summary shall be provided that lists the case number, case title, and priority for each case. The following information shall also be provided for each case:

i. Whether or not the case was screened
ii. Result of screening, e.g., converged, diverged, split system, and inadequate generation
iii. Whether or not the screening indicated any potential violations
iv. Ranking as the result of screening. This may include several numbers such as real, reactive, voltage magnitude, and voltage deviation
v. Whether or not simulated with a full AC run
vi. Results of simulation, e.g., converged with violations, converged without violations, and did not converge, diverged, severity index, previous severity index.
vii. It shall be possible to display the results (Branch flow, Bus Voltages and angles) of CA on network diagram when full AC analysis is carried out.

2.3.7 Power Flow Studies

The Power Flow Studies function computes generation, load, voltage angle and magnitudes as well as active and reactive power flows in the power system, under telemetered conditions related to topology. This also gives a summary of limit violations existing thus giving operator the complete picture on state of power network.

The operator may perform changes on a valid power flow estimate, in both network configuration and system operating conditions. For operation planning, the operator may select a stored power flow case to study particular load or generating conditions.

The results of load flow analysis shall be displayed on single line diagram similar to those used by other data processing modules. These results include line flows and interchange values, as calculated by the program.

The program shall be efficient and reliable and shall include the following features:

Thimphu: Bhutan
Office of the Bhutan Power System Operator

(a) User control of convergence tolerances and other program parameters.

(b) The ability to solve multiple islands in a single program execution.

(c) The ability to freeze all taps and capacitors at their base case positions.

(d) The ability to accept maximum, minimum and initial tap positions as well as step size for each tap changing transformer.

(e) The ability to limit check against pre-selected line and transformer MVA limits and pre-selected bus voltage limits.

(f) The ability to specify minimum and maximum MVAr limits for generators depending upon MW generation.

(g) The ability for the operator to change all alarm limits.

(h) The ability to specify the output of selected generators.

(i) The ability to designate the generator either as PV bus or PQ bus.

(j) The ability to designate a tap changing transformer as controlling the voltage magnitude by changing the tap position during the execution time and give the new position in the output report.

The main inputs are:

(a) Network topology

(b) Line, transformers, power units characteristics

(c) Equipment limits

(d) Voltage controlled buses with identification of the equipment controlling the voltage(Power units, tap changers)

The main outputs are:

(a) Execution summary (Iterations, nodes, etc.)

(b) Voltage angles and magnitudes

(c) Active and reactive power flows

(d) Reactive generation at generating buses

(e) Tap changers positions

(f) Overloaded lines and transformers

(g) Voltage limits violations

(h) Active and reactive total generation

(i) Active and reactive total losses

(j) Reactive MVAr compensation

2.3.8 Interchange Scheduling

Interchange Scheduling (IS) shall be provided at the NLDCs. A record shall be maintained of all the transactions completed the previous and current day currently in progress, and transactions scheduled for up to one year in the future. Completed schedules shall be saved

Thimphu: Bhutan
Office of the Bhutan Power System Operator

in historical data storage for the current and previous months. Operating personnel shall be notified ten minutes (adjustable) in advance of impending schedule changes. Up to six transaction types in various combinations with up to **ten** agencies shall be accommodated. Not all schedule types will be entered into it with all agencies, and the number of transactions with the particular agency will vary. Up to ten transactions in the progress concurrently and up to **fifty** transactions shall be possible. For each transaction it shall be possible to modify capacity, price and MW on 15 minute basis.

Interchange transaction displays shall include a complete list in chronological order of all transactions, as well as displays sorted by agency, by transaction type, by agency and transaction type. The displays shall show completed transaction separately from active and future transactions.

The amount of energy (MWh) scheduled for each transaction shall be calculated for each 15 minutes that each schedule is active. Scheduled transaction energy shall be calculated by the 15-minutes block accounting method, which shall be based on scheduled start/stop times and scheduled transaction MW values. Scheduled summaries shall be maintained as follows:

(a) System summary: 15 minutes basis with daily totals for total purchases, total sales, and algebraic sum of purchase/sale transactions

(b) Agency summaries: 15 minutes basis with daily totals, for each transaction type, for each transacting agency.

NLDCs shall also exchange 15-minutes day-ahead schedule with backup NLDC India & ERLDC India. These data will be made available from a web server at both the Control Centers.

2.3.9 Load Forecast

The restricted quarter-hourly MW demand of the system shall be forecasted for minimum two days in the future by Load Forecast (LF).

The user shall be able to save the forecast results in four output save cases for future use. One of the save cases shall be designated the active load forecast for use by real time PSA functions. However, the study PSA functions shall be able to take any of four save cases of Load forecast as input. In addition, the user shall be able to print and display selected results in both tabular and graphical forms showing restricted demands versus quarter hourly time instants.

LF shall support following method of load forecasting:

a) Profile based LF
b) Average based LF
c) Summation of LF received

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Profile based LF shall use the saved load profiles of the system. It shall be possible to save actual load of past days as load profiles. It shall support minimum 15 different profiles based on 15 minute load basis.

Average based LF shall use actual load profiles of previous days. User shall enter dates/duration of time (from 2 days to 7 days) as input for LF. Based on these dates LF shall retrieve actual load on these dates and shall calculate quarter- hourly average of the loads during the specified dates/time period and this shall be Load Forecast for the selected future day.

LF application shall have web interface. It shall be possible to get load demand of external users through XML files using web services. LF shall sum up the values in the files (corresponding to same time period in each file) send by different external users to reach on the LF for future days. The interface shall also be provided for external users to enter their demand requirement using web for future days instead of using files. Then the LF shall be published on the web server for view by all external users as defined.

LF shall keep history of past eighteen month data. The storage shall be updated each day by replacing the oldest of the same day type with the current day actual load curve. The actual load for each quarter hour block stored shall be average of the quarter hour load corrected for 50 Hz frequency. While storing load in history, it should also take into account load shed. It shall be possible to edit historical load data.

LF should have the feature of dynamic adjustment. Dynamic adjustments shall be based on the degree to which LF determines that the forecast does not match the actual restricted demand for two or more (Configurable) previous quarter hours. If average of mismatch for previous 8 (User configurable) quarter hours exceed a User-adjustable threshold, LF shall determine and make the necessary adjustments to all future quarter hourly values of the current day's forecast automatically. The User shall have the ability to enable and disable dynamic adjustments to the current day's forecast.

The study function such as State Estimator/Load Flow application shall be able to take any save case of Load forecast as input. Error statistics shall be maintained based on the difference between the restricted demand that is forecast six quarter hours in advance (user-adjustable) and the corresponding actual restricted demand when available. The statistics shall include the error in the restricted demand for each quarter hour for eighteen month. It shall also calculate the mean and standard deviation of eacherror.

2.3.10 Hydro Scheduling

Hydro Scheduling (HS) shall determine hydro unit and flow control device schedules for each quarter hour while respecting hydro power station, associated hydro system, and power system constraints. The objective of HS shall vary depending on the run-time option selected by the user. As a minimum, run-time options shall include:

Option A: Maximize the hydro energy production over the duration of the study while satisfying the constraints. Unit should be committed in different time intervals such that at the prevailing head the unit to be operated must be the most efficient.

Option B: Execute HS with the up-down status of each unit and flow control device predefined. All relevant unit schedules shall be computed accordingly. The ability of the user to select the up-down status values from previously saved HS results shall be provided. Unit should be committed in different time intervals such that each unit to be operated at the most efficient output for the prevailing head.

The time period of the HS function shall be minimum two days (192 quarter hours) in future. The hydro scheduling shall have interface with SCADA System.

2.3.10.1 Hydro Model

HS shall incorporate models of hydro units, stations and associated hydro systems of sufficient detail to compute their daily operating schedules. In general, a HS hydro model shall be capable of including the following elements:

(a) Generating units with Pelton, Francis, and Kaplan turbines.

(b) Reservoirs of any size.

(c) Tunnel and penstock supplies to turbines.

(d) Variable tailrace levels.

(e) Rivers and other modeled flows with water travel time delays.

(f) Spillways, including associated discharge gates.

(g) Flow control devices such as valves and gates at various stations, canals, and reservoirs.

(h) Hydro system “node-branch” network topology.

The hydro model shall be capable of modeling hydro unit input-output (I/O) curves (discharge versus MW generation curves at different heads) and efficiency curves (O/V-Curves), and of deriving any necessary incremental water rate (IWR) curves, as a function of net or gross head and number of units in service. In addition, it shall be possible to avoid forbidden operating zones due to cavitation effects, include the head loss effects of penstocks and variable tailrace levels, and apply downstream discharge and rate of discharge limits as well as unit response rate limits.

The hydro model shall also be capable of including the water elevation characteristics of reservoirs as a function of stored water volume. Elevation calculations shall properly account for inflows, discharges, losses, and water travel time delays. The ability to apply reservoir elevation, drawdown, and fill constraints, including targets, shall be provided.

Thimphu: Bhutan

Office of the Bhutan Power System Operator

2.3.10.1.1 HS Input Data

The user shall be able to input the data from Web Service Interface (as described in **Section 8**) and review and modify it from this application, if necessary, prior to initiating a HS solution.

A HS execution control display shall enable the user to set up conditions for running a study and to select program control options. Default values for selected data shall be user-definable to minimize the effort required to set up a HS case. As needed, HS shall be capable of including the following input data:

(a) Generating unit maintenance schedules from OS
(b) Factors for computing power system loss effects from Transmission Loss
(c) Sensitivity Factors
(d) Initial hydro plant conditions
(e) Initial reservoir elevations
(f) Elevation, drawdown, and fill targets for selected times
(g) Generating unit schedules
(h) Water release, flow control device, syphon, and pumping schedules
(i) Irrigation requirements
(j) Historical hydro station discharges and spills to initialize branch flow
(k) calculations that include water travel delays
(l) Study start and stop times.
(m) Unit I/O curve (discharge versus MW generation curves)
(n) Unit efficiency curves (O/V-Curves)

2.3.10.2 HS Constraints

HS shall recognize the following constraints as a minimum:

(a) Units with fixed schedules during specified quarter hours or entire study period
(b) Unit MW response rates
(c) Unit capacities as modified by de-rating and maintenance
(d) Unit availability schedules
(e) Reservoir high and low elevation limits
(f) Reservoir elevation targets
(g) Maximum reservoir drawdown and fill between study increments
(h) Maximum and minimum hydro unit and plant discharge depending on head and unit availability
(i) Maximum hydro unit/plant rate-of-change discharge limit

Thimphu: Bhutan
Office of the Bhutan Power System Operator

(j) Downstream release and rate-of-change release limits
(k) Irrigation requirements
(l) Reservoir elevations at which water is spilled or released through gates
(m) Maximum rate-of-change limit for raising discharge
(n) Maximum rate-of-change limit for lowering discharge

Default values for all of the above data shall be definable by the programmer. All data shall be displayable and changeable by the user.

The constraints shall be broadly classified into hard and relaxable constraints. It shall be possible to either "soften" or "ignore" a relaxable constraint depending on whether or not a penalty is associated with violation of the constraint after it is relaxed. The hard and relaxable constraints will be identified during the design phase. Default penalty weights for the softened constraints shall be user adjustable.

2.3.10.3 HS Solution Characteristics

HS shall include the following solution characteristics:

(a) The user shall be able to activate or deactivate relaxable constraints individually or in groups (e.g., relax all rate-of-change constraints). HS shall automatically relax (soften or ignore) the designated constraints whenever an infeasible condition is encountered.
(b) HS inability to meet any requirement shall not cause a study to be aborted.

Instead, HS shall report the problem together with the time it occurred in the schedule.

2.3.10.3.1 HS Output Data

HS shall include displays that show the following output data per time increment of the study period and which can also be viewed from Web Service Interface:

(a) Unit and station generating outputs
(b) Unit, station, and total system reserves
(c) Unit and station efficiency factors
(d) Explicit indication of committed units
(e) Reservoir levels
(f) Hydro plant heads and head losses
(g) Hydro plant discharges
(h) Spillway gate positions
(i) Water released by hydro plants and hydro systems
(j) Spillage by hydro plants and hydro systems.

Displays shall summarize the HS results on a daily and total study period basis. Details concerning constraints that were relaxed to achieve a solution as well as messages indicating the reason for convergence failure shall be provided. The user shall be able to direct all or selected portions of the HS results to a printer.

2.3.10.3.2 HS Save Cases and Case Comparison

The user shall be able to create a save case for immediate use and to save up to 20 input cases for future use. It shall be possible to save HS results in the same file as the input data. One of the save files shall be designated the active Hydro Scheduling file and shall contain the current schedule of the generating units for use by other SCADA/EMS functions. The user shall be able to view and edit the contents of each save case.

The user shall be able to select two saved cases and direct that they be compared over the same time period. The results shall summarize the differences in input and output data and be available for viewing and printing.

2.4 Dashboard for EMS Applications Assessment Tool

Dashboard shall have following as a minimum:

(a) It shall contains trend based on Boolean function to display the following: State Estimator State (valid/invalid), Tolerable mismatch (% of Error Cost), weight convergence for valid solution, Status regarding Manual Triggering, etc.

(b) It shall contain Trend for the following – Voltage convergence for valid solution, Percentage of Error Cost Mismatch Violations, Total generation, Total Load, Wind Generation, frequency, Maximum Bus Mismatch, Maximum Bus Measurement Mismatch, Maximum Measurement Residuals, etc.

(c) It also contains data for the following –Total number of islands with indication of formation of new island(s), Total Voltage violations, Total Branch Violations, Unsolved contingencies, Total dead units, Total deadlines, Redundancy index, Total Buses, Total Dead buses, Units observable (number and %), Loads observable (number &%), Bus observability (number & %), Total Cost Index of the solution, Load Residual (real & reactive), Line Residual (real & reactive), Unit Residual (real & reactive), Transformer Residual (real & reactive), ZBR Residual (real & reactive), Bus Voltage Measurement Residual, etc.

2.5 Dispatcher Training Simulator

The Dispatcher Training Simulator (DTS) shall be provided at the Main Control Center for training the operators that replicates the real-time power system conditions for at least one user. Some of the major DTS features shall include:

a. Dedicated hardware including the console so that training for operators can be conducted without disturbing real-time operations. The console shall be assignable as trainee or instructor consoles.

b. Instructor control features that include the ability to set up, control, participate in, and review the results of a training session.
c. An ability to obtain data from the SCADA/EMS systems automatically for DTS initialization. The initialization data shall include SE save cases, predefined and instructor defined scenarios.
d. A design that prevents actions performed by the Instructor and Trainee using the DTS from affecting the real-time system database or the actual power system.
e. An ability to simulate actual system disturbances from historical data that is obtained during the DTS initialization.
f. An ability to establish the following training conditions as a minimum:
    - Normal steady-state
    - Generation control
    - Transmission control
    - Heavy load
    - Line, transformer, and tie-line overloads
    - Low voltage
    - Light load
    - High voltage
    - Minimum load (excess generation)
    - System disturbance
    - Loss of major Transformers
    - Loss of tie lines
    - Loss of major transmission lines
    - System islanding
    - Voltage collapse scenario
    - System blackout
    - System restoration including black start

SECTION 3

USER INTERFACE REQUIREMENTS

CONTENTS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 3

USER INTERFACE REQUIREMENTS

3.1 General Requirements

This chapter describes the User Interface requirements for the SCADA/EMS system. It is employer's intent that all functions of SCADA/EMS System shall have common user interface. All user interactions shall be from full-graphics display.

The user interface requirements specified in this section are applicable for the user interface application of the SCADA/EMS system including Historian and Web System. The proposed Historian System shall be a COTS (Commercial off the Shelf) product and it shall have a standard User interface which shall meet the functionality described in this section. All of the features and functions shall be available to any user, except for certain functions for which access is deliberately restricted according to access control restrictions.

3.2 System Users

The term "user" is applied to the personnel interacting with the SCADA/EMS, Historian, NMS, ICCP & Web system. User and personnel based logins shall be provided and logs shall be created corresponding to changes made by that user. These users shall be required to login in one or more of following **user modes**, which include:

a) Supervisor Personnel responsible for SCADA/EMS system administration and management such as assigning the access area to users, creating users etc.

b) Dispatcher Personnel responsible for real-time Power system operations including real-time study. They shall modify data, execute applications and perform supervisory control operations. They shall also be able to monitor the alarms and the related displays of the System Configuration of the system including that of NMS system.

c) Engineer Personnel having access to certain SCADA/EMS system functions and database and responsible for support activities such as post fault analysis, report generation, regular backup of database. However the Engineer shall not be able to acknowledge the alarms and perform Supervisory Control functions.

d) Programmer Personnel responsible for continuing development and maintenance of the system functions, databases, displays and report formats.

e) Viewer/Guest Personnel responsible for accessing displays and published reports such as Web Users and Remote users. These users are never allowed to modify information within the real time system, database, acknowledge alarms and execute system applications nor perform any supervisory control operation.

The Employer shall be able to assign the operation of certain functions, or features of functions, to specific user modes. Each individual user shall be assignable to any one or more user modes. It shall be possible to assign user workstations to modes of operation. The functions permitted for each mode shall be defined in a table.

User access to all functions of system shall follow a consistent set of common user access guidelines. A single sign on mechanism for defining and controlling user access to the system shall be provided. An Identity management application shall be deployed to manage and to help achieve seamless access to all applications for authenticated users.

Password security shall be provided for access to the system, its operating system, its layered products, and other applications. Each password shall be validated against the corresponding user information in the database. Individual user shall be provided with a single set of username & password, for secured login to access all applications. Users shall have the ability to change their own passwords.

3.3 Function and Data Access Security

After a user has successfully logged on, access to the functions, displays, reports, and database elements shall be restricted by pre-assigned operating jurisdictions. These operating area assignments shall be made when the function, display, report, or database element is defined.

The access security function shall compare the user's assigned operating jurisdiction against the operating jurisdictions assigned to the function, display, report, or database element each time a user attempts a console action, such as:

a) Calling a display

b) Entering or changing display data

c) Viewing, editing, or printing a report

d) Web browsing from each operator console & remote operator consoles

Each user login and logout attempt- success or failure shall be logged in an activity log maintained on the system and also recorded as an event and posted to the event log. An alarm shall be defined after a configurable number of unsuccessful attempts to login. Each user action shall be recorded in event log and identified by username. A feature shall be available to automatically log off the user of a workstation after a predefined period of inactivity to safeguard against users who may leave workstation unattended.

3.4 User Interface (UI) Environment

Displays should be based on object oriented approach (for example, dragging a value from a single line display into a trend view to see its history). All the displays shall be accessed through web (any web browser).

A common User Interface shall be provided across applications. It shall provide a common look and feel across all system functions and environments (excluding Historian Systems) including the real time system and backup system.

The same user interface and displays used for real-time shall be used for study mode, and historical playback excluding Historian System. A different background color or similar mechanism shall distinguish between these modes.

It shall be possible to save user specific choice and display configuration and same shall be made available to user whenever and wherever he logs in. UI shall allow each user to configure and save a preferred layout, size, and location of items and elements in windows and displays. The World Display Features shall provide full- graphic world displays that a user shall be capable of panning and zooming. The world display features such as Layers, De-clutter levels (on the basis of voltage levels), Overlays shall be supported. It shall be possible to take images & pictures from third-party software providers such as ‘Google earth’ and other such openly available resources for one of the layers for background.

3.4.1 Dynamic Dashboards

A feature to create dynamic dashboards, simply by selecting, dragging and dropping the points on a dashboard template shall be provided. The dashboard shall have displays like Speedometer, Bar chart, pie chart, line graph etc.

The speedometer display shall also indicate the limits of the analog values. Dashboards shall be definable by the end user without requiring the involvement of an administrator or programmer.

3.4.2 Display recording and playback

An application shall be delivered to capture any display screen continuously. The recording should enabling playback in standard format such as mp4.

3.5 Display interactions

Rapid, convenient, and reliable display requests shall be provided using the following methods. It shall be possible to select display from/ by:

a) A menu display

b) Cursor target selection on other displays

Thimphu: Bhutan
Office of the Bhutan Power System Operator

c) Selection of an alarm or event message.

d) Entering a display name or number.

e) Re-call command for previous display.

f) Selecting a point of interest (substation) from an Overview display.

g) Right click menu option on any display link to enable the user to open the display in a new window or active window. Tagging on real-time display should be possible with facilities such as Call-Out on placing cursor on it. It shall be possible to reach any display of the system with maximum 3 (three) numbers of clicks.

3.5.1 Display navigation

Display navigation methods shall provide a consistent approach for moving within a displays. The use of appropriate methods for Panning with cursor positioning device as well as from scroll bars, Zooming with cursor positioning device, Navigation window for rapid movement on a world display and Rubber-band zooming shall be supported.

3.5.2 Display Note pad

A User shall be able to place and edit a note on any display. A symbol shall appear on the display indicating the presence of Note on that display. The content of the note shall be callable using a cursor target. The contents of these pages shall be editable and accessible by any console. The user shall have the ability to clear any page of this display and to type over previous messages. Notes Summary should be available with user name who has entered the NOTE. Link to navigate the corresponding SLD shall be available in the same summary display.

3.5.3 Quality Code

All displays and reports containing telemetered analog values, device status and calculated values shall have a data quality indicator associated with each data field. The quality indicator shall reflect the condition of the data on the display or report. When more than one condition applies to the data, the symbol for the highest priority condition shall be displayed.

3.6 User Interaction Techniques

The user's interaction with the SCADA/EMS system for power system operations shall primarily be accomplished using a menu item selection technique. The first step in the interaction will be selection of the item to be operated upon. The user shall then be provided a menu of operations applicable to the selected item. The required operation alternatives include:

- Trend
- Data entry

- Device statusentry
- Scan inhibit/enable

A set of parameters shall be presented appropriate to the item type and operation to be performed. For example, selecting an analog value for trending shall cause a menu of parameters, such as range and trend rate etc., to be presented.

As appropriate for the data and function requested, a menu containing output destinations such as screen, printer, or file shall be presented. When the destination is selected by the user, the requested action shall begin.

The user shall be able to end the interaction sequence at any time by selecting a cancel command. A programmer-adjustable time-out cancel shall also be provided.

3.6.1 User Guidance

The SCADA/EMS system shall respond to all user input actions indicating whether the action was accepted, was not accepted, or is pending. For multi-step procedures, the systems shall provide feedback at each step. User guidance messages shall be English text and shall not require the use of a reference document for interpretation. Only employer approved mnemonics can be used.

3.6.2 Function Key Usage

In order to alleviate the operator from the repetitive task, such as calling a particular function, use of virtual keys on the monitor and function keys on the standard keyboard shall be provided. User should be able to define key functions as per their requirements.

3.6.3 Trending

Trending is a display of series of values and average values of parameters on a time axis. Both graphical trend and tabular trends shall be supported by the system. The attributes of the trend display shall be user configurable. The user shall be able to select real-time or historical data for trending on graphical displays and on tabular displays. Further it shall be possible to trend real-time and historical data on the same graphical and tabular trend displays (say previous day and current day frequency being trended on the same display). It should be possible to trend different types of parameters (P, Q, V, I, F etc.) with associated Scales on the same display. Trending of parameters on the same display shall be supported. The user shall be able to select a trend rate different than the sampling rate separately for each trended parameter. Major and minor interval of x & y axis should be user- configurable for any data or time. There shall not be any limitation of trends associated with a single display.

Objects like small window showing trend curve or any table in a selected display should be possible. Tabular & trend presentation of the recent history (user

Thimphu: Bhutan
Office of the Bhutan Power System Operator

configurable sample time and duration) of any data should be available on operator console.

It should be possible to highlight or locate the minimum, maximum and average value of each visible trend through a simple user action.

All SCADA points, System parameters such as communication and application parameters shall be made available for trending, by default. Once the SCADA point is selected for trending, it shall display default period which should be user specified, both in graphical and tabular form. At least one month data should be readily available in the Trend database to provide instant view to the operator based on the selected time period.

3.6.3.1 Graphical Trending

The user shall be able to select and configure trending on Graphical displays enabling user for entry of the following parameters:

a) Data values/name
b) Trend header
c) Scales (unidirectional and bi-directional)
d) Zero offset
e) Trend data rate
f) Trend start time and date (historical and real-time data, minimum of 7 days)
g) Total trend duration (historical and real-time data)
h) Reference lines or shading axes (with default to alarm limits)
i) Colour should be user configurable.

There shall be automatic movement of data down or across the screen as new values are generated. When the number of real-time trend samples reaches the limit that can be displayed, the oldest value shall automatically be removed as the display is updated.

The magnitude of all the trended quantities at a particular time instant shall be displayed when the cursor is placed on the timescale on the trend display. Further the user shall be able to scroll and zoom the viewed area forward and backward.

Shading between each trend value and user-definable axis shall be provided. The major and minor grid shall be user configurable e.g. on the x-axis the time format and displayed time shall not be only displayed as a multiple of “GMT + 6:00”. Trend color shall be changeable based on a comparison of the trend value against associated alarm limits.

Office of the Bhutan Power System Operator Thimphu: Bhutan

Facility to plot X-Y curve on any background where "X" and "Y" could be any user selected tag of real-time or Estimated data.

Possibility of plotting one variable with respect to other shall be there in the system. For e.g. PV curve, PQ curve, etc.

3.7 Tabular Trending

Tabular trending shall be a listing of the time-sequential values of parameters. The tabular trend shall present the data in a tabular form with one column for Date/time and additional columns for each of the trended parameter. It shall be possible to scroll up and down to see the rows. The sampling rate shall be individually definable for each tabular trend.

The user shall be able to print the trend on a user-selected printer without interfering with the continuing trending process.

3.8 Alarms

Alarms are conditions that require user attention. All alarms shall be presented to the user in a consistent manner. Alarm conditions shall include, but not be limited to, the following:

a) Telemetered or calculated value limit violations
b) SCADA/EMS application program generated alarms
c) Communication link failures.
d) SCADA/EMS system hardware or software failures.
e) User Configurable logics.

Each alarm shall be subjected to a series of alarm processing functions. Alarm conditions shall be assigned to one or multiple alarm category and alarm priority levels. Alarms shall also be subjected to advanced alarm processing. The results of the alarm processing shall determine the console(s) that will receive and be authorized to respond to the alarm and the associated actions with the alarm.

All alarm messages shall be recorded and archived in chronological order. Minimum 7 days ALARMS shall be available in real-time. It shall be possible to sort, display and print user selected alarm messages from any console by the user.

3.8.1 Alarm Categories

An alarm category provides the logical interface that connects an alarm condition to a specific Area of Responsibility (AOR) as defined and accordingly alarm shall be reported to user. Every alarm shall be assignable to a category. Each category shall, in turn, be assignable to one or more consoles. A means shall be provided for changing

Thimphu: Bhutan
Office of the Bhutan Power System Operator

operating shifts without reassignment of alarm categories at a console. Console failure shall result in automatic reassignment of alarms to other consoles in a pre-defined manner and shall generate an alarm. Each log-on and log-off shall be reported as an event.

3.8.2 Alarm Priority levels

Each alarm shall be assigned to an alarm priority level. Up to 10 alarm priority levels shall be supported. Each alarm priority level shall be presented in separate display. Provision for element wise alarm for on-line Database editing shall be there. For each alarm, it shall be possible for the programmer to independently configure the following actions:

a) Audible alarm tone type selection and its enabling/disabling. The silencing of audible alarms shall be recorded as event.

b) Alarm messages to be displayed on an alarm summary

c) Alarm message deleted from alarm summary when acknowledged

d) Alarm message deleted from alarm summary when return-to-normal alarm occurs

e) Alarm message deleted from alarm summary when return-to-normal alarm is acknowledged

f) Alarm message deleted by user action.

g) Alarms message shall be generated in SCADA system for events such as failure of primary source of data, e.g. UPS failure, battery failure.

Every Alarm shall be accompanied by an Audible tone which shall be user configurable in real time for some particular events, like:

- Frequency drop.
- Overloading of some important lines.
- Tripping of transformers and lines.
- Generation tripping of stations (individual and total).
- And as per the operator’s requirement.

A dedicated display shall be provided for selection of Audible Tone in separate category of Alarms. The automatic generation and sending of an E-mail and SMS containing operator selected Alarm or user-defined data shall be possible.

This assignment shall determine how the alarm will be presented, acknowledged, deleted, and recorded. All acknowledged Alarms shall be reported as an event along with the identification of user and/or the workstation.

3.8.3 Advanced Alarm Management

Additional standard products for advanced alarm management shall be provided. Desirable features of the alarm management function, as available in the standard product shall be supplied which may include:

a) Minimization of nuisance alarm messages (e.g., repetitive alarms for the same alarm condition)

b) Highlighting of the most urgent messages

c) Display of Alarms Substation wise

d) Sort, filter of alarms by users by node, element, type, date & time.

e) Intelligent Alarm processing (Alarm based on logic of alarms) - to assist operator in quickly finding the root cause of disturbance.

3.8.4 User Interaction for Alarms

The User shall be able to perform the alarm interactions described below

- Alarm Inhibit/Enable
- Alarm Acknowledgment
- Change Alarm Limits
- Annotate an alarm by adding a comment
- Attach a note or document to an alarm
- Copy / Paste and export Alarms into an Spreadsheet and all MS-Office formats for offline analysis

3.8.4.1 Alarm Presentation

Alarm presentation shall be determined by the alarm's category and priority. Displays shall highlight every alarm condition using a combination of color, intensity, inverse video, and blinking. The alarm condition highlighting shall show whether the alarm has been acknowledged. The highlighted alarm condition shall appear on all displays containing that device or value at all consoles regardless of the alarm's category.

Alarm messages shall be a single line of text describing the alarm that has occurred and the time of occurrence. The alarm message shall not require the use of a reference document for interpretation.

The user shall be able to change the alarm limits, inhibit/ enable alarms and acknowledge alarms. All actions (except acknowledgments) shall be logged as events.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

3.8.4.2 Alarm Window

Each screen shall include a scalable window containing symbols for substations, generating stations, computer system facilities and others. These symbols shall blink when an alarm condition is detected for a device or value associated with the symbol. Blinking shall cease and the symbol shall be highlighted when all alarms associated with the symbol are acknowledged. The symbol shall return to its normal presentation when the last alarm associated with the symbol is deleted. Cursor selection of the symbol in alarm shall result in the presentation of a display associated with the symbol.

A special alarm window shall be provided, in which the most recent alarm messages shall be displayed. All summary alarm views shall support ad-hoc sorting. Clicking on a column header in the alarm view (time, station, priority, etc.) shall sort the alarms by that column.

All summary alarm views shall support ad-hoc filtering in which a user can specify filtering criteria in order to easily locate specific types of alarms. Examples include, but are not limited to:

a) Specific Time/Date ranges

b) Alarms exceeding a particular severity

c) Alarm messages containing particular device names

d) Alarm messages containing user annotations

e) Filtering on basis of device type, line name, etc.

It shall be possible to save any number of filtered alarm views for easy retrieval in the future.

3.9 Events

Events are conditions or actions that shall be recorded by the SCADA/EMS system but do not require user action. Events shall be generated under the following conditions

a) User initiated actions

b) Conditions detected by application functions that do not require immediate user notification, but should be recorded.

c) Values returning to normal from a limit violation state event.

Events shall be recorded in the form of an event message. The event message format shall be similar to the alarm message format. Event messages shall be displayed on an events summary.

Event messages shall be archived in chronological order. It shall be possible to sort, display, filter and print event messages from any console.

3.10 Hardcopy Printout

The SCADA/EMS system shall have features to produce a print out of a display, reports, trends, alarms, events etc. from a menu. It shall be possible to take print with various options e.g. Print the viewport, Print the complete display adjusting to a specified page size, Print a selected portion of a display or screen.

The displays shall be printed with white background by default. The borders of the viewport, rulers, file tab shall not be visible in the printout of any display unless specifically chosen. Multiple page displays shall have page numbers like Page X of Y. Also, the options for printing shall include at least choice for orientation, background color, page size, inverse color option, color/ black & white and print preview.

All hardcopy printout shall include the following additional default information apart from the display print out:

a) Date and time of the print out
b) Name of the user who has given the print out command
c) Identification of the console from where print out was generated
d) Name/ Identification of the display

Snapshot of any display full and part thereof if required should be printable in a fit to page format.

3.11 Dynamic Data Presentation

It shall be possible to present any item in the database on any display. All data control capabilities shall be supported from any window of a world display. Device status or data values shall be displayable anywhere on the screen, excluding dedicated screen areas such as the display heading.

All fonts supported by the operating system delivered shall be supported by SCADA/EMS system. Standard X-Window system fonts shall be provided with the SCADA/EMS. Local language fonts (true type fonts) shall also be supported. All fonts shall be supported on the user interface devices and all printers supplied with the system. The types of fonts to be used in a particular display shall be selected at display definition time. There shall not be any limitation on the color and size used for the fonts.

Status and data values shall be presented in the following formats as appropriate:

a) Numerical text that presents analog values, sign and flow direction arrows.
b) Normally the telemetered MW-MVAr values along with the sign and direction shall be displayed on the Single line diagram (SLD) and Network diagram. Bus

Voltage & Frequency shall also be displayed on SLD & Network diagram.

c) Symbols, including alphanumeric text strings for an item, based upon state changes e.g., circuit breaker (OPEN/CLOSE/ INVALID).

d) Symbols, including alphanumeric text strings for indicating the data quality flags.

e) Colours, textures, and blink conditions based upon state or value changes or a change of data quality, e.g., alarm limits.

f) Display of static as well as dynamic fields at any desired angles should be possible - e.g. Static Text of “MW” flow of a line aligned with the line on the world display.

Sample Display building approved guidelines are attached at Annexure-B, the same shall be followed.

3.12 Element Highlighting

Element highlighting techniques shall be provided to draw the attention of Dispatcher to critical state of the system. The highlighting technique such as, change of color, size, color intensity, blinking, Character inversion, Line texture, appended symbols etc. shall be supported. This feature shall be used to highlight alarms, power system device and measurement status, data quality, data entry locations on a display and error conditions.

3.13 Display Types

The following list describes the type of displays that are to be included in the SCADA/EMS system. All Displays shall be having default setting for showing Date & Time. Also wherever applicable Energized/ De-energized state of Power System Elements shall be identified.

3.13.1 SCADA/EMS System Display

A display shall be provided that lists all SCADA/EMS system directory displays. The displays shall be listed in alphabetical order with suitable separation in the list to enhance readability. Each entry in the list shall have a cursor target for display selection. A search facility / filtering should be provided. The displays shall have retrieval with maximum 3 clicks, layered architecture with full control of individual layer, 3D movement. Display features such as Auto-fit to Screen shall be provided. Mash-up interface with Google earth shall also be provided.

Feature to “find/search” stations in the geographical display shall be possible. In case of any pre-defined event the Geographical visualization shall automatically focus on that point grabbing operator attention.

3.13.2 Power System Network Display

A Graphic overview of power system network display of the lines, feeders, network elements color coded by voltage shall be provided. This display shall present the transmission system in a graphic format. Telemetered and calculated data like Real and reactive power flows shall be displayed as a value with a direction arrow. Lines that have exceeded their loading limits shall be highlighted. Substations and power stations shall be depicted by symbols that reflect the presence of alarms at that substation or power station. Cursor selection of a substation/ power station symbol shall result in the associated Single line diagram display for that substation/ power station. Further a graphic overview of national power system network display indicating the important feeders/network elements shall also be provided. Provision for making selection among multiple sets of busload distribution factor, to find the BLF output shall be made available and display for BLF output shall be made available on Network Display.

3.13.3 Interchange Display

The interchange display shall be provided as a schematic diagram showing power transfers between various area/ utilities/ entities. This diagram shall show each power system as a block with actual and scheduled net interchange values outside/ inside the block respectively. Symbolic arrows shall indicate power flow directions. The diagram shall also show schedule deviations. This display shall show the frequency values from substations having tie-lines.

3.13.4 Substation Single Line Diagram Display Menu

A display shall be provided that lists all substations that can be viewed via a Single Line Diagram (SLD). The name of the SLD displays shall be listed in alphabetical order, according to substation name, with suitable separation in the list to enhance readability. Each entry in the list shall have a cursor target for graphic display selection. The menu selection shall allow the user to view the SLD display menu.

3.13.5 Simplified & Chronological SOE Display

The user interface shall be provided for real-time Sequence of Event (SoE) with a dedicated GUI provided to the operator for this purpose.

3.13.6 Sub Station SLD Displays

SLD displays shall be provided for the monitored substations. Each display shall present telemetered, manually entered, and calculated power system data on a Single line diagram that shows substation layout in terms of its buses, switches, lines, and transformers. The feeder names in the SLD shall have linkage with remote substation end SLD associated with that feeder. It shall be possible to move to remote-end substations SLD by selecting this feeder. The user shall be able to perform any user interaction defined by the Specification on these displays. Displays should be "display-

Office of the Bhutan Power System Operator
Thimphu: Bhutan

fit" and there should be no unutilized space. Estimated data shall also be shown on the display.

In the SLD the device names should be displayed along with each device. The names should be automatically generated from the database at the time of creating such displays. Incorporation of any update/changes made on the SLD display into the database automatically maybe preferred.

3.13.7 Substation Tabular Displays

Tabular displays shall be provided for each substation. These displays shall list the real-time values of telemetered, manually entered, and calculated data associated with the substation as well as related information such as alarm limits. The user shall be able to perform any user interaction defined by the Specification on these displays. Display max/min/avg. of 5 min., 15min., 30min., 60min., 6hr., 12hr. & 24hr. Data with time stamp.

3.13.8 Alarm Summary Displays

Display that list or summarize all unacknowledged and acknowledged alarms shall be provided. The summary shall separate acknowledged and unacknowledged alarms. Capacity shall be provided for alarm messages for each alarm summary type. If an alarm summary display becomes full, the oldest messages shall be automatically deleted and the newest messages shall be added. It shall be possible to perform any alarm interaction from this display. Sorting and filtering of alarms on the basis of area, station, voltage level, device type, etc. or any of the combinations of these shall be provided.

3.13.9 Event Summary Displays

Event Summary displays shall list the most recent events and shall be organized by category for those categories assigned to a given console, as one summary display for all categories assigned to a console, or by all conditions system-wide without reference to the categories assigned to a console, as selected by the user. The user shall be able to select between viewing events in chronological or reverse chronological order.

3.13.10 Operating Information Summaries

The operating information summaries defined below shall be provided. Summary items will be listed in reverse chronological order with the most recent item shown on the first page. All summary displays, shall be information-only displays; no user interaction other than display call-up, shall be associated with them.

3.13.10.1 Manual Override Summary

The manual override summary shall list all telemetered and calculated device status and data values for which a user has substituted a value.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

3.13.10.2 Off-Normal Summary

The off-normal summary display shall list devices and values that are found to be abnormal, i.e., are not in their normal state. Telemetered, calculated, and manually entered status and data values shall be included.

3.13.10.3 Out-of-Scan Summary

The out-of-scan summary display shall list device status and data values that are not currently being processed by the system. If an entire telemetry source such as a data set is out-of-scan, the out-of-scan summary shall display the source without any of the individual device status or data values associated with the source.

3.13.10.4 Alarm Inhibit Summary

This display shall list devices and data values for which the user has suspended alarm processing.

3.13.10.5 Graphical Trending Summary Displays

The summary display shall list all items being trended. The list shall include the item name, trace number or color, trend orientation, and trend range. Real-time visualization of data should be possible in graphs such as Pie, Scattered, Surface, Load Duration Curves, Contours, Three-dimensional, data represented in the form of Analog meters, Bar graphs, line graphs, etc.

3.13.10.6 Tabular Trending Summary Displays

The summary display shall list all items being recorded for tabular trends. The list shall include the item name and the file name.

3.13.10.7 Log sheet Summary Displays

The summary display shall provide a list of the log sheets recorded during a 8 hour shift, day, week and month as desired by the user. Further it shall be possible to list the log sheet by username, date, time, serial number.

3.13.10.8 Notepad Summary Displays

This display shall list all the notes attached with displays.

3.13.11 Telemetry Information Summary Display:

Tabular display with filtering of entire telemetered data should be possible using operators such as AND, OR, NOT or any other means and Sorting should also be possible on the basis of Region, Division, Voltage level, type of equipment, data type, data quality, substation, generating station, etc. in ascending, descending and alphabetical order. If operators such as AND, NOT, or OR is used then it must support nesting of operators which is not in the existing system.

Office of the Bhutan Power System Operator Thimphu Bhutan

3.13.12 Contour Displays:

It shall be used for showing large amounts of spatial data e.g. bus voltage magnitudes, percent loading of lines. Displays shall be with facility of appearance of visual alarm of underlying layers and background color for gradient before alarm. Contour of following analogs shall also be available -

Line Flow contour, Overloaded Lines contour, Generation contour, Load contour, etc. Contour of Bus summation should also be available so as to help in getting the mismatches in the data. If redundant MW and MVAr measurements are available in the station then the operator should have a dedicated station-wise display in order to select/deselect the extra analogs used in bus summation.

Geo-spatial display with contour map of Data within geographical boundary of Bhutan shall be provided in which Zoom-in, Zoom-out, Panning option shall be available in the map. Display Builder shall be capable of importing point and placing a pre- defined picture/symbol as per the Latitude and Longitude specified by the user. The “Playback” option shall be made available in the map so that the continuous pattern over the period of time shall be visualized. The pattern shall be exported in a video format so as to use it in offline mode.

The displays mentioned above need to be shown on an interface with background such as Google Map, and it shall have provision for updating manually the latest background map as per user requirement during the project life cycle.

3.13.13 Log Sheets Displays

This display shall facilitate operator to enter messages related to operation of power system. Each message shall have separate log sheets. These log sheets display shall contain serial no., date and time, User name, Message text , message code (if any) and shutdown codes. When a user requests for a new message entry in log sheet, the SCADA/EMS system shall open a new log sheet display with a continued serial no., date and time, User name and space for entering text (up to 5 pages) and code. On completion of the message entry, the system shall prompt for saving the log sheet in the log book or for editing of the message. Once the message is saved in the logbook, the editing of the message shall be prohibited. The message writing shall be facilitated by selection of power system elements from drop down/other methods.

These log sheets shall be stored in the form of log book. Log books shall be archived in Historian system. It shall be possible to retrieve set of log sheet for given period of minimum last 24 hours, say from 06:00 Hours to 14:00 Hours.

3.13.14 Computer system Configuration and Monitoring Displays

Graphic and tabular displays shall be provided that allow the user to:

a) Monitor and revise the configuration of the computer system supplied under the

Thimphu: Bhutan
Office of the Bhutan Power System Operator

project.

b) Monitor the system's resource utilization statistics

3.13.15 Communication Network display

This display shall show information of communication display of the status of the communication links being used for data exchange with other control centers. The display shall also indicate the healthiness of standby communication links. Failure of main or standby communication links shall be suitably alarmed.

3.13.16 SCADA/EMS Application Program Displays

Application program displays shall be provided to satisfy the user interface requirements of the system functions stated throughout this Specification. Application program displays shall be based on a standard user interface design across all applications to provide a common look and feel (excluding for COTS Historian System). The application's information shall be presented in such a way as to facilitate user operations.

3.13.17 Contingency Analysis Display:

The result shall be displayed on the world map and also on 3D display clearly highlighting elements violated with width of the element/ height of 3^{rd} dimension proportional to present value and status change, if any.

3.13.18 Voltage Profile Display

Voltage profile displays shall be provided to present different voltage levels on a geographical display in form of contours. Further, the areas with various voltage levels shall be shown with different colors.

Another voltage profile display shall be provided in form of three dimensional (3-D) display showing voltage contours in a time scale (e.g. voltage levels at Morning Peak, Day off Peak, Evening Peak and Night off Peak) with different colors.

The displays mentioned above need to be shown on an interface with background such as Google Map, etc.

3.13.19 ICCP Database Editing Display

ICCP data base modification display shall be provided to do incremental changes in ICCP database (e.g. addition/deletion of individual Status/Analogue data or stations entire dataset for any ICCP link of that Control Centre.) using standard editing tools of full graphics windows User Interface from the ICCP and SCADA database. Above dedicated display can also be a part of database development system. However it should facilitate all above interaction to achieve ICCP database changes.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

3.13.20 Help Displays

Help displays shall be provided to aid the user in interpreting displayed information and to guide the user through a data entry or control procedure. Help displays shall be provided for each display that is provided with the system. Each display shall have a prominent cursor target that the user can select to request the associated help display. For standard displays, software aids (such as context sensitivity) shall be used to present pertinent help information in an expeditious manner. A programmer shall be allowed to modify and create help displays.

3.13.21 Historian Data display

Historian display shall be different from other displays and shall have user friendly features such as tabs or icons for events, major disturbances, outages etc. for quick report generation for a defined time period. Recently and frequently used fields for report generation and configuration shall be stored as “favorite” reports. The display shall have drop down menus for:

- ✓ Data Elements (MW, MVAR, Min, Average, Max, etc.) and calendar view for selection of Year, Month, week, date and time.

On the display, Provision for selection of format shall be made available (option for word, Excel, PDF) with Export button. On the top of the display types of reports should be displayed, e.g. daily report, Monthly Report etc.

3.13.22 Web Server Displays

The web servers shall provide access to remote clients through COTS Web browsers. If any software component is required for the remote client, the same shall be downloaded to the remote clients whenever clients connect for the first time.

The web server shall use the same SCADA/EMS displays as the real-time SCADA system but render it through web services to the remote clients.

3.13.23 Generator capability curve Display

The display shall show - PQ Generation vis-à-vis PQ capability curve in continuous shifting pattern**.**

3.14 GUI for Text transfer over ICCP

The display shall show the Texts being transferred between Control Centers through ICCP. A dedicated Graphical User-Interface (GUI) shall be provided for the same.

GUI for On-line editing of ICCP database shall be made available to the user. Proper Graphical User Interface for online editing of the ICCP database and mapping with other control centers should be provided.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

3.15 Integration with Electronic Documents

Information related to power system equipment often resides in standard format electronic documents (PDF, DOC, XLS, JPG, etc.). In order to minimise the time for users to locate this related information when needed, the user interface shall provide a mechanism for accessing electronic documents related to any device on a display. This shall be through right-click menu option or similar.

The functionality to send messages and files between SCADA/EMS workstation consoles and to and from workstation consoles between NLDCs (Main & Backup) shall be provided.

Examples of Electronic Documents that should be available in this fashion include:

a) Digital Images

b) Equipment Manufacturer documentation (PDF or HTML)

c) Maintenance and other Historical Reports

d) Switch Orders, etc.

SECTION 4

SYSTEM SOFTWARE REQUIREMENTS

CONTENTS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 4
SYSTEM SOFTWARE REQUIREMENTS

4.1 General Requirements

This section describes the characteristics of system software such as Operating system, and support software (compilers, database development and maintenance, display development, network services, Report generation, diagnostics, security and Backup utilities) provided by Contractor and the original equipment manufacturer (OEM) as necessary to support the applications of SCADA/EMS system. Audit by Operating System OEM for system configuration after Installation & Commissioning shall be tied by the vendor for the proposed system. This section also describes the standards to be followed for all supplied software.

4.2 Software Standards

All software of SCADA/EMS system provided by the Contractor, including the Operating system, Database and support software, shall comply with the industry-accepted software standards. In areas where these organizations have not yet set standards, the software shall comply with those widely accepted de-facto standards put forth by industry consortiums. The Contractor shall commit to meet the "open systems" objective promoted by industry standards groups.

4.2.1 Design and Coding Standards for SCADA/EMS applications

All applications of SCADA/EMS system shall be maintainable by owner using the supplied software utilities and documentation. The software design and coding standards of SCADA/EMS system shall address the followings:

Expansion: Software shall be dimensioned to accommodate the size of SCADA/EMS system as given in **Appendix-C and Appendix-F**.

Modularity: Software shall be modular i.e. functionally partitioned into discrete, scalable, reusable modules consisting of isolated self-contained functional elements and designed for ease of change. The system shall make maximum use of common industry standards for interfaces.

Portability & Interoperability: The system shall be designed for hardware independence and operation in a network environment that facilitates interoperability and integration of third party applications. SCADA/EMS should support multiple database systems including Oracle, Microsoft SQL Server and MySQL.

4.2.2 Operating System

The operating system of all the equipment of SCADA/EMS system including network equipment shall be latest version released up to six months prior to FAT. The operating system shall be hardened to provide robust security. In order to facilitate cyber security requirements including patch management, common operating system is preferable to be used by all server nodes within the SCADA/EMS including Real-time servers, applications servers, and ICCP servers.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.3 Time and Calendar Feature

A GPS based time reference shall be used for synchronizing the SCADA/EMS system time periodically. The internal clocks of all Servers and workstation consoles shall be automatically synchronized within the accuracy of +/-100 milliseconds of synchronized GPS time on NTP protocol. The calendar shall be customizable for working hours, local holidays, weekends etc.

4.4 Network Software

The network software includes software for network communication, network security and network services. The network software shall be provided for each type of network node connection supplied with the initial system and shall be licensed for the quantities and types of nodes defined for the system configuration. It should be able to generate reports for a defined period regarding availability of communication links. In case any communication link is DOWN/OUT/Failure then a pop-up should come up for it along with the SMS and e-mail facility shall be implemented for the same. For the Network Communication, the software shall use a standard network protocol such as TCP/IP.

4.4.1 System Security

The Contractor shall document and implement a Cyber Security Policy in association with the Employer/Owner to secure the system in line with Government guidelines. The overall policy and implementation shall account for:

- Network partition and DMZ through use of Firewall as required to maximize the security of SCADA/EMS system while facilitating access for data and information to all stake holders.
- Implement trusted, un-trusted and DMZ with clear perimeter.
- Prevent users from reading or writing data or files, executing programs or performing operations without appropriate privileges.
- Document all user sign on Auditing during FAT, SAT and during AMC period.
- Record network traffic for detecting unauthorized activity, unusual activity and attempts to defeat system security (SCADA/EMS system designer to propose and document what constitutes normal activity/traffic).
- A user authentication scheme consisting at least of a user identification and password shall be required for the user to request a connection to any network node.
- All unused ports (physical and logical) of all routers and switches shall be disabled.
- All unused services shall be disabled on request.
- In routers, only the specified/required IP addresses should be OPEN.

4.4.2 Remote Diagnostic

Remote Diagnostic facility with necessary Hardware as required shall be provided for communication between the SCADA/EMS system at control center and the Contractor's & Employer/Owner's support office for the diagnosis of system problems. The login shall be protected by a user name & password entry.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.4.3 Network services

The following network services shall be provided for the users of SCADA/EMS system within the LAN if not in conflict with security requirements:

a) Network file management and transfer of files containing text, data, and graphics information
b) Network printing management
c) Network time synchronization
d) Backup over LAN
e) Task-to-task communications to external computers
f) Remote procedure call
g) Remote terminal session

4.5 Network Management system (NMS)

The Network management system shall facilitate following activities:

- Security / Monitoring to protect systems and network from unauthorized access, manage user access, authorizing rights and privileges
- Inventory Management to collect information about computers in the system such as processors, memory, peripherals and processes running on computers
- Performance Management to monitor system and network performance as specified
- Fault Management to recognize, isolate, log and identify fault on network and connected machines, nodes, devices.
- Preferably centralize, consolidate, and correlate events from various disparate monitoring tools.
- Facilitate as universal interface to determine and resolve IT issues quickly across servers, storage, network and Workstation.
- A prediction routine/subsystem/utility using analytics shall be built on top of a real-time, dynamic monitoring to correlate metric abnormalities.
- NMS should be able to prioritize issues based on business impact.

The network management software shall be based on the secured version of Simple Network Management Protocol. The NMS system shall have a user friendly browser based user interface. The NMS shall not impact the availability and performance of SCADA/EMS system.

The Network management system shall monitor from single dashboard and correlate the performance, resource usages and error statistics of all the servers, workstations, routers and LAN devices including propose Employer/Owner networks extension as required:

i) Utilization (CPU and/or channel time being used as applicable) for
   - Servers, Workstations, Storage Devices
   - LAN, Router, Switches
   - Data Links
ii) Memory utilization, Auxiliary memory I/O utilization, of
   - Servers and Other critical nodes

Office of the Bhutan Power System Operator Thimphu: Bhutan

- Mass Storage Devices

The Network Management Software shall:

a) Maintain performance, resource usage, & error statistics and present this information via displays, periodic reports, and on-demand reports. Apart from real-time monitoring, the above information shall be collected and stored at user configurable periodicities i.e. 5 minutes to 60 minutes. The historical data shall be stored for a period of one year at a periodicity of 5 minutes. NMS shall be able to generate reports regarding utilization of RAM and CPU. Export of this data shall be possible in ".csv", ".xls" formats.
b) Maintain a graphical display for connectivity and status of servers and peripheral devices for local area network. Issue alarms when error conditions or resource usage problems occur.
c) Report on application, server and network events from a single console, for faster triage and diagnostics, compliance to provide the IT search and intelligence analytics. The period over which the statistics are gathered shall be adjustable by the user, and the accumulated statistics shall be reset at the start of each period. The statistics shall be available for printout and display after each period and on demand during the period.

4.6 Database Development System (DDS)

The Contractor shall provide all necessary software tools for the development and maintenance of the SCADA, EMS, ICCP, Historian and other databases at Control Center. This tool shall be capable of managing the entire system database. The database development software tool delivered with the SCADA/EMS system shall be used to generate, integrate and test the database.

The database development tool shall facilitate IEC 61970 CIM data exchange of both Incremental and full power system model. CIM compliance shall be provided amongst the CIM version of existing Control Centers as listed in appendix.

The database tool should have facility to export and import model files as per IEC 61970 part 552-4. The product should have facility for exchange and transformation of Power System Model files including Generation and Load through execution of Power flow applications. The following instance data shall be included in the above said exchange:

1. Generation Values
2. Load Values
3. Measurements
4. Transformer Settings
5. Generator voltage control values
6. Device States
7. MVAr Values for Shunt Compensators

This tool shall contain database structure (format) definitions and all initialization data to support the generation of all run-time databases required to implement the system's

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SCADA/EMS functions. The tool shall include consistent procedures to manage and access the databases regardless of the location of the data or the residency of the database management functions within a Control Center. All exchange, co-ordination and procedure required across a Control Center shall be independent of each other. This tool shall allow following modes:

- Incremental data exchange of a function.
- Complete data exchange of a Control Center.

Reasonability, integrity, and referential integrity checks shall be made on user entries to detect errors at the time of entry. Invalid entries, such as entering an invalid data type or attempting to define contradictory characteristics for a database item, shall be detected and reported to the user in an error message. Help displays shall be available to provide additional, detailed information to the user on request.

DDS shall be installed in the NMS/DDS Server alongside the NMS applications.

4.7 CIM compliant Data Modeling Import & Export Tool

The bidder shall provide Database import and export tool, which shall be CIM (Common Information Model- 61970) compliant. This tool shall be repository of NLDC data model and shall facilitate exchange of data model across control centers. A user friendly UI shall be provided to extract/transform/load; as required; model data/parameter/devices for interchange with other Control Centers. The Import & Export Tool shall have feature of searching, sorting and merging on parameters/ devices/ nodes/ company's including that of Power System. It is desirable that the tool facilitate identification and search of nodes/ telemetry points/ values to be exchanged from a given Control Center. The tool shall be able to import & export different versions of CIM.

The tool should be capable of importing and exporting data in PSS/E formats, alternately separate utility may be provided for the same.

4.7.1 Database Management

The database manager shall locate order, retrieve, update, insert, and delete data; ensure database integrity; and provide for backup and recovery of database files. The database manager shall generate and modify all SCADA/EMS data by interfacing with all database structures. In systems with a distributed database, the database manager shall have access to all portions of the database wherever stored. The location of database items shall be transparent to the user performing database maintenance.

Execution of the database manager in any server of the system shall not interfere with the on-line functions of the SCADA/EMS including the normal updating of each server's real-time database. In a primary server, database editing shall be limited to viewing functions, database documentation functions, and functions that change the contents but not the structure of the database. Editing the on-line database shall not affect the operation of the primary/backup configuration.

All newly defined points shall be initially presented to the user with default values for all parameters and characteristics where defaults are meaningful. It shall also be possible to

Thimphu: Bhutan
Office of the Bhutan Power System Operator

initialize a new database point description to an existing database point description. The user shall be guided to enter new data, confirm existing data, and change default values as desired.

All required entries for any database item selected for changes shall be presented to the user. When parameters are entered that require other parameters to be specified, the additional queries, prompts, and display areas required to define the additional parameters shall be presented automatically.

The database manager shall include the mechanisms, in both interactive and batch processing modes, to perform the following functions:

a) Add, modify, and delete telemetered, non-telemetered, or calculated database items and data sources such as data links, and local I/O.
b) Add, modify, and delete application program data
c) Create a new database attribute or new database object
d) Resize the entire database or a subset of the database
e) Redefine the structure of any portion of the database.

A utility function shall be provided that creates, from the run-time database, a source file suitable for submittal to the global database batch processing facility. This utility shall create a new global database file, suitable for editing, that reflects any changes made to the run-time database since the last time the database was generated.

ICCP association with other control centers should be made simultaneously and automatically irrespective of the cause such as Onlining, Communication failure, dataset failure, software failure at either of the ends.

4.7.1.1 Modelling of Power System elements

Modelling of elements for SCADA and Network Applications may be different and the database Administrator shall have the options for above modelling.

4.7.1.2 On-Line Database Editing

Selected database management functions and changes to a run-time database shall be possible without requiring a database generation. These shall be limited to viewing functions, database documentation functions, and changes to the contents, but not the structure of the database. On-line changes shall be implemented in all applicable SCADA/EMS run-time databases without requiring any downtime of the system. Changes shall also be implemented in the global database to ensure that the changes are not lost if a database regeneration is performed. On-line database editing shall not affect the SCADA/EMS system's reaction to hardware and software failures nor shall it require that the exchange of data among servers for backup purposes be suspended. The On-line editing of database and its backup to standby machine should not result into the failover of servers.

4.7.1.3 On-line editing of ICCP database

Online editing of ICCP database shall be made available to the user. Proper User Interface for online editing (without involvement of server failover or re-start) of the ICCP database and mapping with individual control center shall be provided. Provision of ICCP mapping and its editing shall also be provided.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.7.2 Tracking Database Changes

The database manager utility shall maintain Audit trail files for all changes made by all users including on-line database editing. The audit trails shall identify each change including date and time stamp for each change, and identify the user making the change. An audit trail of last 10,000 edit operations shall be maintained.

User shall be able to compare two cases of database at any point of time in Online cases as well as Offline cases.

4.7.3 Initial Database Generation

The Contractor shall be responsible for the initial database generation using data available at control center in association with the Owner. The Contractor shall arrange the required software tool to acquire the initial data from the existing control center at his own cost. The owner shall provide the access to these regional control centers for acquiring the required data.

4.7.4 Development System as a Test Bench

Development system shall be able to provide testing facility for integration of new Control center with Main and Backup SCADA/EMS system before putting it online with Real-time system.

- Integration of new Control Center on ICCP protocol: Development System shall be used to test the integration of new Control Center on ICCP with Main and Backup Control Center. Development System shall have the capability of modelling new ICCP connections for both Main and Backup Control Centers.
- This system shall also be used as a **Test bench for Cyber security** and shall accordingly be equipped with firewall, antivirus and enable mode wherein threat scenarios can be tested with configured security elements before implementing on the main/production system.
- This Test bench for Cyber security shall also be used for VAPT (Vulnerability Assessment & Penetration Tests) e.g. OS fingerprinting, Port scanning etc.

In test bench mode, Development System shall be able to connect through the existing LAN/WAN to the new Control Center and test the link step by step as well as continuous run mode up to 24 hours to observe the data acquisition/exchange process. During the continuous run mode the data collected shall be stored in a temporary files /tables for review to assess effectiveness and stability of integration. All relevant logs for monitoring the communication with Control Center under test such as defined for regular SCADA/EMS system shall be stored and presented and reported on similar displays. The Hardware required for necessary connectivity including the interface with communication links shall be included as part of Development System Hardware.

4.8 Display Generation and Management

The Contractor shall provide necessary software tools preferably browser based for the generation and management of SCADA/EMS displays for both SCADA/EMS system. Display fit, with proper utilization of space, clear visibility of analogs in display fit also with no unused space shall be provided. Utility to import displays through XML files from other control centers shall be possible.

SCADA/EMS displays shall be generated and edited interactively using this display generation software delivered with the system. The display generator and management features specified in the following paragraphs shall be available at the workstation console.

All displays, symbols, segments, and user interaction fields shall be maintained in libraries. The size of any library and the number of libraries shall not be constrained by software. The display generator shall support the creation, editing, and deletion of libraries, including copying of elements within a library and copying of similar elements across libraries. A standard set of libraries and libraries of all display elements used in the delivered SCADA/EMS system shall be provided. All libraries shall have directories that list all elements contained in the library. These directories shall be displayable and printable on demand. All libraries shall include a library compression facility that consolidates unused space created by removal of old elements to allow efficient reuse by added elements.

Displays shall be generated in an interactive mode. The user shall be able to interactively:

a) Develop display elements
b) Link display elements to the database via symbolic point names
c) Establish display element dynamics via database linkages
d) Define linkages to other displays and programs
e) Combine elements and linkages into display layers
f) Combine display layers into displays.

Execution of the display generator functions shall not interfere with the on-line SCADA/EMS functions.

All workstation features and all user interface features defined in this Specification shall be supported by the display generator software. An audit trail of all interactive generations and edits shall be maintained by the display generator software. An audit trail of last 5,000 edit operations shall be maintained.

The display generator shall support the addition, deletion, and modification of segments, including the merging of one segment with another to create a new segment. Segment size shall not be limited. Segments shall be defined at an arbitrary scale factor selected by the user.

4.8.1 Dynamic Transformation Linkages

Dynamic transformations shall be performed on symbols and display segments based upon dynamic linkages to database variables. All linkages to the database shall be defined via symbolic point names. Each symbol or segment stored in a library shall include its dynamic transformation linkages, although the specific point names shall be excluded. Dynamic transformation linkages shall support the dynamic data presentation.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.8.2 Display Generation and Integration

The displays shall be constructed from the display elements described above. The display definition shall allow displays to be sized to meet the requirements of the SCADA/EMS application for which they are used; displays shall not be limited by the size of the viewable area of the screen. The display generation software shall allow unbroken viewing of the display image being built as the user extends the size of the display beyond the screen size limits. Each display shall include the display coordinates definition that will permit a user to navigate successfully to the portion of the display that is of interest.

It shall be possible for a user to build a new display starting with a blank screen, a DXF formatted file imported from another system, or an existing display. Graphic display shall consist of multiple display layers. The definition of each layer shall include a range of scale factors over which the layer shall be visible. The display generator shall also support manual control of layer visibility, where the user of the display shall determine the layers on view. Each display may incorporate manually and automatically (by scale factor) displayed layers. The user shall also define the periodic update rate of the dynamic information on the display and any programs called before or after presentation of the display.

The display generator shall support the integration of new and edited displays into the active display library. During an edit session, the display generation software shall allow the user to store and recall a partial display. To protect against loss of display work when a server fails, the current work shall be automatically saved every five minutes (user adjustable) to an auxiliary memory file.

The display generator shall verify that the display is complete and error-free before integrating the display into the active display library. It shall not be necessary to regenerate any display following a complete or partial system or database generation unless the database points linked to the display have been modified or deleted.

4.8.3 Import / Export CAD Drawings

The display generator shall support the import of drawings, including power system one-line diagrams, developed by Employer/Owner on Auto CAD. The display generator should have the capability to import the files from latest version of AUTOCAD including older versions for display generation. Further the drawings may also be used in the SCADA/EMS system as the static background for displays. The display generator shall provide the capability (through the display generation process), to add, delete, and modify the dynamic information supplied to the drawings using the specified features of the display generation and management software. As necessary, Employer/Owner will replace the static background by importing a new drawing from the CAD system and re-linking associated database elements. The display generator shall allow a user to update the dynamic information to reflect any changes required by the updated drawing.

The display generator shall also have facility to export the SCADA/EMS displays in DXF or DWG format to be used in AUTOCAD.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

4.9 Software Utilities

Some of the software utilities, which are required to be delivered along with the SCADA/EMS system, are described here. However Contractor shall supply all software utilities used to develop and maintain SCADA/EMS software, whether or not specifically described by this Specification.

The software utilities shall operate on-line (in background mode) without jeopardizing other SCADA/EMS application functions those are running concurrently. Utility software shall be accessible from workstations, processor terminals and servers.

4.9.1 USB port controller utility

The utility shall enable control on USB ports for disabling unauthorized usages. Its functional specifications shall be as follows:

- It shall block USB devices based on device identity, port identity, device type (e.g. allowing all keyboards, etc.)
- A provision for listing acceptable devices (white-listing) shall also be provided.
- It shall log all USB port access events.

A dedicated system shall be identified for exchanging data with SCADA system in a secure manner after scanning the file to betransferred.

4.9.2 Auxiliary Memory Backup utility

Software utility, to take backup of auxiliary memory files of server and workstation onto a user-selected archival device such as NAS on Network, shall be supplied. The backup utility shall allow for user selection of the files to be saved based on:

a) Server and workstation
b) File names (including directory and wildcard designations)
c) File creation or modification date and time
d) Whether or not the file was modified since the last backup.

A utility for taking image backup of auxiliary memory files of the Servers and workstations shall be provided. The utility shall allow restoration of the servers/workstation from this image backup without requiring any other software.

4.9.3 Image Backup and Restoration Utility

An image backup of the as built system of each of the Servers and workstations shall be provided on a user-selected archival device such as NAS on Network or any state of the art backup system, which shall be used to restore the system. Automatic full or incremental back up capability of selected systems at user defined intervals shall be provided. It should be possible to restore or recover any software/system at a selected time from backup. Last three image back-ups to be maintained.

4.9.4 On-Line Monitoring Diagnostics

On-Line monitoring diagnostic programs shall be provided for verifying the availability of the backup equipment and for limited testing of devices without interfering with on-line operations of the SCADA/EMS system or the failover capability of the devices.

Redundant communication line interface equipment shall be tested by periodically retrieving data over these lines and checking for the ability to communicate with the redundant channel and for any errors.

Designated backup server(s) and associated auxiliary memories shall be automatically tested for proper operation to ensure they are ready if needed for a failover contingency. Any failure to perform diagnostic functions correctly shall cause an alarm to be issued.

4.9.5 Data Exchange Utilities

Facility of data export and import from and to SCADA/EMS system to external system shall be provided as detailed below:-

- **Through OPC Server**: A full OPC server compliant to the latest standard shall be provided in order to export real time data, alarms, historical data etc. to the external system. OPC clients for WINDOWS and Linux shall also be supplied. If client software is based on the user system than at least 15 user license for each shall be provided. Server should be licensed accordingly.
- **Through ODBC/JDBC**: Capability of export of SCADA data to external system through ODBC shall be provided. All system parameters in the real- time database including real time data, calculated data, application configuration parameters and application output shall be available through the ODBC interface. Limitation if any or pre-requisite on PC for use of this interface, shall be clearly defined. It shall be possible to export data through SQL queries to external system.
- **Injection of external values**: Suitable facility of injecting values from external system to SCADA database should be provided. API along with utilities shall be supplied to facilitate this feature. It should be possible to use this API for developing the programs on Windows or Linux system using .NET or Java languages.

4.9.6 Other Utility Services

The SCADA/EMS shall include the following utility services:

a) Loading and storage of information from labelled portable media storage units as dictated by the requirements of this Specification.

b) On line access to user and system manuals for all software products (e.g., Operating System and Relational Database Software) and SCADA/EMS applications shall be provided with computer system.

c) The contractor shall provide utilities for preparing the .pdf output for the displays/reports available in the SCADA/EMS system. It should also be possible to export all such reports to any MS-Office format.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

d) Displays and Reports for Web server - The Contractor shall provide utilities for preparing displays and reports suitable for Web publishing. These utilities shall be used to generate, all required displays and reports from the SCADA/EMS system displays and reports, automatically (without requiring rebuilding).
e) Antivirus Software - All computers and firewalls shall be provided with the latest antivirus software as on date of supply. The antivirus software shall have the capability of having its virus definitions updated from time to time. The Contractor shall be responsible for the maintenance & update of the antivirus software.
f) Software Upgrade - The Contractor shall be responsible for the maintenance & update of the patches and signatures of Operating system, SCADA/EMS system and Web System up to AMC period.

Automated patch management tools shall be provided to expedite the distributions of patches to the system. These tools should consider the possibility to use standardized configurations for IT resources.

4.9.7 E-Log Book (or Shift Log Book)

This utility shall be installed on Operator's console and shall be used by the shift operators. Functional Requirements of e-logbook are as follows –

- Minimum direct data entry through features such as configurable list boxes and check boxes with pre-configured site-specific information.
- Users with necessary access rights can create new shift messages manually.
- Logs shall be accessible by multiple users according to permission levels.
- It shall generate message codes for switching activity in the grid.
- Any selected Alarm, SoE, event and log shall be sent as an entry to the logbook.
- Automatic population of standard fields from other reports (for e.g. relevant information from the operator's report should automatically get populated in the shift supervisor's report.)
- Export information to Excel, Word, CSV and PDF.
- Import information from Excel and CSV.
- Storage of logbook data should be in SCADA Historian.
- Statistical analysis of messages and logs data shall be possible.
- Filtering and searching features.
- On demand printing.
- Multiple status markings for shift book entries such as "pending", "sent for simulation", etc. The entries with such status would be carried forward automatically to the next shift operator's logbook.
- It shall be possible to link attachments to and entry and get it displayed.
- Selecting any shift book entry and transmitting it bye-mail.
- Multicolor options for different priority levels of logs.

4.10 Device Configuration of Network Equipment

The device configuration of all the network equipment shall be as per the latest Cyber Security guidelines given by Government appointed Organization.

4.10.1 New Generation Firewalls

As per the proposed network architecture, both the external and internal firewalls should be properly configured to segregate networks into different segments. The following strategies shall be followed for secure configuration of firewalls:

- Cleanup rule.
- Place a ‘Deny Any-Any’ rule at the end of the rule base.
- Never create an ‘Allow any-any’ rule.
- Allow rules should be created only for required services.
- This will result in all traffic being disallowed, unless specifically allowed.
- Lockdown/stealth rule.
- All traffic destined for the firewall itself should be disallowed.
- Anti-spoofing rule.
- Place anti-spoofing rule as per RFC 1918 and 2827.
- Enable DoS/DDoS features on Firewall.
- Enable application level filtering of firewall including for SCADA.

4.10.2 Routing features

Necessary control should be applied on the router to stop unwanted traffic and attacks at the perimeter itself. In the secure configuration of a router, the following strategies should be considered:

- Deploy proper access management and avoid remote administration.
- Enable secret password.
- Change default SNMP community string.
- ACLs (Access Control Lists) should include
- Apply egress/ingress filter
- Filter all RFC 1918, 3330 address space and special/reserved address
- Permit the required services for the required IP addresses only
- Deny everything else.
- Turn on logging to a central syslog server.

4.10.3 Intrusion Detection & Prevention System

The required features of the Host Based Intrusion Detection Systems (HIDS) and Network based Intrusion Prevention System (NIPS) are described below:

4.10.3.1 Intrusion Detection and Prevention System (Host Based):

Host based Intrusion Detection and Prevention System module shall be provided for all machines. IDS shall be able to perform following actions:

Thimphu: Bhutan
Office of the Bhutan Power System Operator

- Capability for Detecting the intrusion attempt that may take place, intrusion in progress and the intrusion that has taken place.
- Flag and check unauthorized access
- Notify/Alarm/message of intrusion to:
  a. Management console
  b. Event log
  c. Administrator by e-mail
- Create an audit trail for user and file access activity, including file accesses, changes to file permissions, attempts to install new executable and/or attempts to access privileged services
- In an event where user accounts are added, deleted, or modified, changes to key system files and executable is done in by unauthorized account or there is unauthorized attempt to overwrite vital system files, to install Trojan horses or backdoors suitable action should be taken such as:
  a. Terminate User (intruder) Login
  b. Disable User (intruder) Account
  c. Forge a TCP FIN packet to force intruder connection to terminate
- Should provide events check for suspicious file transfers, denied login attempts, physical messages (like an Ethernet interface set to promiscuous mode) and system reboots.

4.10.3.2 Network based Intrusion Prevention System (NIPS):

The NIPS shall provide complete inline protection from network-based application layer threats by scanning packet payloads for malicious traffic. It shall detect, classify and stop malicious application, viruses, worms and spyware/adware etc.

After detecting an intrusion attempt NIPS should be able to perform following actions:

a) Reconfigure the firewalls provided in this package.
b) Send an SNMP Trap datagram to the management console.
c) Send an event to the event log.
d) Send e-mail to an administrator to notify of the attack.
e) Save the attack information (timestamp, intruder IP address, victim IP address and port, protocol information).
f) Force intruder connection to terminate.
g) NIPS shall have capability to detect various operating system of devices/ servers running on the network and profile them for more visibility and protection. (for Impact assessment & Vulnerability analysis).

4.11 Cyber Security

The following guidelines/strategies shall be taken care of by the Contractor for making the entire Control Center immune to Cyber Attacks.
All the Hardware, OS and application software shall be hardened.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

- Network Zoning shall be implemented as per the proposed architecture given in **Appendix – I of Part-A**. However, the Contractor may suggest other methods of network architecture without compromising the security of the System.
- No user shall be allowed to access remote network zones other than the adjacent zone.
- All default user id & passwords shall be changed.

All log in/log out and cable plug in/plug out shall also be logged in Central Syslog server.

4.12 Monitoring of Critical Infrastructure Protection Standards

A dedicated software utility/application shall be deployed in the system as part of NMS or on dedicated nodes having following features:

- Proactive management of threats through automated collection, and delivery of identified patches (all major operating systems and applications) across delivered networks.
- Complete network-based scanning enabling assessment and analysis of threats impacting network.
- Configurable monitoring to enable Regulatory and standards-based assessment of end points compliance.
- Create custom remediation packages to address recurring configuration issues, remove unauthorized files and applications, and patch software.
- Robust data warehouse that enables creation and sharing of reports on all aspects of the system's remediation efforts in support of policy compliance.
- Comprehensive - software that streamlines and automates audit workflows and IT risk management to provide crucial visibility across the IT environment and ensure compliance with identified regulations, mandates and internal policies.
- Policy-based enforcement of application use to secure endpoints from malware, spyware and unwanted or unlicensed software.
- Policy-based enforcement of removable device use to control the flow of inbound and outbound data from endpoints.
- Asset Discovery - scan network and auto-discover the assets, saving hours of manual effort, and increasing trust in the identification of systems and software in delivered environment.
- Continuous Monitoring - continuously collect detailed status information on all critical cyber assets and immediately detect any changes.
- Automated Assessment - automatically aggregate and analyze security data and alert on suspicious events or modifications that impact compliance status.
- Audit-ready Evidence - quickly generate reports and dashboards that fully document, by requirement, compliance with security controls and processes.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 5
HARDWARE REQUIREMENT

Thimphu: Bhutan
Office of the Bhutan Power System Operator

CONTENTS

SECTION 5
HARDWARE REQUIREMENT

1.1 General

This section describes the technical requirements of all the hardware envisaged in the BOQ for the SCADA/EMS system. The minimum hardware specifications (RAM, Aux. Memory, interfaces etc.) for all equipment are specified in **Appendix-H** as enclosed with this document and the bidder has to submit the details of the supplied hardware**.** The Bidder shall asses the adequacy of hardware specified in the BOQ & if any additional hardware or higher end hardware configurations are required to meet all the requirements of the technical specifications, the same shall be included in the offer. **The Bidder's proposal shall include necessary calculations to clearly establish that the proposed hardware meets the functional and performance requirements of the technical specification.**

The bidders are encouraged to optimize the requirement of hardware for servers and processors where one or more applications can be combined or distributed in any combination with adequate redundancy. However certain applications are to be hosted on independent hardware.

1.2 Technical Requirements for Hardware

All hardware shall be manufactured, fabricated, assembled, and finished with workmanship of the highest production quality and shall conform to all applicable quality control standards of the original manufacturer and the Contractor. All hardware components shall be new and suitable for the purposes specified. All hardware shall be of reputed make.

All hardware shall include self-diagnostic features. On restoration of power after interruption they shall resume operation. All servers, workstations (consoles), and network equipment (Switches, routers, firewall etc.) shall be compatible for remote monitoring using secure SNMP Ver. 3.0. All hardware shall support both IPv6 and IPv4.

The contractor shall ensure that at the time of final approval of hardware configuration and BOQ, all the hardware is as per the current industry standard models and that the equipment manufacturer has not established a date for termination of its production. Any hardware changes, except version upgrade in same series, proposed after contract agreement shall be subject to the following:

a) Such changes/updates shall be proposed and approval obtained from Employer along with the approval of Drawings/documents.
b) The proposed equipment shall be equivalent or with better features than the equipment included in the Contract.
c) Complete justification along with a comparative statement showing the original and the proposed hardware features/parameters including brochures shall be submitted to the Employer for review and approval.
d) Changes/updates proposed will be at no additional cost to the Employer.

Thimphu: Bhutan Office of the Bhutan Power System Operator

e) The porting of software shall be at no additional cost in case of replacement of hardware during the AMC period by Owner in consultation with contractor.

1.3 Hardware Configuration

In this technical specification all hardware has been broadly classified as “Server” and “Peripheral device”. The term “server” (also referred as “processor”) is defined as any general-purpose computing facility used for hosting application functions as defined in the specification. The servers typically serve as the source of data, displays, and reports. The term “Peripheral Device” is used for all equipment other than servers. Peripheral device includes Workstation consoles, WAN router, LAN, printer, Time & Frequency system, storage device, Firewalls etc.

The redundant hardware such as Servers, Firewall, and LAN etc. shall work in hot standby manner. All the servers and networking equipment (Firewalls, LAN equipment etc.) shall be mounted in rack panel. The Typical hardware configuration is attached at **Appendix H.**

1.4 Servers (Rack mountable Servers)

The Servers shall have provision for expansion of the Processor, auxiliary memory and Main memory (RAM) by 100% of the delivered capacity. This expandability shall be possible at site with addition of plug in modules.

Rack mountable Servers: Servers shall be mounted in a rack (panel) and rack mountable TFT monitor, keyboard and mouse using an IP based KVM switch to access all servers & peripherals in the panel. However the grouping of servers in a rack shall be such that the primary and backup servers for a system function are located in different panels.

All servers shall be hot swappable, have backplane redundancy, dual redundant power supplies and be capable to operate on single power supply module. And there shall not be any interruptions in the operation of servers when there is a failover between the two AC Power Supply of the server. Power supply related Alarms shall be integrated with SCADA and corresponding alarms (both audio and visual) shall be displayed for the operator.

Servers supplied shall be compatible to connect with the external storage and other network components identified in the BOQ, necessary additional hardware (if any) required for connectivity shall be part of servers.

1.5 Networking Equipment

1.5.1 Firewall/New Generation Firewall

The New Generation Firewalls shall be provided as per BOQ. It is required that both side firewalls (Internal and External) are supplied from two different manufacturers. All firewalls shall be hardware box firewall as per the requirements mentioned in **Appendix-H.** It shall be capable for data exchange between two networks over various communication media such as copper cable, fiber optic cable, etc.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

The contractor shall provide firewall with URL filtering, AMD features, an Intrusion Detection and Prevention System (including alerting to the network administrator of malicious network activity originating from internal or external sources), which shall be integrated to detect and prevent intrusion, worm, virus, etc. It also should support third party remote VPN client including its software. Definition updates for virus, signatures, software patches, subscription etc. shall be done or taken care by the contractor until the end of the AMC period.

1.5.2 Local Area Network (LAN) and device interfaces

Dual LAN is envisaged for the System at both Main Control Centre and backup Control Centre. LAN switches shall be as per the features mentioned in **Appendix H**.

1.5.3 Centralized Management Console (CMC)

A separate appliance/server/machine shall be supplied to be used as Centralized management console for the HIDS, NIPS, firewall & Anti-APT (Advance Persistent Threat) Device, and Router cum firewall. The management console shall perform the following functions:

- Create and deploy new policies.
- For Centralized Logging of messages from all systems across the network as a Central Syslog server.
- Collect and archive audit log for post event analysis.
- Maintain an Integrated Event Database.
- Provide an integrated Reporting System.
- Getting Virus definition, signature, patches etc. update from internet and updating the system automatically.
- Keep latest copy of the definitions and configurations defined in respective network device e.g. routes/configuration defined in Routers, policies defined in firewalls, etc.
- Performance monitoring.

1.6 Auxiliary Storage for Historian

Auxiliary Storage shall be provided that shall be sized adequately and be used for online storage and all online data backup for Historian. It shall be connected to the server through specialized high speed cable. The historian system shall facilitate Employer’s Application data storage also. The sizing of the same shall be suitably sized by the contractor to meet the specification requirements. There shall not be any single point failure i.e. there shall be zero down time with single element failure. The supplied storage should be able to transfer the data from this storage to SCADA/EMS server via the Historian server seamlessly and it must be user configurable.

1.7 Network Area Storage (NAS)

A NAS shall be provided for storing image backup of all servers and workstation. It should be possible to restore or recover any software/system at a selected time from backup. The NAS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

shall be sized to accommodate all servers' and workstations' image backup. Also, there should be possibility to store at least 3 previous image backup files of servers and workstations.

1.8 Workstation Consoles

Workstation console shall consist of a workstation driving one or more monitors, a single wireless keyboard and a wireless mouse. Wireless range of Keyboard and Mouse should be at least 20 meters. The user shall be able to switch the keyboard and mouse, as a unit, among all the monitors at a console seamlessly.

Workstation consoles shall be used by the dispatchers or operators for control, monitoring, and operation of power system. All workstation consoles shall support full-graphics displays. In addition, each workstation in the Control room shall be provided with two speakers for alarming.

1.9 Router

Router shall be used for data exchange between various control centers over various communication media such as copper cable, PSTN/leased line, fiber optic cable, etc. The router shall have the following features:

- shall support the OSI and TCP/IP protocols
- Shall support dynamic discovery of routes
- Shall support 10/100Mbps dual LAN interface, however Routers for Remote console end may have single LAN interface
- shall support X.21/ V.35/G.703 interface for interfacing with communication links
- shall support a speed of 64 kbps configurable up to 2 Mbps at each port

For normal operation, router shall use all channels between two control centers and in the event of any channel failures, traffic shall be re-routed to the remaining healthy channels with an attempt to generally balance the load.

1.10 Engineering Terminal

The Engineering Terminal shall be a Laptop to facilitate portability. Processor terminal shall have dual LAN interface, USB, HDMI port, etc. This mobile workstation/craft terminal (laptop) shall be from reputed brands with minimum configurations features as specified in the **Appendix H**.

1.11 Printers

All printers shall be interfaced with dual Ethernet LAN. Except for output capabilities unique to any printer type (such as extended character sets or graphic print capabilities), there shall be no limitations on the use of any printer to perform the functions of any other printer.

1.12 Video Projection System (VPS)

The VPS will be used to project displays of SCADA/EMS system independently of workstation console monitors. The supplied SCADA/EMS software and hardware shall use the Existing VPS system (M/s Barco) and integrate seamlessly.

1.13 GPS based Time Facility

To determine Universal Coordinated Time (UTC) source, GPS based Time Facility shall be provided for Control Centre computer system. The time receiver shall include propagation delay compensation and shall also include an offset to permit correction to local time.

The time receiver shall detect the loss of signal from the UTC source. A loss-of-signal shall be sent to the computer systems and used as a telemetry failure indication and result in an alarm in the SCADA system.

The GPS system receiver unit shall have digital displays for viewing UTC day of the year, time and frequency display. The frequency display shall have suitable interface with the SCADA system such that any selected power system frequency measurand in the SCADA system can be assigned to it. Local Frequency shall be captured and displayed in SCADA for the operator.

All required interface in this regard shall be included in the scope of supply.

1.14 Furniture

The contractor shall provide furniture as per the following specifications. All furniture shall be of reputed make and shall be complied with the latest version of standard ISO 11064. However the specific design, finish and color of all furniture shall be subject to Employer's approval.

a) Workstation desk:

Each workstation/ shall be provided with a suitable desk as follows:

- Sectional frame suitably clad with hardwood or hard wearing material.
- Desktops of a durable, scratch resistant, non-reflecting finish of suitable thickness.
- Proper Channels for Power, LAN and Telephone cabling with 100% spare capacity i.e. integrated cable management system shall be in place.
- Adequate space shall be provided on the desktop for writing area, to accommodate the operator workstation, mouse, telephone console and other miscellaneous items.
- Drawers, shelves and miscellaneous fittings.
- Access shall be allowed for maintenance to equipment mounted on or in the desk. Pull out Drawer, Doors or removable panels shall be provided for this purpose.
- Adjustable (Height) Desks (sit-and-stand with step-less automatic height adjustment).

- Independent electronic powered height adjustment of monitors' platform and work space.

b) Chairs

- Two chairs shall be provided at each workstation.
- The chair shall be of high backed design with arm rests, covered in durable woven material.
- The chairs shall be of good quality and suitable for continuous use without discomfort.
- Pneumatic Seat height and back angle adjustments shall be provided, capable of easy operation.

c) Furniture/Fixtures for all other items which are not mounted in the racks (e.g. Printers) shall also be provided by supplier.

1.15 Environmental Conditions

Equipment located in the computer/ control room shall operate over an ambient temperature range of 16˚C to 30˚C, with a maximum rate of change of 5˚C per hour. Relative humidity will range from 20% to 80% non-condensing. Further, all Hardware to be supplied under the project shall be RoHS complaint (Restriction of Hazardous Substance) in Electrical & Electronics Equipment.

1.16 Acoustic Noise Level

The noise level of any equipment located in the server room shall not exceed 60 dbA measurements at three feet from the enclosure. The noise level of equipment located outside the server room shall not exceed 50 dbA three feet from the enclosure. Sound-deadening enclosures shall be provided where necessary to meet these requirements.

1.17 General Construction Requirements

The enclosures/panels, used for mounting or placement of equipment, shall be constructed in accordance with the following requirements.

1.17.1 Panels

In case the equipment are mounted in panel type of enclosures, then such enclosures shall be finished inside and out. All cabinet metal shall be thoroughly cleaned and sanded to obtain a clean, smooth finish. All surfaces shall be treated to resist rust and to form a bond between the metal and the paint.

Moving assemblies within the enclosure, such as swing frames or extension slides, shall be designed such that full movement of the assembly is possible without bending or distortion of the enclosure or the moving assembly. Enclosures shall not require fastening to the floor to preclude tipping of the enclosure when the moving assembly is extended. No cables shall be

Thimphu: Bhutan
Office of the Bhutan Power System Operator

visible, all cables shall be properly clamped, and all entries shall be properly sealed to prevent access by rodents.

Cooling air shall be drawn from the conditioned air within the room. Ducted or directed cooling air to the enclosures will not be supplied by Employer.

All wiring shall use copper conductors. Conductors in multi core cables shall be individually color coded.

Wiring within the enclosures shall be neatly arranged and securely fastened to the enclosure by non-conductive fasteners. Wiring between all stationary and moveable components, such as wiring across hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wire.

All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame retardant material and shall not produce toxic gasses under fire conditions.

The panel shall have door on both sides.

The finish colors of all enclosures/panels shall be finalized during detailed engineering. The rack shall be provided with trays for mounting routers, KVM switches, NIPS devices also. There should be provision for 12 plug power strips (at Least).

1.17.2 Enclosure Grounding

A safety ground in accordance with Bhutan standards shall be provided within each enclosure and shall connect to the ground (green) wire of the ac power input. All necessary and required Earthing shall be provided and executed by the vendor. However, in case of existing Earthing, all necessary test shall be carried out by the vendor and approved by the Employer.

1.17.3 Interconnections

All signals cabling between component units of the computer systems shall be supplied by the Contractor. Plug-type connectors with captive fasteners shall be used for all signal interconnections. The connectors shall be polarized to prevent improper assembly. Both ends of each interconnection cable shall be marked with the cable number and the identifying number and location of each of the cable's terminations. Each cable shall be continuous between components; no intermediate splices or connectors shall be used. Terminations shall be entirely within the enclosure. Different color-coding standard for cable identification shall be used.

SECTION 6
CONFIGURATION CHARACTERISTICS

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CONTENTS

SECTION 5
CONFIGURATION CHARACTERISTICS

The ability of the SCADA/EMS systems to perform their specified tasks under normal conditions and under conditions of hardware and software failure is of paramount importance to employer. This section presents requirements for monitoring and managing the hardware and software configurations of these systems.

1.1 General Requirements

The SCADA/EMS system envisages some functions as critical functions and others as non-critical functions as defined in Part-B of the specifications. Every critical function must be supported by sufficient hardware and software redundancy to ensure that no single hardware or software failure will interrupt the availability of the functions for a period exceeding the automatic transfertime.

The non-critical functions may not be provided with hardware and software redundancy.

The redundancy requirement for hardware of SCADA/EMS system at control centers shall be as follows:

LAN switches: The System shall have dual LAN architecture for systems as shown in Part – A: Appendix-I. All LANs shall be configured as redundant. All equipment shall have dual LAN connectivity.

Servers: All the servers for critical applications shall be configured as redundant.

Printers: All Printers shall be non-redundant devices.

Workstation Consoles: These shall be configured as non-redundant devices.

GPS based Time facility & digital indicators: The time and frequency system & digital indicators shall be configured as a non-redundant device.

New Generation Firewalls/Routers: Firewalls/Routers shall have physical redundancy as well as channel redundancy i.e. redundant channels of a remote destination shall be configured on different routers.

Communication interfaces with other control center computer systems: The communication interfaces with other control center computer systems shall be configured as redundant.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

1.2 Server and Peripheral Device States

A server group is one or more servers that perform a subset of SCADA/EMS or other application functions in either a primary/backup manner or distributed manner (where the on-line functions performed by the server group are distributed among multiple primary servers). For example, one server group may be configured to perform all SCADA and Scheduling Functions, while other server groups perform ICCP and PSA functions.

Server and device states shall identify the operating condition of each Server and peripheral device of SCADA/EMS systems and shall be used to determine the system's reaction when restart and failover operations take place. Server and device states shall be assigned by failover functions, restart actions, and by user command.

1.2.1 Server States

Each Server shall be assigned to one of the following states:

a) Primary: A primary Server performs any or all of the on-line functions described in this Specification

b) Backup: A backup Server replaces a primary Server in the event of primary Server failure or upon user command. It shall communicate with the primary Server to maintain backup databases and monitor the state of the primary Server.

c) Down: A Server is down, when it is not communicating with the SCADA/EMS system and is not capable of participating in any system activity.

1.2.2 Peripheral Device States

Each peripheral device shall be assigned to one of the following states:

a) Primary: The primary peripheral device is logically attached to a primary Server or primary Server group. If the primary Server or primary Server group fails and its functions are reassigned to a backup Server or backup Server group, the peripheral device shall follow the reassigned functions.

b) Backup: A backup peripheral device is used to replace a primary peripheral device in the event of primary peripheral device failure. It shall communicate with the primary Server or primary Server group to maintain its readiness to be assigned as a primary device.

c) Down: A down device cannot be accessed by the SCADA/EMS system.

1.2.3 Functional Redundancy

Every critical function must be supported by sufficient hardware redundancy to ensure that no single hardware and software failure will interrupt the availability of the functions for a period exceeding the automatic transfer time.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Replacement of faulty items of the system and its restoration shall not result in any loss of functionality or performance. The stand by elements of redundant system shall be fully monitored at all times.

Non-critical functions are those that support maintenance and development of database, application software and training of users. No hardware redundancy is envisaged for these functions.

1.3 Server and Device Interconnections

Redundant interconnections shall be provided among all Servers within a Server group, among all Server groups, and among all Servers (including Server groups) and all workstations located in control center. The interconnections shall support Servers and peripheral devices data exchange over both the LANs. Recovery from a single LAN or any other interconnections failure shall not require any failover. Loading of both the LANs shall be equally distributed.

1.4 Backup Databases

The system shall maintain backup copies of all databases without requiring any manual intervention, so that system operations may continue in the event of Server, device or software failure. The backup databases shall be updated with the current contents of the primary databases such that all changes to a primary database are reflected in the backup database within 30 seconds of the change. The backup databases shall be maintained in such a manner as to be protected from corruption due to Server and device failure. Backup databases shall be preserved for system input power disruptions of any duration. The information maintained in the backup databases shall include:

a) Telemetered, calculated, and manually-entered values and their attributes, including quality codes, control inhibit state, and tag data

b) Data and associated attributes maintained by the Information Storage and Retrieval function

c) Alarm, event, and summary displays (such as off-normal, control inhibit, and alarm inhibit displays) or sufficient information to rebuild the displays in their entirety (including the time and date of the original data entries, not the time and date the display is newly created)

d) Application function execution, control, and adaptive parameters and input and output data, including power system analysis and scheduling save cases.

All Changes resulting from the addition or deletion of items in an existing database, structures and restructuring of databases shall be automatically backed up in the backup databases by the backup function.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

1.5 Error Detection and Failure Determination

All Servers, devices, on-line functions, and maintenance functions in system shall be monitored for fatal and recoverable errors. All errors shall be recorded by the system for review by maintenance personnel. Each type of error (e.g., Server failure, memory access violation, device reply time-out, or message checksum error) shall be recorded separately with a date and time tag.

Failure monitoring logic shall be distributed within the computing network and shall detect all failures that affect the availability of network resources or services. Failure monitoring functions shall be independent of application function and user modes. The failure monitoring and error detection function shall preferably provide event notification for 3rd party products e.g. SNMP messages.

An error manual shall be given listing down the trouble shooting manual for daily works.

A trouble shooting manual should be given to rectify the frequently encountered errors in the system.

1.5.1 Server Errors

All fatal and recoverable errors of all Servers operating in the primary and backup states shall be detected and recorded by the SCADA/EMS system. Server failure shall be detected and annunciated to the user within 10 seconds of the failure.

1.5.2 Device Errors

All fatal and recoverable errors of all peripheral devices shall be detected and recorded. Each type of recoverable error shall be assigned a threshold by the programmer. Peripheral device (except printers) failure shall be detected and annunciated within 10 seconds of the failure.

1.5.3 Software Errors

Execution errors in on-line and maintenance functions that are not resolved by program logic internal to the function shall be considered as fatal software errors.

Fatal software errors shall result either in termination of the function or shall be handled as a fatal Server error. The action to be performed shall be defined by the programmer for each function. If the function is to be terminated, future executions of the function shall also be inhibited until the function is again initiated by the programmer.

On the occurrence of each fatal software error, Server and operating system error codes and messages shall be recorded in the SCADA/EMS system.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

1.6 Server Redundancy and Configuration Management

When a failure of a primary Server in a redundant group is detected, the computer system shall invoke the appropriate server failure recovery actions. Failure recovery is the capability of automatically transferring the functions (failover) from primary hardware resources to secondary hardware resources or restarting the server when a failure-monitoring function detects a failure. The failover shall be the preferred failure recovery approach and restart shall only be used when failover is not possible.

After an error threshold-induced automatic transfer, the former primary server shall remain in an inactive (down) state so that a post-mortem analysis can be performed. A manual restart shall be necessary to bring it to the active ready state.

After a transfer caused by a Server failure or power loss, the former primary server shall either reboot into the ready state automatically or wait for manual intervention, depending on Employer's configuration management set-up.

If all alternate Servers are unavailable when the operating Server fails, the system shall attempt to automatically restart operating Server a programmable number of times.

Failures of Servers operating in the backup states shall not initiate failover or restart actions. The SCADA/EMS system shall only change the state of failed processor to 'DOWN'.

When a failure of a primary Server in a non-redundant group is detected, the computer system shall invoke restart actions. Functions assigned to a failed Server in a non-redundant group may be lost until the failed Server is restored to service.

All Server failures shall be enunciated by alarms. The alarms shall identify the failed Server(s), all Server state changes, and the success or failure of any restart and failover operations. For any server crash, manual transfer or threshold-induced transfer a crash dump file shall be automatically generated for analysis using standard interactive support tools. All such system events and crash dump file shall be transferred to Historian system automatically.

1.6.1 Server Failover

A failover (transfer of critical functions) to an alternate Server shall occur, as a minimum, under any one of the following situations:

- Non-recoverable failure of a server performing a critical function
- User request for a transfer of servers
- Failure of a periodic function to execute on schedule.

In the event of server failover, the functions of the failed Server shall be restarted in a working/functioning Server. Immediately upon detection of a failure, the failed Server's state

Thimphu: Bhutan
Office of the Bhutan Power System Operator

shall be changed to down state. All devices assigned to the failed Server shall be reassigned to its backup Server without any manual intervention.

The on-line functions of the failed Server, having execution periodicity less than or equal to 30 seconds, shall be assigned to its backup Server within 30 seconds of the failure except for Historian System. In case of failure of Historian System; the Historian System data shall be stored in the SCADA/EMS system till the failover of Historian System is completed to avoid data loss. This stored data shall be transferred to the Historian System automatically after restoration of Historian System.

The on-line functions of the failed Server, having execution periodicity greater than 30 seconds, which were in progress at the time of failover or were missed during the failover, shall be assigned to its backup Server within 120 seconds.

1.6.2 Restart

Restart involves the ability of any server to self-detect its non-recoverable errors and to attempt to restart the SCADA/EMS system functions.

The restart logic shall determine the desired state of the failed Server and the on-line function(s) to be initiated in this Server. The restart logic shall also preclude conflicts among Servers, such as assigning too few or too many Servers to the primary state and the erroneous duplication of functions in multiple Servers. All maintenance functions executing in the restarting Server shall be suspended to expedite the restart process.

Restart shall include initialization of the SCADA/EMS function(s) and internal parameters, updating of databases, establishing access to peripheral devices, and execution of the function(s). Databases may be updated from backup databases or from static initialization database copies stored on auxiliary memory depending on the nature of the restart. The use of the static initialization databases shall be restricted to user-invoked restarts. If insufficient peripheral devices are available to perform the on-line function(s), the restart logic shall generate an alarm requesting user intervention.

Restart as described above shall be completed within 30 seconds.

1.6.3 Server Start-up

A Server start-up shall be performed when commanded by a user and when Server input power is interrupted and restored such that the operating environment of the Server is established prior to restarting the on-line functions. Establishment of the operating environment may include execution of self-diagnostics, reloading the operating system and system services, and connection to and verification of communications with all nodes on the control center computer system LAN. The server start up shall be completed within 5 minutes with all functions scheduled for execution.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

1.6.4 System Power-On Start-up

The SCADA/EMS system shall automatically restart itself when input power is interrupted and restored. System start up shall include Server start up, initialization of all network devices, initialization of peripheral devices, initialization of all communications with data sources and other control centers, resumption of all SCADA/EMS functions and notifications to the users that startup has been completed. System power-on startup shall be completed within 10 minutes.

1.6.5 Server Redundancy

All the critical functions shall reside on redundant servers. One of the redundant Servers shall normally be assigned to the backup state and it may also participate in on-line activity as a primary Server for some functions as per the design of the contractor. It is Employer's intent that each control center computer system satisfies all of the performance requirements of this Specification with one Server of each Server group assigned to the backup or down state.

1.7 Peripheral Device Redundancy and Configuration Management

When failure of a redundant peripheral device is detected, the control center computer system shall automatically invoke the appropriate device failover actions so that on-line functions, which are using the failed device, are preserved. Failure of a server's dependent device like auxiliary memory, if any, may result in Server failover.

When failure of a non-redundant device is detected, the SCADA/EMS system shall not invoke Server failover or server restart actions. On-line functions using a failed, non-redundant device may be lost until the failed device is restored to service.

All device failures shall be annunciated by alarms. The alarm text shall identify the failed device(s), all device state changes, and the success or failure of any device failover operations.

1.7.1 Device Failover

The device failover shall result in an orderly transfer of operations to a backup device in the event of failure of primary device. The device failover function may replace a failed device with an identical backup device or with a backup device that is different from the normal device.

Device failover actions shall be completed and the backup device shall be operating within 30 seconds of detection of the device failure.

1.7.2 Device Reinstatement

Data links to other control center computer systems, failed devices shall be reinstated by user command only. If the control center computer system has failed any RTU, other data source, or the communication channel (including the modem/controller) connecting the system to the

Thimphu: Bhutan
Office of the Bhutan Power System Operator

RTU or data source, communications with the RTU data source shall be retried at a periodicity specified by the programmer. When reliable communications are re-established, as determined by a programmer-adjustable number of consecutive retries (initially three), the RTU, data source or communication shall be automatically returned to Operation.

1.8 Configuration Management Displays

Each SCADA/EMS system shall include schematic and tabular displays for configuration management. The displays shall depict the state of each Server, peripheral device, and their interconnections, and include facilities for initiating user- commanded changes to the state and assignment of devices to Servers and user- commanded restarts, Server and device failover and Server start-ups. Displays to view and control the status of backup databases shall also be provided. Status of SCADA/EMS functions (Primary/ Backup) shall be displayed on the display.

1.9 Data synchronization between Main and Backup Control centers

Both the Main and the Backup systems shall be operational during normal circumstances. The Main control center shall update the Backup Control Center automatically. Main Control Center shall be primary Control Center for operations at all times, when available. The sync periodicity of data at Backup Control Center from Main Control Center shall be as follow:

- Real time data shall be updated every 10 second
- Historian System data shall be updated at least every hour.

In case of failure of the Main Control Center, the Backup Control Center shall take over operations and functions of Main Control Center. When Main Control Center recovers from failure, Backup Control Center shall update all data, including Historian System data, at Main Control Center. The takeover of main Control Center functions by Backup Control Center shall require manual intervention.

Each SCADA/EMS shall be configured to communicate with other Control Centers as specified in the scope and shall have the database and full set of displays & reports. If communication with datasource is available with one Control Center (say main Control Center) and not with other Control Center (Say Backup Control Center) then other Control Center data shall be updated by the first Control Center which has updated values.

Both Main and Backup Control centers shall get the data on IEC 60870-5-104 from stations and data exchange among control centers on ICCP. Alternatively, backup System can be updated from the Main by exception within 10 seconds.

The real-time databases (except the databases used for development, display building, historical data) at both the control centers shall be synchronized (integrity check) every 600 seconds.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

The failover shall not be affecting the data communication and they would continue reporting to the Main and Backup Control center without any data loss.

The databases used for development display building and source code shall be synchronized on daily basis automatically.

Both the Main and Backup Control Center shall monitor each other's availability at least every 120 seconds by communicating to each other. An alarm shall be generated when a failure of the other control center is detected. In case of failure of the Main Control Center, the Backup Control Center shall takeover operations and functions. When Main Control Center recovers from failure, Backup Control Center shall update all data at Main Control Center for the period it was down.

SECTION 7

INSPECTION AND TESTING

CONTENTS

Thimphu: Bhutan

SECTION 7
INSPECTION AND TESTING

7.0 Introduction

All materials furnished and all work performed under this Contract shall be inspected and tested. Should any inspections or tests indicate that specific hardware, software, or documentation does not meet the specified requirements, the appropriate items shall be repaired, replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies? After correction of deficiencies, all tests necessary to verify the effectiveness of the corrective action taken shall be repeated. Deliverables shall not be shipped until all required inspections and tests have been completed, all deficiencies have been corrected to employer's satisfaction and the hardware and software have been approved for shipment by employer.

7.1 Inspection

Employer representatives shall be allowed access to the Contractor's facilities during system manufacturing and testing and to any facility where hardware or software is being produced. Office facilities, equipment, and documentation necessary to complete all inspections and to verify that the SCADA/EMS system is being produced and maintained in accordance with the Specification shall be provided to employer's representatives by the Contractor.

Employer representatives shall be allowed to review and verify the functional implementation of the SCADA/EMS software informally in conjunction with scheduled project meetings at the Contractor's facilities. No test plans, procedures or reports are required to support these informal software demonstrations.

Employer representatives shall be allowed to inspect the Contractor's hardware and software quality assurance standards, procedures, and records. Documents identified in the approved software quality assurance plan will be inspected to verify that the Contractor has performed the required quality assurance activities.

The inspection rights described above shall not apply to subcontractors supplying standard computer hardware, peripheral equipment, and third-party software products. The inspection rights shall apply to subcontractors developing new software for inclusion in the SCADA/EMS system and to sub-system suppliers. Generally, equipment items shall be inspected and tested as part of the hardware integration demonstration described in coming sub sections, and third-party software products shall be tested as part of the functional performance test described in coming sub sections.

7.1.1 Inspection Certificate

The Contractor shall give the employer Inspector 14 days prior written notice of any material being ready for testing in Bhutan and six weeks for outside Bhutan. Such tests and expenses of Inspectors shall be to the Contractor's account. The employer Inspector, unless witnessing of the tests is waived, will attend such tests on the scheduled date for which employer Inspector has been so notified or on a mutually agreed alternative date.

The employer Inspector shall, within 14 days from the date of inspection as defined herein, give notice in writing to the Contractor of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The

Thimphu: Bhutan

Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet said objections. When the factory tests have been completed at the Contractor's or Subcontractor's works, the employer Inspector shall issue a certificate to this effect within 14 days after completion of tests but if the tests are not witnessed by the employer Inspector, the certificate shall be issued within 14 days of receipt of the Contractor's Test Certificate by the employer Inspector. The completion of these tests or the issue of the certificates shall not bind employer to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.

In all cases where the Contract provides for tests, whether at the premises or works of the Contractor or of any Subcontractor, the Contractor except where otherwise specified shall provide free of charge items such as labor, materials, electricity, fuel, water stores, apparatus and instruments, as may be reasonably demanded by the employer Inspector or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall provide facilities to the employer Inspector or his authorized representative to accomplish testing.

The inspection by employer and issue of Inspection Certificate thereon, shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Program forming a part of the Contract.

The Contractor shall keep employer informed in advance of the time of starting of the progress of manufacture of material in its various stages so that arrangements can be made for inspection.

Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by employer's representative.

Certificates of manufacturing tests shall be maintained by the Contractor and produced for verification as and when desired by employer. No material shall be dispatched from its point of manufacture until it has been satisfactorily inspected and tested. Testing shall always be carried out while the inspection may be waived off by employer in writing only.

However, such inspection by employer's representative(s) shall not relieve the Contractor from the responsibility for furnishing material, software, and equipment to conform to the requirements of the Contract; nor invalidate any claim which employer may make because of defective or unsatisfactory material, software or equipment.

7.2 Test Plans and Test Procedures

Test plans and test procedures shall be provided by the Contractor for all tests (excluding inspections and software demonstrations pursuant to **Section 7.1**) to ensure that each factory and field test is comprehensive and verifies the proper performance of the SCADA/EMS elements under test. During the development of test plans and test procedures for the system, emphasis shall be placed on testing each conditional logic statement, checking error conditions, and documenting the simulation techniques used. The test plans and test procedures shall be modular to allow individual test segments to be repeated as necessary. They shall be subject to employer approval.

Thimphu: Bhutan

7.2.1 Test Plans

The test plans shall describe the overall test process, including the responsibilities of individuals and the documentation of the test results. The following shall be included in the test plans:

a. Test schedule on a day-by-day basis

b. Responsibilities of Contractor and employer personnel

c. Record-keeping assignments, procedures, and forms

d. Procedures for monitoring, correcting, and retesting variances

e. Procedures for controlling and documenting all changes made to the hardware and software after the start of testing

f. Block diagrams of the hardware test configuration, the external communication channels, and any test or simulation hardware.

7.2.2 Test Procedures

The test procedures shall describe the individual tests segments and the steps comprising each segment, particularly the methods and processes to be followed. The test procedures shall include the following items:

a. Name of function to be tested

b. References to the functional, design, user, and any other documents describing the function

c. List of test segments to be performed and the purpose of each test segment

d. Set-up conditions for each test segment, including descriptions of the test equipment

e. Descriptions, listings, and instructions for test software tools and displays if any.

f. Step-by-step descriptions of each test segment, including user actions for each test step

g. Expected results for each test segment, including pass/fail criteria.

h. Descriptions of the techniques and scenarios to be used to simulate system field inputs and controlled equipment

i. Copies of any certified test data to be used in lieu of testing.

7.3 Test Records

Complete records of all factory and field acceptance test results shall be maintained by the Contractor. The records shall be keyed to the test procedures. The following items shall be included in the test records

a. Reference to appropriate test procedure

b. Date of test

c. Description of any test conditions, input data, or user actions differing from that described in the test procedure

Thimphu: Bhutan
Office of the Bhutan Power System Operator

d. Test results for each test segment including a pass/fail indication

e. Identification of Contractor's test engineer and employer's representative if any.

f. Provision for comments by employer's representative

g. Copies of any variance reports generated

h. Copies of reports, display copies, and any other hardcopy generated as part of the test.

7.3.1 Reporting of Variances

Starting from the dry run test period, a variance report shall be prepared by Contractor personnel each time a deviation from the requirements of this Specification is detected in areas such as system functions, design parameters, performance, documentation, test plans, and test procedures. The report shall include a complete description of the variance, including:

a. Sequential identifying number assigned to the variance

b. Date and time the variance was detected

c. Appropriate references to the test procedures and this Specification

d. Description of test conditions at the time the variance was detected

e. Identification of Contractor and employer representatives

f. Estimated date and time when variance is expected to be fixed

g. Description of the corrective actions taken (to be completed as part of the variance resolution process)

h. Dated signature lines for the employer and Contractor representatives to signify reporting and correction of the variance.

Each variance shall be assigned to one of three classes defining the action to be taken to resolve the variance:

a. Class 1: Testing will immediately stop and the Contractor will evaluate and correct the variance before testing is resumed

b. Class 2: Testing will continue and the variance will be evaluated and corrected by the Contractor at the end of the current session but prior to further testing

c. Class 3: Testing will continue and the variance will be evaluated and corrected at a mutually agreed upon time.

The class shall be assigned by the Contractor with employer approval.

Variance reports shall be available to employer for review and comment at all times and shall be submitted by the Contractor to employer at the start of the availability test. The Contractor shall maintain and periodically distribute a variance summary that lists for each variance the report number, a brief description of the variance, its class, and its current status (open or resolved). A variance summary shall also be submitted with the progress report.

Thimphu: Bhutan

7.3.2 Resolution of Variances

All actions taken to correct variances shall be documented on the variance report by the Contractor. Sufficient information shall be provided to enable an employer representative to determine the need for and extent of retesting, the need for testing interactions of the correction with any previously tested hardware or software, and the need for updating appropriate documentation. A variance shall be deemed resolved after retesting has been performed to the satisfaction of employer and the Contractor and employer representatives have acknowledged correction of the variance on the variance report.

7.4 Test Initiation

The following conditions must be satisfied before starting any test (exclusive of inspections or demonstrations pursuant to **Section 7.1**):

a. All test plans and procedures for the test shall be approved by employer.

b. All hardware and software engineering design change orders shall be incorporated into the system under test.

c. All relevant documentation including drawings, lists of deliverables, and software functional and design documents, and user manuals shall be approved by employer.

d. A complete regeneration of the software under test for which source code is being supplied shall be performed immediately prior to the start of factory testing.

e. All operating system parameters, files, and configuration information shall be saved to archive media so that the SCADA/EMS operating environment can be recreated starting with an un-initialized system. The existence and completeness of this data shall be demonstrated to employer.

f. All database, display, and report definitions shall be saved to archive media so that the databases, displays, and reports can be recreated if necessary.

g. The image backup of all applications of SCADA/EMS system shall be taken on the archive media so that SCADA/EMS system software can be regenerated if necessary.

h. A complete dry run of each factory test (excluding the integrated system test) shall be conducted by the Contractor using the approved test plans and test procedures. Written certification that the dry run has been successfully completed shall be provided to employer at least one week prior to the start of each factory test. At employer's option, employer representatives will witness and participate in the dry run of any test.

7.5 Test Completion

A test shall be deemed to be successfully completed only when:

a. All variances have been resolved to the satisfaction of employer

b. All test records have been transmitted to employer

c. Employer acknowledges, in writing, successful completion of the test.

Thimphu: Bhutan

7.6 Test Suspension

Any time employer representatives believe that the quantity or severity of variances warrants suspension of any or all testing, the test shall be halted, remedial work shall be performed, and the complete test shall be repeated. The repeat of the test shall be scheduled for a date and time agreed upon by both the Contractor and employer.

7.7 Factory Test Requirements

The database, displays and the report formats developed by the contractor shall be demonstrated and verified by the employer before factory testing.

All EMS/SCADA functions, inter-control center communication as well as performance shall be tested and demonstrated, for Main & Backup CC configuration. The Employer will participate in and witness these tests.

All hardware and software associated with Main & Backup Control Centers shall be staged and completely tested with simulated data at the Contractor's facility. The material inspection and clearance certificate for all hardware shall be issued only after successful completion of FAT as per specification. The ICCP and IEC60870-5-104 data exchange shall be simulated in the factory test environment.

The Contractor is responsible for conducting all factory tests. Employer will witness all tests and will perform selected test procedures. Knowledgeable Contractor personnel shall be present at all times to assist employer representatives with factory testing as needed. Employer will not accept un- witnessed test results of any hardware or software without previous written authorization.

Each of the factory tests described below (i.e. the hardware integration test, the functional performance test, and the integrated system test, unstructured tests) shall be carried out under factory test.

- During FAT Serial number of product shall be noted.

7.7.1 Hardware Integration Test

The hardware integration test shall confirm that the computer hardware conforms to this Specification and the Contractor-supplied hardware documentation. The hardware integration test shall be performed when the computer hardware has been installed in the Contractors factory. The operation of each item shall be verified as an integral part of the system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. Equipment expansion capability shall also be verified during the hardware integration test.

7.7.2 Functional Performance Test

The functional performance test shall completely verify all features of the SCADA/EMS hardware and software. As a minimum, the following items shall be included in the functional performance test:

a. Inspection of all equipment for conformance to drawings/document and satisfactory construction and appearance

Thimphu: Bhutan
Office of the Bhutan Power System Operator

b. Testing of the proper functioning of all software, including test cases with normal and exception user-entered inputs and responses

c. Simulation of local error and failure conditions

d. Verification that ultimate expansion requirements are met.

e. Verification of data link interfaces with other Control Centre systems

f. Simulation data link communication errors and channel failures, including incorrect check codes and random channel noise bursts

g. Testing of all user interface functions, including random tests to verify correct database linkages

h. Simulation of hardware failures and input power failures to verify the reaction of the system to server and device failure

i. Demonstration of all features of the database, display, and report generators and all other software maintenance features

j. Demonstration of the software utilities, libraries, and development tools.

k. Verification that the computer system meets or exceeds employer's performance requirements

l. Verification of the accuracy of hardware and software documentation via random tests

m. Testing of spare parts

n. Test descriptions

7.7.3 Integrated System Test

The integrated system test shall verify the stability of the SCADA/EMS hardware and software after the functional performance test has been successfully completed. During the integrated system test, all SCADA/EMS functions shall run concurrently and all Contractor-supplied equipment shall operate for a continuous 100-hour period. The test procedure shall include periodic repetitions of the normal and peak loading scenarios defined in **Appendix-D.** This minimum level of activity may be augmented, at the discretion of employer, by other activities that represent normal day-to-day operation of the system as long as these activities are conducted in accordance with the training and documentation provided with the system. These other activities may include, but shall not be limited to, database, display, and report modifications, software development activities, configuration changes (including user-commanded server and device failovers), and the execution of any function described in this Specification.

The integrated system test shall assure employer that the computer system is free of improper interactions between software and hardware while the system is operating as an integrated unit. In case during the 100 hour period testing un-commanded functional restart or server or device fail occurs the test shall be extended by 24 hours each time such a fail over occurs. Further the test shall not be conducted with the failed device.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

7.7.4 Unstructured Testing

Periods of unstructured testing shall be allocated to allow employer representatives to verify proper operation of the SCADA/EMS under conditions not specifically included in the approved test procedures. Unstructured testing shall be conducted in compliance with the following conditions:

a. A minimum of 25 percent of the actual test period shall be reserved for unstructured test of the system by employer representatives

b. The Contractor's test representative shall be present and the Contractor's other technical staff members shall be available for consultation with employer personnel during unstructured test periods

c. All simulation software, test cases, and other test facilities used during the structured portions of the factory tests shall be made available for employer's use during unstructured testing

d. Unstructured testing shall not begin prior to the start of the functional performance test

e. Unstructured testing shall be allowed at employer's discretion both at the end of a structured test segment and after completion of the functional performance test.

7.8 Field Tests

The Contractor's maintenance records shall be reviewed prior to field (also referred as site) testing to identify all hardware and software modified, repaired, or replaced between the completion of factory tests and the start of field testing. Interfaces to all communications circuits shall be established by the Contractor and the proper operation of these circuits shall be verified.

For the purpose of interpreting the requirements for test plans, test procedures, test records, test initiation, and test completion, field testing shall be considered a single test accomplished for each computer system in three phases: (1) the field installation test, (2) Pre-field performance test, and (3) the field performance test.

7.8.1 Field Installation Test

The field installation test shall provide verification that computer system is operationally equivalent to the system that successfully completed factory testing. The responsibility for the conduct of the field installation test shall rest with the Contractor. Employer will witness all tests and will perform selected test procedures. Knowledgeable Contractor representatives shall be present at all times to assist employer representatives with the testing.

The field installation test shall consist of the functional performance test **(Section 7.7.2** to confirm operation of basic functions such as data acquisition, user interface, and the support and utility functions. All hardware shall be tested by running diagnostics. The exact content of the field installation test shall be determined jointly by the Contractor and employer.

7.8.2 Pre-Field Performance Test

After the field installation test, the Contractor shall:

i. verify the operation of data links and remote consoles

Thimphu: Bhutan

Office of the Bhutan Power System Operator

ii. correct and update the database, reports, and displays

iii. install and test employer/owner-developed software if any and

iv. Establish connectivity with SCADA/EMS system and other IT application provided by employer/owner.

The Contractor shall be responsible for providing and installing corrections for all variances found during this period prior to the start of the field performance test. Further the contractor shall also train the dispatchers before field performance test starts.

7.8.3 Field Performance Test

After the completion of activities as per sub clause **7.8.2**, the Contractor shall conduct the field performance test to verify those parts of the functional performance test that were not fully tested as part of the field installation test. All variances found during this period shall be fixed by the Contractor or otherwise resolved to employer's satisfaction prior to the start of the availability test.

The field performance test shall concentrate on areas of SCADA/EMS operations that were simulated or only partially tested in the factory (e.g., system timing and loading while communicating with data links and system reaction to actual field measurements and field conditions). The validity of factory test results determined by calculation or extrapolation shall be examined. The Contractor shall be required to repeat selected portions of the field installation test during the field performance test if employer believes that previously tested functions have since been modified and are not operating in accordance with the Specification. Provisions for unstructured testing by employer personnel shall be provided.

7.9 Availability Test

After field performance test, a 1000-hour availability test shall be conducted on all supplied systems in an integrated and simultaneous manner under normal day-to-day operating conditions. The test shall verify the reliability and integrity of the database, displays, report and all communication interfaces and, under these conditions, verify system availability for 99.9%. Further each server and device if applicable shall meet a minimum availability of 98% individually. In case of field devices, if applicable, downtime of individual such devices are to be excluded from system availability calculations, however, minimum 50% of field devices shall be reporting for test to continue.

7.9.1 Test Responsibilities

Employer will be responsible for conducting the availability test. The test shall consist of normal SCADA/EMS operations without special test equipment or procedures. Test records defined in the availability test plan and procedures will be maintained by employer personnel. Employer/Owner will operate and maintain the system according to procedures described in the approved Contractor documentation. SCADA/EMS maintenance on an on-call basis shall be provided by the Contractor during the availability test period. When on-site maintenance support is needed, qualified Contractor personnel shall arrive at the site within maximum four (4) hours of notification and shall keep employer/Owner fully informed of the progress in problem resolution. For availability purposes, this service response time and the associated on-site maintenance time shall be taken into account as defined in **Sections 7.8.1 & 7.8.2.**

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Office of the Bhutan Power System Operator

The contractor shall maintain an inventory of spare parts, which may be required to achieve the specified availability. These spares shall be in addition to the mandatory spares. All spare parts used during the availability test shall be drawn from contractor's inventory.

During the availability test period, employer reserves the right to modify the databases, displays, reports, and application software. Such modifications will be described to the Contractor at least 48 hours in advance of implementation to allow their impact on the availability test to be assessed, except where such changes are necessary to maintain control of the power system.

7.9.1.1 Downtime

Downtime occurs whenever the criteria for successful operation defined in **Section 7.10** are not satisfied. Downtime shall be measured from the start of diagnostic procedures until full service is restored. In the event of multiple failures, the total elapsed time for repair of all problems (regardless of the number of maintenance personnel available) shall be counted as downtime. For on-site response the delay in response time (more than four hours) shall be added to downtime.

7.9.1.2 Hold-time

During the availability test, certain contingencies may occur that are beyond the control of either employer or the Contractor. These contingencies may prevent successful operation of the system, but are not necessarily valid for the purpose of measuring SCADA/EMS availability. Such periods of unsuccessful operation may be declared "hold-time" by mutual agreement of employer and the Contractor. Specific instances of hold-time contingencies are:

a) Scheduled Shutdown: During scheduled shutdowns, or if an equipment failure occurs while its backup device is scheduled out-of-service, the resulting system outage shall be hold-time, provided that service can be restored according to Contractor-specified procedures within 30 minutes.

b) Power Interruption and Environmental Excursion: Loss of power or manual shutdown in the event of loss of environmental control shall be considered hold-time. If the system is operated during periods of power or environmental conditions beyond those specified, any resultant downtime shall also be considered hold-time.

c) Intermittent Failure: Periods during which an intermittent, recurring software or hardware failure is experienced will be considered hold- time, provided that the Contractor is engaged in remedial action and normal functions can be restored by Contractor-defined procedures whenever the failure occurs. Instead of accounting for the actual intermittent downtime, one hour of downtime shall be counted for each 120 hours of otherwise successful operation while the problem persists.

d) Failure of employer's Software: Time during which the system is down due to failure of software written and independently produced by employer shall be considered hold-time. If a failure in such software cannot be overcome by Contractor-defined procedures, execution of the failed program will be suspended. Programs developed by employer personnel under Contractor supervision are specifically excluded from this provision.

e) Service Response Time: A maximum four (4) hours of hold time will be allowed for the Contractor to respond to each call for maintenance support. The time between detection of a failure and the start of diagnostic procedures shall also be considered hold-time when performed by employer's personnel.

f) Corrected Design Defect: Hold-time may be declared by mutual agreement to ensure against similar future occurrences if a failure occurs due to a defect in system design for which the Contractor defines and implements corrective measures. In such a case, hold- time shall be allowed in increments of 120 hours to allow verification of the corrective action.

7.9.2 Test Duration and Criteria for Acceptance

After the elapse of 1000 hours of cumulative test time, the availability shall be calculated considering the downtime recorded. Should availability falls short of specified percentage, the contractor may either

a. Continue the test by moving the starting time of the test forward and continuing the test until the consecutive hours have been accumulated and the specified availability has been achieved subject to maximum of 75 days, Or

b. The contractor may restart the test for 1000 hours, however, more than two such restart shall not be allowed.

To establish that all failures have been satisfactorily repaired prior to the end of the availability test, no downtime, intermittent (hold time) failures, or more than one un-commanded fail over shall have occurred within 240 hours of the test's conclusion.

In the event of repeated unsuccessful reruns of the availability test, employer may invoke the default provisions described in **Volume I** of the Specification. The successful completion of the availability test will lead to Operational Acceptance of the system.

7.10 Criteria for successful operation

The system shall be designed to meet the total system availability of 99.9%. That is, the ratio of total operational time minus downtime to total operational time shall be equal to or greater than 0.999. Total operational time shall not include the hold time. The system shall be considered available as long as all the critical functions defined are available. Further each server and device shall meet a minimum availability of 98% individually.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 8

WEB SYSTEM FUNCTIONS

CONTENTS

SECTION 8
WEB SYSTEM FUNCTIONS

8.1 Introduction

These Applications are to be performed with due consideration for cyber security standards as per ISO 27000. Only authenticated users shall be given Read/Write/Modify permissions based on their authority levels defined for different applications. There may be as many as 10 different categories of users for the same. The IT services should generally comply with the ISO 15000 standards for IT services management.

Design of system should meet high availability requirements and the web servers should be designed in cluster for load balancing. In case of failure of one of the servers, all the clients shall automatically switch to the other server.

8.2 Web System

8.2.1 Web and Data Replica Server

The Web Server at the Main Control Centre are in active-active configuration. Web Server shall be provided with host based Intrusion detection system (HIDS). The HIDS will be installed on all the machines connected in the DMZ LAN as depicted in **Part A, Annexure-I: System Architecture** of Volume – II (Lot 1). The NIPS shall be tightly integrated with the firewall.

The Data Replica server (RD Server) shall be used for staging relevant real-time and Historical data to be served from Web Applications so as to avoid exposure of SCADA/EMS system to external world. The server shall get real-time data from SCADA/EMS Server as it is available in real-time and Historical data (data and reports) from Historian System. Historical data in Data replica server shall remain synchronized with the Historian System.

Web server shall get the data (real-time and historical) from Data Replica server and meet the requirements of web users (external users including users of Cyber Security Test Bench).

8.2.2 Web Applications

The Web Server at control center is to function as source of information on Control Centre Power System. It will be accessed by diverse set of external users through commercially available web browser. Any additional client software, if required, at external clients/users ends, the same shall be made dynamically available from Web server for its downloading by these external clients. There shall not be any restriction to the number of clients downloading this software (i.e. Unlimited number of client downloads shall be provided). It shall also be possible to access the data and display by using mobile phones/ tablets on various OS i.e. Android, iOS, windows etc. Bidder should supply tools/apps to adapt display/data for access by windows, Android and iOS based devices.

The offered web application shall meet following requirements:

a) Sized to support 100 concurrent external clients/users for providing access to real-time and Historical data. There shall be no limitation on number of users.

b) External clients/users shall be connected to the web servers only. These users shall be denied direct access to the SCADA/EMS system.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

c) Internal SCADA/EMS users shall not have any dependency on the availability of the Web application /server.

d) Data, Displays, Trends and Reports requested by External users/clients shall be serviced by Web servers.

e) For the purpose of transfer of data, displays and reports from the SCADA/EMS and Historian System to the Web System, the SCADA/EMS and Historian System shall initiate a session with the Data Replica server and any attempt to initiate a session by the Web system shall be terminated by the Firewall. Interface between Web system and SCADA/EMS and Historian System zone shall preclude the possibility of external clients defining new data, Report and Displays.

f) The Web Server shall provide access to any of the real-time data and displays, for viewing by external clients/users. The access to each display shall be definable on per user type basis. It shall be possible to define up to 50 user types. Further the SCADA/EMS system administrator shall exercise control over the real-time displays which can be accessed through the Web server.

g) The Web Server shall enable downloading of selected Historian System data. For the purpose of sizing, storage of two months Historian System data for 100% of data points as specified in **Appendix F** shall be considered. The Historian data shall be updated on minimum hourly basis automatically in the web system. The web users shall be able to download data by specifying the period and data points on the web page. The above data values shall be definable on a per user type basis.

h) The Web Server shall store and make available for downloading and viewing selected real-time data, both the values and a composite quality code of the points for web users. For the purpose of sizing, data equal to 100% data points as specified in **Appendix F** shall be considered. This data shall be made available in ODBL/OLE/XML/MySQL format in every minute (to be overwritten periodically). The users shall be able to download this file using web service. The above data points shall be definable on a per user type basis. It shall be possible to define up to 50 user types.

i) The Web Server at NLDC shall facilitate exchange of schedules and other information from Generation/Transmission/Distribution/Bulk-Consumer licensee to the NLDC SCADA/EMS functions.

j) Reports from the Historian System shall also be transferred and shall be available for access to web users. These shall be organized in a well-structured directory for easy navigation by the remote users. Access to each report shall be defined on user type basis.

Real-time data on Web Server shall be updated every minute. SCADA/EMS server fail over shall be transparent to the web servers.

The access to Web Server/site shall be controlled through User ID and password to be maintained /granted by a system administrator. Further, different pages/data access shall be limited by user type (i.e. general user, stakeholder, third party/business user, etc.). The access mechanism shall identify and allow configuration of priority access to selected users.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Further, Tools shall be provided for maintaining the website, Web Server configuration, FTP configuration, Mailing lists setup and customer support. Tools to import SCADA/EMS Power System Applications (PSA) displays for web server shall be included.

A display shall be provided which shall list all the analogs with details such as station name, voltage level, analog type etc. It shall be possible to filter and sort the data based on station name, voltage level and analog type. This display shall be accessible by only Supervisor/Administrator of SCADA/EMS System. This display shall be used to assign accessibility to a user based on the Area, Company and Station Name, Voltage level, generators, tie-lines, point type, point and any combination of these. This assignment to a user shall be applicable for both real time data and historical data access.

8.3 Web Services interface

Supplied system shall support Web Services that allows external user and application to interact with Web applications and publish and subscribe any data. Web Services shall be accessible via standard Internet communication protocols like HTTP, XML. Bidder shall supply .Net or Java based tool kit to create and configure services to publish data items name, values, Quality code, tag, time series of values etc.

SECTION 9

AUXILIARY POWER SUPPLY

CONTENTS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 9
AUXILIARY POWER SUPPLY

8.0 Introduction

This part of the section describes the items related to SCADA/EMS but doesn't cover under the other topics. Basically, it includes UPS, Battery, and ACDB which are also under the scope of the contractor and has to be defined as a line item in the BOQ mentioned.

8.1 Uninterruptible power supply (UPS) requirement

8.1.1 UPS Functions

The UPS shall be a continuous-duty, online, solid-state power supply system designed to provide power conditioning and uninterrupted power supply to critical loads. The critical loads to be served by the UPS include the SCADA/EMS system computers, emergency lighting, and other critical loads at the control center necessary to sustain the real-time operation.

The two UPS systems shall normally be running in parallel mode, however, it shall be possible to run each UPS in independent mode. The necessary hardware and software including cabling & interfaces required for the parallel operation shall be provided by the contractor. Each UPS system shall consist of various sub-systems such as rectifier/-charger, batteries, solid state Pulse Width Modulation (PWM) based inverter, static bypass switch, manual maintenance bypass switch, load transformer, panels, cables, and accessories, etc. as required under this Specification. The facilities shall also be provided to manually control the UPS through its control panel.

In the event of a loss of the Input primary AC source, the UPS equipment shall provide uninterrupted power to the critical loads from the output of the inverter subsystems through batteries.

8.1.2 UPS Configuration

A conceptual auxiliary power supply system configuration indicating the UPS systems running in parallel is given in **Figure 1**. The UPS primarily uses the inverter subsystem to deliver AC power to critical loads. In case of UPS failure, the Static Bypass provides an alternate path to ensure continuous AC power supply to critical loads. Further, a manual maintenance bypass switch is also to be provided for the maintenance of the UPS.

Each UPS system provided by the Contractor shall include the following main equipment as well as any other components necessary for the complete and proper operation of the UPS:

a) Rectifier/charger unit
b) inverter
c) Low Voltage disconnect feature to disconnect the Battery bank
d) Static bypass switch
e) Manual maintenance bypass switch
f) Load transformer and required filters
g) Control panel, automatic controls, and protection

h) All necessary cables, MCCBs/MCBs/ switches /fuses, and other support hardware.

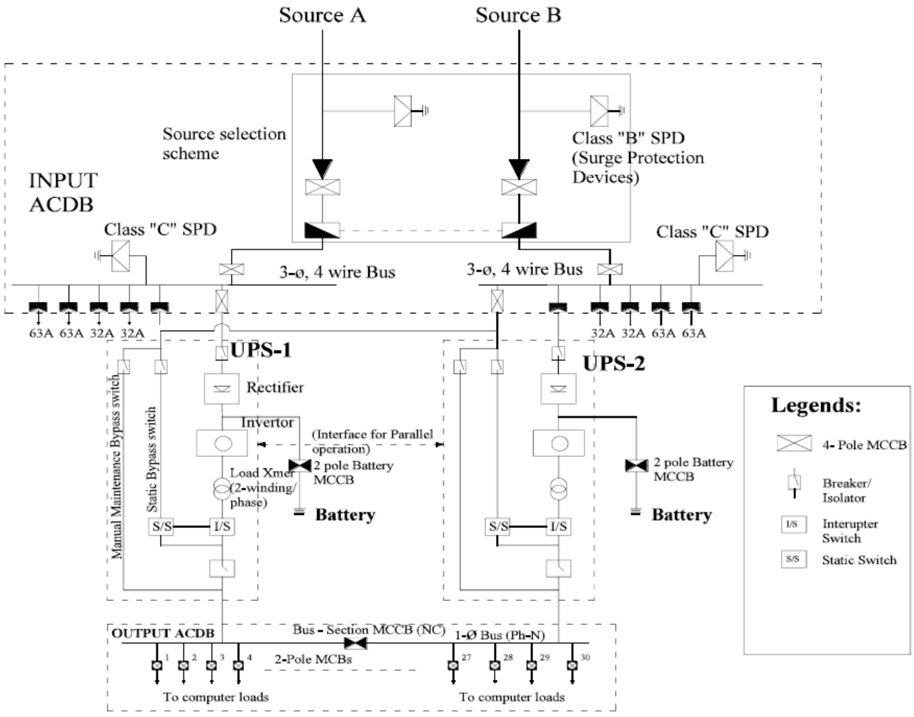

Figure 1: Conceptual Auxiliary Power Supply System configuration

8.1.3 UPS Operation

The UPS shall provide continuous regulated sine wave AC power to the critical loads.

As indicated in **Figure 1**, the two UPS systems shall be running in a parallel configuration where each UPS system shall supply half of the critical loads through the AC distribution board. In the event of failure/outage, of one of the UPS systems, all the connected critical loads will be continued to be supplied through the healthy UPS without any interruption or distortion. In the event of failure/outage, of both the UPS systems, all the connected critical loads to it will be continued to be supplied through the static bypass switch without any interruption. Further, it shall be possible to run both UPS in independent mode by suitable configuration changes.

It shall be possible to isolate/disconnect one of the UPS for maintenance without any interruption to the connected load. The design of the UPS shall have the capability to isolate any failed piece of equipment viz. Rectifier/charger unit, inverter, and battery for maintenance.

The rectifiers/chargers shall provide voltage-regulated DC power to the inverters while also charging and maintaining the batteries at full capacity. The inverters shall normally operate in synchronism with the main AC power source. Upon loss of the mains AC power source or its frequency deviating beyond a preset range, the inverters shall revert to their own internal frequency standard i.e. free running mode. When the main source returns to normal, the inverters shall return to synchronized operation with the mains AC source. Such reversal of operation of inverters from synchronous to free running mode and vice-versa shall not introduce any distortion or interruption to the connected loads. A suitable settable dead band for frequency may be provided to avoid unnecessary frequent reversal of inverter operation between free running mode and synchronized mode under fluctuating frequency conditions.

The control of the UPS system shall be based on microprocessor technology providing monitoring and control of the rectifier/charger, Inverter, static switches, firing, and logic control.

8.1.4 UPS equipment design features

The output rating of each UPS system is stated in Appendix - A, BOQ the design of the UPS shall have the capability to isolate any failed piece of equipment viz. Rectifier/charger unit, inverter, and battery for maintenance. UPS equipment design shall consider the following electrical parameters:

- UPS equipment shall comply with IEC 62040 or equivalent. EN/BS standards for design, performance, and EMC requirements.
- The input mains AC supply to the UPS shall be 415 volt AC, 3-phase, 4-wire, 50Hz. The input supply voltage may vary +10% to -15% from nominal and the frequency may vary from 47.5 to 52.5 Hertz.
- The UPS shall be suitable for operation on Mains input AC on phase sequence reversal
- The UPS shall provide a 3-phase, four-wire output plus ground.
- The UPS shall supply power to the connected loads at 415 volt AC, 3-phase,
- 50 Hz. 0.8-lagging power factor.
- The UPS shall provide continuous regulated sine wave AC power to the connected loads.
- The overall efficiency of the UPS; input to output, shall be a minimum of 90 percent with the batteries fully charged and operating at full load and unity power factor.

The requirements of each sub-system of UPS are detailed below:

8.1.4.1 Rectifier/Charger Unit

Each rectifier/charger unit output voltage shall be regulated to match the characteristics of the Contractor-supplied batteries and inverter. The output shall be current-limited to protect the rectifier/charger unit circuitry and to prevent the batteries from over-charging.

The rectifier/charger unit shall be installed in a single enclosure along with the UPS system electronics. The rectifier/charger units shall have the following characteristics:

a. Input capacity, voltage, and frequency as stated in clause 2.4 above.
b. Input current limit of 125 percent of the nominal full load input current.
c. Maximum input current distortion of 5 percent RMS total harmonic distortion (THD) at nominal input voltage and under full load
d. Capacity to recharge the batteries to 90% State of Charge from fully discharged state (i.e. ECV of 1.75 V) within 8 hrs. while carrying full load where battery charging current shall be considered as at least 20% of
e. Battery AH capacity.
f. Temperature-dependent battery charging with temperature sensing probes

Thimphu: Bhutan
Office of the Bhutan Power System Operator

mounted on the battery banks.

g. Automatic float cum boost charging feature.

8.1.4.2 Inverter

Each inverter shall supply the critical loads at the rated frequency as mentioned above. The inverters shall have the following characteristics:

- The nominal output voltage shall be as defined in clause 2.4, +1 percent at any load level.
- The transient voltage response shall not exceed 4 percent for the first half-cycle recovery, and 1 percent within ten cycles for a 100 percent step load application or removal.
- The free running frequency shall not deviate by more than +0.1 percent for the rated frequency of 50 Hz.
- The inverters shall be synchronized to the main AC source unless that source deviates from 50 Hz by more than +1 percent (adjustable to 1/2/3/4/5 percent).
- The output voltage harmonic distortion shall not exceed 5 percent and RMS and no single harmonic component shall exceed 3 percent.
- The inverters shall be capable of operation at at-least 80 percent of the nominal capacity at the rated power factor and be capable of operation with loads ranging from the rated through unity power factor. The inverter shall be suitable to accept 100% load at a crest factor of at least 3:1 for the Switching Mode Power Supply (SMPS) of computer system equipment without de-rating.
- The inverters shall provide protection logic to automatically shut down and isolate from the load when the battery voltage drops below a preset voltage.
- The inverters shall provide an interrupter switch to isolate the unit from the load on the failure of the inverter unit. The interrupter switch shall be rated to carry the full continuous load and to interrupt the inverter under full fault load conditions.
- The inverters shall be capable of supporting a startup surge or overload of 150 percent of rated output for up to 60 seconds.
- The inverter shall. Include two winding/phase load transformers of one to one ratio with electrostatic shielding. This load transformer can be either internal or external to the UPS panel.

8.1.4.3 Static Bypass Switches

Each UPS system shall include static bypass switch to facilitate automatic transfer of critical loads from the inverter sub-system output to bypass AC source and vice-versa under the following conditions:

- The inverter of both the UPS load capacity is exceeded
- An over- or under-voltage condition exists on the inverter output
- Inverter of the both the UPS fails

The bypass switches shall be static, high speed devices rated to transfer and carry full rated load continuously. The static bypass switches shall provide protection to prevent out of phase transfers. The switching speed of the static bypass switches shall be less than 1 millisecond. During the changeover, the output voltage should not fall below

205V A.C., 50Hz +5%., in order to avoid any disruption to computer load supply. An automatic transfer back to the inverter subsystems shall occur if the transfer from the inverter subsystems was caused by a temporary overload and the load has returned to normal or by a temporary over/under voltage condition on inverters output and the voltage has returned to normal. Transfer back to the inverter subsystems, both automatic and manual, shall be inhibited under the following conditions:

- The frequency of bypass AC source is outside the specified frequency band.
- The inverters output voltage and frequency are beyond the preset range.
- An overload exists

8.1.4.4 Manual maintenance bypass switch

Each UPS system shall include manual maintenance bypass switch to facilitate transfer of the critical load from the UPS output to the raw AC mains source. This switch shall berated to transfer and carry continuous full rated load and shall be provided with suitable protection to avoid inadvertent closing of this switch when UPS is running either in normal mode or static bypass switch mode. This switch is primarily provided to facilitate maintenance of the UPS system.

8.1.4.5 Battery requirement for UPS

Each UPS system 'shall have a set of storage batteries designed for continuous UPS application. The batteries shall be maintenance free VRLA type Batteries.

8.1.4.6 Battery Breaker for UPS system

A 2-pole MCCB of suitable rating shall be provided near the battery bank (at suitable location on the frame of the battery bank) to allow disconnection of the batteries from the rectifier/charger unit and inverter. This shall also provide over-current protection to the battery circuits.

8.1.5 UPS Control/Monitoring

The Contractor shall supply control panel to permit automatic & manual operation, monitoring, manual control, and indication of alarms pertaining to the UPS operation through local man machine interface (MMI). The remote monitoring of both the UPS systems including all alarms, status and analog values of each UPS along with Battery should be possible from web interface.

8.1.5.1 Controls

UPS manual controls shall include the following:

- DC under-voltage shutdown setting
- UPS NORMAL/BYPASS/MAINTENANCE/OFF control
- UPS Parallel or independent mode of operation selection control
- Adjustment of frequency of inverter for synchronization with input mains.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

8.1.5.2 Display

In each UPS system, a local display of the following operating status, alarm indications, analog measurements and potential free contacts for wiring to remote alarms shall be provided:

Analog measurements:

- AC input voltage
- AC output voltage
- AC output current
- AC output frequency
- DC voltage of battery
- DC current of battery

UPS operating status:

- UPS on inverter mode / static bypass
- Load on Battery

Alarm conditions:

- Input mains fail
- Input supply phase sequence reversal (if rectifier/charger is blocked)
- UPS fail
- Overload
- Battery Low voltage
- Battery path open

Potential free contacts:

- Input mains fail alarm
- Battery low voltage alarm

These potential free contacts shall be wired to Output ACDB panel.

Accuracy class of each analog and digital instrument shall be 1.0 or better except for frequency display which shall be at-least 0.5. Frequency meters display shall be in the digital form. All indicating instruments shall be flush mounted on panel front. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment without removing or dismantling the instruments. Composite meter or LCD display to indicate more than one analog quantity is also acceptable.

8.1.6 Automatic orderly shutdown software

A suitable automatic orderly shutdown software shall be provided by the contractor to shut down the computer systems connected to UPS, in case of UPS problems such as Low Battery voltage and low remaining Battery autonomy time. These computers may have different operating systems such as HP UX, True64 UNIX (DEC), IBM-AIX, SUN Solaris,

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Office of the Bhutan Power System Operator

Windows 10 etc. The automatic orderly shutdown of all computers including servers, workstation consoles & PCs shall be required at each control center.

This software shall take into consideration the parallel configuration of the UPS. Each UPS shall have SNMP card suitable for connection to the Ethernet LAN of the computer. Systems. The contractor shall supply all required hardware & software including interconnecting cables/interfacing hardware as required for their design. The contractor shall also provide support for the installation of this software in different computers.

8.1.7 Input/ Output Switches for UPS system

The input /output switches shall be provided as indicated in Figure 1. The input supply to the UPS shall be provided from Input ACDB/LT panel as indicated in Figure 1. Further, a suitably rated output switch shall also be provided to allow disconnection of the inverter subsystem output from the load of the UPS.

8.1.8 Noise Level

Noise generated by the UPS under normal operating condition shall not exceed 78 dB measured five (5) feet from the front of the cabinet surface.

8.1.9 Environmental Conditions

The UPS shall be capable of continuous operation without failures in the following environmental conditions:

- Temperature - Ambient temperature of o° to 50°C, and
- Humidity - 5 to 95%, non-condensing.

8.1.10 Enclosures/ Earthling

The UPS electronic equipment and associated circuitry shall be housed in a freestanding enclosures. Modules and subassemblies shall be easily replaceable and maintainable with front access only. The enclosures shall be painted inside and outside.

Cable entry shall be from the top/bottom of the enclosures and shall be finalized during detailed engineering. The enclosures shall not have doors that are wider than 80 cm and doors shall be hinged with locking. Keyed locking is required with identical keys for all enclosures. The enclosures shall not exceed 220 cm in height. The applicable degree of protection of enclosures shall be IP20. However, the top of the cubicle shall be fully covered to avoid ingress of any water from top.

Each enclosure or enclosure group shall include safety earth networks within the enclosure. The safety earth network shall terminate at two/more studs for connecting with the existing earth mat. Each earth network shall be a copper bus bar, braid, or cable. Use of the enclosure frame, skins, or chassis mounting hardware for the earth network is not acceptable. The Contractor shall be responsible for proper grounding of

UPS system & all associated equipment. The Contractor shall provide earthing inside the panels, between the panels and to the employer provided nearest available earthing grid/raiser, including any other special earthing, if required. The connection to the nearest

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Office of the Bhutan Power System Operator

available earthing grid shall be made by the contractor through GI strip with proper protection.

8.1.11 Cable Connections

All internal cables and wires shall be of stranded copper conductor, sized according to their current requirements with minimum insulation rating of 1100 VAC. Extra-flexible wire shall be used for all circuits mounted on door or swing panels within the UPS. All connections between the Contractor supplied equipment and Employer-supplied power and critical loads shall be through breakers supplied by the Contractor. These breakers shall permit power connections using compression or crush type terminals rated in accordance with each connection. All terminals shall be clearly labelled. The Contractor shall provide drawings showing the type and construction of the field wiring terminations as well as mounting and breaker characteristics.

8.1.12 Availability

The UPS shall be designed for a minimum availability of 99.9 percent. Availability of the

UPS is defined as:

% Availability = (1-(downtime/total operating time))*100

8.1.13 Maintainability

The UPS shall be designed to permit rapid isolation and repair/replacement of all hardware failures. The design shall consider easy access and identification of all electronic modules and maintenance points.

8.1.14 Testing requirements

The bidder shall submit, along with the bid, the UPS type test reports of earlier conducted tests (including performance, functional & EMI/EMC tests requirements) on the same make & rating as offered as per IC 62040 or equivalent EN/BS standards.

The testing requirements are defined as per Table below.

Sl. No.	Test	Type Test	FAT	SAT	Clause Ref. of IEC std.
A	**Performance & Functional tests: (Performance Tests as per IC 62040-3, Table 3)**				
1	**Control and monitoring signals**	X			6.3.1
2	**UPS input tests**	X			6.3.2
	a) Steady state input voltage tolerance	X			6.3.2.1
	b) Input frequency variation	X			6.3.2.2
	c)Input Inrush current	X			6.3.3
3	UPS Output characteristics- Static conditions	X			6.3.4
	a) Output - Normal mode - No load	X			6.3.4.1
	b) Output - Normal mode - Full load	X			6.3.4.2
	c)Output - Stored energy mode - No load	X			6.3.4.3

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	d)Output - Stored energy mode - Full load	X			6.3.4.4
	e)Output voltage unbalance test	X			6.3.4.5
	f)DC components in the output	X			6.3.4.6
	g) Output -Normal mode - Overload	X			6.3.5.1
	h)Output - Stored energy mode - Overload	X			6.3.5.2
	i)Output - Normal mode - Short circuit	X			6.3.5.3
	j)Output - Stored energy mode -short circuit	X			6.3.5.4
	k)UPS rated output fault clearing capability-Normal mode	X			6.3.5.5
	l)UPS rated output fault clearing capability Stored energy mode	X			6.3.5.6
4	**UPS output dynamic tests**	X			6.3.6
	a)Change of operating mode - Normal to stored energy - Linear load	X			6.3.6.1
	b) Change of operating mode - Stored energy to normal - Linear load	X			6.3.6.2
	C)Change of operating mode - Stored energy to normal mode	X			6.3.6.3
	d) Change of operating mode - Normal to bypass mode	X			6.3.6.4
	e) UPS output load steps - linear Icad	X			6.3.7.1
	f)Reference non-linear load output distortion - normal mode	X			6.3.8.1
	g) Reference non-linear load output distortion-stored energy mode	X			6.3.8.2
	h) Reference non-linear load change of operating mode	X			6.3.8.3
	i) Reference non-linear load steps- normal mode	X			6.3.8.5
	j) Reference non-linear load steps- stored energy mode	X			6.3.8.6
5	**Stored energy and restored energy tests**	X			6.3.9
	a) Stored energy time	X	X	X	6.3.9.1
	b) Restored energy time	X	X	X	6.3.9.2
	c) Efficiency and input power factor	X			6.3.10
6	**Back feed tests**	X			6.3.11
	Functional Tests as per IEC 62040-3, Table 4.				
7	Interconnection Cable Check	X	X	X	6.6.1
8	Light Load Test	X	X		6.6.3
9	UPS Auxiliary Devices Test	X	X	X	6.6.4
10	Synchronization Test	X			6.6.5
11	A.C. input failure Test	X	X	X	6.6.6
12	A.C. input return Test	X	X	X	6.6.7
13	Simulation of parallel redundant UPS fault	X	X	X	6.6.8
14	Transfer Test	X	X	X	6.6.9

Thimphu: Bhutan
Office of the Bhutan Power System Operator

15	I Full Load Test	X	X		6.6.10
16	Current division in parallel or parallel redundant UPS test	X	X		6.6.14
17	Battery ripple current test	X			6.6.17
18	Output over voltage test	X			6.6.22
19	Periodic output voltage variation test	X			6.6.23
20	Harmonic Components test	X	X		6.6.26
21	Earth Fault test	X			6.6.27
22	On site ventilation test	X		X	6.6.28
23	Audible noise test	X			7.3
24	Standby generator compatibility test			X	6.6.29
25	Parameter/Configuration settings	X	X	X	
26	Coordination & Discrimination tripping of associated Breakers (MCCB/MCBs) in upstream& downstream		X	X	
B	**EMI /MC Tests:**				
	(Tests requirements as per IEC 62040-2)				
1	Immunity to electrostatic discharges (Requirement of level 3, performance criterion A)	X			3.2 Annex.D.2
2	Immunity to radiated electromagnetic fields (Minimum requirement level 3, performance criterion A)	X			3.3 Annex.D.3
3	Immunity to fast transients (Minimum requirement level 4, performance criterion A)	X			3.4 Annex.D.4
4	Immunity to surges (As per IEC 61000-4-5, Level 4), performance criteria A	X			3.5 Annex.D.5
5	Immunity to low-frequency signals (i) Power line harmonics and inter-harmonics (ii) Immunity to voltage dips	X			3.6 Annex.D.6 D.6.1 D.6.2
6	Radio frequency interference and conducted noise test (Conducted & Radiated Emission).	X			Clause 2
C	**Environmental tests:**	X			
	(Tests requirements as per IC 62040-3)	X			
	Environmental tests (for operating condition tests - under Normal operation of UPS)	X			7.1 &7.2
1	a) Dry heat test at 50 °C for 16 hrs.	X			
	b) Damp heat test at 40°C + 2°C at humidity of 90% to 95% for 96 hrs.	X			
	c) Cold test at 0° C for 2 hrs.	X			
	d) Damp heat test repeat	X			
	NOTE: Besides above, the tests may also be conducted to verify the functional and other requirements as per specifications. * For Type Tests, only the test reports to be submitted along with the bid.				

Thimphu: Bhutan
Office of the Bhutan Power System Operator

	# For UPS FAT, battery related tests shall be conducted on similar type or dummy batteries available in factory

8.2 Battery Requirements

8.2.1 Valve Regulated Lead Acid (VRLA) maintenance free Battery

The contractor shall supply Valve Regulated Lead Acid (VRLA) maintenance free Battery with each UPS. Each UPS battery set shall have sufficient capacity to maintain output at full rated load as indicated in BOQ in **Appendix A**. The battery shall be capable of being recharged to 90% State of Charge (SOC) from the fully discharged condition (1.75V/cell) within 8 hrs. In all cases, the battery is normally not allowed to discharge beyond 80% of rated capacity (80% DOD) at 10 hours rate of discharge.

The supplier, supplying the cells/batteries as per this document shall be responsible to replace/repair free of charge, the battery/cell becoming faulty, owing to defective workmanship or material as per the provisions of the bid document

8.2.2 Constructional Requirements

The design of battery shall be as per field proven practices. Partial plating of cells is not permitted. Paralleling of cells externally for enhancement of capacity is not permitted.

Protective transparent front covers with each module shall be provided to prevent accidental contact with live module/electrical connections.

8.2.2.1 Containers

The container material shall have chemical and electro-chemical compatibility and shall be acid resistant. The material shall meet all the requirements of VRLA batteries and be consistent with the life of battery. The container shall be fire retardant and shall have an Oxygen Index of at least 28%. The porosity of the container shall be such as not to allow any gases to escape except from the regulation valve. The tensile strength of the material of the container shall be such as to handle the internal cell pressure of the cells in the worst working condition. Cell shall not show any deformity or bulge on the sides under all working conditions. The container shall be capable of withstanding the rigors of transport, storage and handling. The containers shall be enclosed in a steel tray.

8.2.2.2 Cell Covers

The cell covers shall be made of suitable material compatible with the container material and permanently fixed with the container. It shall be capable to withstand internal pressure without bulging or cracking. It shall also be fire retardant. Fixing of Pressure Regulation Valve & terminal posts in the cover shall be such that the seepage of electrolyte, gas escapes and entry of electro-static spark are prevented.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

8.2.2.3 Separators

The separators used in manufacturing of battery cells, shall be of glass mat or synthetic material having high acid absorption capability, resistant to sulphuric acid and good insulating properties. The design of separators shall ensure that there is no misalignment during normal operation and handling:

8.2.2.4 Pressure Regulation Valve

Each cell shall be provided with a pressure regulation valve. The valve shall be self-resalable and flame retardant. The valve unit shall be such that it cannot be opened without a proper tool. The valve shall be capable to withstand the internal cell pressure specified by the manufacturer.

8.2.2.5 Terminal Posts

Both the +ve and -ve terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolt hole shall be coated with an acid resistant and corrosion retarding material. Terminal posts or any other metal part which is in contact with the electrolyte shall be made of the same alloy as that of the plates or of approve material that does not have any harmful effect on cell performance. Both +ve and -ve posts shall be clearly and unambiguously identifiable.

8.2.2.6 Connectors, Nuts & Bolts, Heat Shrinkable Sleeves

Where it is not possible to bolt the cell terminals directly to assemble a battery, separation-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitably lead coated to withstand corrosion due to sulphuric acid at a very high rate of charge or discharge.

Nuts and bolts for connecting the cells shall be made of copper, brass or stainless steel. Copper or brass nuts and bolts shall be effectively lead coated to prevent corrosion. Stainless steel bolts and nuts can be used without lead coating.

All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing the environmental impact including a corrosive environment.

8.2.2.7 Flame Arrestors

Each cell shall be equipped with a Flame Arrestor to defuse the Hydrogen gas escaped during charge and discharge. Material Of the flame arrestor shall not affect the performance of the cell.

8.2.2.8 Battery Bank Stand

All batteries shall be mounted in a suitable metallic stand/frame. The frame shall be properly painted with the acid resistant paint. The suitable insulation shall be provided between stand/frame and floor to avoid the grounding of the frame/stand.

8.2.3 Capacity Requirements

When the battery is discharged at 10 hour rate, it shall deliver 80% of C (rated capacity, corrected at 27°Celcius) before any of the cells in the battery bank reaches 1.85V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75V/cell) within 8 hrs. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life. Float voltage of each cell in the string shall be within the average float voltage/cell +0.05V band. The capacity (corrected at 27°Celcius) shall also not be less than C and not more than 120% of C before any cell in the battery bank reaches 1.75V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at C/10 rate:

a. After Six minutes of discharge: 1.98V/cell
b. After Six hours of discharge: 1.92V/cell
c. After 8 hours of discharge: 1.85V/cell
d. After 10 hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35° Celsius for period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within +0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt hour efficiency shall be better than 80%

8.2.4 Expected Battery Life

The battery shall be capable of giving more than 1200 charge/discharge cycles at 80%

Depth of discharge (DOD) at an average temperature of 27° Celsius. DOD (Depth of

Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery on discharge to its rated capacity. The battery sets shall have a minimum expected operational life of 5 years at normal operating conditions or 1200charge/discharge cycles (whichever is early).

8.2.5 Routine Maintenance of Battery system

For routine maintenance of battery system, the contractor shall supply one set of following tools:

a. Torque wrench.
b. Tool for opening /closing of pressure regulation valve of battery.
c. Hand held digital multi-meter for measurement of resistance, AC/DC voltages.

8.2.6 Testing requirements

The contractor shall submit type test reports for the battery for the same make, model

& rating as offered as per the IEC 60896 or equivalent IS/EN/BS/TEC standards. In the event, the type test reports for exact rating is not available, the bidder shall submit type test reports for higher rating Battery. The testing requirements are defined as per Table below:

Sl. No.	Test	Type Test	FAT	SAT
1	Verification of marking			
	-Visual observation			
	- Dimensional inspection	X	X	X
	- Polarity checking			
2	Capacity test	X	X	X
3	Suitability for floating battery operation (to be conducted for 3 months instead of six months)	X		
4	Endurance in discharge/charge cycles (instead of 50, 25 discharge / charge cycles shall be followed)	X		
5	Charge Retention	X		
6	Short-circuit current and internal resistance	X		
7	Mechanical Tests			
	-Vibration Test (procedure as per IEC 60068-2-6)	X		
	- Free fall Test (procedure as per IEC 60068-2-32)	X		
	NOTE			
	1. The batteries shall meet the general requirements as per IEC60896/EN 60896.			
	2.*Only the type test reports to be submitted.			

8.3 AC Distribution Boards Requirements

The Contractor shall provide AC power distribution boards (ACDBs) as specified. The distribution boards shall distribute power to the Employer equipment and provide protection against failures on feeder circuits. The scope for distribution boards includes supply, installation, wiring, cabling, and commissioning of all associated hardware as required for distribution of power. The contractor shall supply and install MCCBs, Surge protection devices, cable and all associated items of adequate rating for providing input to the UPS (Refer Figure 1). There shall be AC Distribution Boards consisting of one no. 'Input ACDB' and one no. 'Output ACDB'. A conceptual configuration showing the components and arrangements is given in Figure 1. The size and characteristics of each MCCB, MCB & Surge Protection Devices (SPDs) shall be determined and provided as per the requirement of the scheme. The quantity of MCCBs, MCBs, Contactors & Surge Protection Devices (SPDs) shall be supplied as per Figure 1. The MCCBs conforming to IEC-60947-2 and IS 13947-2/IEC 60947-2 shall be of Four (4) Pole type of requisite rating. All the MCCBs shall provide over-current, short circuit protection and coordinate with associated breakers in upstream & downstream such that faults are cleared reliably with discrimination. The contractor shall extend safety earth connections from Input ACDB panel & Output ACDB panel to nearest earth grid /riser or earth pit using either suitably sized Copper cable or through 50 x 6 sq. mm GI strips. The requirement of AC distribution boards are as follows:

Thimphu: Bhutan
Office of the Bhutan Power System Operator

8.3.1 Input ACDB

The input ACDB shall have following characteristics: (a) the rating shall be of minimum as stated in the BOQ. (b) It shall be provided with 4 nos. of Four (4) Pole type MCCBs which shall conform to IS 13947-2/IEC 60947-2. The coordination for the overload and short-circuit tripping of the MCCBs/MCBs with upstream and downstream switchgear shall be provided for the satisfactory discrimination. It shall be provided with Class 'B' & 'C' type surge protection. The surge protection shall be in compliance with IEC 61312, IEC 61024 and VDE 0100- 534 for following surges:

(i) Low Voltage Surges (Class C):	
Between	**Requirement**
R-N, Y-N, B-N	In≥10kA, 8/20 μS for each phase
N - PE	In≥20kA, 8/20 μS
In = Value of Nominal Discharge Current	

(ii) Lightning Electromagnetic impulse and other High surges (Class B):	
Between	**Requirement**
R-N,Y-N, B -N	Iimp≥50kA, 10/350 μS for each phase
N - PE	Iimp≥100kA, 10/350 μS
Limp = Value of Lightning Impulse Current	

The blind spots shall be avoided as per IEC 61312-3.

8.3.2 Output ACDB

a. The Contractor shall provide Output ACDB panel for distribution of power to the computer system. The rating shall be of minimum as stated in the BOQ. This distribution board shall be suitable for free-standing or wall mounted type. In this ACDB, total 30 number of feeders (10 numbers per phase) shall be provided. The type of distribution board whether free-standing or wall mounted type shall be finalized during detailed engineering.
b. One number of 4-pole Bus section MCCB of requisite rating shall be provided which shall be kept in normally closed (NC) condition when both UPS are running in parallel. This MCCB shall have suitable locking mechanism to avoid inadvertent opening while UPS are running in parallel.
c. For distribution of power from the UPS output, MCBs (6 to 25 Amps) of Double Pole type as per quantity indicated in Figure 1 shall be provided. The contractor shall coordinate with SCADA/EMS package contractor for the finalization of the MCBs ratings. All MCBs shall be of Curve B current characteristics to have faster fault clearing time and shall conform to IEC-60898 and IS 8828.
d. Output ACDB shall have indicating lamps for each phase & both section of bus charged indication.
e. 2 numbers of Voltmeter with selector switch for all phases on section of each bus

Thimphu: Bhutan
Office of the Bhutan Power System Operator

8.3.3 Enclosures/Panels

The equipment of ACDB shall be physically mounted either in a free standing or in a wall mounted enclosure/panel as finalized during detailed engineering. The MCCB and sub-assemblies shall be easily replaceable and maintainable. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The Contractor shall state the type, size, and weight of all enclosures and indicate the proposed manner of installation. The applicable degree of protection of enclosures shall be at least IP21. Each ACDB and equipment within ACDB enclosures shall be clearly labelled to identify the enclosure/equipment

8.3.4 Testing Requirement

Equipment shall be factory tested before dispatch to site as per requirement of section 7, of this specification.

8.3.4.1 Factory Test

A factory test shall be conducted on all the offered equipment (UPS, DCPS, Battery, ACDB & associated equipment) and shall include, but not be limited to the following, appropriate to the equipment being tested:

- Verification of all functional characteristics and requirements specified
- Voltage drop and transients generated during switching operations
- UPS System efficiency tests
- Inspection and verification of all construction, wiring, labeling, documentation and completeness of the hardware.

Before the start of factory testing, the Contractor shall verify that all changes applicable to the equipment have been implemented. As a part of the factory tests, unstructured testing shall be performed to allow Employer representatives to verify proper operation of the equipment under conditions not specifically tested in the above structured performance test. A minimum of 8 hours of the factory test period shall be reserved for unstructured testing. The Contractor's test representative shall be present and the Contractor's technical staff members shall be available for consultation with Employer personnel during unstructured test periods. All special test facilities used during the structured performance test shall be made available for Employer’s use during unstructured testing. In addition to above, a list of factory tests for UPS, DCPS & Battery is specified at the end of the respective sections of these equipment.

8.3.4.2 Field Performance Test

After the equipment has been installed, the Contractor shall start up and check the performance of the equipment of field locations. All hardware shall be aligned and adjusted, interfaces to all inputs and outputs installed, operation verified, and all test readings recorded in accordance with the Contractor's recommended procedures. The field performance test shall exhibit all functions of the equipment and duplicate factory test. All variances must be corrected prior to the start of the field performance test. In addition to above, a list of site tests for UPS, DCPS & Battery is specified at the end of the respective sections of these equipment.

8.3.4.3 Availability Test

Availability Test shall be carried out for 15 days. During the test the APS system shall be used as required to be used for day-to-day operation of the DMS system of DMS Project. In case of any failure or mal-operation during this period the contractor shall take all necessary action to rectify the problems. APS system shall be accepted by the employer only after rectification of the problem in a mutually acceptable manner.

8.3.4.4 Technical support

Technical support shall be provided by the Contractor through final acceptance of the facilities by Employer. This support shall be available on-site within two working days, when deemed necessary by Employer. The Contractor remains solely responsible for correction of variances and warranty problems.

After final acceptance of the facilities, the Contractor shall provide continuing technical support for a minimum of 15 years. Consultation with knowledgeable Contractor technical support personnel and trained field service personnel shall be readily available on a per-diem basis to assist Employer personnel in maintaining, expanding, and enhancing the facilities.

8.3.4.5 Maintenance of Equipment

The Contractor shall be responsible for the maintenance of the equipment until successful completion of field installation tests, the spares required for the same shall be provided by the contractor. All maintenance performed by the Contractor, subcontractors or OEMs shall be in accordance with procedures and schedules recommended by the equipment OEMs.

Equipment maintenance activities by the Contractor shall be recorded in an equipment maintenance log. Corrective and preventative maintenance entries in the equipment maintenance log shall include the following information:

- Identification of the item being maintained, repaired, replaced, or upgraded
- Name of the person who performed the repair
- List of the maintenance procedures performed
- Date and time when the malfunction was detected
- Description of the malfunction or of any problems encountered
- Date and time when the malfunction was corrected
- Description of the corrective action taken.

Logs shall be available for Employer inspection at all times and shall be delivered to Employer when field performance tests are completed.

8.3.4.6 Data Requirement Sheets

Data requirement sheets (DRS) for UPS, Battery & ACDB are enclosed at the end of this section. These will be duly filled in by the bidder & submitted along with the bid.

During detailed engineering, contractor will be required to submit detailed DRS to include all technical parameters of the equipment to ensure that the offered equipment meets all the technical specification requirements.

8.4 Cabling & Enclosure Requirements

The contractor shall supply, install and commission all power cables, control cables, network interface cables and associated hardware (lugs, glands, cable termination boxes etc.) as required for all equipment. The contractor shall be responsible for Cable laying and termination at both ends of the cable. The Contractor shall also be responsible for termination of feeder cables at contractor's equipment end including supply of suitable lugs, glands, terminal blocks & if necessary cable termination boxes etc. All cabling, wiring, and interconnections shall be installed in accordance with the following requirements.

8.4.1 Power Cables

All external power cables shall be stranded Aluminum conductor, armored XLPE/PVC insulated and sheathed, 1100V grade as per IS 1554 Part-I. The conductor for the Neutral connection from UPS to Output ACDB shall be sized 1.8 times the size of the Phase conductors to take care of the non-linear loads. However, the cable between UPS & Battery-bank shall be of stranded copper conductor (armored type).

8.4.2 Cable Identification

Each cable shall be identified at both ends which indicates the cable number, and the near-end and far-end destination. All power cables shall have appropriate color for identification of each phase/neutral/ground. Cable marking and labelling shall comply with the requirements of the applicable standards:

8.4.3 Cable and Hardware Installation

The Contractor shall be responsible for supplying, installing, and terminating all cables and associated hardware (lugs, glands, etc.) required to mechanically and electrically complete the installation of facilities for the project.

8.4.4 Enclosures/Panels design

Enclosures/panel shall be of free standing type of design, in case of specifically it is not mentioned in the relevant section. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The panel shall not have doors that are wider than 80 cm and doors shall be hinged with locking as per standard design of the manufacturer. Keyed locking is required with identical keys for all panels. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for others shall be minimum 1.6 mm. The panels/boards shall be equipped with necessary cable gland plates.

Wiring within panel shall be neatly arranged and securely fastened to the enclosure by non-conductive fasteners. Wiring between all stationary and moveable components, such as wiring across hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wire. Conductors in multi conductor cables shall be individually color coded, and numbered at both ends within enclosures.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

The enclosures shall be painted inside and outside. The finish color of all enclosures shall be an aesthetically pleasing and shall be approved by the Employer. Further, finish color of external surfaces shall be preferably of same color for all enclosures/panels. Maintenance access to the hardware and wiring shall be through lockable, full height, from doors. Each panel shall be supplied with 240 VAC, 50Hz single phase sockets with switch. All labelling shall be consistent with Contractor-supplied drawings.

8.4.5 Enclosure/Panel Earthing

Each enclosure shall include suitable earth networks within the enclosure. Earth network shall be a copper bus bar, braid or cable inside enclosures. The safety earth network shall terminate at two/more studs for connecting with the earthing grid. Safety earthing cables between equipment and enclosure grounding bus bars shall be minimum size 6 mm^2, stranded copper conductors, rated at 300 volts. All hinged doors shall be earthed through flexible earthing braid.

For all enclosures requiring AC input power, the green earthing wire from the AC input shall be wired to the safety earthing stud. The Contractor shall provide all required cabling between enclosures for earthing. The contractor shall connect safety and signal earths (as applicable) of each enclosure to the Employer provided nearest earth grid/earth riser through suitable 50X6 sq. mm. GI strips or suitably sized copper cable.

The signal earthing network shall terminate at a separate stud connection, isolated from safety ground. The stud connection shall be sized for an external earthing cable equipped with a suitable lug. All earthing connections to equipment shall be made directly to each equipment chassis via earthing lug and star washer. Use of the enclosure frame, skins, or chassis mounting hardware for the earthing network is not acceptable.

8.5 Data Requirement Sheets

- UPS

Sl. No.	Description	To be filled by Bidder
1	Name of the manufacturer	
2	Model no. of the offered UPS	
3	Rated capacity (in KVA) for supplying load at 0.8 lagging pf	
4	Suitable for input frequency of 50 Hz+/-5%	Yes/No
5	Suitable for 3-ph Input voltage 415V with -15% to +10% variation	Yes/No
6	Suitable for input mains phase sequence reversal	Yes/No
7	Nominal Output voltage 240V, 3-Ph, 4-wire at 50 Hz	Yes/No
8	Whether degree of protection of enclosures is IP20 & suitable protection of vertical ingress of water from top surface provided	Yes/No
9	Output frequency (in synchronized mode) adjustable as per specification requirement	Yes/No
10	Suitable for operation at least 3:1 crest factor	Yes/No

Thimphu Bhutan Office of the Bhutan Power System Operator

11	Overall efficiency of UPS (with battery fully charged and operating at full load of 16 kW at unity power factor) >=90%	Yes/No
12	Suitable for operating ambient temperature of 0 to 500C, 5 to 95% RH, non-condensing at full rated load of 32/16 kW	Yes/No
13	Applicable standards for UPS	
14	Rectifier/Charger Rated output current (Supporting calculations to be furnished)	
15	Maximum input current total harmonic distortion (THD) at nominal input voltage and under full load <=5 % RMS	Yes/No
16	Whether rectifier/charger is able to re-charge the fully discharged (up to 1.75 V/cell) batteries to 90% State of Charge while carrying full load within 8 hrs.	Yes/No
17	Whether inverter is able to deliver rated full load up to Battery End Cell voltage of 1.75 V/cell	Yes/No
18	UPS output voltage variation w. r. t. nominal voltage	
19	Output voltage harmonic distortion (<=5 % RMS)	Yes/No
20	Whether capable of supporting a startup surge or overload of 150% of rated output for 60 sec.	Yes/No
21	Variation in free running frequency w. r. t. nominal frequency of 50 Hz (<= +/-0.1%)	Yes/No
22	Whether the feature of protection logic provided to automatically shut down and isolate from the load when the battery voltage drops below a preset voltage	Yes/No
23	Whether the UPS is capable of operating in parallel redundant UPS configuration with one or more with equal load sharing and required hardware & software is included in the offer	Yes/No
24	Static Bypass Switching time <=1msec	Yes/No
25	Whether UPS monitoring software, Windows PC for remote monitoring of UPS systems, interconnecting cables & interfaces included in the offer	Yes/No
26	Whether a suitable automatic orderly shutdown software is offered to shut down the computer systems connected to UPS, in case of UPS problems such as Low Battery voltage, remaining Battery autonomy time, etc.	Yes/No
	Whether this software shall take into consideration the parallel configuration of the UPS.	Yes/No
	Whether the offered automatic orderly shutdown software is suitable to operate on different operating systems such as HP UX, IBM-AIX, True64 UNIX (DEC), SUN Solaris, Windows 2000/XP etc.	Yes/No
	Whether this software is suitable to run on about 20 computers incl. servers, workstation consoles & PCs	Yes/No
27	Whether each UPS is having a SNMP card suitable for connection to the Ethernet LAN of the computer systems	Yes/No

28	Whether for the UPS panel, the thickness of the structural frames and load bearing members is minimum 2.0 mm and for others is minimum 1.6 mm.	Yes/No
29	Manufacturer’s technical catalogues enclosed with the Bid	Yes/No
30	Whether offered equipment is type tested as per standards defined in the technical specifications	Yes/No
31	Whether Type test reports are enclosed for offered or higher rating UPS	Yes/No

- Battery

Sl. No.	Description	To be filled by Bidder
1.	Name of the manufacturer	
2.	Type (maintenance free VRLA) & Model no. of offered Battery	
3.	Battery AH capacity (in AH) at C_{10}, 27^{o} C temp.	
4.	Total number of cells in each UPS / DCPS Battery Bank	
5.	Nominal voltage of each cells	
6.	Applicable standards	
7.	Maximum Boost charging current supported (in % of AH capacity)	
8.	Float charging voltages of each cell	
9.	Boost charging voltages of each cell	
10.	Battery minimum operating life time (in years)	
11.	Manufacturer’s technical catalogues enclosed with the Bid	Yes/ No
12.	Whether offered battery is type tested as per standards defined in thetechnical specifications	Yes/ No

- ACDB (Input and Output)

Sl. No.	Description	To be filled by the bidder
1	Name of the manufacturer	
2	Input ACDB sized for 20kVA	Yes/No
3	Output ACDB sized for 20kVA	Yes/No
4	Whether for ACDB panel, the thickness of the structural frames and load bearing members is minimum 2.0 mm and for others is minimum 1.6 mm	Yes/No
5	Whether degree of protection of enclosures is at least IP41	Yes/No
6	Applicable standards of MCCB/MCB are as per specification	Yes/No
7	Make of MCCB/MCB	Yes/No
8	Whether Class "B" and "C" Surge protection devices (Ph-N, N-E) are provided in Input ADCB panel	Yes/No
9	Make and rating of Class "B" and "C" SPDs	Yes/No

Appendix A

Glossary

AC	Alternating Current
ABT	Availability Based Tariff
ACM	Alternating Current Model
A/D	Analog-to-Digital
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Exchange
ATC	Available Transmission Capability
AVR	Automatic Voltage Regulation
BDF	Bus Load Distribution Factors function
BEA	Bhutan Electricity Authority
BLF	Bus Load Forecast function
BOQ	Bill of Quantity
CA	Contingency Analysis function
CADD	Computer Aided Drafting and Design
CB	Circuit Breaker
CCAPI	EPRI Control Center Application Program Interface
CIM	Common Information model
CMIP	Common Management Information Protocol
COP	Current Operating Plan function
CPU	Central Processing Unit
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
DAT	Digital Audio Tape
DC	Direct Current
DM	Differential Mode
EMS	Energy Management System
F	Frequency
FAT	Factory Acceptance Test
FTP	File Transfer Protocol
GPS	Geographic Positioning System
GUI	Graphics User Interface
HI	Historical Information function
HS	Hydro Scheduling

Thimphu: Bhutan
Office of the Bhutan Power System Operator

HSM	Hydro System Model
HV	High Voltage
I	Current
ICCP	Inter-Control Center Communications Protocol
IEEE	Institute of Electrical and Electronics Engineers Inc.
IEC	International Electro technical Commission
I/O	Input / Output
IS	Interchange Scheduling function
ISO	International Standards Organization
ISR	Information Storage and Retrieval function
IWR	Incremental Water Rate
JDBC	Java Data Base Connectivity
LAN	Local Area Network
LD&C	Load Dispatch and Communication
LDCs	Load Dispatch Centers
LDAP	Lightweight Directory Access Protocol
LED	Light-Emitting Diode
LF	Load Forecasting function
MMI	Man Machine Interface
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
NAS	Network Attached Storage
NLDC	National Load Dispatch Centre
NSP	Network Status Process function
NTP	Network Transfer Protocol
OLTC	On Load Tap Changer
OM	Operations Monitor
O&M	Operation and Maintenance
OS	Outage Scheduler
OSI	Open Systems Interconnection
P	Active Power
PAS	Power Application Software
PF	Power Flow
PMU	Phasor Measurement Unit

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PSA	Power System Analysis function
PSM	Power System Model
PSMU	Power System Model Update function
Q	Reactive Power
RC	Remote Console
RDBMS	Relational Data Base Management System
RM	Reserve Monitoring
RPC	Reactive Power Controller
RTU	Remote Terminal Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SE	State Estimator
SMTP	Simple Mail Transfer Protocol
SOE	Sequence-of-Events
SLD	Single Line Diagram
SNMP	Simple Network Management Protocol
SQL	Structured Query Language
TCP/IP	Transmission Control Protocol / Internet Protocol
UI	User Interface; UNIX International
UPS	Uninterruptible Power Supply
V	Voltage
VPS	Video Projection System
VT	Voltage Transformer
WAN	Wide Area Network

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Appendix B

Sample REPORTS

This SCADA/EMS appendix contains the format requirements for a number of typical Reports as part of SCADA/EMS system. Report shall not have any sizing limitations (software) except the hardware processing resources, if any.

Reports generation software shall provide the capability to add future points as it becomes necessary. Delivered system shall include total storage for 10 times the space required for the reports defined in this appendix.

SYSTEM PARAMETERS REPORT
Name of Substation:
Report type: Daily System Parameters
Date:

Time	Bus 1		Bus-n		IC-1				IC-n				Tr-1				Tr-n				F-1				F-n			
	V	F	V	F	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF
0130																												
0230																												
0330																												
0430																												
0530																												
0630																												
0730																												
0830																												
0930																												
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1530																												
1630																												
1730																												
1830																												
1930																												
2030																												
2130																												
2230																												
2330																												
2430																												
Min																												
Max																												
Ave																												

Table 1: Daily System parameters

Thimphu: Bhutan
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Name of Substation:
Report type: Daily System Parameters
Date:

Time	Bus 1		Bus-n		IC-1				IC-n				Tr-1				Tr-n				F-1				F-n			
	V	F	V	F	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF	A1	A2	A3	PF
0130																												
0230																												
0330																												
0430																												
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0630																												
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1730																												
1830																												
1930																												
2030																												
2130																												
2230																												
2330																												
2430																												
Min																												
Max																												
Ave																												

Active and Reactive Power Report
Name of Substation:
Report type: Monthly Active and Reactive Power Report
Month:

Day	IC-1		IC-n		Total (IC-1:IC-n)		Tr-1		Tr-n		Total (Tr-1:Tr-n)		F-1		F-n		Total (F-1:F-n)	
	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
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25																		
26																		
27																		
28																		
29																		
30																		
31																		
Min																		
Max																		
Ave																		

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Name of Substation:
Report type: Daily Active and Reactive Power Report
Date:

Time	IC-1		IC-n		Total (IC-1:IC-n)		Tr-1		Tr-n		Total (Tr-1:Tr-n)		F-1		F-n		Total (F-1:F-n)	
	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar
0130																		
0230																		
0330																		
0430																		
0530																		
0630																		
0730																		
0830																		
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1630																		
1730																		
1830																		
1930																		
2030																		
2130																		
2230																		
2330																		
2430																		
Min																		
Max																		
Ave																		

Table 2: Active and Reactive Power Reports (Daily, Weekly, Monthly, Yearly)

Name of Substation:
Report type: Daily Active Energy Report (MWH)
Date:

Time	IC-1	IC-n	Tr-1	Tr-n	F-1	F-n
0130						
0230						
0330						
0430						
0530						
0630						
0730						
0830						
0930						
1030						
1130						
1230						
1330						
1430						
1530						
1630						
1730						
1830						
1930						
2030						
2130						
2230						
2330						
2430						
Total (MWH)						

Thimphu: Bhutan
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NLDC Shift summary — Morning/Evening/Night shift

1. Maximum Demand during shift: 400MW — Minimum Demand during shift: 200MW

i.National grid frequency remained within limit during the shift

ii. Voltage Status

Name of element	Voltage (kV) before regulation	Reason	Measures/Action taken	Voltage (kV) after regulation
132kV KHP_MAT	139kV	Internal line disruption at Rangia end.	Shunt reactor closed at KHP, no other improvement measures.	137kV

2. Shutdowns: Planned, ad-hoc & emergency						
Name of element	Nature		Schedule	Availed Time & Date	Reasons	Restoration time/Remarks
400kV THP-MAL	Planned	CB	09:00(23/08/2021) -17:00(30/09/2021)	9:10:00 AM (24/08/2021)	AMP	Still out
	Ad-hoc	RB				

3. Tripping/Restoration of generating unit				
Line/ICT	Tripping time	Reason	Normalised time	Remarks
THP unit 2	10:35 (12/08/2021)	reverse power	11:38 (12/08/2021)	no generation loss

4. Line/ICT Tripping/Revival				
Line/ICT	Tripping time	Reason	Normalised time	Remarks
400kV THP-MAL	17:35 (12/08/2021)	tower collapsed	still out	Declared Faulty

5. Elements on standby/idle charge		
Name of element	Time	Remarks
400kV THP-SIL 2	10:35 (12/08/2021)	standby

6. Non compliance					
Agency/Stakeholder(s)	Name of element	Date	Description	Remarks	Site official on duty
JLG	220kV JLG-DAG	18-Feb-21	Code was issued from our office to Jigmeling s/s after being informed that maintenance of 220kV JLG-DAG line was completed	After issueing code to both the s/s we were informed by TMD Gelephu that the line was charged without Work Permit Return..	Tshering Yuden

7. New shutdowns received						
Name of element		Nature	Schedule	Availed by	Reasons	Remarks
400kV THP-MAL		P/C	09:00(23/08/2021) -17:00(30/09/2021)	THP	AMP	Approved

8. Any other issues

Handed over by	Taken over by

Table 3: NLDC shift summary

DATE OF REPORTING-21/01/2021

GENERATION OUTAGE REPORT FOR 20/01/2021

Western region			Eastern region		
Planned					
STATION /AGENCY	Unit No.	Capacity (MW)	STATION /AGENCY	Unit No.	Capacity (MW)

Total:

Forced					
STATION /AGENCY	Unit No.	Capacity (MW)	STATION /AGENCY	Unit No.	Capacity (MW)

Total:

Grand total:

Table 4: Generation outage report

Thimphu: Bhutan

Office of the Bhutan Power System Operator

DATE OF REPORTING-21/01/2021

LINE/ICT OUTAGE REPORT FOR 20/01/2021

	Name	Region	Ownership	Outage		Revival		Reason of outage/Remark
				Date	Time	Date	Time	
1	400kV THP-SIL 1	WR	BPC	12/8/2021	7:00	12/8/2021	9:00	High Voltage

Table 5: Line and ICTs' outage report

	SEM_BPC	PRO_BPC	CHM_BPC	CHP_DGP	CHP_DGP	JLG_BPC	MAT_BPC	GEL_BPC	NKO_BPC
	FDR	FDR	FDR	FDR	FDR	FDR	FDR	FDR	FDR
	C_OLA_SEM	C_CHM_PRO1	C_CHM_PRO	E_CHP_MAL	C_CHP_TAP	D_JLG_TIN	D_MAT_RANGIA	D_GEL_SALA	D_DEO_NKO
Time	MW	MW	MW	MW	MW	MW	MW	MW	MW
6/1/2022 12:00:00 AM	-6.23	-2.76	2.78	59.17	9.02	46.13	55.46	11.33	33.27
6/1/2022 12:05:00 AM	-6.10	-2.76	2.74	60.36	8.88	46.89	55.84	11.06	33.01
6/1/2022 12:10:00 AM	-6.03	-2.76	2.74	63.06	8.88	45.39	55.19	11.61	33.39
6/1/2022 12:15:00 AM	-6.03	-2.63	2.69	64.57	8.67	45.39	56.39	11.37	33.39
6/1/2022 12:20:00 AM	-6.16	-2.63	2.63	63.07	8.67	45.39	55.00	12.94	33.39
6/1/2022 12:25:00 AM	-5.81	-2.53	2.56	64.35	8.48	45.39	56.22	11.96	33.39
6/1/2022 12:30:00 AM	-5.85	-2.56	2.59	65.28	8.49	44.90	55.70	12.10	33.00
6/1/2022 12:35:00 AM	-5.70	-2.56	2.59	62.20	8.49	44.90	55.70	14.13	33.00
6/1/2022 12:40:00 AM	-5.75	-2.56	2.54	61.94	8.54	44.81	55.88	14.45	32.98
6/1/2022 12:45:00 AM	-5.75	-2.56	2.51	63.02	8.49	44.81	55.53	13.61	32.98
6/1/2022 12:50:00 AM	-5.67	-2.50	2.51	64.67	8.49	45.00	55.38	13.05	32.98
6/1/2022 12:55:00 AM	-5.67	-2.50	2.51	64.67	8.49	45.10	54.12	13.35	32.98
6/1/2022 1:00:00 AM	-5.54	-2.50	2.45	64.67	8.49	44.51	54.48	13.24	32.77
6/1/2022 1:05:00 AM	-5.54	-2.50	2.45	64.67	8.49	44.51	54.43	12.95	32.77
6/1/2022 1:10:00 AM	-5.54	-2.50	2.40	66.04	8.28	43.50	54.43	13.25	32.77
6/1/2022 1:15:00 AM	-5.63	-2.38	2.40	66.04	8.28	49.00	44.19	12.14	27.32
6/1/2022 1:20:00 AM	-5.51	-2.37	2.39	66.04	8.09	49.00	44.07	11.88	27.32
6/1/2022 1:25:00 AM	-5.51	-2.37	2.39	67.46	8.09	49.00	44.07	11.63	27.32
6/1/2022 1:30:00 AM	-5.56	-2.37	2.43	67.03	8.13	42.77	52.52	12.92	32.51
6/1/2022 1:35:00 AM	-5.42	-2.37	2.38	67.03	8.13	42.77	52.49	12.92	32.51
6/1/2022 1:40:00 AM	-5.74	-2.31	2.38	67.03	8.13	42.77	52.49	12.92	32.51
6/1/2022 1:45:00 AM	-5.47	-2.31	2.38	67.03	8.13	42.77	52.49	12.92	32.51
6/1/2022 1:50:00 AM	-5.47	-2.38	2.33	67.03	8.13	42.77	52.49	12.92	32.51
6/1/2022 1:55:00 AM	-5.34	-2.38	2.38	68.42	8.13	42.77	52.49	12.92	32.51
6/1/2022 2:00:00 AM	-5.23	-2.38	2.38	68.42	8.13	42.77	51.35	13.28	31.72
6/1/2022 2:05:00 AM	-5.55	-2.34	2.38	68.42	8.13	42.77	52.59	12.90	31.72
6/1/2022 2:10:00 AM	-5.20	-2.34	2.38	67.04	8.13	42.77	52.59	12.90	31.72
6/1/2022 2:15:00 AM	-5.20	-2.34	2.32	67.04	8.13	42.77	51.33	12.90	31.72
6/1/2022 2:20:00 AM	-5.20	-2.34	2.37	67.04	8.13	39.11	49.57	13.41	31.72
6/1/2022 2:25:00 AM	-5.20	-2.34	2.31	68.41	8.13	41.37	51.61	12.54	31.72

Table 6: Load profile (5 minutes block for the period of 1 month)

	OLA_BPC	PRO_BPC	MAL_BPC	MAL_BPC	MAL_BPC	MAL_BPC	SEM_BPC	SEM_BPC	CHP_DGP	CHP_DGP	THP_DGP	THP_DGP	JLG_BPC	JLG_BPC	JLG_BPC	JLG_BPC	KHP_DGP	MAT_BPC
	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS	BUS
	C_B1	C_B1	F_B1	F_B2	E_B1	E_B2	C_B1	C_B2	E_B1	E_B2	F_B1	F_B2	F_B1	F_B2	E_B1	E_B2	D_B1	D_B1
Time	KV	V_RY	KV	KV	KV	KV	KV	KV	KV	KV	KV	KV	KV	KV	KV	KV	KV	KV
6/1/2022 12:00:00 AM	67.17	65.12	408.17	404.45	216.32	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.71	410.34	227.03	225.30	136.28	133.18
6/1/2022 12:05:00 AM	67.17	65.12	408.17	404.45	217.62	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.55	410.39	227.05	225.40	136.46	133.55
6/1/2022 12:10:00 AM	67.17	65.12	408.17	404.45	217.91	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.55	410.39	227.05	225.40	136.27	132.96
6/1/2022 12:15:00 AM	67.17	65.15	408.17	404.45	217.91	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.55	410.39	227.05	225.40	136.27	132.96
6/1/2022 12:20:00 AM	67.17	65.15	408.17	404.45	217.91	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.55	410.39	227.05	225.40	136.40	132.96
6/1/2022 12:25:00 AM	67.17	65.18	408.17	404.45	217.91	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.55	410.39	227.05	225.40	136.40	132.96
6/1/2022 12:30:00 AM	67.17	65.20	408.17	404.45	216.11	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.38	410.04	227.09	225.20	136.62	133.98
6/1/2022 12:35:00 AM	67.17	65.20	408.17	404.45	216.11	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.38	410.04	227.09	225.20	136.62	131.27
6/1/2022 12:40:00 AM	67.17	65.20	408.17	404.45	217.25	218.58	67.70	67.62	222.84	223.58	407.05	407.01	409.95	409.66	226.66	224.10	135.04	131.46
6/1/2022 12:45:00 AM	67.17	65.20	408.17	404.45	217.50	218.58	67.70	67.62	222.84	223.58	407.05	407.01	409.95	409.66	226.66	224.10	135.04	131.10
6/1/2022 12:50:00 AM	67.17	65.10	408.17	404.45	217.50	218.58	67.70	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	135.17	131.36
6/1/2022 12:55:00 AM	67.17	65.10	408.17	404.45	217.50	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	135.46	131.36
6/1/2022 1:00:00 AM	67.17	65.10	408.17	404.45	217.50	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	135.46	131.36
6/1/2022 1:05:00 AM	67.17	65.10	408.17	404.45	217.50	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	135.49	131.36
6/1/2022 1:10:00 AM	67.17	65.10	408.17	404.45	217.50	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	135.49	131.36
6/1/2022 1:15:00 AM	67.17	65.10	408.17	404.45	217.50	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	135.38	131.36
6/1/2022 1:20:00 AM	67.17	65.14	408.17	404.45	217.50	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	135.38	131.36
6/1/2022 1:25:00 AM	67.17	65.14	408.17	404.45	217.50	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.29	410.00	226.73	224.20	134.73	131.36
6/1/2022 1:30:00 AM	67.17	65.15	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	134.82	131.86
6/1/2022 1:35:00 AM	67.17	65.15	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	135.07	131.86
6/1/2022 1:40:00 AM	67.17	65.14	408.17	404.45	217.37	218.58	67.69	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	135.08	131.86
6/1/2022 1:45:00 AM	67.17	65.14	408.17	404.45	217.37	218.58	67.69	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	134.88	131.86
6/1/2022 1:50:00 AM	67.17	65.24	408.17	404.45	217.37	218.58	67.69	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	134.85	131.86
6/1/2022 1:55:00 AM	67.17	65.24	408.17	404.45	217.37	218.58	67.69	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	134.85	131.86
6/1/2022 2:00:00 AM	67.17	65.24	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	134.85	131.86
6/1/2022 2:05:00 AM	67.17	65.15	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	135.32	131.86
6/1/2022 2:10:00 AM	67.17	65.15	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	135.32	131.86
6/1/2022 2:15:00 AM	67.17	65.15	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	135.32	131.86
6/1/2022 2:20:00 AM	67.17	65.15	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	135.69	131.86
6/1/2022 2:25:00 AM	67.17	65.15	408.17	404.45	217.37	218.58	67.64	67.62	222.84	223.58	407.05	407.01	410.12	409.77	226.73	225.10	135.69	131.86
6/1/2022 2:30:00 AM	67.17	65.26	408.17	404.45	217.43	218.58	67.64	67.62	222.84	223.58	407.05	407.01	411.08	410.76	227.25	225.40	135.73	132.29
6/1/2022 2:35:00 AM	67.17	65.26	408.17	404.45	217.43	218.58	67.88	67.62	222.84	223.58	407.05	407.01	411.08	410.76	227.25	225.40	135.73	132.29
6/1/2022 2:40:00 AM	67.17	65.38	408.17	404.45	217.34	218.58	67.88	67.62	222.84	223.58	407.05	407.01	411.08	410.76	227.25	225.40	136.00	132.29
6/1/2022 2:45:00 AM	67.17	65.33	408.17	404.45	217.34	218.58	67.88	67.62	222.84	223.58	407.05	407.01	411.08	410.76	227.25	225.40	136.17	132.29
6/1/2022 2:50:00 AM	67.17	65.33	408.17	404.45	217.34	218.58	67.88	67.62	222.84	223.58	407.05	407.01	411.08	410.76	227.25	225.40	136.12	132.29
6/1/2022 2:55:00 AM	67.17	65.33	408.17	404.45	217.34	218.58	67.88	67.62	222.84	223.58	407.05	407.01	411.08	410.76	227.25	225.40	136.22	132.29

Table 7: Voltage profile (5 minutes block for the period of 1 month)

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APPENDIX C

SYSTEM DESIGN PARAMETERS

The SCADA/EMS system shall be designed as per the technical parameters defined in the specification and as specified here.

The SCADA/EMS system sizing such as databases, network elements, ICCP (No. of control centers), etc. and the Historian System sizing shall be done to accommodate expansion by 200% i.e. equal to 300% of the present system sizes specified in **Appendix F** and calculated value sizing requirements specified in **Appendix C.**

The auxiliary memory utilization of any of the computers shall not exceed 25% of its delivered capacity. This memory utilization includes the memory used for storage of data for the defined duration as specified in the technical specification.

The following tables specify the design capacities, execution rate, and response times required. Depending on the type of item, the design capacity represents either the total number of that item to be supported by the installed computer system or the rate at which that item shall be processed. No. of points specified under Design Capacity shall include the expansion requirements.

The execution rate indicates how frequently a function shall execute if it is a periodic function.

Some functions execute periodically as well as upon request and/or as a result of external conditions. Other functions execute strictly as needed, upon request, and/ or as required by the external conditions.

The response time indicates the maximum acceptable wall-clock time to complete a function and to present and/or store the results, as appropriate. In the case of data exchange between the computer systems, the delivery time is the elapsed time between the initiation of the data transmission request by one system and storage in the application function database of the receiving system, assuming there is no delay due to the communications line.

The Appendix is organized as:

Table 1 – Design Parameters for SCADA Functions

Table 2 – Design Parameters for Historian System Functions

Table 3 – Design Parameters for EMS Functions

Table 4 – Design Parameters for User Interface

Table 5 – Design Parameters for Configuration Characteristics

TABLE 1 – Design parameters for SCADA functions (Reference Section 1)

Sec. Ref.	FUNCTION DESCRIPTION	DESIGN CAPACITY	EXECUTION RATE	RESPONSE TIME

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1.1.1	**RTU Data Acquisition**			
	Scan Rate	8	2 sec to 1 hour	
	Status Data Update		4 seconds by exception and a integrity scan every 10 minutes	
	Analog Data Update		Periodic: 10-15 seconds, Spontaneous: 5 seconds	
	Telemetry failure and Delete from Scan			
	No. of communication retries	10		
	Exploratory scan	2	30 sec to 10 minutes	
1.1.2.1	**Data Exchange between Control Centers**			
	Status Data Update	No. of points specified in Appendix- F	by exception and integrity scan every 10 minutes	1 sec
	Analog Data Update	No. of points specified in Appendix- F	periodic 5 sec	1 sec
1.1.2.4	**Data exchange with other application**			
	Real-time data & Alarms	No. of points specified in Appendix- F	5 sec	1 sec
	Historical data	No. of points specified in Appendix- F	Scan Rate	5 sec
	Modeling data	No. of points specified in Appendix- F	On demand	5 minutes
1.1.4.1	**Data Processing - Analog Data**			
	Reasonability Limit checking	High and Low reasonability limits per analog point	Each time the value is received in SCADA	1 sec
	Limit Monitoring (Operational, Alarm, Emergency limits)	High and Low for each limit per analog point	Each time the value is received in SCADA	1 sec
	Zero dead-band processing	One dead-band %	0.1% to 2%	1 sec
	Data Validity tests	No. of points specified in Appendix-F	Each time the value is received in SCADA	1 sec
1.1.4.3	**Calculated Data Processing: (The internal points used for calculation shall be additional)**			
	Arguments for analog calculations	100	Each time a value is received in SCADA	
	Arguments for status calculations	100	Same as above	

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	No. of calculated analog data (Real time Min, Max & avg. for each 5 minute time duration and three more calculated data)	6 X total no. of analog points defined in Appendix-F	Each time the value is received in SCADA	
	No. of calculated Status data	2 X total no. of status points defined in Appendix-F	Each time the value is received in SCADA	
	MVA and Power Factor Calculations	No. of feeders, transformers, generators, loads, etc.	Same as above	
	MW and MVar Integration	No. of feeders, generators, loads, and transformers.	Same as above	
	Rate of change	No. of analog points defined in Appendix-F	Same as above	
1.1.6	**Continuous Real-time data storage & playback**			
	Sizing	Sized for all telemetered status and analog points with quality codes as specified in Appendix-F	Each time the value is received in SCADA	
	Data storage on Auxiliary memory	3 months		
	Redundant data Source processing	As per specification	As per specification	
	Network Status processor	For all status points defined for power system size	Triggered by status change	1 sec after updation in SCADA database
	Sequence-of-Events recording	1000 events circular buffer in the SCADA database	Each time the value is received in SCADA	1 sec

TABLE 2 – Design Parameters for Historian System Functions (Reference Section 1 & 2)

FUNCTION DESCRIPTION	DESIGN CAPACITY	EXECUTION RATE	RESPONSE TIME
Real-time data snapshot			
No. of data	Total no. of points defined in Appendix-F (different rates for different values, set at 10 seconds for deciding storage capacity)	5 seconds to 1 hour	2 sec
Duration of online storage	6 Years		
Storage of SCADA/EMS system statistics			

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ICCP Communication statistics	No. of ICCP Connections	15 minutes	1 minute
Duration of Online storage	1 Year	As per specs	
SOE Data	5 Years	Every 5 minutes	1 minute
Historical information			
Storage of files and save cases	10 save cases and 10 output results of each EMS Application	As per specs	5 Minute
System message Log Storage & Retrieval			
No. of logs storage	7,000 entries per day	15 minutes	
Online storage	12 months		
Historical trend (Historian)	On demand for any of the stored analog value	As per specs	5 sec
Reports	200	As per specs	10 sec per report-consisting of 1000 Data Points

TABLE 3 - Design Parameters for EMS Functions (Reference Section 2 and 8)

NAME	DESIGN CAPACITY	EXECUTION RATE	RESPONSE TIME
Outage Scheduler	2X (No. of all modelled devices) including at least 10 revisions per schedule	On demand or Daily	10 Seconds
Power System Analysis			
Real-Time Mode		5 minutes Event trigger On demand	30 seconds
Multi-User Study Mode Number of Concurrent Users	3 users	On demand	30 seconds
Number of Save Cases	10 cases		
State Estimation		5 minutes Event trigger On demand	30 seconds
Bus Load Forecast	252 sets (12x7x3)	5 minutes	5 seconds
Contingency Analysis		10 minutes On demand	5 minutes
Predefined Contingencies	15 cases		
Full AC Analysis	5 cases		
Power Flow		20 minutes on demand	5 seconds
Web System Functions (As per Section - 8)			
Update of display			3 sec

TABLE 4 - Design Parameters for User Interface (Reference Section 3)

NAME	DESIGN CAPACITY	EXECUTION RATE
Function and Data Access Security Operating jurisdictions	16	
User Interface Environment		
Layers	8	
Tag Placement & Removal	4	
Tag Types Tags per device	4	
TREND (Online) in SCADA		
a) Trend files	For each data points as defined in Appendix-F	
b) Variables per trend viewport/window	8	
c) Samples per trend variable	10,000	
d) Configurable Sampling rate		2 sec, 10 sec, 30 sec, 1 min, 10 min, 30 min, 60 minutes
e) Time period of trend	At least 1 week	
ALARMS		
Alarm priority levels	8	
Alarm Message Recording on auxiliary memory	50,000	
EVENTS Event Message Recording on Auxiliary memory - events	50,000	
Function & Data Access Security Operating Jurisdictions	16	

Table 5 - Design Parameters for Configuration Characteristics (Specification Reference- Section 4 & 6)

DESCRIPTION	DESIGN CAPACITY	EXECUTION RATE	RESPONSE TIME
Single Line Display			
Validation of one substation SLD	As per spec requirement	Spec	Less than 5 Minutes
Acceptance of one substation SLD	As per spec requirement		Less than 1 Minutes
Network Diagram			
Validation of Network Diagram	As per spec requirement		Less than 30 Minutes
Acceptance of Network Diagram	As per spec requirement		Less than 5 Minutes
Backup Databases Data backup		30 seconds or event driven	5 seconds
Server Errors and failure detection			10 seconds
Device Errors and failure detection			10 seconds

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Server failover			60 seconds
Function period < 30 sec. Function period > 30 sec.			120 sec
Server Start-Up			
Hot Start			5 minutes
Warm Start			10 minutes
Cold Start			15 minutes
Device Failover			30 seconds
Main and Backup Control center			
Real-time data Update		10 seconds	2 seconds
Integrity scan		10 Minutes	
Monitoring of each other's availability		2 minutes	2 seconds

APPENDIX-D

PERFORMANCE REQUIREMENTS

The SCADA/EMS system shall be designed as per the technical parameters defined in the specification and as specified here.

The SCADA/EMS system (such as databases, network elements etc.) shall be sized to accommodate expansion by 200% of the present power system size, i.e. it shall be sized to accommodate three times of the existing system size **(Appendix F).**

The auxiliary memory utilization of any of the computers shall not exceed 25% of its delivered capacity. This memory utilization includes the memory used for storage of data for the defined duration as specified in the technical specification.

This appendix is organized as:

Table 1 – Performance Requirements

Table 2 – Normal Level of Activities

Table 3 – Peak Level of Activities

The performance specified here are the maximum times required of the user interface during average and peak loading conditions. Averaged or other statistically processed response and update times will not be acceptable. The execution periodicity and response rate mentioned in Appendix C; shall be maintained for all the application software. The performance analysis shall be part of the Technical proposal in the bid.

An updated performance analysis to reconfirm the ability of each system to meet employer's performance requirements will be submitted by the Contractor after completion of detailed system design.

Failure to meet the performance criteria shall require the contractor to provide all necessary hardware and software modifications and additions until the performance criteria are satisfied.

Table 1- Performance Requirements

a) User interface requirements

At no time the SCADA/EMS system shall delay the acceptance of User request or lockout console operations due to the processing of application functions. Response times for following user interfaces are defined below.

Sl. No.	User Interface Requirements	Response time
(i)	Requests for call-up of displays shall be acknowledged with an indication of request is being processed	Within 2 sec
(ii)	Any real time display and application display (except RDBMS displays) on workstation console, Complete display & data values shall appear on	Within 3 sec after acknowledgement of request 10 sec

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	screen RDBMS Displays/Reports for online data	
(iii)	Manual Data entry of the new value shall appear on screen	Within 2 sec
(iv)	Display (including Trends) update rate	Every 2 sec for 4 displays together to be completed in 0.5 sec
(v)	Panning of a world display from one end of screen to other end of screen in a continuous manner	Within 2sec
(vi)	Response time for display of Alarm and event after receipt in SCADA system	Within 2 sec of receipt in system
(vii)	Alarm and event acknowledgement	Within 2 sec
(viii)	Requests for printing of displays shall be acknowledged with an indication of request is being processed	Within 2 sec
(ix)	Requests for generation of reports shall be acknowledged with an indication of request is being processed	Within 2 sec
(x)	Video projection system display update rate (Shall be performed during SAT)	Every 2 sec for 4 displays together to be completed in 0.5 sec
(xi)	Export of trend data	1 sec
(xii)	Dynamic Dashboard	1 sec
(xiv)	Supervisory Control	2 second plus scan time + device operation time + communication time
(xv)	User request to jump to a different zoom factor shall cause display to be presented	Within 2 sec
(xvi)	Historical playback reconstruction set-up for at least 48 hours' time span	Within 1 minute
(xvii)	Display of real-time trends in SCADA of at least 250 points (1 week data scan rate samples)	Within 5 sec

b) **Utilization**

Description	**Average Utilization**	**Comments**
PROCESSOR UTILIZATION Servers and Workstations	15% 25%	Normal loading Peak loading
LOCAL AREA NETWORKS Unconditional Access (e.g., Ethernet)	15% 25%	Normal loading Peak loading
AUXILIARY MEMORY Access & Transfer capacity	15% 25%	Normal loading Peak loading

c) NMS functionality Impact

The NMS shall not impact the availability and performance of SCADA/EMS system and shall not load more than 3% of any host CPU, 1% Network Bandwidth and shall have secure communication.

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Description	Shall not load more than	Comments
PROCESSOR UTILIZATION of any host CPU.	3%	Peak loading
NETWORK Bandwidth	1%	Peak loading

Table 2- Normal Level of Activities

The normal level of activity shall simulate system activities spread over one hour period to generate normal loading scenario. During the testing, the response times and the average utilizations shall not exceed the specified values. The following conditions define normal level of system activity to generate the normal loading scenario. Test simulation shall be done using software tool to generate this loading within 1 hour. Staggering of loads during the test duration of 1 hour is permitted but there shall be at least one hour crossing.

a) All data exchange with other systems shall occur as specified in the Specification.
b) 50% of the analog values shall be changing in every scan.
c) Average, Maximum and minimum value shall be calculated on its own for 100% of the analogs as per Sample Reports of **Appendix-B**.
d) All periodic functions shall be executed at the rates defined in **Appendix-C**.
e) The following SCADA/EMS functions shall be executed on-demand:

SCADA/EMS FUNCTION

Sl. No.	Function	Number of demand executions
A	**SCADA Functions**	
1	Network Status processor	50 state changes
2	SOE	100 SOE Point Reported
B	**EMS Functions**	
1	Contingency Analysis	2 Studies
2	Power Flow	2 Studies
3	Outage Scheduler	Define 10 new Schedule and two revisions of 5 schedules
4	Load Forecast	1 Study
5	Interchange Scheduling	10 schedule changes
6	Hydro Scheduling	1 study

a) Alarms (30 X no. of substations) per hour shall be generated. Each alarm shall be acknowledged individually within 5 seconds.
b) Events (30 X no. of substations) per hour shall be generated.
c) 60 Supervisory control actions shall be performed over the 1-hour test period using normal supervisory control procedure.
d) 1 display per workstation per minute shall be called up.
e) Communication channels shall be monitored as specified.
f) Fail and restore 1 ICCP server connection every 30 minutes.
g) Exchange at least 3000 data points with offline System in real time through Web Services.

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h) Web servers to be accessed by 50 people simultaneously.
i) The following user interface actions shall be performed.

USER INTERFACE ACTIONS

Display Selection	**30 per operator workstation**
Display Updates	Each operator workstation shall display 3 updating and 1 non-updating display window per monitor. **Updating displays:** • alarm summary list • world display containing a S/S SLD • Network display **Non-updating displays:** • SCADA/EMS System Display
Data Entry	5 data entry actions from any single display
Display Trending	8 display trends, each trending 8 variables
Reports	Prepare and printing of 10 reports as described in **Appendix-B**

a) Communications channel monitoring shall be performed.
b) The following maintenance activities shall be performed:

MAINTENANCE ACTIVITIES

Function	Task
On-Line Database Editing	Modify 20 data points in each of the 5 Substations
Display Generator and Management	Modify 5 single-line diagram and 5 tabular display
Storage of EMS data files as per section 2	(a) Transfer and store 1 save case for each application (b) Transfer and store 2 files of selected 10 minutes duration of continuous real-time data for playback and trending

a) Display of real-time trends in SCADA of at least 500 points (1 week data samples).
b) Following backup and system update activities shall be performed:

Image backup	SCADA/EMS Servers and ICCP Servers
Data Archival	Archival of Historian data on the NAS/SAN system.
Security Patch update	All machines shall be updated using patch management system.
Backup Control Center synchronization	Historian Data: data hourly Real time data: every 10 second

Table 3: PEAK LEVEL OF ACTIVITIES

The peak level of activity is in addition to the normal level of activity described in NORMAL LEVEL OF ACTIVITIES above to generate peak loading scenario. The peak level of activity shall be applied for a five-minute period. During the next ten minutes, only the normal level of system activity shall be applied. This test shall be repeated for four consecutive fifteen-minute periods, for a total peak level test time of one hour. The five-minute peak loading period shall coincide with SCADA/ EMS system period where all periodic software is scheduled for execution and at least one five minute period shall span an hour boundary to consider the scheduled hourly periodic activities. There shall be no restrictions on the period when the five-minute peak can occur.

The software execution rates, response times and performance requirements defined in **Appendix – C & D** shall not exceed during the peak loading conditions. The following conditions shall define the additional peak level of system activity:

a) System Alarms
   i. 300 alarms in a scan cycle starting the five-minute period (50% status changes and 50% analog limit violations)
   ii. 200 alarms per minute for five minutes (50% status changes and 50% analog limit violations)
   iii. 50% of the alarms shall be acknowledged within the five-minute period (automatic acknowledgement is unacceptable).
b) Display Requests - 6 display requests per minute per console
c) Supervisory Control - 3 supervisory control actions per minute
d) Reports - Prepare 5 additional reports.
e) Fail and restore communication with 1 ICCP server every 30 minutes.
f) Fail and restore with one other control center every 15 minutes.
g) 100% of the analog values shall be changing in every scan instead of 50% considered during the normal level of activities.

Appendix E

QUESTIONNAIRE

The following set of questions has been prepared to aid in evaluation of the SCADA/EMS proposals. The Bidder shall submit answers to all questions. **A question that requires a lengthy reply that is already contained in the body of the proposal may be answered by providing an exact volume, section, page, and paragraph reference.**

Ref. Part A: Section 1: Introduction and General Information

1. Please describe how the Communication with existing RTU will be established in the new Control Centre without interrupting the operations in the existing System?

2. How does bidder propose to acquire and merge all the SOE (Sequence of Events) data between main and backup Control Centers?

3. The existing database is available in XLS file. How will the bidders system integrate the existing database into new system?

4. The existing historical database is in Oracle X and data is available in CSV format also. How will this data be integrated with the new historian server?

Ref. Part A, Section 2 & 4: Training and Maintenance and Support Services

5. Describe any user groups that exist for the Bidders' equipment and software.

6. Describe how the maintenance responsibility requirements will be met.

7. Describe the Bidder/OEM upgrade and information services that are available for offered system.

8. Please elaborate arrangement with OEM for maintenance of the hardware such as Video Projection System, Servers, UPS, DG set etc.

9. Provide the complete itemized list of proposed consumables, including quantities.

Ref. Part A, Section 3: Project Management, Testing, and Documentation

10. Provide a preliminary project schedule. This scheduled shall include the payment milestones defined in Volume I and be consistent with the implementation plan.

11. Describe the difference in the proposed documentation and the documentation required as per specification.

12. Provide a sample Software Functional Requirements Document.

13. Provide a sample Software Design Document.

14. Provide a sample User Document for Dispatchers.

15. Provide a sample System Administration Document

16. Identify the formats (e.g., MS Word, .DXF drawing format) and media (e.g., CD, DVD, paper copy) to be used for final documentation of the following:

17. Standard documents produced by the bidder

18. Standard documents produced by third-party suppliers

(a) Custom or modified standard documents

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(b) Other final documentation.

Ref. Part B, Section 1: SCADA System Functions

19. Indicate the degree of compliance to IEC 61970:

a. How will IEC compliance be achieved in the proposed EMS configuration?

b. Identify and describe specific limitations concerning the offered applications that can be integrated via the standard compliant interfaces

c. Elaborate proposed migration in all above cases of non-conformance

20. When was the offered release of product released? What percentages of your current users are on the offered release of product or say one version earlier? What is the roadmap for the next release? How many are on version older than 7 years?

21. Describe how the security provision in bidder's system confirms to IEC 62351 Standard?

22. List the non-critical functions of SCADA/EMS System Applications offered? How the security certificates for ICCP shall be generated and managed for implementation of Secure ICCP? How Secure ICCP will be configured when ICCP at other end is not Secure ICCP compliant? What policy is recommended for renewal of certificates and Certificate renewal List (CRL) for Secure ICCP implementation?

23. Describe the procedure for defining or changing scan rates and assigning RTU points to specific scan rate groups.

24. How demand scan can be done by user for individual scan groups and collectively?

25. How is the ICCP Backup communication channel tested periodically?

26. Describe the procedure followed for the RTU Time synchronization by the SCADA/EMS system? How the proposed solution will achieve the time synchronization of existing RTUs.

27. Describe the RTU Communication protocol modelling tool provided with the SCADA/EMS system?

28. Describe the RTU communication monitoring, recording and statistics function provided with the SCADA/EMS system and its transfer to Historian System.

29. What is the Bandwidth needed for data exchange between the Main and Back Control Centers?

30. Describe the details of ICCP profile to be implemented by vendor in the proposed system. Provide the PICS statement and ICCP Association Information Exchange Form (EPRI) for the ICCP protocol provided with the SCADA/EMS system?

31. Describe the various ICCP blocks which shall be used for exchange of data and messages. Also please describe:

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a) The API/application through which local applications interface to ICCP to send or receive data

b) Management functions for controlling and monitoring ICCP data links including user interface to ICCP for user management of ICCP data links

c) Failover schemes to meet availability requirements

d) How data, programs or devices will be controlled or managed in the local SCADA/EMS to respond to requests received via ICCP data link

32. Describe how the Historian system is proposed to meet the requirements? Describe its features.

33. How the network topology processing function would function while playing back historical data?

34. Describe how the Historian historical information data retrieval mode will operate when displays or the SCADA/EMS database have changed since the time the Historian data was collected.

35. How will the user archive a selected time window of interest for Real time storage and playback in Historian and retrieve the same in future? How long will the archived snapshot remain in Historian?

36. Describe the structure of the power system model database and describe any restrictions to model sizing and types of model elements, including element types not listed in the Specification. Also submit the modelling parameters and give comparison w.r.t. CIM (IEC 61970) components.

37. Please describe the OPC server features of SCADA/EMS System. How many OPC clients does it support?

38. Is there any limitation or pre-requisite to access real-time data through Personal Computer? Please mention the platform and product limitation if any for the above functionality.

39. Which protocol will be used for Main-Back Control Centre Communication? If Proprietary, what are the advantages of using proprietary protocol between Main and Backup Control Centre compared to Standard ICCP?

40. Describe the philosophy to be followed for exchange of model data with the boundary system / control centers in case of full and equivalent model exchange and its maintenance.

41. How to do ‘Redundant data Source processing i.e. how the best quality and highest ranking value will be stored in the database?

<u>Ref. Part B, Section 2: EMS System:</u>

42. Explain how State Estimation estimates un-telemetered transformer tap positions.

43. How the proposed system shall use the PMU Data for State estimation? Describe the ability of Bidder’s EMS application to integrate with PMU

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measurements if sufficient PMU data is available.

44. Can Current Phasor measurement be used as an input in Hybrid State Estimator? Explain what changes will happen in algorithm?

45. How will the functionality of automatically replacing the status of switching device to close if MW and MVAR flow on the device is more than the threshold value if open.

46. Describe your HVDC model experience i.e. list of projects where implemented as part of State Estimator and OPF.

47. Describe the method for calculating and updating the busload distribution factors, including the time-filtered switch parameter feature.

48. Describe the ability of system to model Generators based on Solar & Wind.

49. Describe the State Estimation function's use of the measurement set in achieving a solution and any requirements or limitations regarding these measurements.

50. Describe the technique and the pseudo-measurements used for solving the unobservable portions of the power system model. Also describe how the impact of the pseudo-measurements on the quality of the overall State Estimation solution is minimized.

51. Describe the technique for detecting and handling bad data, including measurement bias errors. What provisions will be available to detect and/or correct status errors?

52. Explain your experience with the proposed technique, giving special emphasis to detecting and handling multiple bad data.

53. Describe the ability of State estimator to run separately for different categories wise to measure the state for different voltage level?

54. Describe the impact on storage to store 18 months data on line for LF.

55. Describe the technique by which the Similar-Day Load Forecast function will select candidate days according to their similarity to the predicted weather conditions.

56. What facilities allow for the effects of localized weather conditions to be taken into account, e.g., rainfall can affect load in urban areas less than in rural areas?

57. Describe the methodology of the proposed Hydro Scheduling function. Also describe the constraints that can be handled and the method for enforcing and relaxing constraints to ensure solution feasibility.

58. Describe the proposed mathematical algorithms and technique for hydro system modeling and scheduling and discuss the choice of the proposed method.

59. Please describe the proposed solution to exchange data with IT application such as scheduling using web services.

60. Please list the size of database being offered in.

<u>Ref. Part B, Section 3: User Interface Requirements</u>

61. Please elaborate how you plan to structure the user login – single sign on –

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across the platform for all applications i.e. SCADA, Network, Historian, Web, etc. Will it require a separate hardware for identity management?

62. Please elaborate how the MIS subsystem (Web and Historian) is placed with reference to main SCADA EMS and how SCADA users' identity will be managed for login to these across the firewall.

63. Can SCADA/EMS Operator access the historical data for making reports or seeing the logs of NMS System with Single Sign on?

64. Describe the graphics user interface capabilities of proposed user interface and possibility of using drag/drop/encircling of nodes on world display/tabular display for calculation/ element identity.

65. Describe the procedure for trending real-time data. Further please comment on possibility of default trending of all the SCADA data, say for past 24 hours or any other period.

66. Describe how the proposed quality code of the data being trended can be displayed in Graphical trends and Tabular trends?

67. Describe the approach used by the Alarm Management function to filter alarms and present only the most significant alarm information to the user.

68. Describe the alarm message formats and modification capabilities to be included with the proposed SCADA/EMS.

69. Describe the methods for report review and data modification.

70. Describe the display building procedure for features such as Rotating of 'text' alignment at some angle/ horizontal/vertical, font in italics, bold, support for no. of Font sizes.

71. Describe the printing functions and the options provided like orientation, background color, page size, color/black & white ,print preview, printing complete display and printing a part of display selected by user..

72. Describe how the user interface for Web users (Remote Consoles/External clients) is different than the user interface for the local Operator workstations.

73. Describe how data will be made available to the Web Server users for downloading.

74. Is there any standard display for limit override summary or it will have to be customized?

75. Is it possible to integrate any Video Conferencing Utility to facilitate online meeting and discussion among operators of Control Centre/Sub Stations? Will it require a separate channel for communication? What will be the impact of the

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same on ICCP/RTU data if the same channel is used?

76. Is there any provision for instant messaging among operators of same/different control centers in the supplied product?

77. Is it possible to integrate Video Surveillance feeds from Substation on to the operator screens? Will it affect RTU/ICCP Communication if same Communication Channel is used?

78. Can the supplied system display text in displays and report in "dzongkha" language (national language of Bhutan)?

79. Describe the approach used for drag & drop of any object within an application as well as from one application to other applications (for example, dragging a value from a single line display into a trend view to see its history).

80. Describe the approach used for using standard editing tools of full graphics windows User Interface e.g. cut, paste, copy, drag, drop from the ICCP and SCADA database.

<u>Ref. Part B, Section 4: System Software Requirements</u>

81. Provide descriptions of the proposed software design standards and the industry standards that are used. How the proposed product is Service Oriented Architecture (SOA) compliant?

82. Please describe the NMS offered for management and resource monitoring and proposed solution for security and patch management and update.

83. Describe the time synchronization process from GPS receiver and SCADA/EMS computers and Web Servers. What is the accuracy of time synchronization achieved for the Computers on local LAN?

84. Describe the Remote diagnostic capability provided between the SCADA/EMS system at control centers and the bidder's support offices or through the user's remote facility.

85. List all network software proposed and that which is available from the bidder and from the hardware manufacturer.

86. Describe the proposed network security software tools and environment for the employer network of users.

87. Please elaborate on the issues if any for Fire Wall configuration and redundancy of connection of Historian with SCADA/EMS.

88. Provide those parts of the database user's manual that describe the Bidder's standard approach to building and maintaining the database, including the types of data structures used and the proposed scheme for the various system functions to access this database.

89. Describe the support tools provided that allow data to be moved between Source database and real-time data sets, as applicable.

90. Elaborate the editing of database (SCADA) in real time and the parameters

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allowed for editing.

91. Describe the complete set of performance data collected, how data quantities are measured, and the calculations that are performed.

92. Provide a software summary chart that includes all programs in the proposed system. The following entries shall be included for each program, called program, and subroutine:

Sub System	Name/ Function	Language	Status
SCADA System			
EMS System			
User Interface			
Historian			
Sub System	**Name/ Function**	**Language**	**Status**
CFE			
Web System			
NMS			
ICCP			
Database Development System			
Security			
Load Forecast			

Legends:

(a) Name and Function: Program name and statement of its function

(b) Language: Programming language in which the program is written.

(c) Status: The date of initial release and project name of first use in a control system, or the expected delivery date for new, altered, or custom-designed SCADA/EMS software

93. Describe the features of the proposed on-line documentation access capability for all software products provided with computer system.

94. Is it possible to selectively integrate the databases files of various constituents in the region and automatically generate SCADA/EMS and ICCP databases for any desired Control Centre in the Region?

95. Explain, how the data/file from different versions of CIM in underlying control centers shall be integrated at NLDC?

96. Describe method available for mapping/identifying/generating ICCP data sets using the CIM tool.

97. Explain, how the different versions of CIM underlying control centers shall be integrated at NLDC?

Ref. Part B, Section 5: Hardware Requirements

98. Provide a timing analysis for the normal and peak load conditions defined in Appendix for Performance Requirements. State all assumptions made and include all calculations used to produce the timing study.

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99. Describe the capabilities and features of the proposed video projection system.

100. Describe how the SCADA/EMS configuration can change, grow, and be expanded to meet future system requirements.

101. Please submit a calculation sheet for individual and total heat as well as electrical load of the all Control Centre equipment for calculation Air Conditioning and Power Supply Requirements.

102. Please elaborate the data base development applications hosting and hardware requirement. Also indicate the node on which it is proposed to be housed in offered configuration.

Ref. Part B, Section 6: Configuration Characteristics

103. Describe how the Backup databases are maintained in the SCADA/EMS system.

104. Provide a schematic diagram of the proposed system configuration.

105. Describe the Error detection and failure determination of the critical SCADA/EMS system functions and servers.

106. Please describe how Systems of Main and Backup RLDC be synchronized for various application. What will be the failover mechanism?

Ref. Part B, Section 7: Inspection, Testing and Maintenance

107. Provide an availability analysis for the proposed configurations to meet an availability goal of 99.9%. The analysis shall include the mean time between failures (MTBF) and mean time to repair (MTTR) of all components, and the historical, statistical basis for the analysis. Specific assumptions on availability of spare parts, maintenance responsibility etc. not in line with proposed contract shall be listed. The analysis shall also present the availability for individual devices.

108. Provide a sample test plan and corresponding procedures for factory test of an application program.

109. Provide a sample test plan and corresponding procedures for Load testing & functional testing of Web Server application and it should also exhibit how the performance and scalability of applications would be tested.

Ref. Part B, Section 8: Web System Functions

110. Describe the Web services being supplied in the bidder's proposal. How will these web services import of data from offline applications into the SCADA or Historian server? Similarly how real time/offline data in SCADA/Historian will be pushed to offline applications using web services.

Ref. Part B, Appendix D: Performance Requirements

111. Please describe the report generation facility for creation by dispatcher which will provide sample reports attached at Appendix-B.

112. Please describe how these reports will be published for the web users.

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113. Identify type of displays that will not meet the required display response times (local and remote consoles) and state the guaranteed response times of these displays.

114. Describe how the various load scenarios shall be simulated. List the tools which will be used for creating the load scenarios, measurement of performance and timing.

115. Describe how the performance of web server will be met as mentioned in the performance table for servers, when hundreds of virtual users would be accessing the application simultaneously, without effecting the load on application performance, and how the scalability of all web applications are being managed.

116. How performance requirements are relaxed to make optimal use of system resources during conditions of excessive loading (beyond the specified requirement in this specification), which affects the operation of critical functions?

<u>Miscellaneous Questionnaire:</u>

1. How the User Interface will automatically re-initialize the various parameters (operator selected) associated with State Estimation process after running a specified number of times by the operator. Please submit the sample page/report of the proposed system.

2. Please elaborate and attached a sample report/page that how On-line editing of ICCP database should be possible. Any changes made in SCADA database should be automatically reflected in ICCP database. Proper User Interface for online editing of the ICCP database and mapping with other CC can be provided.

3. Show with a sample print out that how Every Alarm should be accompanied by an Audible tone which should be configurable for some particular events also, like:

(a) Frequency drop.

(b) Overloading of some important 400kV lines.

(c) Generation tripping of important stations (individual and total).

(d) And as per the operator’s requirement.

4. Also, clarify and submit supporting printout that a dedicated display can be provided for selection of Audible Tone in separate category of Alarms and The automatic generation and sending of an E-mail & SMS containing operator selected Alarm or user-defined data should also be possible.

5. What are the hardware and software requirements for sending Email and SMS? The required hardware and software would be connected to which server?

6. Submit a sample report showing that Facility to plot X-Y curve on any background where “X” and “Y” could be any user selected tag of real-time or estimated data.

7. Submit a sample report & elaborate that how Geo-spatial display with contour map of Data within geographical boundary of India should be provided in which Zoom-in, Zoom-out, Pan, etc. option should be available in the map. Display Builder should be capable of importing point and placing a pre-defined picture/symbol as per the Latitude and Longitude specified by the user. The “Playback” option should be made available in the map so that the continuous pattern over the period of time should be visualized. The pattern should be exported in a video format so as to use it in offline mode.

8. Submit a sample report & elaborate that how Customization of axis in creating the trends, the “x” & “y” axis range of every interval can be displayed. In other words, the major and minor grid should be user configurable in such a way so as to avoid these limitations.

9. Submit a sample report & elaborate that how Display building features such as Auto-fit to Screen, user-defined font size for visualization, automatic pop-up display for calculations, shall be provided in the system.

10. Submit a sample report & elaborate that how Visualization displays of SCADA/EMS system shall be able to take images from third-party software providers such as Google Earth, etc. as the background images.

11. Submit a sample report & elaborate that how Feature to “find/search” stations in the geographical display should be possible.

12. Submit a sample report & elaborate that how, In case of any pre-defined event the Geographical visualization should automatically focus on that point grabbing operator attention.

13. Submit a sample report & elaborate that how the “playback” or “reconstruct” option which fetches the archived data and displays it in the required display should be able to export the corresponding playback of data in video format so that it could be visualized offline in some other system.

14. Can “rate of Change” be added specifying that this should be automatically associated with every analog data field.

15. Please submit a detailed report telling that how all RLDC being upgraded on different CIM versions e.g. 10th version, 12th version etc. shall be finally merged into one CIM model at NLDC. As the SCADA/EMS system should be CIM compliant and import of SCADA and Network database should be possible from RLDCs with minimum efforts required in modeling of database.

16. Explain how provision to define multiple sites for each telemetered data shall be given. In case the data from one site is not available then the data should be fetched from other site.

17. Clarify & submit a report that how Statistical analysis for availability of telemetered data should be provided such as Period of availability/non-availability and its reporting based on various filters such as point-wise, station-wise, region-wise, etc.

18. Explain how an Integration tool with user interface can be provided for real-time

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SoE integration at NLDC.

19. Submit a sample format/report showing that how the proposed system is doing the merging of SoE from text and CSV files.

20. Please explain how the SCADA/EMS system shall integrated with PDC (Phasor Data Concentrator) for WAMS (Wide Area Measurements Systems).

21. Explain how the functionality of importing and adapting of historical data stored in existing Historian for integration in new system, shall be done.

22. How the historian of Main NLDC interact with that of Backup NLDC?

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Appendix F
Power System Sizing (Existing)

The initial power system size for Control Centers is provided in the following Tables:

Table 1 shows the approximate number of power system components for Control center sizing. These components need to be modelled for State Estimation and Power Flow Studies, whether or not they have associated telemetry. All the points used for calculations are not telemetered.

Table 2 shows the ICCP data to be exchanged with other Control Centers. A more accurate count will be supplied during project implementation.

Table 3 shows the Data to be exchanged with Off-line applications through web Services, ODBC, OPC servers, etc.

Table – 1: Power System Components Sizing

Power System Component	No. of Components
Substations	39
Overhead Lines	127
Transformers	132
Generating Units	24
Shunt Reactors	4

Table – 2: ICCP Point Counts for Control Centers

<table>
<tr><th rowspan="3">Type of Data</th><th colspan="5">Database Sizing – ICCP Point Count per connection (for each direction)</th></tr>
<tr><th rowspan="2">Data Exchange between Main & Backup CC</th><th colspan="2">Data Exchange of CC with DMS, Thimphu</th><th colspan="2">International Connection</th></tr>
<tr><th>Main CC</th><th>Backup CC</th><th>Main CC</th><th>Backup CC</th></tr>
<tr><td>Analog Points</td><td>8,000</td><td>200</td><td>200</td><td>200</td><td>200</td></tr>
<tr><td>Status Points</td><td>10,500</td><td>100</td><td>100</td><td>100</td><td>100</td></tr>
</table>

Table – 3: Point Count for exchange with other Applications

Data Source	No. of Points
Analog Points from SCADA	8,000
Status Points from SCADA	10,500
Analog points from Historian	8,000
Status points from Historian	10,500

Note:

The EMS/SCADA system shall not have any limitations except performance w.r.t. to increase in Database sizing. In case of any resizing or expansion of database is required due to constraint of system parameter in delivered system other than that listed in the table above, it shall be the responsibility of the vendor to re-size the delivered system without any cost to the customer during the entire course of the project including the AMC period.

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Appendix – G

Bill of Quantity for SCADA/EMS system

Sl. No.	Item Description	Unit	Quantity Main NLDC	Quantity Backup NLDC	Total Quantity
A	**MAIN EQUIPMENT**				
1	**Application Software**				
1.1	SCADA applications	Lot	1	1	2
1.2	ICCP Communication	Lot	1	1	2
1.3	Network Management System	Lot	1	1	2
1.4	Historian System (ISR)	Lot	1	1	2
1.5	EMS applications				
a)	- Network Topology	Lot	1	1	2
b)	- State Estimation	Lot	1	1	2
c)	- Optimal Power flow Analysis	Lot	1	1	2
d)	- Bus Load Forecast (BLF)	Lot	1	1	2
e)	- Contingency analysis	Lot	1	1	2
f)	- Interchange Scheduling	Lot	1	1	2
g)	- Hydro Scheduling	Lot	1	1	2
h)	- Load Forecasting	Lot	1	1	2
1.6	Web Server Application	Lot	1	1	2
1.7	Dispatcher Training Simulator (DTS)	Lot	1	-	1
1.8	Centralized Management Console applications	Lot	1	1	2
1.9	Patch Management software	Lot	1	1	2
1.10	Image Backup software	Lot	1	1	2
1.11	Antivirus server software	Lot	1	1	2
2	**Computer System Hardware**				
2.1	Servers				
a)	SCADA/EMS Server	Nos.	2	2	4
b)	Historian System (ISR) Server	Nos.	2	2	4
c)	ICCP Server	Nos.	2	2	4
d)	Communication Front End (CFE) Sever	Nos.	2	2	4
e)	NMS Server	Nos.	2	2	4
f)	Web/Replica Data/ Antivirus/ Patch Management Server	Nos.	1	1	2
g)	Centralized Management Console / Image Backup	Nos.	1	1	2
h)	Dispatcher Training Simulator Server	Lot	1	-	1
2.2	Dual TFT Monitor				
a)	Operator Workstation console	Lot	5	2	7
b)	Workstation for DTS	Lot	2	-	2
2.3	Engineering Laptop	Nos.	3	1	4
2.4	New Generation Firewall				

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a)	External NGFW	Nos.	1	1	2
b)	Internal NGFW	Nos.	2	2	4
2.5	LAN switches				
a)	Dual SCADA/EMS LAN	Lot	1	1	2
b)	Dual CFE LAN	Lot	1	1	2
c)	Dual DMZ LAN	Lot	1	1	2
d)	DTS LAN	Nos.	1	-	1
2.6	Auxiliary Storage for Historian	Nos.	1	1	2
2.7	NAS Box	Nos.	1	1	2
2.8	Server Rack With IP based KVM Switch	Nos.	3	3	6
2.9	Multifunction Laser Printer	Nos.	1	-	1
3	**Time and Frequency System displays**				
3.1	Time & Frequency System (GPS based)	Lot	1	1	2
3.2	Digital display for Day	Nos.	1	1	2
3.3	Digital display for Time	Nos.	1	1	2
3.4	Digital display for Frequency	Nos.	2	2	4
4	**ICCP Integration**				
4.1	Integration with Indian NLDC	Lot	1	1	2
4.2	Integration with DMS	Lot	1	1	2
5	**Furniture**	Lot	1	1	2
B	**MISCELLANEOUS**				
1	Heavy duty Air Conditioner	Lot	-	1	1
2	Uninterruptible Power Supply (UPS)	Lot	1	1	2
3	AC Distribution Board (ACDB)	Lot	-	1	1
4	Civil works	Lot	1		1
C	**TRAINING FOR SCADA/EMS**				
1	Training requirements	Lot	1		1
D	**SPARES**				
1	Servers including all main memory, auxiliary memory, interface cards complete one of each type	Lot	2		2
2	LAN switch one of each type	Lot	2		2
3	Router	Nos.	1		1
E	**ANNUAL MAINTENANCE CONTRACT**				
1	SCADA/EMS Systems	Lot	1		1

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APPENDIX- H

Hardware Specifications

1. Servers

SCADA/EMS, HISTORIAN, ICCP, CFE, NMS/DDS & DTS

(Please fill for each server as per BOQ)

Sl. No.	Description of the Features	Minimum Quantity of the features	Offer by the Contractor
1.	Application		
2.	Manufacturer		
3.	Model No.		
4.	Specint & Specfp	As per the base runtime requirements of SPEC CPU 2006 Benchmarking Standards.	
5.	Processor	Min 2x8 core	
6.	RAM	32 GB delivered, expandable up to 64 GB The operating system delivered should support expansion up to 32 GB of RAM.	
7.	Internal Auxiliary memory	500GB delivered with RAID1 configuration, expandable up to 1TB (in case of virtualization of server dedicated storage capacity shall be provisioned) The operating system delivered should support expansion up to 1 TB of Internal Auxiliary Memory.	
8.	External Auxiliary Memory (**Only for HISTORIAN)**	As per specification in Part B Section 5	
9.	Internal Optical Drive	DVD RW	
10.	Interfaces	* All servers shall have 4 - 1GB Ethernet ports)	
11.	User interface	Through KVM switch & console for each individual Panel.	
12.	Mounting	Rack mountable	
13.	Dual AC Power Supply (in Watts)	Yes	
14.	Heat Load		

2. Web Server

Sl. No.	Description of the Features	Minimum Quantity of the features	Offer by the Contractor
1.	Application		

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2.	Manufacturer		
3.	Model No.		
4.	Specint & Specfp	As per the base runtime requirements of SPEC CPU 2006 Benchmarking Standards.	
5.	Processor	Min 2x8 core	
6.	RAM	16 GB delivered, expandable up to 32 GB The operating system delivered should support expansion up to 16 GB of RAM.	
7.	Internal Auxiliary memory	500GB delivered, expandable up to 1TB The operating system delivered should support expansion up to 1 TB of Internal Auxiliary memory.	
8.	Internal Optical Drive	DVD RW	
9.	Interfaces	1 GB dual Ethernet ports*	
10.	User interface	Through KVM switch & console for each individual Panel.	
11.	Mounting	Rack mountable	
12.	Dual AC Power Supply (in Watts)	Yes	
13.	Heat Load		

3. Dual TFT Monitor

a. Operator Workstation consoles

Sl. No.	Description of the Features	Minimum Quantity of the features	Offer by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Specint & Specfp	As per the base runtime requirements of SPEC CPU 2006 Benchmarking Standards.	
4.	RAM	16 GB delivered, expandable up to 32GB. The operating system delivered should support expansion up to 16 GB of RAM.	
5.	Internal Auxiliary memory	500GB delivered, expandable up to 1TB. The operating system delivered should support expansion up to 500 GB of Internal Auxiliary Memory.	
6.	Internal Optical Drive	Blu-Ray Drive RW	
7.	Speakers	In built	
8.	Interfaces	1 GB dual Ethernet ports USB Ports	
9.	User interface	Two 23” wide screen (16:9 aspect ratio), HD with minimum Resolution (1920x1080) LED Color monitors, keyboard & optical mouse	

10.	Mounting	Desktop mounting	
11.	AC Power Supply (in Watts)		
12.	Heat Load		
13.	Video Graphics Card with Dedicated memory.	Min 4 GB	

b. Workstations for DTS:

Sl. No.	Description of the Features	Minimum Quantity of the features	Offer by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Diagonal Viewable size	23”	
4.	Color support	16.7 million	
5.	On screen control	Required	
6.	Touch and Gesture Friendly	Yes	
7.	Anti-glare & anti-static	Yes	
8.	Tilt, Swivel	Yes	
9.	Aspect ratio	16:9	

Monitors for KVM Console:

Sl. No.	Description of the Features	Minimum Quantity of the features	Offer by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Diagonal Viewable size	17”	
4.	Color support	16.7 million	
5.	On screen control	Required	
6.	Anti-glare & anti-static	Yes	

4. Engineering Terminal

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Specint & Specfp	As per the base runtime requirements of SPEC CPU 2006 Benchmarking Standards.	
4.	RAM	16GB – LPDDR4x	

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5.	Internal Auxiliary memory - with SSD hard disk	1TB	
6.	Internal Optical Drive	DVD±RW	
7.	Screen	15”	
8.	Keyboard	Keyboard	
9.	Mouse	Wireless	
10.	HD Web cam	Inbuilt	
11.	Interfaces	1 GB dual Ethernet ports Minimum 2 USB 3.0 Ports HDMI Port. Should Provide console cable separately.	

5. Firewall/NGFW

Features/Characteristics required of both internal external Firewalls:

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1	Manufacturer		
2	Model No.		
3	Data encryption support	3DES (168 bits), AES 128-, 192-, 256- bit and hashing algorithm like MD5 , SHA-1, IKE, PKI (X.509) and IKEv2 with EAP	
4	Support Active-Active mode	Yes	
5	High Availability & Load balancing	Yes	
6	Support NAT, PAT & Policy based NAT/PAT, Mapped IP (MIP), Virtual IP(VIP) & MIP/VIP grouping	Yes	
7	IP address assignment features	PPPoE, DHCP	
8	Support VoIP protocols	H.323, SIP, MGCP, SCCP	
9	IPv6 features	Syn Cookie, Syn-proxy DoS attack detection, SIP, RSTP, Sun-RPC, ALG’s, RIPng, BGP4, DHCPv6 Relay, IPv4 to IPv6 translations & Encapsulations.	
10	System management	Using web UI, Command Line interface (console/telnet/SSH).	
11	Filtering of packets based on Source address, destination address, protocol type, user, port number, URL.	Yes	
12	Filtering of protocols	FTP, SMTP, HTTP, HTTPS, SNMP, UDP, ICMP, RPC, DNS, DHCP, ARP, TCP, POP3	
13	URL filtering features	Yes (External)	No (Internal)
14	Authentication protocols	RADIUS, LDAP and PKI methods	

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15	Dynamic routing protocols	RIP v2, OSPF, & BGP	
16	DoS & DDoS prevention	Yes	
17	TCP reassemble for fragmented packet protection	Yes	
18	Brute Force attack mitigation	Yes	
19	SYN cookie protection	Yes	
20	Zone based IP spoofing	Yes	
21	Malformed packet protection	Yes	
22	DNS guard features	Yes	
23	Content filtering	JAVA & ActiveX blocking	
24	System Logging & monitoring	Syslog, Email, SNMPv2 and VPN Tunnel Monitor.	
25	Stateful packet inspection	Yes	
26	Assign zones to virtual & physical interfaces (dot1q encapsulation)	Yes	
27	Virtual firewall support (added- different policies for diff routes can be defined, for multiple LAN concept)	Yes	
28	Next Generation (proprietary of Checkpoint) IPS support (added- was already mentioned in sec-4, not mentioned in DRS of firewall hence added)	Yes	
29	Detect and protect based on Geo location (added- e.g. C country, B-country/ continent, etc.)	Yes	
30	Detect devices based on operating system (added in sec-4 also)	Yes	
31	Detail logging and packet capture (added- Basic feature of any IPS)	Yes	
32	Detail granular/ customized reporting-added	Yes	
33	Anti-APT (or Anti BOT), Adv. Persistent Threat		
34	Threat Extraction/ Sandboxing/ File sanitization (additional software blade shall be needed for advance cyber security) at gateway level- for web server file upload/ download req e.g. for monthly upload, 1 GB (peak) daily including PDF or word or excel files.		
35	Prevention of DDoS & DoS- added		
36	Out of Band Log and config management		
37	Dual Power Supply (in Watts)		
38	Heat Load		

Sizing Parameters for each Firewall:

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
		External Firewall	Internal Firewall
1.	Manufacturer		
2.	Model No.		
3.	No. of users	Unlimited	Unlimited
4.	Minimum number of concurrent sessions	500000	500000
5.	Minimum new sessions per second processing	20000	20000
6.	Minimum Firewall throughput (multi-protocol, IMIX, http/https/smtp/etc)	1 GBps (this is the basis for other parameters set accordingly)	1 GBps
7.	Minimum 3DES/AES VPN throughput	300 Mbps	500 Mbps
8.	Remote VPN	unlimited	unlimited
9.	No. of VLANs	50	100
10.	Minimum IPSec VPN peers	500	500
11.	Minimum number of 1xGbE LAN ports	8	8
12.	Virtual Firewall support	5	5
13.	Anti-Malware Detection features	Yes	Yes

6. LAN Switch

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Functions	For connecting all servers & peripheral devices on Local Area Network (LAN).	
4.	Conform to standards	ISO8802 or IEEE 802 Series Standards	
5.	Switching capability	Layer-2 switching manageable	
6.	Interface ports	** Minimum 8 port - 1GBps Ethernet ports , balance ports of 100 Mbps.	

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7.	Memory	Flash memory – 64 MB or more and DRAM 128 MB or more (to distinguish the high end switches from basic switches which have even 2 MB/10 MB switches)	
8.	Cable standard	Cat 6 or higher bandwidth cable	
9.	Mounting	Rack mountable	
10.	Power Supply (in Watts)	Yes	
11.	Heat Load		

*** However, the no. of ports in a LAN switch shall be as per the network architecture & the no. of servers/devices on that LAN.*

7. Auxiliary Storage for Historian

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Capacity	Minimum usable capacity of 10 TB	
4.	Spare HDD	1 Nos.	
5.	Expandability	Min 50% expandable including slots	
6.	RAID level	5	
7.	SAN Type and Interface ports	Fiber optic, iSCSI etc.	
8.	Snapshot feature with License	Yes	
9.	Hard Drives speed	15000 or more rpm	
10.	Hot swappable Hard Drives	Yes	
11.	Dual Power Supply	Yes	
12.	Dual Controller	Yes	

8. Network Attached Storage (NAS)

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1	Manufacturer		
2	Model No.		
3	Capacity	Minimum usable capacity of 5 TB	
4	Spare HDD	2 Nos.	
5	Expandability	50% Spare Slots	
6	RAID level	5	
7	Hard Drives speed	15000 or more rpm	
8	Hot swappable Hard Drives	Yes	
9	Dual Power Supply	Yes	

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9. Server Panels

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Functions	For mounting or placement of equipment	
4.	Mounting	Floor mounted with front & rear access to hardware and wiring	
5.	Cable entry	Bottom	
6.	Internal lighting lamp	Yes, with door interlock	
7.	230V AC, 15/5 A Internal power socket with switch	Yes	
8.	All material used in the panel are flame retardant	Yes	
9.	All Louvers provided with suitable wire mesh	Yes	
10.	Dual AC Power Supply (in Watts)	Dual Power Supply	
11.	Heat Load		

10. Color Laser Printer

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Functions	Print, scan, email, fax	
4.	Paper size	A3, A4	
5.	Print speed	30 Color pages/minute of A4 size & 15 Color pages/minute of A3 size.	
6.	Print resolution	600x600 dpi	
7.	Paper weight	75-200 GSM	
8.	First page out time	8 sec	
9.	Duty cycle	100000 pages per month	
10.	Paper handling capacity	Minimum 500 sheets for input tray & 500 sheets for output tray.	
11.	Automatic duplex printing	Yes	
12.	Landscape and portrait orientation	Yes	
13.	Interface	1GB dual LAN ports	
14.	Heat Load		

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11. Black & White Laser Printer (Multifunction Device)

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Functions	Print, Scan, Copy, Fax	
4.	Paper size	A3, A4	
5.	Print speed	30 pages/minute of A4 size & 15 pages/minute of A3 size.	
6.	Print resolution	600x600 dpi	
7.	Scan resolution	600x600 dpi	
8.	Paper weight	75-200 GSM	
9.	First page out time	8 sec	
10.	Duty cycle	Heavy duty, 100000 pages per month	
11.	Paper handling capacity	Minimum 500 sheets for input tray & 500 sheets for output tray. Duplex automatic document feeder for minimum 15 pages (scan/fax).	
12.	Automatic Duplex printing	Yes	
13.	Landscape and portrait orientation	Yes	
14.	Interface	1GB dual LAN ports	
15.	Heat Load		

12. GPS based time facility

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Time stability of internal time base	Minimum 2ppm	
4.	Propagation delay compensation	Yes	
5.	Include an offset to permit correction to local time	Yes	
6.	Reverting to internal time base upon loss of signal from UTC source	Yes	
7.	Resynchronization Delay	Not more than 5 minutes.	
8.	Accuracy of resynchronization	< 1.5 Micro Sec	
9.	Interfaces	Ethernet ports - 2 IRIG-B port - 2	

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10.	Power Supply (in Watts)		
11.	Heat Load		

13. Digital Displays for GPS Based Time facility

Sl. No.	Description of the Features	Minimum Quantity of the features	Offered by the Contractor
1.	Manufacturer		
2.	Model No.		
3.	Functions	For viewing UTC day of the year and time and frequency	
4.	Day display format	XXX (MON through SUN)	
5.	Time Display format	24 Hours, HH:MM:SS, where hour display will be from 00 to 23 hours format.	
6.	Date format	MM: DD: YY	
7.	Frequency display	XX.XX Hz	
8.	Display digit requirements	Display Digit height $\geq$7.5cm	
9.	Mounting of displays	Wall/panel mounting	
10.	SCADA Interfaces	Frequency	
11.	Power Supply (in Watts)		
12.	Heat Load		

Note: Country of Origin for all above items shall be mentioned respectively.

APPENDIX I

Tentative Data Structure for Historian system For SCADA/EMS Applications

Data Structure for SCADA

A. Analog

1	Time	Device Database name	Device Actual name	Instantaneous Value	Maximum		Minimum	
					Value	Time	Value	Time
2	TIME Block (for each 15 minutes)	Device Database name	Device Actual name	Active energy	Reactive Energy	Reactive Energy as per SEM philosophy.		

Note:

1. Only sending End values should be transferred to ISR. The logic should be built in SCADA in case of error (suspect, -ve loss etc.) the other end values with proper sign correction should be transferred to ISR.
2. The sampling rate for the instantaneous value is per minute

B. Digital

1	**Time**	**Device Database name**	**Device Actual name**	**status**

Note:

Only topological status change device should be transferred to ISR on exception

C. SOE

1	**Time in milliseconds**	**Device Database name**	**Device Actual name**	**status**	**Clock synchronism action Status**

Note: SOE data will be transferred to ISR system every 15 minutes or on demand

D. Alarm/System Activity Log

1	**Time**	**Device Database name**	**Device Actual name**	**status**	**Violation Type**	**Application**
						(SCADA /Configuration/ICCP/ RTN ET/CONTIN GENCY/OPF etc.)

Note: ALARM data will be transferred to ISR system every 15 minutes or on demand

Sizing

1. The sizing requirement for SCADA points will be same as per the SCADA sizing requirement.
2. Mass storage of files for 5 savcases of each EMS applications, 10 Output results of each

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Appendix J

EXTRACTS OF IEC 62351-5 Clause 11

11 Protocol implementation conformance statement

11.1 Overview of clause

Implementors of this specification shall supply the information in this section on request. An "X" in a box means that the implementation supports the listed feature.

11.2 Required algorithms

If the implementor does not declare support for an algorithm marked "(required)", interoperability cannot be guaranteed.

If an algorithm is not supported due to export restrictions, the implementor shall provide a copy of the export restriction that prohibits its export. This algorithm shall not be supported if and only if export restrictions do not allow any mechanism of exportation. If this algorithm is not supported, the implementation shall be clearly documented as adhering to the export restrictions, as supplied. The documentation shall also specify that the interoperable/base specification requirements are not supported. Samples of the documentation shall be provided.

11.3 HMAC algorithms

☐ HMAC-SHA1 (required)

☐ Other ______________________

11.4 Key wrap algorithms

☐ AES-128 key wrap (required)

☐ Other ______________________

11.5 Maximum error count

☐ Fixed at 2

☐ Configurable

11.6 Use of error messages

☐ Transmits error messages

EXTRACT OF IEC 62351-4 Clause 7

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7 Conformance

7.1 General conformance

Conformance to this part shall be determined by the implementation of Clauses 5 and 6.

Additionally, the following table of supported cipher suites shall be provided:

– m (mandatory): shall be supported;
– (optional): may be supported.

Table 3 – Supported cipher suites

Key Exchange		Encryption	Hash	Support		
Algorithm	Signature			Interoperable	Export restriction	Supported
TLS_RSA_		WITH_RC4_128_	SHA	o	C1	
TLS_RSA_		WITH_3DES_EDE_CBC_	SHA	o	C1	
TLS_DH_	DSS_	WITH_3DES_EDE_CBC_	SHA	o	C1	
TLS_DH_	RSA_	WITH_3DES_EDE_CBC_	SHA	o	C1	
TLS_DHE_	DSS_	WITH_3DES_EDE_CBC_	SHA	o	C1	
TLS_DHE_	RSA_	WITH_3DES_EDE_CBC_	SHA	o	C1	
TLS_DH_	DSS_	WITH_AES_128_	SHA	o	C1	
TLS_DH_	DSS_	WITH_AES_256_	SHA	o	C1	
TLS_DH_		WITH_AES_128_	SHA	o	C1	
TLS_DH_		WITH_AES_256_	SHA	m	C1,C2	

C1 – at least one of the cipher suites shall be supported based upon export restrictions. TLS interoperability may not be possible if TLS_DH_WITH_AES_256_SHA is not supported.

C2 – if support is not declared, the implementation shall provide a copy of the export restriction that prohibits the export of the cipher suite. This suite shall not be supported if and only if export restrictions do not allow any mechanism of exportation. If this suite is not supported, the implementation shall be clearly documented as adhering to the export restrictions, as supplied. The documentation shall also specify that the interoperable/base specification requirements are not supported. Samples of this documentation shall be provided as part of user documentation so that users can understand that the implementation may not be interoperable due to export restrictions.

7.2 Conformance of IEC 60870-6 TASE.2 security

IEC 60870-6 implementations, claiming to support standardized security, shall conform to this specification.

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VOLUME II

LOT 2

TECHNICAL SPECIFICATIONS FOR TELECOMMUNICATION SYSTEM

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SECTION 1

INTRODUCTION AND GENERAL INFORMATION

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CONTENTS

SECTION 1
INTRODUCTION AND GENERAL INFORMATION

This **Volume II (Lot 2)** of the specification describes the Communication System being procured by the Office of BPSO under Ministry of Economic Affairs. The Communication System shall include termination equipment and other associated equipment required to support data, teleprotection and voice communication requirements of the BPSO. This specification also describes the functional and performance requirements of the Communication system to be supplied.

1.1 Introduction

The existing RTUs/SAS report to the main and backup control centers using IEC-60870-5-104 protocol. The RTUs/SAS are connected with Ethernet interface of the nearest SDH node in the existing SDH network, which carry the signals to the control centers.
Bhutan Power Corporation Ltd. is planning to replace PLCC system with fiber optic based Teleprotection system in all HV Substations and transmission lines connecting hydropower plants, and export lines to India. The existing PLCC system are non-functional. All HV substations are connected with fiber optic network.

The existing communication equipment in the fiber optic network is being upgraded by BPSO in this work. Since the same communication network shall be used for teleprotection system, the offered teleprotection equipment shall be suitable for communication through upgraded communication equipment. Any required equipment/items for seamless transition from existing SDH based network to upgraded network equipment including a seamless integration of proposed teleprotection system to communication network shall be included in the scope.

The installation, testing and commissioning of teleprotection system at each substation shall be coordinated in a phased manner with upgradation of communication equipment.
The existing SDH network equipment of BPSO are on all substations rated 66kV and above. The existing and proposed network over OPGW/ADSS is attached in **Appendix B.** The existing SDH communication equipment shall be replaced by new communication equipment at selected locations, and the network shall be configured to form a ring topology, as depicted in Figure B-2 of **Appendix B**.

BPSO shall ensure fiber availability between all the terminal nodes. Fiber distance and losses details is attached in **Appendix E.** The Contractor may visit site to assess actual requirement of fiber losses, space, earthing and power requirements for bidding purpose. However, supply, installation, and configuration of new terminal equipment in the selected nodes to make them communicable with existing varied make of SDH will be in the contractor’s scope. Detailed technical specifications for terminal equipment required is mentioned in the **Section 2**.

1.2 Scope of Works

The Contractor’s scope of work under this package shall include in complete conformity with the sections of this specification. This includes overall Project Management having Survey,

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Planning, Design, Engineering, Documentation, Integration, Supply, Delivery to site, Unloading, Insurance, Storing, Handling, transportation to final locations, Installation, Termination, Testing, Demonstration for acceptance, and Commissioning. Contractor's obligations include, but not limited to the following:

a) The Contractor shall work with the aim to complete the project on or before the schedule and shall follow all relevant and applicable international/national codes and standards. The Contractor shall also be required to do the works not envisaged herein and specifically mentioned below, but otherwise required for overall completion of the project, within the quoted price/awarded value of work to the Contractor.

b) Development of detailed project implementation plan which shall include the activities of both Contractor and the Employer, showing all key milestones such as facilities readiness and clearly identifying the nature of all information and project support expected from the Employer.

c) Project management, project scheduling, including periodic project reports documenting progress during the contract period.

d) Supply, Installation, Configuration and Commissioning of MPLS-TP backbone Telecommunication Network for all locations/sites specified in the **Appendix-B**.

e) Interoperability or easy transition of data from the existing makes of SDH (GE, ABB, Tejas, RAD, ECI) to proposed MPLS-TP equipment.

f) Installation and integration of Network Management software, hardware and firmware.

g) Proposal of new network architecture implementing ring topology wherever possible to ensure absolute reliable and stable link with minimal fluctuation. Proposed tentative network topology is mentioned in **Appendix B**. However, final network topology design will be decided during detailed engineering.

h) Site visits, surveys, and necessary arrangements to inspect, identify and to provide best architecture and solution for implementation in the existing network.

i) After the site survey, the Contractor shall submit to the Employer a survey report on each site. This report shall include at least the layout of all new equipment in the room as required, proposed routing of power, earthing and cables, availability of space and AC/DC power supply, proposals for new panels/trenches/facility modifications if required and identify all additional items required for integration at each site/location.

j) Seamless Migration and Integration of existing services (SCADA, Teleprotection, VoIP, RHMI, PMU, CCTV, AMR and Voice) with minimum downtime of 1 hour at each location/site.

k) The Contractor shall prepare and submit the Network Design Basis document meeting Employer's requirements after the award of contract. As a part of Network Design Basis document, the engineering and design details like; Hop-wise Optical link budget calculations, MPLS-TP based Telecom systems set up for providing SCADA, Voice, CCTV, RHMI, VoIP, Teleprotection & data communication facilities, space and power provision, NMS integration/interfacing to existing telecom system/network, station-wise equipment/cabling lay-out plan, system/network availability calculations, etc. are to be provided as a minimum.

l) Design, engineering, supply, delivery, installation, testing and commissioning of teleprotection system in HV transmission lines including all related works like cable connection and configuration of the telecommunication system for satisfactory operation of teleprotection system.

m) All transmission lines connecting generating hydropower plants i.e. CHP, THP, BHP, KHP, MHP, & DHP to be provided with teleprotection at both ends. The installation of teleprotection equipment shall be coordinated with respective hydropower plants.

n) All interconnecting 400kV, 220kV & 132kV transmission lines to India to be provided with teleprotection. The installation of teleprotection equipment shall be coordinated with respective Indian counterparts.

o) 220kV & 400kV transmission lines have Main-I & Main-II distance protection, while 66kV & 132kV transmission system have Main and Backup protection. For 220kV & 400kV lines both Main-I & II protection to be covered. For 66kV & 132kV lines only Main protection to be covered.

p) The offered teleprotection system shall be upgradable in the future with technological advance.

q) All equipment, material and services required for the functioning of teleprotection system complete in all respect are deemed to be included in the scope.

r) On-site training and field demonstration to site officials during installation, testing and commissioning of teleprotection system.

s) Provide detailed knowledge transfer training plan.

t) Provide Defect Liability Period of one year with effect from signing of the project completion date.

u) Provide detailed Maintenance and Management plan for the next 3 years from the end of Defect Liability Period. The plan should include minimum of 1 key technical staff capable of providing technical support and services at site.

v) The dismounted communication equipment and its accessories shall be transported to a designated location which shall be finalized during the detailed engineering.

w) All cabling as required, including cable trenches, hose pipe, wiring and interconnections to the equipment being supplied and integrated (new and existing) at the defined interfaces.

x) Provide all additional equipment necessary to ensure compatibility between new and existing equipment.

y) Supply of Spares identified under AMC along with main items to meet contingency during installation period and during AMC period.

z) Factory and site testing of all hardware, software and firmware provided. Produce Type Test report to the Employer and if required by the Employer, conduct Type

Test.

aa) Provide the Quality Assurance Plan and access to the manufacturing process.

bb) Transportation of equipment and all other components from location of manufacturing to the locations of installation. The Contractor shall also make necessary arrangements for transportation/shifting of the material from stores to respective sites for installations. Statutory clearances including clearance of customs, entry tax as required for all the supplied items.

cc) Storing, maintenance of storing area and security including full responsibility for protection from any disasters such as fire, theft, pandemic (corona virus) etc. for all the items to be supplied.

dd) Functional and performance test of the complete system concerning and connecting all the MPLS-TP based telecom equipment, Compatibility test carrying STM 4 level traffic in supplied MPLS-TP system and NMS.

ee) All documentations and drawings as specified.

The list of transmission lines connecting generating hydropower plants (GENCOS), HV substations and export lines to India along with power system transmission network and fiber network have been provided as **Appendix-H**.

Any items not specifically mentioned in the specification but which are required for successful erection, testing & commissioning, and satisfactory operation of telecommunication system are deemed to be included in the scope unless specifically excluded. Therefore, bidder shall be fully responsible for providing all equipment, material, and services complete in all respects.

The Contractor shall also be responsible for overall co-ordination with internal/external agencies, project management, training of Owner's manpower, loading, unloading, handling, moving to final destination for successful erection, testing and commissioning of the substation/switchyard.

It should be noted that design information and BoQ are provisional only. The contractor shall verify the design data during the site surveys and detail engineering and finalize the BoQ as required for ultimate design and system performance. However, the location/area of execution of works under this Project shall not be limited only to the locations indicated in the appendices. The employer reserves the right of execution of works within the stipulated quantity variation provision at places other than those indicated in the appendices at the same rates, terms and conditions.

1.3 Mandatory Qualification Criteria

The Bidder should have successfully supplied at least 5 numbers of MPLS-TP equipment along with Network Management System in the preceding seven (7) years which shall be reckoned from the final due date of submission of bid.

All such supplied equipment should have satisfactory operation for the period of minimum two (2) years which shall be reckoned from the final due date of submission of bid.

1.4 General Bidding Requirements

The Bidder shall be responsive to the Employer's technical requirements as set forth in this specification. To be considered responsive, the Bidder's proposal shall include the following:

a) The Technical Proposal including the documents listed in **Table 1.1** shall be provided in the bid.

b) A detailed project implementation plan and schedule that is consistent with Employer's specified objectives. The plan shall include the activities of both the Contractor and Employer, show all key milestones, and clearly identify the nature of all information and project support to be provided by Employer.

c) A System Description Document describing the overview of bidder's proposed Software and Hardware System.

d) A clearly defined plan to develop a system support organization, based in Bhutan and capable of providing a full range of local services (including software and hardware maintenance and upgrade support) for the life of the delivered Communication System.

e) The migration plan detailing the minimum space and logistics requirement at existing site/location, expected downtime in existing system, dismantling of the existing system and shifting the operation to the new system.

Table1.1: Bid Documents Checklist

S. No.	Description	Enclosure	Reference
1.	Completed Data Requirement Sheets (As per **Appendix –D** of Technical Specification)	Pages	Sectional references
2.	Type Test Certificates for Equipment offered as applicable	Pages	Sectional references
3.	Performance Certificate of one year of successful operation from at least one customer.	Pages	Sectional references
4.	Quality Assurance Program	Pages	Sectional references
5.	Detailed Project Implementation Plan	Pages	Sectional references

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Office of the Bhutan Power System Operator

6.	Maintenance Strategy	Pages	Sectional references
7.	Schematic Diagram of Proposed System Configuration	Pages	Sectional references

Specifications and codes shall be the latest version, inclusive of revisions, which are in force. Where new specifications, codes and revisions are issued during the period of the contract, the contractor shall attempt to comply with such, provided that no additional expenses are charged to the employer.

1.5 Table of Compliance

Bidder shall use one copy of Volume I, "Commercial Bid" and Volume II, "Technical Specifications" to indicate compliance status and Technical Status with those volumes. Within the right-hand margin, Bidder shall indicate compliance status and, technical Status to each paragraph and an index key for any explanation or comment.
In addition, the Bidder shall annotate the Table of Contents of each of the above stated volumes to provide a high-level summary of compliance status and Technical Status. In both cases, the following symbols, and no others, shall be used:

Compliance Status:
C- Bid complies with all requirements
A- Bid is not compliant with the requirements, but a functional alternative is proposed.
X- Bid takes exception to the requirements and no functional alternative is proposed.

Technical Status:
S - Bidder's Standard product will be used to meet the Requirements
D- Bidder will take development work to meet the requirements

Only one symbol of Compliance Status and one symbol of Technical Status shall be assigned for a paragraph and shall indicate the worst-case level of compliance for that paragraph. This annotation may be handwritten.

Bidder shall also underline, on the compliance copy, all requirements to which exceptions have been taken (X) or to which alternatives have been proposed (A).

Each alternative shall be clearly and explicitly described. Such descriptions shall use the same paragraph numbering as the bid document sections addressed by the alternatives. All alternative descriptions shall be in one contiguous section of the Bidder's proposal, preferably in the same volume, and titled "Alternatives." A separate section titled "Exceptions" should be provided containing any discussion or explanation Bidder chooses to provide concerning exceptions taken. Alternatives which do not substantially comply with the intent of the bid documents will be considered exceptions.

The Employer will assess the merits of each alternative and exception and will be the sole judge as to their acceptance.

1.6 Organization of the Lot 2 of Volume II

Section 2 through 5 provide the requirements of communication system to be provided as follows:

Section 2: Network Configuration and Equipment Characteristics
Section 3: Network Management System (NMS)
Section 4: Environmental, EMI, Power Supply, Cabling and Earthing Requirements
Section 5: Project Management,Testing, Spares, Maintenance, Training and Documentation Requirements

Appendix A: Acronyms
Appendix B: BoQ
Appendix C: List of Tests
Appendix D: Technical Data Requirement Sheets
Appendix E: Optical Fiber Link Details
Appendix F: Warranty
Appendix G: AMC
Appendix H: Substation-Lines Connectivity
Appendix I: Project Implementation Plan

1.7 Applicable Standards

The applicable standards are mentioned in the respective technical section. The offered equipment shall conform to the standards mentioned in the specification except to the extent modified by this specification. In case of any discrepancy between the description given in the specification and the standards, the provisions of the technical specification shall be followed. The parameters not specifically mentioned in technical specification shall conform to the standards mentioned in this specification.

SECTION 2

NETWORK CONFIGURATION AND EQUIPMENT CHARACTERISTICS

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CONTENTS

SECTION 2
NETWORK CONFIGURATION AND EQUIPMENT CHARACTERISTICS

2.1 Introduction

This section describes the functional requirements, major technical parameters for termination equipment system and other items to be provided under this Project. All necessary training material shall be provided by the Contractor.

2.2 General Network Characteristics

2.2.1 Description

The RTUs/SAS located at various location reports to Data Center using IEC 60870-5-104 protocol. The proposed communication shall provide connectivity of RTUs/SAS over TCP/IP protocol using Ethernet interface. Further, the proposed network shall also support the requirement of voice, video & RHMI connectivity and teleprotection.

The detailed BoQ is described in **Appendix B**.

2.2.2 Functional Requirement

The primary function of the communication network is to provide highly reliable data and voice communication system in support of the SCADA/EMS. The communication support requirement for SCADA/EMS system for low and high speed data, and voice circuits. A brief summary of the communication system requirements is as follows:

a) Low speed (100-1200 kbps) data channel from RTUs to respective data center in case of existing RTUs. At present 10Mbps of dedicated bandwidth is used to connect all RTU spread throughout the network.

b) Data channel for existing PMUs. At present 10Mbps of dedicated bandwidth is used to connect all PMUs spread throughout the network. Similar or higher dedicated bandwidth should be allocated for PMU channel.

c) The connectivity envisaged between RTUs and Control Center is Wide Area Network (WAN) on TCP/IP using IEC 60870-5-104 protocol.

d) VoIP channel support for various substations and generating plants. At present 6 Mbps of dedicated bandwidth is used to connect all VoIP phones spread throughout the network.

e) Data transport supporting Network Management System.

f) RHMI requiring minimum of 4 Mbps and CCTV requiring minimum of 50Mbps dedicated channel support for various substations.

g) Dedicated Teleprotection channel support for HV substations.

h) MPLS-TP based backbone network with modular 1+1 redundant chassis with min 4 x 10G and option to add 10G interfaces for future upgrade. The system should have the capability to support E1 and STM1 CEM.

2.2.3 System Synchronization

The Contractor shall provide clock synchronization at a central location. The clock signal will then be distributed downstream for all communication equipment available at each termination equipment location. Where clock cannot be distributed over communication interface, separate GPS shall be provided for synchronization purpose. Appropriate interface(s) in the termination equipment to be supplied and all other associated hardware shall be provided by the contractor.

2.2.4 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostics testing to be executed both locally and from remote locations, manually and or initiated under NMS control. Such testing shall not affect the functional operation of the system.
Preventive and problem-oriented maintenance of the communication system shall be performed using diagnostic tools. They shall support complete maintenance of all system elements and shall permit the diagnosis of any fault. For all redundant systems, disconnection and repair of any failed device shall not interrupt the operation of the system.

2.2.5 Equipment Availability

The average per link subscriber to subscriber availability shall be at least 99.97 %. The per link subscriber to subscriber availability is defined as the availability between any two data or voice subscribers at the two end of an available communication (On fiber optic) link.

The calculated availability is defined as the theoretical availability determined by the statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the Termination equipment system. The downtime of fiber optic cable and associated equipment shall not be considered in the aforesaid availability calculations.

To ensure that the equipment and configuration proposed by the bidders shall be capable of demonstrating the specified availability figures it is required that the Bidders shall include in their proposal a calculated availability analysis for the proposed equipment/ subsystem. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided in the proposal. The analysis shall be based on an availability block diagram and shall include the mean-time-between-failure (MTBF) and mean-time-to-repair (MTTR) of all the components on the link. The Contractors shall indicate in the analysis the MTBF and MTTR and the resulting availability of each point-to-point link. For this analysis, an MTTR of at least 4 hours shall be assumed.

2.3 General Equipment Characteristics

All Contractor supplied equipment shall be new and of the finest production quality. The Employer will not accept modules or printed–circuit boards that are modified by appending wires or components. Wired strapping options shall be incorporated in the board designed to meet the above requirement.

2.3.1 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

All field modifications of the hardware, firmware and software that is required to meet installation and/or performance specifications, shall be fully documented as part of the deliverables, both as a separate field modification record and as corrected equipment/configuration documentation.

2.3.2 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BoQ and configuration requirements, including spares, as identified in the appendices.

Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion. The Contractor is required to size and equip the system to include all envisaged channel cards.

The equipment proposed for teleprotection system shall be sized and equipped with sufficient capacity to support the number of transmission lines connected to each substation.

a) Teleprotection Interface

S/No.	Description	Capacity
1	Integrated distance teleprotection interface	Yes
2	Integrated optical teleprotection interface	Yes

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3	Addressing of protection commands	Yes
4	Loop test for reassuring delay time	Yes
5	1+1 switch-over less than 10ms	Yes

b) Interface for Commands Tx/Rx for Distance Protection Scheme

S/No.	Description	Unit	Capacity
1	Number of independent commands	Number	Min. 4 commands Max. 32 commands
2	Transmission time max	ms	6
3	Protection voltage max.	V DC	250
4	1+1 com path protection		Yes
5	Digital display type counter module to count Tx & Rx command operation for each command with count storage circuitry, Selectable working voltage 48V/110V/220V DC and with arrangement on front of module to reset counter (Tx, Rx) for each command separately.		Yes

c) Interface(s) for Differential Protection

S/No.	Description	Unit	Capacity
1	Optical interface C37.94	Mbit/s	2.048
2	Minimum Ports/Interface	Number	4
3	Payload for protection relay	Kbit/s	64 = 768

2.3.3 Redundancy Requirements and Protection Schemes

The contractor shall provide 1+1 redundancy on the power supply cards, controller cards, and traffic cards for the terminal equipment and its peripherals.

In case the equipment offered by the Bidder does not support the above-mentioned minimum protection methods, the bidder shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost

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Office of the Bhutan Power System Operator

to Employer. The bidders shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

2.3.4 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

2.3.5 Equipment Lifespan

All equipment supplied shall have a minimum expected life of ten (10) years from the date of operational acceptance.

2.4 Terminal Equipment System

The Termination Equipment system is defined to include the equipment that interfaces the subscriber (user) to the available Transmission System. The descriptions of these equipment are as follows:

2.4.1 Telecommunication Equipment

The communication equipment shall be implemented in the selected locations specified in **Appendix B**. Hybrid network shall be established comprising of SDH and new equipment. Further, ring topology shall be implemented in the network. The new equipment and existing SDH shall be used to collect field data and connect to the fiber optic to transport over the communication network.

The FO Communication equipment to be supplied shall be MPLS-TP providing all the features e.g. protection and performance monitoring. It should offer carrier-class Ethernet, MPLS and IP capabilities to carry converged, multi-service Packet Networks like SCADA, Automation, Teleprotection and Legacy applications. This shall be integrated with existing SDH network. The new equipment to be supplied shall be interoperable with different makes of SDH and other network elements.

All software and hardware shall support IPv4 and IPv6 simultaneously. The Contractor shall provide connectorized jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection.

The fiber optic transmission equipment shall have minimum specifications as follows:

a) The equipment shall be compact and in composite construction and light weight suitable for installation in 1RU width 19" rack. All modules shall be integrated in the same shelf. All connectors shall be accessible from the front and comply with international specifications. However, the mechanical design and construction of each card/unit shall be inherently robust and rigid under all conditions of operation, adjustment, replacement, and storage. The actual dimensions and weight of the equipment shall be furnished by the Contractor.

b) The Equipment shall be connection-oriented packet switching model with traffic engineering capabilities that allow deterministic control of the use of network resources. It shall support traffic engineered point to point (P2P), point to multipoint (P2MP) and Multipoint to Multipoint (MP2MP) transport path.

c) It shall support Packet and Ethernet services, MEF CE2.0 (E-Line, E-LAN, E-Tree, E-Access) which provides interoperable interconnection, management, and performance. Link aggregation with LACP (IEEE 802.3ad), PN and VPN based Ethernet and IP, MPLS –TP and multicast applications (IGMP v2/v3) shall be supported. It should have minimum interface of 8x10/100/1000Base-T, 8x100/1000Base-X, 3x10GE.

d) All port should be Auto and Manual configurable to set parameters like: Rate/Bandwidth, Half/Full Duplex, etc.

e) It shall be possible to monitor transmit and receive power on all optical interface ports on the Equipment.

f) Ethernet ring protection scheme, ERPS (Ethernet ring protection switching) standardized in ITU-T G.8032 should be supported.

g) All software and hardware shall support IPv4 and IPv6 simultaneously.

h) It should have card-level protection, hardware redundancy MSP 1+1 for main cards including Power supply, Controller, and IO cards. It should be Hot swappable for higher availability and recovery of service shall be within 50ms.

i) It should deliver MPLS-TP linear protection with two LSPs to achieve 1:1 or 1+1 mode of protection within 50ms.

j) It should offer OAM functions of both Ethernet OAM (IEEE 802.3ah, IEEE 802.1ag and ITU-T Y.1731 PM) and MPLS-TP OAM (G 8113.2). It should allow real-time monitoring of end-to-end circuits, connections or trunks, facilitating fast detection and isolation of faults.

k) It should support Continuity check (CC) using BFD and Connectivity verification (CV) using LSP ping & traceroute and PW ping & traceroute for continuous or on-demand diagnostics to show their status.

l) It should define Alarm suppression and fault indication with AIS/RDI/CFI, performance monitoring for frame loss and delay with LM/DM/OAM-LB/LT, support Multi-segment Pseudowire and guaranteed service level agreement (SLA).

m) Traffic classification based on Port, VLAN, port+VLAN, IEEE 802.1p, DSCP and Differentiated Services (DiffServ).

n) It shall be possible to rate limit the traffic in MPLS-TP tunnels at minimum 64 kbps granularity. It shall also be possible to configure end-to-end MPLS-TP tunnels & PWs through NMS.

o) Quality of service (QoS) should be enforced by using CoS class mapping into 8 different priority queues. Scheduling disciplines based on Strict Priority and Weighted Round Robin (WRR).

p) Bandwidth Control with Ingress policing per service and Egress shaping per service along with Weighted Random Early Discard (WRED) for congestion management.

q) It should further support Tunnel and PW Traffic Engineering CIR/PIR Two rate, three color marking.

r) Mesh, dual homing, multi-ring, ring, star and linear topologies should be supported.

s) For security, it should support RADIUS (Authentication, Authorization and Accounting) following IEEE 802.1X standard, SSH for remote management, ACLs and provide Port security and mirroring.

t) It should support Circuit emulation services; SAToP, CESoPSN and CEP and Encapsulation of TDM & IP over MPLS and Ethernet VPWS, VPLS using Pseudowire. All Ethernet interface shall be configurable as client interface (UNI) and network interface (NNI).

u) It should support service interfaces for nx64kbps, C37.94 and E1 interface over packet.

v) It should have Ethernet physical layer timing synchronization SyncE with ESMC supporting IEEE 1588v2, Stratum3 clock or better and in case of loss of timing reference the clock holdover should be provided.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

w) The equipment shall have power supply operating on -48 VDC ± 15%, 50Hz power supply. It should also have Over-load, Over-voltage and Reverse Polarity Protection.

x) The equipment shall have operating temperature between -20°C to 60°C and humidity of 95% non-condensing.

y) Downloading of configuration shall be possible from remote. The equipment shall have LED for alarm indication. It shall be managed locally by a standard PC/Laptop and remotely by central NMS through standard interface in line with ITU-T standards. Local management interface of the equipment shall be of RS-232 or Ethernet type.

z) Supplied MPLS-TP under this project should support downloading of configurations to keep configuration backups for future references. Suitable file transfer protocols such as RFC 959 File Transfer Protocol (FTP), RFC 5905 NTP Client, RFC 1350 Trivial File Transfer Protocol (TFTP), Secure File Transfer Protocol (SFTP), Secure Shell (SSHv2), SNMP v2/v3 and Syslog with Syslog Accounting. Downloading of backup configuration of any node on the network should be possible via any other node in the network.

aa) Pre-connectorized Optical patch cords shall be of G.625D fibre with suitable connecter type such as FC, LC, SC. It should be of type single mode and simplex. The Patch cord return loss shall be equal to or better than 40dB and insertion loss equal to or less than 0.5dB.

bb) Pluggable SFP, SFP+ support should be provided as per the network requirement. All the SFP/SFP+/XFP should be with two ports i.e. one is TX port to transmit the signal, and the other one is RX port to receive signals. Amplifier/Signal boosters shall be provided wherever necessary.

cc) The Teleprotection and communication system has to ensure easy and secure function of teleprotection. Therefore, the following features must be provided:

- At least an 8-bit command addressing for teleprotection signal shall be provided to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.
- An automatic and periodic loop test (<100s) must be provided for a signal delay measurement.
- A switch-over of the teleprotection command in less than 10ms must be guaranteed.
- The configuration of the teleprotection must be integrated into the communication configuration tool to ensure easy maintenance.

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- The teleprotection shall be software programmable via PC HMI with Graphical User Interface (GUI) & NMS software.

dd) Module to transmit Protection Commands (For distance protection scheme)

1. This module shall support following features related to protection commands:
    - Transmission of 4 independent and simultaneous protection commands bi-directionally (i.e. Transmit/Receive independently).
    - All 4 commands Transmit/Receive independently such that in case of all four commands if transmitted from one end then all four shall be received at the opposite end.
    - User programmable individually to support blocking, permissive tripping or direct tripping protection schemes.
    - Accept protection command signals in the range of 48V DC – 250V DC. The DC voltage supply in substations are as follow:
        i. 66kV & 132kV substations: 110 V DC
        ii. 220kV & 400kV substations: 220V DC
        iii. Communication equipment: 48V DC
    - All inputs and outputs shall be isolated and with EMC immunity for harsh environment.
    - Security and dependability shall be selectable and programmable.
    - It shall also be able to drop and insert commands, transfer commands as a transit station and to realize AND-and OR-combinations between commands.
2. The teleprotection module shall provide:
    - A command counter (Digital display type) which counts trip Send/Receive commands with circuitry to store the counts, with selectable voltage range (48V, 110V & 220V). Arrangement to reset the counter on the front counter panel shall be provided.
    - The teleprotection interface as per relevant standards shall allow the protection scheme i.e. permissive tripping, direct tripping, blocking/unblocking etc.
3. The teleprotection module shall further support:
    - Signal delay measurement.
    - 1+1 protection, switching shall be done within less than 4ms (typical

value).

- Periodically automatically initiated loop-tests (e.g. every 60s).
- Command addressing: This function shall be used to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.

Under no circumstances will the module cause trip-commands in case of power supply failure or when equipment is put into or taken out of service.

ee) Module to interface directly with Protection Relays (For optical interface). This module shall have optical ports each of them allowing direct connection to protection relays with interfaces complying with ANSI/IEEE C37.94 standards. Each interface shall support all 12 time slots (12x64kbits/s) in accordance with ANSI/IEEE C37.94 standards.

ff) The expandability for future requirement to be supported by offered equipment which shall be achieved by just inserting the cards in access equipment.

Detailed specifications can be found in **Appendix D**.

2.4.2 Optical Link Performance Requirements

The optical fiber link performance requirements are specified as follows:

2.4.2.1 Link Budget Calculations

The fiber optic link budget calculations shall be calculated based upon the following criteria:

a) Fiber attenuation: The fiber attenuation shall be taken to be the guaranteed maximum fiber attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

b) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 mms.

c) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

d) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed “End of Life (EOL)” parameters. In case, the End of Life parameters are not specified for the Telecom equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

e) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

f) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

g) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

h) Dispersion: The fiber dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibers.

i) Bit Error Rate: The link budget calculations shall be done for a BER of 10-10.

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fiber optic link during detailed engineering.

For finalizing the FOTS system design & BoQ, above methodology shall be adopted taking into account fiber attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

2.4.2.2 Link Performance

The Link performance for ES, SES and BER for the fiber optic links shall correspond to National Network as defined in ITU-T G.826.

2.4.2.3 FODP to Telecom Equipment

The Contractor shall be responsible for connectivity between the FODP and the Telecom equipment. Most of the FODP provides FC connection, with few FODP providing SC connection.

The patch-cord laid between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

SECTION 3

NETWORK MANAGEMENT SYSTEM

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CONTENTS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 3
NETWORK MANAGEMENT SYSTEM

3.1 Introduction

The Contractor shall provide a Network Management System (NMS) for operational support to communication equipment including teleprotection system. This NMS shall provide the capability to monitor, reconfigure, and control elements of the Termination equipment systems from a centralized location. This NMS system shall assist Employer in the operations and maintenance of the Termination equipment system resources including system performance, the diagnosis of problems, the implementation of remedial actions and the allocation or reallocation of communications resources and addition/deletion of elements. The NMS system shall be accessible from any nodes in the network.

The Contractor shall supply a single NMS for all the NEs (Network Elements). The bidder shall provide details of the offered NMS in the bid.

3.2 Applicable Standards

The NMS design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010.

3.3 NMS Architecture

The NMS shall provide:

a) Collection of Management data from all Network Elements (NEs) to be supplied under **Lot-2, Volume II**.

b) Processing of above management data by using processor(s) located at a centralized location.

c) Monitoring and control of the NEs as defined below:

I. NMS System at NLDC Thimphu shall support management of all termination equipment supplied and monitoring of complete termination equipment system under this project. At a minimum functions of Element Management Layer (EML) as defined in ITU-T M3010 shall be provided. The detailed functions are described below. The contractor shall provide suitable router/s, interface or any other hardware required to transport the NMS information of the NEs up to NLDC. Accordingly, bandwidth as required shall be provided by the employer for NMS purpose.

II. Monitoring and control of NEs using craft terminals as defined in this specification. System monitoring of Temperature, Input Voltages, Power modules, Fiber losses, Fans and Memory utilization.

III. Remote console of NMS at Main NLDC shall be provided at Backup NLDC.

Thimphu Bhutan
Office of the Bhutan Power System Operator

d) Communication channel support for NMS system.

The supplied NMS system shall be capable of handling all management functions for at least 200% of the final network elements. Further, the centralized NMS system shall also have provision for addition of at least two remote operator consoles. The NMS hardware shall be so designed that failure of a single processor shall not inhibit any of the functionality of the NMS System. The Contractor shall submit for Employer's approval the NMS architecture describing in detail the following subsystems/features:

a) Database used in NMS
b) Master Processor, server/workstation, LAN, Peripherals and hardware
c) Software and operating system
d) Local Consoles
e) Craft Terminals
f) Data communication between NEs, Local Consoles, Remote Consoles and NMS Processor(s)
g) Routers/Bridges
h) Expansion Capabilities

3.4 Management Functions

The NMS shall support following Management functions:

3.4.1 Configuration Management

Configuration management is concerned with management, display and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

a) Provide tools to establish and maintain the backbone topology and configuration information and provide dynamic graphical maps depicting the configurations.
b) Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.
c) Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.
d) Provide facility for automatic & manual device discovery of all Network Elements (NEs). Updating, deletion and retrieval of the managed network topology data shall

also be provided.

e) Provide verification testing to support new equipment installation.

f) Have specification and settings of all the NE installed.

g) Support configuration of various error/fault/alarm generation threshold; configuration and management of in-band secured management channel for their management from NMS.

h) Facilitate configuring end to end Label Switched Path (LSP) and Pseudo wire (PW) trail and assigning network resources to the trail. Enabling/disabling of protection switching of trails.

i) Support configuration & management of features like: E-Access (Access EPL, Access EVPL), E-LAN (EP-LAN, EVP-LAN), E-LINE (EPL, EVPL) and E-Tree (EP-Tree, EVP-Tree).

j) NMS shall have backup provision for Configuration data, Cross-connection data, Trail Data and NMS System data.

k) NMS should be able to track network availability. It should provide comprehensive network availability report for a selected period.

3.4.2 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

a) Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colors on links and nodes as well as through text.

b) Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity of unit/module level in a system.

c) Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms information and notifications with all details (type, occurrence, severity, probable cause and clearing, etc.). The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms, minor alarms and warning alarms with different colors.

d) Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.

Thimphu Bhutan
Office of the Bhutan Power System Operator

e) Storing and processing of historical alarm information for at least 30days minimum. Retrieving functions with filtering capabilities for historical alarms and events shall be provided.

f) The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.

g) Track network equipment failure history. Alarm export to a remote location should be possible without any additional software.

h) The management system shall also provide audible alarms (with a provision to disable the same, as and when required by Owner), whenever a new alarm enters the management log.

3.4.3 Performance Management

Performance management is concerned with evaluation of the use of network equipment and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

a) Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions.

b) Provide Delay measurement and Loss measurement for Packet services.

c) Monitor signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources. Specifically provide displays to permit the operator to:

   I. Select/deselect network equipment, events, and threshold parameters to monitor.
   II. Set monitoring start time and duration or end time.
   III. Set monitoring sampling frequency.
   IV. Set/change threshold values on selected performance parameters.
   V. Generate alarm events when thresholds are exceeded.
   VI. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
   VII. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs.
   VIII. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

IX. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

3.4.4 Security Management

The NMS shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only and write (configure).

The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the NMS system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write" access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control.

Providing protection to network resources and services from unauthorized access through maintaining the user database which contains their password and their related authorization levels. Only the system administrator has the authorization to access and edit the user information.

Monitoring of the login and logout activities of the system and record such activities as a sequence event. Every login and logout activity shall be recorded in a log file with information such as username, login and logout time and successfulness of login attempt. The information in the log file shall be retrievable and browse-able by the system administrator. Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

3.4.5 Software Management

The NMS shall provide loading and installation of new system software or software patches.
It shall have Local or Remote Software Download (with appropriate user authorization) through FTP / TFTP with display of message regarding the progress, successful or failed operation.

3.4.6 Inventory Management

The NMS shall have features showing inventory based on the available device inventory, keeping track on any change in the network inventory and indicating absence/presence of any physical module/hardware and also indicating the usage of module.

Thimphu Bhutan Office of the Bhutan Power System Operator

3.5 Communication Requirement and Integration

The Contractor shall provide all required interface cards / devices, LAN, routers/bridges, channel routing, cabling, wiring etc. and interfacing required for full NMS data transport. NMS channel shall be provided in the payload channel of the transmission equipment. The Contractor shall provide suitable interfaces in their supplied equipment for transport of NMS data. The bidders shall describe in the proposal the NMS data transport proposed to be used by the bidder in detail including capacity requirements and various components/equipment proposed to be used.

3.6 Craft Terminal

Each termination equipment to be supplied shall include provision for connecting a portable personal computer (PC)/ Laptop computer to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

a) Change the configuration of the station & the connected NEs

b) Perform tests

c) Get detailed fault information

3.7 Hardware Requirements

3.7.1 Server/Workstation and Craft Terminal

The vendor shall provide a server/workstation PC and a craft terminal laptop. The server/workstation and craft terminal shall have minimum Quad Core processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, IBM, HP make shall be supplied. INPUT Power shall be 230 V with dual power Input and provide licensed MS Window/Linux/UNIX/Solaris with Anti-Virus provisioning.

The server/workstation shall have minimum configuration of Intel i5 or equivalent processor with minimum of 3.2 GHz speed, 8GB RAM, DVD-ROM drive, 500 GB internal Hard Disk Drive, 101-Enhanced style USB keyboards, USB mouse, parallel, serial / USB (3.0) ports.
VDUs shall be dual 24” wide screen (16:9 aspect ratio), HD Resolution (1920x1080) LED Colour monitors with keyboard & optical mouse with 2meter extension cable. Appropriate network drive card supporting GbE LAN shall also be provided.

CPU enclosures shall be desktop type and shall include available expansion slots except for the Craft Terminal which shall be a laptop. The craft terminal shall have minimum configuration of 3.2 GHz processor, 8GB DDR3 RAM, Blu-ray drive, 500 GB Hard Disk Drive, keyboard, mouse/trackball etc., USB (3.0), RS-232 serial interface, 1 GbE Ethernet port, and a battery back-up of at least 4 hours.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

Converter, L2 switch, L3 switch etc. required to setup NMS for managing supplied MPLS-TP equipment under this project, should be provided by the Contractor.

3.7.2 DC to DC Converter

The Contractor shall provide 110VDC to 48VDC converter as per BoQ. The detail specification are as follows:

- Input/Output: 110V DC to 48VDC
- Power rating: 500W
- Mounting: Mountable within 19'' rack Communication panel

All the necessary cabling and miscellaneous items required for completion of the work should be under the scope of the Contractor.

3.8 General Software/Firmware Requirements

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

The Contractor is required to provide licensed NMS software. The NMS software should be user friendly.

3.8.1 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats i.e. dbase, dxf, excel, ASCII etc. as applicable.

3.8.2 Revisions, Upgrades and Maintainability

Software revisions, upgrades and maintainability is specified as follows:

3.8.2.1 Versions

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required.

All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming. All software shall be easily user expandable to accommodate the anticipated system growth, as defined in this specification. Software

Thimphu: Bhutan
Office of the Bhutan Power System Operator

provided shall be compliant with international industry standards such as IEEE, ISO and OSF.

3.8.3 Database(s)

The Contractor shall develop all the databases for the final network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of NMS system. NMS operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

3.8.4 Help

All applications shall be supported by user accessible help commands that shall assist the user in the performance of its tasks. Help commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 4

ENVIRONMENT, EMI, POWER SUPPLY, CABLING & EARTHING REQUIREMENTS

Thimphu: Bhutan
Office of the Bhutan Power System Operator

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CONTENTS

SECTION 4

ENVIRONMENT, EMI, POWER SUPPLY, CABLING AND EARTHING REQUIREMENTS

4.1 Introduction

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation for Communication system. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in a High Voltage power system environment.

4.2 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

4.2.1 Temperature and Humidity

The equipment may not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in the table below:

Temperature Range: To Specification Operation without Damage Shipping/storage	(Un Controlled Environment) 0 to +45˚C -20 to +60˚C -40 to +60˚C
Relative Humidity, non-condensing	Up to 95%
Elevation: Operating Non-operating	 to 3500 m to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack modification or equipment upgrades to ensure the proper operation of the installed equipment.

4.2.2 EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location.

4.2.3 Tropicalization

Communications equipment may also be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

4.2.4 Contaminants

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

4.3 Primary Source AC/DC Power Requirements

Facilities will be required to support both AC and DC power load requirements of communications equipment as specified below:

4.3.1 AC Power Supply

It will be the Employer's responsibility to provide required Primary AC Power support for communications equipment installed under this specification. The Primary AC Power supplied will be 230 VAC ± 10%, 50Hz with a frequency variance between 46 and 55 Hz. All equipment and components provided under this specification requiring Primary AC Power shall be designed for normal operation under the above stated tolerances for 230 VAC supply.

4.3.2 -48V DC Power Supply

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 230 V AC) provided under this specification, shall use -48V DC uninterrupted primary source power. The contractor shall intimate the Employer the requirement of maximum projected load at -48 V DC for their equipment. The power supply may vary normally within the voltage range -42 to -56 V DC and the supplied equipment shall operate satisfactorily within this range.

4.3.3 Power Distribution and Protection

The Employer will furnish one source primary 230 VAC and/or -48 VDC power in each building. However, the equipment shall facilitate termination of two sources. It shall be the Contractor's responsibility for the connection and distribution of all Primary AC and -48V DC source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

4.4 Signal Cabling

Connectorised signal cabling/wiring requires marking with a unique identifier at each connectorised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations. Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fan out point.

All signal cable, wiring and terminations shall be clearly labeled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

4.5 Equipment Sub-Racks and Cabinets (Enclosures)

All equipment provided under this specification, shall be physically mounted in existing subracks and cabinets (enclosures). The Contractor may visit the site to determine and propose the modification for existing rack to fit in new equipment with Employer approval on the manner of installation for each location. Any modification done will be under the scope of Contractor.

New panel shall be installed in locations where panel is not available or the existing panel is not spacious enough. The panels supplied shall be of height not less than 1.5 meters. The panel should be of appropriate width and breadth to hold the supplied MPLS and teleprotection equipment's appropriately, with enough space for cabling and provides easy access for maintenance.
Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

4.5.1 Modification of Sub-Rack/Panel

Any equipment added in existing Sub Racks for modification purpose, shall meet the following minimum requirements:

a) Equipment shall be steel/aluminium fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

b) Equipment covers shall be provided for exposed components mounted in equipment sub Racks.

c) Dust and moisture protection shall meet or exceed IP20 standards.

4.6 Lightning and Transient Voltage Protection

The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:

a) At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.

b) All equipment installed under this specification that requires 230VAC primary power, shall be surge protected.

4.7 Station Safety Earthing and Signal Grounding

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

a) All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards

b) Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.

c) Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sq mm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.

d) The safety earth network shall be connected to "earth ground" at the safety earth

Thimphu: Bhutan
Office of the Bhutan Power System Operator

stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.

e) The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

At each location, the Employer shall extend the existing station earth to the equipment room. The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract.
The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer's approval.

4.8 Interconnections

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor-supplied drawings.
The Contractor shall supply and install all primary power cords, power strips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution cabling, and power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded. Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks. Plug-type connectors with captive fasteners (i.e. DB-25, etc) shall be used for the interconnection of all inter and intra enclosure signaling cable.

4.9 Locations for Supplied Equipment

The supplied equipment shall generally be located in the existing SDH equipment panel within the same communications room located in the Control Building whenever possible. However, in general instant, NMS workstations may be located in Control room which may be away from the communications room.

4.10 Cabling Routing

In case NMS workstations are located remotely, the Contractor shall provide all cable, wiring, interfacing and installation to facilitate communication channel requirements for NMS.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

SECTION 5

PROJECT MANAGEMENT, TESTING, SPARES, MAINTENANCE, TRAINING & DOCUMENTATION

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CONTENTS

SECTION 5
PROJECT MANAGEMENT, TESTING, SPARES, MAINTENANCE, TRAINING AND DOCUMENTATION

5.1 Introduction

This section describes the requirements for project management, schedule, quality assurance, Contractor-supplied training, support services, Payment Charges Calculation and maintenance of the supplied equipment.

5.2 Project Management

The Contractor shall assign a Project Manager with the authority to make commitments and decisions that are binding on the Contractor. Employer will designate a Project Manager to coordinate all Employer project activities. All communications between Employer and the Contractor shall be coordinated through the project managers. The project managers shall also be responsible for all communications between other members of the project staffs including sub-contractor, if any.

5.3 Project Schedule

The project implementation plan is as given in **Lot 2: Appendix I**. Based upon this the bidder shall submit a preliminary project implementation schedule along with the bid. The detail project implementation schedule shall be submitted by the Contractor after award for Employer's approval, which shall include at least the following activities:

a) Site Survey
b) Testing at Site for interface with Control Centers, RTUs'/SAS.
c) Documents, DRS, Drawing submission and approval
d) Type Testing
e) Hardware purchases, development/manufacturing, and integration
f) Dispatch schedule
g) Receipt, Storage, Installation & Field update
h) Factory & Site Testing
i) Training
j) Commissioning

The project implementation schedule shall include the estimated period for completion and its linkage with other activities. The Project implementation schedule shall also contain Employer activities required for the Contractor to complete the system.

5.4 Progress Report

A progress report shall be prepared by the Contractor each month against the activities listed in the project schedule. The report shall be made available to Employer on a monthly basis, e.g., the 10^{th} of each month. The progress report shall include all the completed, ongoing and scheduled activities and transmittals issued and received for the month.

5.5 Transmittals

Every document, letter, progress report, change order, and any other written transmissions exchanged between the Contractor and Employer shall be assigned a unique transmittal number. The Contractor shall maintain a correspondence index and assign transmittal numbers consecutively for all Contractor documents. Employer will maintain a similar correspondence numbering scheme identifying documents and correspondence that Employer initiates.

5.6 Review Meetings

Progress meetings shall be scheduled by the Project Manager and attended by the Contractor and Employer to review progress of the project. Progress meetings shall be used to review the progress report, written correspondence exchanged since the last meeting, and open action items. The Contractor shall also attend technical meetings as required to discuss technical aspects of the project and to review Employer comments on approval documents. When appropriate, these technical meetings shall be conducted as extensions to the progress meetings.

5.7 Testing

This section describes general requirement applicable to all type of equipment being supplied under the project. For System and Equipment specific requirements are given in respective parts of the specifications.

5.7.1 Quality Assurance and Quality Control Program

The Contractor shall maintain a Quality Assurance/Quality Control (QA/QC) program that provides that equipment, materials, and services under this specification whether manufactured, designed or performed within the Contractor's plant, in the field, or at any sub-contractor source shall be controlled at all points necessary to assure conformance to contractual requirements. The program shall provide for prevention and ready detection of discrepancies and for timely and positive corrective action. The Contractor shall make objective evidence of quality conformance readily available to the Employer. Instructions and records for quality assurance shall be controlled and maintained at the system levels. The Contractor shall describe his QA/QC program in the Technical Proposal, (along with samples from his QA/QC manual) and shall submit his QA/QC Manual for review and acceptance by the Employer.

Thimphu: Bhutan

Such QA/QC program shall be outlined by the Contractor and shall be finally accepted by Employer after discussions before the award of Contract. A Quality Assurance Program of the Contractor shall generally cover but not be limited to the following:

a) The organization structure for the management and implementation of the proposed Quality Assurance Program.

b) Documentation control system.

c) Qualification data for key personnel.

d) The procedure for purchase of materials, parts/components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases, etc.

e) System for shop manufacturing including process controls.

f) Control of non-conforming items and system for corrective action.

g) Control of calibration and testing of measuring and testing equipment.

h) Inspection and test procedure for manufacture.

i) System for indication and appraisal of inspection status.

j) System for quality audits.

k) System for maintenance of records.

l) System for handling, storage, and delivery.

m) A Quality Plan detailing out the specific quality control procedure adopted for controlling the quality characteristics of the product.

The Quality Plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

Neither the enforcement of QA/QC procedures nor the correction of work mandated by those procedures shall be cause for an excusable delay. An effective Quality Assurance and Quality Control organization shall be maintained by the Contractor for at least the duration of this Contract. The personnel performing QA/QC functions shall have well-defined responsibility, authority, and organizational freedom to identify and evaluate quality problems and to initiate, recommend, or provide solutions during all phases of the Contract. The QA/QC organization of the Contractor shall be an independent administrative and functional structure reporting via its manager to the Contractor's top management. The QA/QC manager(s) shall have the authority within the delegated areas of responsibility to resolve all matters pertaining to quality to the satisfaction of Employer when actual quality deviates from that stated in the Work Statement.

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of equipment/materials. The scope of the duties of the Employer, pursuant to the Contract, will include but not be limited to the following:

- Review of all the Contractor's drawings, engineering data etc.
- Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the Contract.
- Inspect, accept or reject any equipment, material and work under the Contract in accordance with the specifications.
- Issue certificate of acceptance and/or progressive payment and final payment certificate
- Review and suggest modification and improvement in completion schedules from time to time; and
- Monitor the Quality Assurance program implementation at all stages of the works.

The Employer or his duly authorized representative reserves the right to carry out Quality Audit and Quality Surveillance of the systems and procedures of the Contractor's/his vendor's Quality Management and Control Activities.

5.7.2 Inspection, Certificate and Test

The Contractor shall give the Employer two weeks in case of domestic supplies and six weeks in case of foreign supplies written notice of any material being ready for testing. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Employer, unless witnessing of the tests is waived, will attend such tests on the scheduled date for which Employer has been so notified or on a mutually agreed alternative date. If Employer fails to attend the testing on the mutually agreed date, Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and Contractor shall forthwith forward to the Inspector, duly certified copies of the test results in triplicate.

The Employer shall, within fourteen (14) days from the date of inspection as defined herein, give notice in writing to the Contractor of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet said objections. When the factory tests have been completed successfully at the Contractor's or Sub-contractor's works, the Employer shall issue a certificate to this effect within fourteen (14) days after completion of tests but if the tests are not witnessed by the Employer, the certificate shall be issued within fourteen (14) days of receipt of the Contractor's Test Certificate by the Employer. The completion of these tests or the issue of the certificates shall not bind the Employer to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.

In cases where the Contract provides for tests, whether at the premises or works of the Contractor or of any Sub-contractor, the Contractor except where otherwise specified shall provide free of charge items such as labor, materials, electricity, fuel, water stores, apparatus and instruments, as may be reasonably demanded by the Employer or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall provide facilities to the Employer or his authorized representative to accomplish testing.

The inspection by Employer and issue of Inspection Certificate thereon, shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Program forming a part of the Contract.
The Contractor shall keep the Employer informed in advance of the time of starting of the progress of manufacture of material in its various stages so that arrangements can be made for inspection.
Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.

Certificates of manufacturing tests shall be maintained by the Contractor and produced for verification as and when desired by the Employer. No material shall be dispatched from its point of manufacture until it has been satisfactorily inspected and tested. Testing shall always be carried out while the inspection may be waived off by the Employer in writing only. However, such inspection by the Employer's representative(s) shall not relieve the Contractor from the responsibility for furnishing material, software, and equipment to conform to the requirements of the Contract; nor invalidate any claim which the Employer may make because of defective or unsatisfactory material, software or equipment.

All materials furnished and all work performed under this Specification shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, all deficiencies have been corrected to Employer's satisfaction, and the equipment has been approved for shipment by Employer.

Should any inspections or tests indicate that, specific hardware, software or documentation does not meet the Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.
The test shall be considered complete when (a) when all variances have been resolved (b) all the test records have been submitted (c) Employer acknowledges in writing the successful completion of the test.

Access to the Contractor's facilities while manufacturing and testing are taking place, and to any facility where hardware/software is being produced for Employer shall be available to

Employer representatives. The Contractor shall provide to Employer representatives sufficient facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification. Inspection rights shall apply to the Contractor's facilities and to subcontractor facilities where equipment is being manufactured.

Inspections will be performed by Employer, which will include visual examination of hardware, enclosure cable dressings, and equipment and cable labeling. Contractor documentation will also be examined to verify that it adequately identifies and describes all wiring, hardware and spare parts. Access to inspect the Contractor's hardware quality assurance standards, procedures, and records that are applicable to the facilities shall be provided to Employer.

5.7.3 Test Plans & Procedures

Test plans for both factory and field tests shall be provided by the Contractor to ensure that each test is comprehensive and verifies all the features of the equipment are tested. The test plans for factory and field tests shall be submitted for Employer approval before the start of testing.

The contractor shall prepare detail testing procedure in line to specification and submit for Employer's approval. The procedure shall be modular to the extent possible, which shall facilitate the completion of the testing in the least possible time.
The test procedures shall include the following items:

- Objective of each test.
- Parameter(s)/function(s) to be tested.
- List of reference standards/ codes of practice.
- Set-up and conditions for testing, including block diagrams of the test configuration and a list of test equipment.
- Sequence of tests to be followed
- Procedures to be followed
- All inputs and outputs for each test segment
- Expected results
- Acceptance criteria for each test sequence.
- Copies of any certified test data, if applicable.

5.7.3.1 Test Records

The complete record of all factory and field acceptance tests results shall be maintained by the Contractor. The records shall be maintained in a logical form and shall contain all the relevant information. The test reports shall be signed by the testing engineer and the engineer witnessing the tests.

5.7.3.2 Reporting of Variances

A variance report shall be prepared by either Employer or Contractor personnel each time a deviation from specification requirements is detected during inspection or testing. All such variances shall be closed in mutually agreed manner.

However, at any stage if Employer feels that quality of variances calls for suspension of the testing the testing shall be halted till satisfactory resolution of variances, which may also involve re-testing.

5.7.4 Type Testing

The list of required type tests is given in **Appendix-C** of this specification. It may be mentioned that Contractor shall demonstrate the performance of the equipment in conformance to the approved DRS. The functional tests shall be carried out on one sample before commencement of the type tests mentioned below and shall be repeated after the completion of the type tests on the same sample.

Type Tests shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

- The Contractor shall submit within 30 days of Contract Award, copies of test reports and certificates for all the Type Tests that are specified in the specifications and that have previously been performed. These certificates may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in these specifications carried out at Internationally accredited labs and witnessed by third party/customer's representatives.

- Type Tests shall be performed at no cost to the employer for all equipment types for which certification is not provided as required in (a) above, or if it is determined by the Employer that the certification provided is not acceptable. If any of the type tests are required to be carried out at the discretion of employer despite valid type test certificate, the same shall be carried out by the Contractor at the cost of Employer. The bidder shall quote testing charges for each type test individually.

- Type Tests shall be certified or performed by internationally reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as in the specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

- The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer/ Owner.

- Testing charges for all the type tests listed in the specifications shall be indicated separately for each item (excluding expenses of Inspector/ Employer's representative) in the prescribed schedule of the bidding document. The total amount of these charges will be considered in the bid evaluation process.

- The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

- In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type tests at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

5.7.5 Factory Acceptance Tests (FAT)

Factory acceptance tests shall be conducted on randomly selected samples (10% of batch size, minimum 1) of final assemblies of all equipment to be supplied. However visual inspection shall be carried out on 100% basis for all the equipment/items offered.

Factory acceptance testing shall be carried out on Communication Equipment, NMS, etc. and all other items for which price has been identified separately in the Bid Price Schedules. Equipment shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC).

Successful completion of the factory tests and the Employer approval to ship shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried

out in the presence of the Employer's authorized representatives unless waived for witnessing by Employer's representatives is intimated to the contractor.
Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation in this Section by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the communication equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Communication system of Termination equipment are given in **Appendix C** of this specification.

However, this list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. In general, the FAT for other items shall include at least: Physical verification, demonstration of technical parameters, various operational modes, functional interfaces, alarms and diagnostics, etc.

5.7.5.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

In case a number of equipment are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipment which are necessary to demonstrate the performance, irrespective of the percentage. Physical verification shall be carried out on 100% of the offered quantity as per approved FAT procedure.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

5.7.5.1.1 List of FAT – General

These tests shall be carried out as applicable to all equipment to be supplied. The following list of tests shall be supplemented by the Contractor's standard factory acceptance test plan.

a) Physical inspection for conformance to drawings and appearance of equipment, Inventory Check.

b) Technical characteristics shall be demonstrated in relation to specifications.

c) Performance of alarms switches and controls.

d) Tests of spare card slots and tests of spare parts by substitution.

e) All online and offline diagnostic features and built in test equipment features shall be tested.

f) Test of auto recovery after power failure.

g) Random inspections to verify the accuracy of documentation.

5.7.5.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc. The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

5.7.6 Site Acceptance Tests

The Contractor shall be responsible for carrying out site tests and inspection for all equipment supplied in this contract as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate. Site acceptance testing shall be carried out for Communication system which includes new communication device and other associated devices.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract work satisfies every requirement specified. A minimum Site Acceptance Testing requirement for communication equipment is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for equipment installation.

Site acceptance tests shall be divided into two levels. The first level (Phase 1 SAT) shall consist of Site Installation & Commissioning Tests. The second level (Phase 2 SAT) shall consist of Integrated System Tests. The completion of Phase 1 and Phase 2 SAT shall be considered as pre-commissioning of the system.

Thimphu: Bhutan

5.7.6.1 Installation & Commissioning Test

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense.

In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated.

The minimal installation & commissioning test requirements for the Communication system of Termination equipment are provided below:

5.7.6.1.1 Installation Tests for Communication Equipment

The following includes the minimum installation testing for new communication equipment, NMS and other associated devices**:**

A) Communication Equipment Installation Testing

- Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
- Power supply/converter voltage measurements
- Functional and performance testing of MPLS-TP
- Craftsperson interface, alarm and control functional performance
- Rack and Local alarms
- Safety and signaling earthing system
- Simulation of failure conditions and failover of protected components

B) NMS Installation Testing

- Physical inspection for conformance to drawings, rack elevations and appearance of equipment and cabling.
- Workstation hardware inventory, configuration, and characteristics.
- Demonstration of proper operation of all hardware, including workstations peripherals.

5.7.6.2 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the data and voice channel required to interconnect the various control centers and RTU/SAS. The integrated testing for a batch shall include end-to-end testing of back-bone network included in that batch. Integrated testing for last batch shall include testing of the entire back-bone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during FAT and SAT testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all communication equipment, the network management system and other components.

At a minimum the following tests shall be included in the integrated testing:

- Equipment configuration shall be checked to establish that it supports the channel routing.
- End-to-end testing of all individual voice channels. Operation shall be checked in terms of quality of voice, call initiation and call termination processes.
- End-to-end testing of all individual data Circuits originating from SCADA Front Ends and to establish proper interfacing with Front End Processor and to demonstrate proper operation of channels.
- Testing of NMS to demonstrate proper operation of all functions: Configuration Management, Performance Management, Fault Management, Security management and Reports generation. All the standard features of the NMS shall be demonstrated for proper functioning.
- Demonstration of Protection switching.

5.7.7 Network Stability Test

Upon completion of the SAT, Network Stability Test will be conducted for a continuous period of 48 hours. During this test it shall be ensured that all installed MPLS-TP equipment are manageable from NMS system and further end-to-end Ethernet link test will be conducted for few networks to meet the performance objectives.

5.7.8 Trial Run

Upon successful completion of the Network Stability Test, the Contractor shall keep all the telecom equipment installed for 30 days as 'TRIAL RUN' to monitor them for 30 days to meet the performance objectives.

During this period, the Contractor shall provide specialist Engineers and Technicians to maintain the total log, incidents, failures and for assisting site engineer and for total co-ordination. However, the normal operation and maintenance of the system shall be performed by the personnel of the Employer trained for the purpose.

If during, 'Trial run' any defects is noted in the system, the Contractor shall rectify, replace the same to the satisfaction of the Employer and provide report, history of all faults. The

decision to repeat the final test or restart the 'Trial run' shall be of Employer depending upon the severity of the defect.
Ideally, during the trial run, no shutdown of the system due to failure of equipment should happen.

If the system fails to come up to the guaranteed performance, the Contractor, within a period of 30 days shall take any and all corrective measures and resubmit the system for another 'Trial Run'. All modifications, changes, corrective measures, labour, etc. shall be at the cost of the Contractor. In case, the date of completion for the second trial run exceeds the time schedule for the project, the Contractor shall be liable to pay liquidated damages. If the system fails to reach the guaranteed performance even after the second trial run, the Employer shall be free to take any actions as he deems fit against the Contractor and to bring the system to the guaranteed performance with the help of Third party at the expense of the Contractor.

5.7.9 Commissioning

The new MPLS-TP network and associated equipment shall be considered to be commissioned and taken over, only after successful completion of the 'Trial Run'. The date of successful completion of 'Trial Run' shall be treated as the 'Completion Date'.

5.8 Mandatory Spare Parts

The Contractor shall provide the Mandatory Spare Parts required for the system. During installation and pre-commissioning of the new equipment and associated systems, the Contractor shall have enough number of commissioning spares so that the installation is not held up because of non-availability of commissioning spares. The Contractor shall ensure that the spares meant for operation and maintenance is NOT used during installation and commissioning. The mandatory spare parts shall be used as and when required and no separate charges are payable.

The spare parts set for each terminal equipment, will consist of at least one (1) of each replaceable equipment interfaces & modules, subunit or part. Extra modules, subunits or parts shall be included in the set if there is sufficient reason to anticipate a greater failure rate.

5.9 Maintenance and Support Services

5.9.1 Defect Liability Period/Warranty

The one-year period commencing immediately after the Operational Acceptance is called the Defect Liability Period. Operational Acceptance shall be given on successful completion of Trial Run. During this period, the Contractor shall replace or repair all defective parts and shall be responsible for maintaining an operational system to achieve the availability of 99.95% for all nodes. The contractor's maintenance engineer shall report to the site for restoration of the system within 6 hours excluding travel time, in case of complete breakdown of the link. Within four (4) months from Contract Award Date, the Contractor shall submit a comprehensive maintenance strategy for the maintenance of the system during the Defect Liability Period. For this period which commences immediately after operational acceptance, the actual outage frequency and the availability achieved during the period shall be calculated periodically, jointly by the Contractor and the Employer as per the **section 5.10**. During the Defect Liability Period, the spare parts and tools and tackles supplied by the Contractor to Employer under the present procurement including items in the "Mandatory" lists, shall be issued as required by the Contractor.

Only these supplied items and no additional items, with the exception of general purpose toolkits, shall be used by the Contractor for all its testing and preventive & restorative maintenance activities.

If any additional spare parts are required or found to be required, these additional items shall be provided by the Contractor, within a reasonable time, up to the expiry of the Defect Liability Period, at no additional cost to Employer. Since the spare parts shall be "issued for use", by the end of the Defect Liability Period, the Contractor shall replenish the spare parts stock to the original level plus any additional spares required, found to be required or additionally identified as above.

All test equipment and tools & tackles issued to the Contractor shall be "issued for use" and shall be returned at the earliest in "as issued" condition.

5.9.2 Post Defect Liability Period AMC Provisions

The Contractor shall provide comprehensive AMC service for all supplied equipment under this project after the completion of Defect Liability Periodperiod as per **Appendix G**.

5.9.3 Support Services

The contractor shall ensure the availability of service, spare and expansion parts for the supplied equipment for a minimum period of 10 years from Operational Acceptance by the Employer or 7 years from the date of withdrawal from production whichever is earlier. However, the termination of production shall not occur prior to operational acceptance by Employer. All the equipment's and associated items supplied by the Contractor shall be guaranteed to give specified performance for the period of 12 months from the date of acceptance of the system by the Employer.

The contractor shall provide a support personnel during the defect liability and AMC period. The so deployed support personal shall be qualified personnel having at least 5 years of experience in the delivered MPLS-TP system. Official deputed shall be a permanent employee on the direct pay roll of the vendor. The contractor shall submit the CV's to Owner/Employer for approval before deployment at site. The Owner can ask the Contractor to replace the personnel deployed for maintenance support if his performance is not found to be satisfactory.

The support personal shall report the daily network status to the Employer engineer during the AMC and Defect Liability Period. The support personal shall report the minimum of following.

a) Functional and non-functional equipment in the network.
b) All alarms
c) Actions taken to resolve issues and alarms in the network.
d) Assistance required from the employer to fix issues in the network.

5.9.4 Continuing Maintenance Concept

After the Operational Acceptance, all normal maintenance will be undertaken by the Contractor in collaboration with the Employer contractor as per "defect liability period" and AMC terms. The Contractor shall ensure that the training imparted and the provided spare parts and tools & tackles are sufficient for testing & maintenance activities.

5.10 Payment Charges Calculation

It is the endeavor of both the contractor and Owner to maximize system availability to the extent possible. If the contractor fails to provide the required system availability or agreed support as during Defect Liability Period and AMC period, the following payment deductions shall be applied:

5.10.1 Calculation of Communication System Availability

Availability would be on per quarter per site basis. The formula to be used for availability computation would be as under.

Availability per quarter yearly (per site) =
$$\frac{\text{THQ} - (\text{S1} \times 1 + \text{S2} \times 0.8 + \text{S3} \times 0.5)}{\text{THQ}} \times 100\%$$

Where THQ is total hours in the quarter

S1 is the total non-available hours in Severity Level-1 in the quarter.

S2 is the total non-available hours in Severity Level-2 in the quarter.

S3 is the total non-available hours in Severity Level -3 in the quarter.

The Severity Level-1, Severity Level-2, and Severity Level-3 corresponds to all technical problems categorized as Critical, Major and Minor, respectively, in the AMC Document under **Appendix G**.

The non-availability hours for availability calculation shall be counted from the end of the allowed Action Resolution time as given in AMC Document under **Appendix G**. A standardized register shall be maintained at each site containing full details of each outages, actions taken by Owner to correct the problem, applicable Severity level, time of reporting to the contractor support engineer/support centers pursuant to the appropriate methods in the Agreement, allowed Response time as per the Response times defined in above section, actual Resolution time and signature of Engineer-in-charge as well as the contractor's support engineer of the site.

Duration of outages over and above the Action Resolution time, as defined in AMC Document under **Appendix G** in each of the Severity levels shall be counted for the non-availability computation and shall be clearly brought out in the register. The resolution may be accomplished by a work around, and such solution shall mark the end of non-availability. In the event of frequent failures at a site, due to a common cause, the first FPR (Field Problem Report) logged shall be used for the purpose of availability calculation. However, simultaneous multiple outages due to unrelated cause would be counted separately.

5.10.2 Deduction for Inconsistency in System Availability

Table 5.1: Maintenance charges reduction

Availability for overall Communication Systems per quarter	**Deduction as % of the apportioned price of total Defect Liability Period & AMC for Communication System portion of the contract applicable for that site (software/hardware price)**
> 97%	NIL
Less than 97%	Deduction of 2% of the apportioned price of the apportioned quarterly Defect Liability Period & AMC for every 0.5% or part there of decrease in availability under 97%.

The deduction shall be made from the 10% retention held by the Employer for the Defect Liability Period. Deduction for AMC period shall be made from the AMC charges. However,

Thimphu: Bhutan

total cumulative deductions shall be restricted to Maximum of 50% of scheduled invoice value for that quarter.

The computation of Availability / Non-availability would be rounded up to 2 decimal places at each Control Center on quarterly basis and any deduction in the maintenance charges thereof would be calculated as stated above on pro-rata basis.

5.11 Training

The Contractor shall provide a comprehensive training program that prepares Employer's personnel for on-site installation support, operation, and maintenance of the supplied equipment. All courses, instruction and documents shall be in the English language.

There shall be at least two training courses, one at Contractor/Manufacturer premises and another at site(s) when the system will be made operational.

The details of the training requirements furnished here shall only be tentative and shall be finalized only after completion of detail engineering.

During training:

a) All necessary training material shall be provided by the Contractor. Each trainee shall receive individual copies of all technical manuals and all other documents used for training.

b) Class materials, including the documents provided to the trainees as well as class hand-outs, shall become the property of the employer. Employer reserves the right to copy such materials, but for in-house training and use only.

c) Hands-on training shall utilize equipment similar to that being supplied under the contract.

d) For all training courses the travel (e.g., Airfare) and daily expenses will be borne by the employer. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangements.

e) The Contractor shall quote training prices individually for each course as per training requirements given at the end of this section.

f) The schedule, location, detailed contents, for each course shall be finalized during detail engineering. The number of participants in the training program may undergo a change. The training shall be completed in a single batch for each course.

g) Employer will have the option to cancel any or all training courses. In the case of cancellation, the rate quoted against the respective course will not be paid to the Contractor.

The training courses, duration, and the number of employer personnel to be trained in each course are identified in **Table 5.2**

Table 5.2: Training Requirements

Sl. No.	Description	No. of trainees	Duration in weeks		Total Man-Weeks	
			In Bhutan	At Contractor's Facility	In Bhutan	At Contractor's Facility
1	Communication system Design, Installation and Maintenance	5	2	2	10	10
2	Teleprotection	10	1	1	10	10
3	Communication NMS	3	1	1	3	3
	TOTAL	**18**	**4**	**4**	**23**	**23**
	One Man-week = 5 working days					

5.11.1 Annual Training

The employer's personnel shall be given a weeklong short-term training/refresher course annually after the completion of the one-year defect liability period until the end of AMC. This training shall be mainly focused on Sl. No. 1 and Sl. No. 3 of **Table 5.2**.
This training shall be conducted at the employer's premises by the Contractor personnel who are experienced instructors. The associated cost for the contractor personnel must be clubbed with the AMC cost.

5.11.2 Training Requirement for Communication System

The training shall focus on various aspects associated with design, installation, testing & commissioning of Communication system. The training course shall include:

5.11.2.1 Communication System Design, Installation and Maintenance

This training intends to provide a strong theoretical knowledge and practical skills to design and implement a large network intended to support different kind of services such as IP, teleprotection and serial data-based services. It should provide enough exposure, experience and resources to the Employers engineers to be able to identify, troubleshoot and rectify any issues pertaining to the supplied communication system. The training shall cater to following skills:

A) System Design: To design network with to support, various network topology such as (ring, star, bus, etc.), routing, quality of service and redundancy schemes. This training shall impart theoretical knowledge on the supplied communication system. The training shall include an overview of the network configuration and indicate the functional responsibilities of all major subsystems including the network monitoring system hardware and software.

B) Installation: The installation & Maintenance training shall be provided on Communication Equipment, its accessories and NMS. The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive & restorative maintenance of the respective communication systems purchased by the Employer. The training courses shall cover equipment installation, testing & commissioning, operation, interfaces and cabling between equipment, preventive maintenance, diagnostic tools and troubleshooting procedures, corrective maintenance, and expansion procedures for all equipment. The courses shall provide theoretical background and extensive hands on experience. Course participants shall operate actual equipment and diagnose and repair simulated failures.

Apart from this training the Employers personal shall be fully associated with Engineering, installation, testing and commissioning activities.

5.11.2.2 Communication Network Management System (NMS) Course

The NMS training shall familiarize the Employer's maintenance personnel with the concepts and techniques for installing, configuring, programming, maintaining, troubleshooting, extracting reports and data from the Contractor supplied NMS and its associated database.

The Contractor shall train the Employer's personnel who will operate the communications network, in the functional capabilities of the communication equipment. Each course shall provide a thorough understanding of the general design concepts, features, and user interface requirements for local and remote monitoring of the equipment, as well as procedures for restoring service after equipment and power failures. Each course shall include hands-on training using the actual hardware and software being delivered to the Employer.

Training aids for each course shall include the Operator's User Manual for each type of equipment. Operator training that is a standard part of the maintenance training will be applicable. The minimal NMS Training requirements are:

- Features of the software being supplied.
- System installation, configuration procedures, including operating system & database parameterization and buffer sizes.
- Operating system concepts, including resource allocation, priority level processing.
- Performance monitoring, diagnostic messages, and restoration procedures.
- Concepts and techniques for creating, modifying, and saving database, displays, and reports.

5.11.2.3 Teleprotection

The Teleprotection training shall familiarize the Employer's maintenance personnel with the concepts and techniques for installing, configuring, maintaining and troubleshooting protection relay communication via the supplied MPLS-TP equipment.

5.12 Documentation

To ensure that the proposed systems conform to the specific provisions and general intent of the Specification, the Contractor shall submit documentation describing the systems to Employer for review and approval. Further the Contractor shall also submit the drawings/documents for all the equipment & software required for site installation, testing and commissioning and thereafter operation of the system. The Contractor shall obtain approval of Employer for the relevant document at each stage before proceeding for purchase, manufacturing, system development, factory testing, erection, site testing, training etc.

Each document shall be identified by a Contractor document number, the Employer document number, and the Employer purchase order number. Where a document is in a revision block along with an indication of official approval by the Contractor's project manager, each revision of a document shall highlight all changes made since the previous revision.

The Contractor shall submit two hard copies of each document/drawing for Employer's review and approval along with soft copy with each submission. After approval two set of all the documents shall be submitted as final documentation, however, for site specific documents two sets of documents shall be provided for each site. Any changes observed during field implementation shall be incorporated in the as-build drawing and required sets of same shall be submitted to Employer. In addition to paper copies all the documents shall

Thimphu: Bhutan

also be provided on electronic media in two copies. In case any documentation requirement is specified in the relevant section the same shall apply for the equipment /system defined in that section. The following document shall be submitted as applicable for the subsystem.

a) System Description Documents (Overview)
b) Data Requirement sheets
c) Drawings/Documents for manufacturing/Assembly of the equipment/system
d) Drawings/Documents for installation of the equipment/system at site
e) NMS description/design documents
f) Type test reports
g) Factory Test reports
h) Manuals for each equipment
i) System Configuration Parameter Details
j) Site Testing documents
k) Training documents
l) System Administrator/User guide
m) Inventory of the hardware
n) Panel General and Internal Arrangement drawing indicating modules, components location etc.
o) Schematic drawing/Installation drawing/External cable laying & termination schedule details
p) Communication Channel Plan

The Contractor shall also supply two sets of User manuals/guides/O&M manuals/manufacturer's catalogues for all the equipment & software supplied under the contract one set each of which shall be at all the locations where the System has been installed. The user manual shall at minimum include the principle of operation, block diagrams, troubleshooting and diagnostic and maintenance procedures. Considering all the components of the project briefly the following documents/drawings shall be required under the project. It is not acceptable to supply user manuals of systems, functions and applications as it exists. The user manuals shall be oriented towards system users and system deployed for NLDC Bhutan.

The documentation pertaining to third party or OEM products may be supplied in the format as available from the third party/OEM. If both formats (Paper/electronic) are available then the above mentioned copies of documents shall be supplied in both the formats, however, in exceptional cases where the Contractor is not able to get more copies due to copyright laws restriction, the issue will be mutually agreed upon on case to case basis.

The documents to be submitted shall include the following information:

5.12.1 Functional Description

Functional description documentation shall be provided for each function described in **Lot 2**. It shall include the following information for each function:

a) Introduction describing the purpose of the function with references to other documentation to aid the reader's understanding of the functions performed.

b) Performance requirements that describe the execution periodicity and the tuning parameters that control or limit the capabilities of the software.

c) Complete description of the operation, data, and logic interfaces with other functions.

d) Sample displays where applicable.

5.12.2 System Administration Documentation

System administration documentation shall be provided to guide Employer personnel in the operation and procedures required to generate and update the systems, including system software, database, application software, and other elements of the systems. System administration documents shall be provided for the following items:

a) Network communications management

b) Processor configuration

c) System performance monitoring

d) Software maintenance

e) Application software parameters and tuning guides

f) Other Contractor-supplied system software not included above.

5.12.3 Test Documentation

Documentation for all factory, field, and availability tests that apply to Communication system for BPSO project shall be provided in accordance with the requirements as defined in technical specifications.

5.12.4 Training Documentation

Training documentation shall be provided for all courses in accordance with the requirements as defined in technical specifications. The Contractor shall submit a comprehensive list of the document as applicable for the offered system for Employer's approval immediately after signing of the contract and the documents shall be finalized as per the approved list. The schedule for submission/approval of documents shall be in line to overall project schedule.

APPENDIX A

Acronyms

AIS	Alarm Indication signal
APS	Automatic Protection Scheme
BER	Bit Error Rate
BFD	Bidirectional Forwarding Detection
BoQ	Bill of Quantity
BPSO	Bhutan Power System Operator
CC	Continuity Check
CCITT	International Telegraph and Telephone Consultative Committee is an International Advisory Committee that establishes International Standards.
CEPT	European Conference of Postal and Telecommunications Administrations(Conference Europeanen des Administrations des Postes et des Telecommunication)
CIR	Committed Information Rate
CV	Connectivity Verification
dB	Decibel(s)
DM	Delay Measurement
DRS	Data Requirement Sheet
DWSM	Dual Window Single Mode
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ES	Errored Seconds
FAT	Factory Acceptance Test
FO	Fiber Optic
FRU	Field Replaceable Unit
IEC	International Electrotechnical Commission, Geneva, Switzerland
IEEE	Institute of Electrical and Electronics Engineers, Inc.
ITU	International Telecommunication Union
LAN	Local Area Network
LB	Loopback

Thimphu: Bhutan
Office of the Bhutan Power System Operator

LM	Loss Measurement
LT	Link Trace
MICC	Material Inspection and Clearance Certificate
MQP	Manufacturing Quality Plan
Ms	Milli-second
MTBF	Mean-Time-Between-Failure
MTTR	Mean-Time-To-Repair
MUX	Multiplexer
NE	Network Equipment
NLDC	National Load Dispatch Centre
NMS	Network Management System
OEM	Original Equipment Manufacturer
PABX	Private Automatic Branch Exchange
PC	Personal Computer
PIR	Peak Information Rate
PMU	Phasor Measurement Unit
QA/QC	Quality Assurance/ Quality Control
RDI	Remote Defect Indication
RHMI	Remote Human Machine Interface
RTU	Remote Terminal Unit
SAS	Substation Automation System
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SES	Severely Errored Seconds
SNMP	Simple Network Management Protocol
TCP/IP	Transmission Control Protocol/ Internet Protocol
TMN	Telecommunication Management Network
WAN	Wide Area Network

Thimphu: Bhutan
Office of the Bhutan Power System Operator

APPENDIX B

Bill of Quantities

*The quantities indicated herein are tentative. The actual quantities of the items may vary without any limit based on final approved design of the system.

Table B. 1: Bill of Quantity for Communication System

Sl. No.	Item Description	MPLS-TP		Teleprotection Interface	
		Unit	Quantity	Unit	Quantity
A	**Supply of Main Equipment**				
1	National Load Dispatch Centre (NLDC)	Set	1	Set	-
2	Chubachhu Substation	Set	1	Set	-
3	Dechencholing	Set	1	Set	2
4	Olakha Substation	Set	1	Set	2
5	Gidagom Mini-hydrel	Set	1	Set	-
6	Chumdo Station	Set	1	Set	4
7	Watsa Substation	Set	1	Set	-
8	Chhukha Hydropower Plant	Set	1	Set	6
9	Gedu Substation	Set	1	Set	2
10	Phuentsholing Substation	Set	1	Set	3
11	Singhigaon Substation	Set	1	Set	2
12	Malbase Substation	Set	1	Set	7
13	Samtse	Set	1	Set	3
14	Gomtu	Set	1	Set	2
15	Tala Hydropower Plant	Set	1	Set	4
16	Semtokha Substation	Set	1	Set	5
17	Lobeysa Substation	Set	1	Set	2
18	Basochhu Hydropower Plant	Set	1	Set	3
19	Tsirang	Set	1	Set	3
20	Dagachhu Hydropower Plant	Set	1	Set	-
21	Jigmeling Substation	Set	1	Set	10
22	Backup NLDC, Jigmeling	Set	1	Set	-
23	Mangdechhu (MHP)	Set	1	Set	5
24	Gelephu Substation	Set	1	Set	2
25	Yurmoo Substation	Set	1	Set	2
26	Tintibi Substation	Set	1	Set	3
27	Nganglam Substation	Set	1	Set	3
28	Nangkor Substation	Set	1	Set	3
29	Kurichhu Hydropower Plant	Set	1	Set	2
30	Kilikhar Substation	Set	1	Set	2
31	Corlung Substation	Set	1	Set	2

Thimphu: Bhutan
Office of the Bhutan Power System Operator

32	Kanglung Substation	Set	1	Set	2
33	Phuntshothang Substation	Set	1	Set	2
34	Motanga Substation	Set	1	Set	4
35	Deothang Substation	Set	1	Set	2

Sl. No.	Item Description	Unit	Quantity	Remarks
B	**Supply of Other Equipment**			
I	**NMS at NLDC**			
1	Software	LOT	1	
2	Work Station / Server	LOT	2	
3	Craft Terminal	Nos.	2	
II	**Supplementary Modules for Main Equipment**			
1	E1 Interface	Nos.	1	
2	64 kbps Interface	Nos.	1	
3	C37.94 Interface	Nos.	1	
4	Ethernet Interface	Nos.	1	
III	**Spares**			
1	MPLS-TP	Set	3	
IV	**Miscellaneous**			
1	DC to DC Converter	Nos.	10	
2	GPS	Set	1	
3	Panel/Cabinet	Nos.	5	
V	**Annual Maintenance Contract**			
1	Year 1	LOT	1	
2	Year 2	LOT	1	
3	Year 3	LOT	1	
VI	**Training For Communication System**			
1	Design, installation and maintenance of Communication equipment	LOT	1	
2	Communication NMS	LOT	1	
3	Teleprotection	LOT	1	
VII	**Installation, Testing and Commissioning**			
1	Installation, Testing, and Commissioning of the Communication System	LOT	1	

Note:

*Each set of MPLS-TP shall include at least main and redundant power supply module, controller card to access the configuration of the set and access other connected sets in the

Thimphu: Bhutan
Office of the Bhutan Power System Operator

network, support for MPLS-TP functions, SFP (as per optical distance and losses mentioned in Appendix E), Ethernet Module that provides at least 8 interfaces, E1/T1 module that provides E1/T1 interfaces.

* Each set of Teleprotection Interface shall include at least main and redundant power supply module, cables connecting protection relays (Main I & II, or Main & Backup as per the Appendix H) and all other necessary accessories for proper functioning of the Teleprotection.

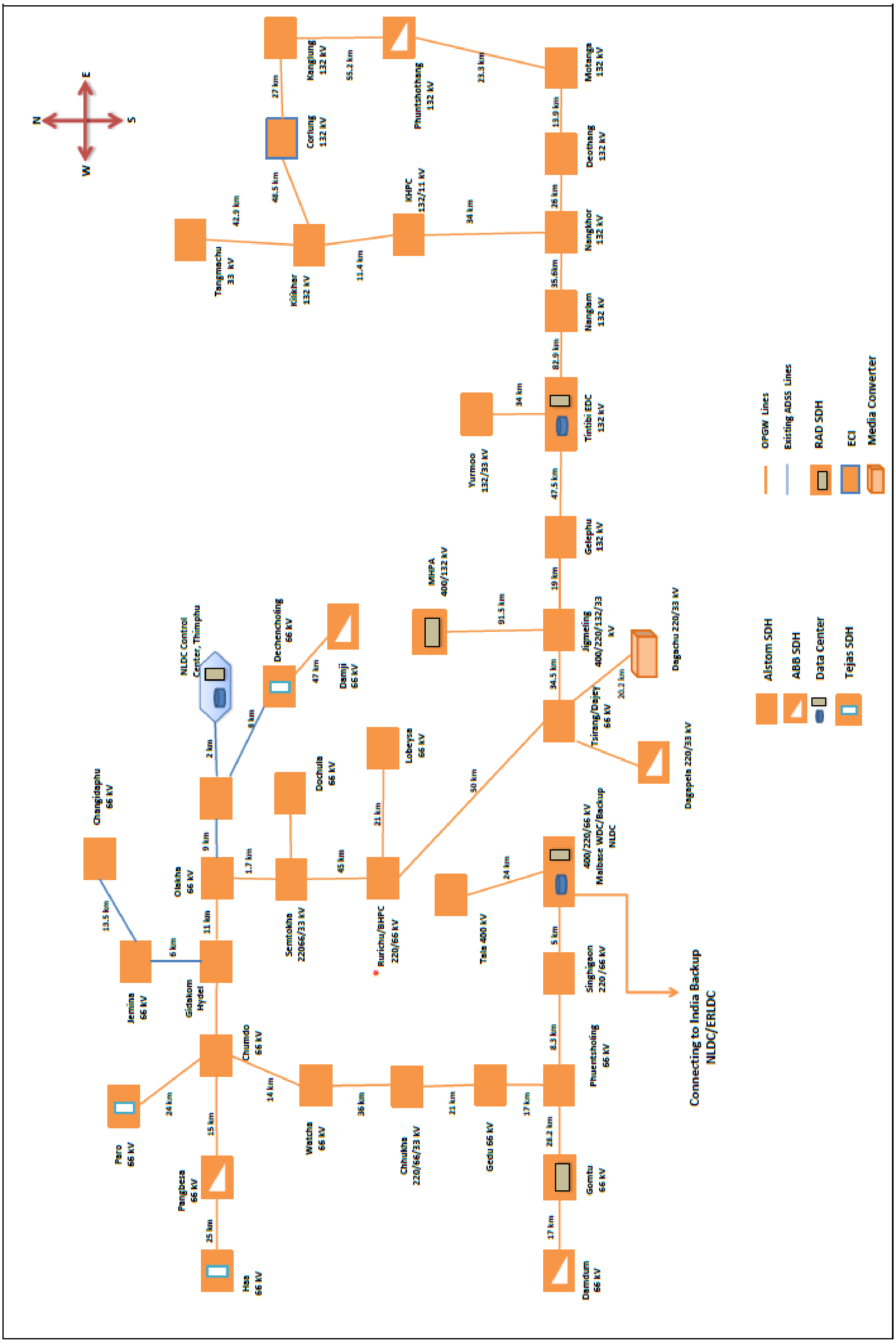

Figure B-1: BPSO existing network.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

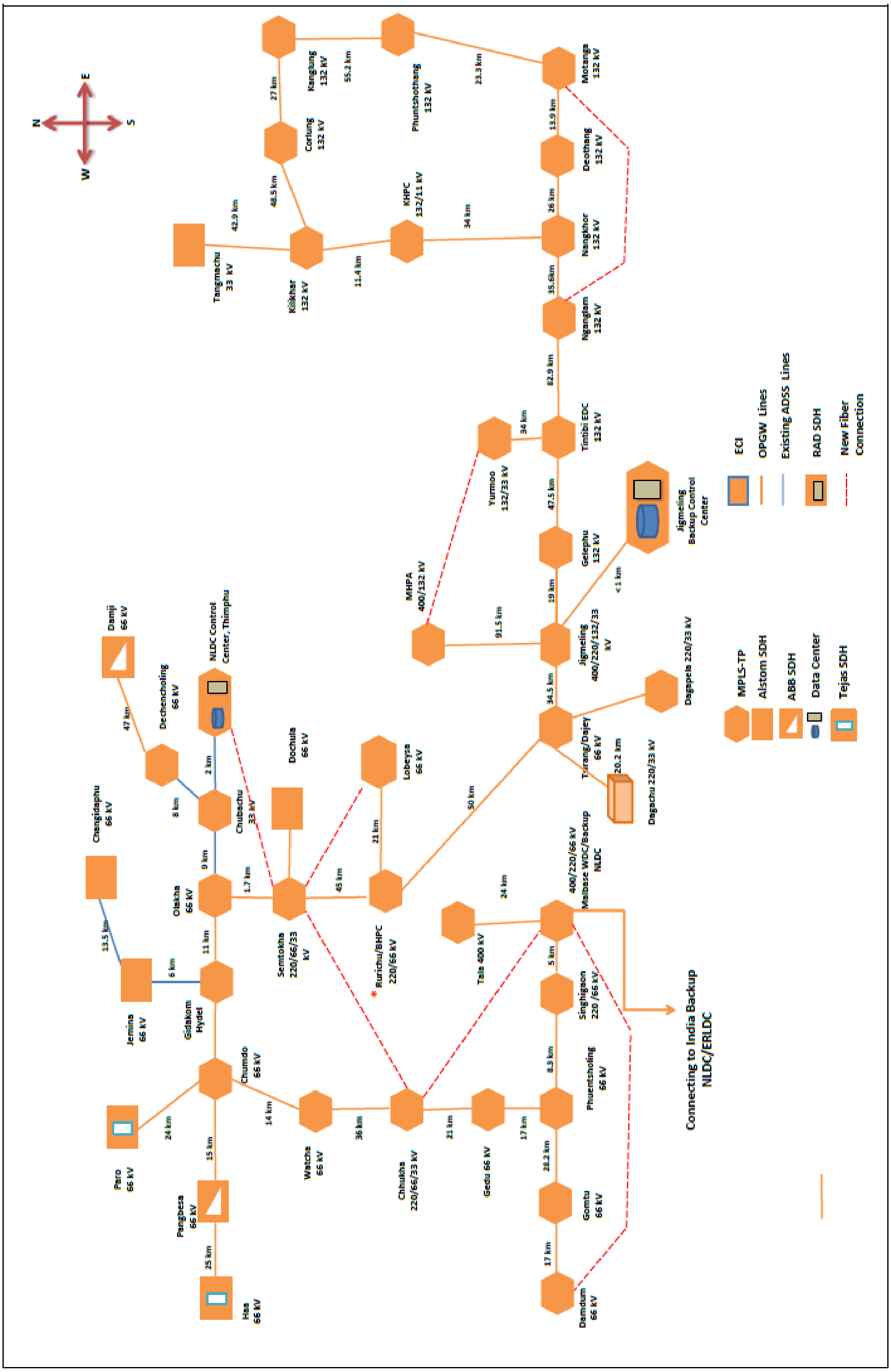

Figure B-2: BPSO Proposed network.

APPENDIX C
Type Testing/Factory Acceptance Testing Requirement

Wherever the referenced test procedures or the technical specifications call for visual inspection for damage, the test report shall include a full description of observed status of the sample. (Visually inspected samples shall also be color photographed and copies of color photographs shall be included in type test report)

C-1. Type Tests on new communication equipment

C-1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 68.

a) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 68-2-1, test method Ad, with the following specifications:

1. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.
2. Degree of Severity: Test shall be done at 0°C.
3. Acceptance Criteria: No degradation of performance during and after the test.

b) Low Temperature Test: Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 68-2-1, test method Ad, with the following specifications:

1. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).
2. Degree of Severity: Test shall be done at -10°C.
3. Acceptance Criteria: Degradation of performance is allowable during the test; however, there shall be no degradation of performance in the *post-test*.

c) Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 68-2-2, test method Bd, with the following specifications:

1. Test Duration: The equipment is started up as soon as thermal equilibrium has been

reached and operated for 96 hours. Its performance is checked during the test.

2. Degree of Severity: As per specified operation to specification range in this specification.

3. Acceptance Criteria: No degradation of performance during and after the test.

d) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 68-2-2, test method Bd, with the following specifications:

1. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

2. Degree of Severity: Test shall be done at 55°C.

3. Acceptance Criteria: Degradation of performance is allowable during the test; however, there shall be no degradation of performance in the *post-test*.

e) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 68-2-3 with the following specifications:

1. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

2. Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

f) Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 68-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

1. Number of cycles required is five (5)

2. The degree of severity: temperature TL: As per Operation to specification range specified in this specification.

3. Cycle duration for each temperature is three (3) hours.

4. Ramp: 1°C/minute.

Thimphu Bhutan
Office of the Bhutan Power System Operator

5. Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

C-1.2 Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 870-2-1.

a) Immunity Tests

The list of Immunity tests is specified in Table below:

<table>
<tr><th>Sl/ No.</th><th>Immunity test IEC 1000-4-1</th><th>AC Power Supply</th><th>DC Power Supply</th><th>Control & Signal</th><th>Telecom line</th><th>Parameters</th></tr>
<tr><td>1.1</td><td>Voltage Fluctuations</td><td>Yes</td><td>Yes</td><td>N/A</td><td>N/A</td><td rowspan="2">Table 11 of IEC 870-2-1:1995 – Level: 1</td></tr>
<tr><td>1.2</td><td>Voltage dips and fluctuations</td><td>Yes</td><td>Yes</td><td>N/A</td><td>N/A</td></tr>
<tr><td>2.1</td><td>100/1300 uS surge</td><td>Yes</td><td>Yes</td><td>N/A</td><td>N/A</td><td>Table 12 of IEC 870-2-1:1995 – Level : 4</td></tr>
<tr><td>2.2</td><td>1.2/50 – 8/20 uS surges</td><td>Yes</td><td>Yes</td><td>Yes</td><td>N/A</td><td rowspan="3">IEC 870-2-1: 1995 – Level : 4</td></tr>
<tr><td>2.3</td><td>Fast transient bursts</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>2.4</td><td>Damped oscillatory waves</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>3.1</td><td>Electrostatic discharge</td><td colspan="4">Yes</td><td>Table 13 of IEC 870-2-1: 1195 – Level : 4</td></tr>
<tr><td>4.1</td><td>Power frequency magnetic field</td><td colspan="4">Yes</td><td rowspan="2">Table 14 of IEC 870-2-1: 1995 – Level : 4</td></tr>
<tr><td>4.2</td><td>Damped oscillatory magnetic field</td><td colspan="4">Yes</td></tr>
<tr><td>5.1</td><td>Radiated electromagnetic field</td><td colspan="4">Yes</td><td>Table 15 of IEC 870-2-1: 1995 – Level : 4</td></tr>
</table>

b) Emission Tests

The list of Emission tests is specified in Table below:

Sl/ No.	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parameters
1.	LF disturbance voltages CCITT recommendation P.53	N/A	Yes	N/A	N/A	
2.	Transient disturbance voltages	Yes	Yes	N/A	N/A	
3.	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
4.	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
5.	RF radiated fields CISPR 22	Yes				

c) Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class: VW1 of Table 18.

C-1.3 Mechanical Tests

The following tests shall be performed with the equipment packed according to the Contractor's specifications to demonstrate safe transportation of the equipment:

a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 68-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document IEC 68-2-6. For the vibration response investigation (clause 8.1 of IEC 68-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.
The endurance test conditions are selected according to the vibration withstand requirements.

b) Shock Test

The procedure of this test is defined in IEC Publication 68-2-27 (each test) with a semi sinusoidal shape (clause 3.1.1.2).
The recommended severity shall be A = 294 m/s2, D = 18ms. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 68-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68- 2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 68-2-29.

C-2. Factory Acceptance Test for Termination equipment

The factory acceptance tests for Termination equipment as specified in Table below:

Item	**Description:**
1.	Physical Inspection for conformance to drawings and appearance of equipment
2.	Performance of supervision, alarm, control and switching systems, diagnostics, loop backs, Craftsperson interface etc.
3.	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for the channel banks/low-level multiplexers
4.	Framing, signaling, and operational and maintenance tests consistent with applicable CCITT requirements
5.	Simulation of failure conditions and failover of each redundant unit
6.	Test of spare card slots and test of spare parts through substitution
7.	Checks of power supply/converter voltage margins, ripple levels, noise rejection, and short circuit and over voltage protection
8.	Random inspections to verify the accuracy of documentation

C-3. FAT for NMS:

Physical inspection of NMS hardware for conformance to approved BoQ & drawing. Testing of NMS to demonstrate proper operation of all functions: Configuration Management, Performance Management, Fault Management and Security Management. All standard features and required customization of the NMS shall be demonstrated for proper functioning.

Office of the Bhutan Power System Operator
Thimphu Bhutan

APPENDIX D

Technical Requirement Sheet

Make:

Model:

Country of Origin:

SN	Specified Technical Requirements		To be filled by Bidder
1	List of core(common) cards/ modules:		
2	Packet and Ethernet Services		
	A	Maximum Interface (Electrical/ Optical):	
	B	Support VLAN Services:	
	C	Ethernet OAM:	
	D	Support Spanning Tree:	
	E	IPv4 and IPv6 support:	
	F	Adjustable port BW(Auto/Manual) and Transmission (Half/Full Duplex): (Yes/No)	
	G	Applicable Standards compliance MEF CE 2.0 (Yes/No):	
3	MPLS-TP		
	A	MPLS-TP OAM -Continuity check (CC) & Continuity verification (CV): -Active and On-demand status: -Traffic Performance; Forwarding performance at	

		scale, including latency and delay variation:	
	B	L2/L3 VPN:	
	C	Service Scalability -Number of supported LSPs/PWs:	
	D	Service Quality- Number of supported service levels to meet SLAs:	
	E	MPLS FRR:	
	F	Directions:	
	G	Applicable Standards:	
	H	Multi-Segment Pseudowire:	
4	Protection		
	A	Hardware redundancy (MSP 1+1):	
	B	Ethernet Ring Protection (ERPS):	
	C	MPLS TP Linear protection:	
	D	Switching time less than 50ms (Yes/No):	
	E	Link Aggregation:	
5	QoS		
	A	Supports 8 CoS Queuing(Yes/No):	
	B	Scheduling Disciplines:	
	C	Congestion Management:	
	D	Traffic classification based on Port, VLAN, Port + VLAN (Yes/No):	
	E	Bandwidth Control:	

Thimphu Bhutan
Office of the Bhutan Power System Operator

	F	Applicable Standards:	
6	Security		
	A	Port security & mirroring:	
	B	SSH:	
	C	MPLS-based Encryption Layer 2.5:	
	D	Access Control list (ACL):	
	E	Solution for Cyber threats:	
7	Management		
	A	NMS, SNMPv2/v3:	
	B	System monitoring(Temperature, voltage, power, fans, fiber losses and memory utilization):	
	C	Remote monitoring:	
	D	Configuration, Fault, Performance and Security Management:	
	E	Firmware upgrade:	
	F	Command line interface(CLI):	
	G	Secure user management:	
	H	Software:	
8	Services		
	A	CES: (SAToP, CESoPSN and CEP)	
	B	Control: (V.35, X21, RS-232, V.24, V.11, V.36)	
	C	Voice: (E1/T1, FXO/FXS, 2/4 E&M, OMNI, VoIP)	
	D	Video surveillance:	

9	Teleprotection		
	A	Digital Communication interface (Yes/No) -Standard = ITU-T G.703 -Interface = C37.94 -Speed / bandwidth = 2.048Mbps -Protocol = E1 (G.703)	
	B	8 Number of Input Binary Commands (Yes/No)	
	C	8 Number of Output Binary Commands (Yes/No)	
	D	Protection Schemes: -Direct Transfer Tripping, -Permissive Tripping, -Blocking Tripping	
	E	Command Combination, AND / OR	
	F	Command Transfer Time <2ms	
	G	Total Back-to-back command transfer and operate time, excluding propagation delay <5ms	
	H	Supported Command Voltages, User Selectable 110V DC / 250V DC	
10	Possible to define CIR/PIR (Yes/No):		
11	Timing and Synchronization(Yes/No): -SyncE with ESMC, - 1588v2, -External timing 1PPS and TOD, -Internal Stratum 3 clock (holdover state)		
12	Topologies support (Yes/No): Mesh, dual homing, multi-ring, ring, star, linear		
13	Environmental Operating Limits		

	-Operation Temperature without damage: -20°C to +60°C (Yes/No): -Storage Temperature: -Humidity up to 95%, Non-condensing(Yes/No): - Operating Elevation up to 3500m (Yes/ No):	
14	Power Supply -48VDC & 230VAC (Yes/No):	
15	Dual Power Supply (Yes/No):	
16	Hot swappable cards(Yes/ No):	
17	Rack mountable 19" (Yes/No):	
18	Physical dimensions (W x D x H in inches):	
19	-Environmental Compliances: -Safety: -EMC/EMI:	
20	Interoperability with SDH Technology:	
21	Interoperability with different vendors:	
22	Pluggable SFP/CSFP/SFP+ support:	
23	No. of MSP protected directions:	
24	No. of plug-in slots available:	
25	No. of interface on E1 card:	
26	Shock & Vibration- Can withstand transportation & handling by air, sea and road under packed conditions (Yes/No):	
27	Support monitoring of LSP and PW:	
28	LED for alarm indication in Equipment:	
29	E1 Port I/O impedance (Ω):	
30	Support FTP, TFTP and SFTP (Yes/No):	

31	User Selectable / Automatic Periodical Link Test (Yes/No):	
32	Link Performance Alarms (Yes/No):	
33	System Performance Alarms(Yes/No):	
34	Alarms Logging (Yes/No):	
35	Event (Command and Switching) Logging (Yes/No):	

APPENDIX E

Optical Link Details

BPSO uses 4 fiber cores from the OPGW cable, to collect data from Power Plants and Substations from all parts of Bhutan. The connectivity of all MPLS nodes will be made on all 4 fiber cores. 1st pair of fiber shall be configured as primary link and 2nd as protection link. If the primary link fails, the traffic should automatically shift to protection link.

Sl/ No.	SITES	Distance (km)	Power Transmit (dBm)	Receive Power (dBm)	Power Budget (dBm)
1	NLDC-Chubachu	2	-10.5	-20	9.5
2	Chubachu-Olakha	9	-10.7	-20.7	10
3	Olakha-Gidakom	11	-9.9	-29.5	24.1
4	Gidakom-Chumdo	7	-10.5	-18.7	8.2
5	Chumdo-Watsa	14	0.7	-16.7	17.4
6	Watsa-CHP	36	0.5	-23.4	23.9
7	CHP-Gedu	21	-1.2	-26.3	25.1
8	Gedu-Pling	17	0.8	-14.5	15.3
9	Pling-Singhigaon	8.3	-10.3	-20	9.7
10	Singhigaon-Malbase	5	-10.4	-27.2	16.8
11	Malbase-Tala	24	-12.1	-14.2	2.1
12	Olakha-Semtokha	1.7	0.7	-17.4	18.1
13	Semtokha-BHP	45	0.9	-18.1	19
14	BHP-Tsirang	50	-1	-23.7	24.7
15	Tsirang-Jigmeling	34	0.6	-11.1	12.7
16	Jigmeling-Gelephu	17	0.8	-19.7	20.5
17	Gelephu-Tintibi	47.5	0.5	-21.2	21.7
18	Tintibi-Nganglam	82.9	0.4	-25	25.4

Office of the Bhutan Power System Operator
Thimphu: Bhutan

19	Nganglam-Nangkhor	35.6	0.7	-14.4	15.1
20	Nangkhor-KHP	34	0.6	-14.3	14.9
21	KHP-Kilikhar	11.4	-10	-23.8	13.8
22	Kilikhar-Kanglung	31.8	-	-	-
23	Kanglung-Phuntshothang	55.2	-	-	-
24	Phuntshothang-Motanga	23.3	-	-	-
25	Motanga-Deothang	13.9	0.9	-29.2	30.1
26	Deothang-Nangkhor	25.6	-1	-13.1	12.1

APPENDIX F

Warranty

The details of services to be provided under warranty shall include but not limited to the following for all supplied items under this project and all the cost for these supports are in the scope of Contractor:

Scope of Warranty

a) Technical Support Service

- ON-LINE SUPPORT
  This includes 24 x 7 (24 hours x 7 days a week) online support for Contractor supplied equipment. Employer shall utilize this service by intimating the bidder of its unique customer ID in case of any contingency and Contractor in turn provide telephonic support. Depending upon the severity of the issue, engineer shall be sent by Contractor to the site.
  For providing online technical support, the necessary hardware and software shall be provided free of cost to Employer, so as to directly logging into the system by the Contractor's technical support team.

- ON-SITE SUPPORT
  For the problems not resolved through above-mentioned On-line technical support service, the Contractor shall provide on-site technical support all throughout the warranty period of 12 (twelve) months. For the same, Contractor's engineer/personnel, who shall be capable of trouble shooting and looking after the health of the system, shall be made available along with required tool, tackles & maintenance spares at Employer's locations to resolve the problem efficiently. Additionally, during the warranty, the Contractor shall use his own instrument, spares, man-hour, communication facilities, hardware, software, materials, etc. for the rectification of any problem.

b) All technical problems related to Hardware, Software and network operation shall be covered under comprehensive AMC which will be prioritized into 3 severity categories:

- Critical – Traffic or service is affected & Service outage has occurred w.r.t any hardware, software or any other problem in the supplied system under this work order. It is the highest level of problem. The Contractor shall provide solution on top priority.
- Major – Major alarm report in the system (the service is not affected). The Contractor shall provide solution within stipulated resolution time.
- Minor – All other problems and issues not covered by previous categories.

c) Maximum Allowed Times for diagnosis, technical support / Onsite Visit etc., for complete resolution of the reported problem for resolving different kind of problems are as follows. Not meeting the same will attract penalty as per penalty implication of AMC, mentioned

Thimphu: Bhutan
Office of the Bhutan Power System Operator

in the tender document:

- Critical: Within 2 Days from lodge of complaint by Employer with Contractor.
- Major: Within 5 days from lodge of complaint by Employer with Contractor
- Minor: Within 10 Days from lodge of complaint by Employer with Contractor

d) ADVANCE REPLACEMENT SERVICE

The “Advance Replacement” service provides for the replacement of a defective Fields Replacement Unit (FRU) by an equivalent FRU upon request of replacement from Employer. Using this service, the Contractor from its warehouse/ factory will ship an equivalent unit (feature, function, fit compatible) in maximum 3 days without waiting for receipt of the defective module / part(s). The defective module / part(s) will be sent to Contractor immediately.

For repairing, faulty hardware will be sent to Contractor from site locations of Employer. Accordingly, the FRU hardware shipment shall be made directlyto respective Employer locations, from where the faulty hardware is received and all costs for this are to be borne by Contractor.

e) DOCUMENTATION DELIVERY AND SOFTWARE UPDATION SERVICE

Under Documentation delivery service bidder is required to provide engineering practices and Technical Bulletins for updates at free of cost. All the latest software updates for complete system are also required to be provided under warranty.

Any type of software up-gradation under warranty, being carried out by the OEM which is necessarily to be incorporated in the supplied systems for compatibility with future adds-on/ spare cards and facilities shall be carried out by the OEM/supplier free of cost to EMPLOYER.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

APPENDIX G

Comprehensive AMC of Supplied System

G-1. Brief of AMC services

Contractor shall also provide comprehensive AMC of all supplied system for 3 years, after expiry of Defect Liability Period.

G-2. Scope of AMC

a) All technical problems related to Hardware, Software and network operation shall be covered under comprehensive AMC which will be prioritized into 3 severity categories:

- Critical – Traffic or service is affected & Service outage has occurred w.r.t any hardware, software or any other problem in the supplied system under this work order. It is the highest level of problem. The Contractor shall provide solution on top priority.
- Major – Major alarm report in the system (the service is not affected). The Contractor shall provide solution within stipulated resolution time.
- Minor – All other problems and issues not covered by previous categories.

b) Action Resolution Time is the maximum for diagnosis, technical support / Onsite Visit etc., for complete resolution of the reported problem for resolving different kind of problems are as follows. Not meeting the same will attract penalty as per penalty implication of AMC, mentioned in the tender document:

- Critical: Within 2 Days from lodge of complaint by Employer with Contractor.
- Major: Within 5 days from lodge of complaint by Employer with Contractor
- Minor: Within 10 Days from lodge of complaint by Employer with Contractor

c) Wear & tear of spares & consumables and the corrective actions on the "Hardware", "Software" & "Firmware" of all supplied hardware in totality required for the maintenance of the networks implemented through this Work Order.

d) The contractor support personal shall provide onsite 24 x 7 (24 hours x 7 days a week) round-the-clock technical support for Hardware, software, NMS, and Network operation problem diagnosis including off site support & tele-conversation with Employer personnel for the network commissioned through this Work Order.

e) For the problems not resolved through above-mentioned technical support service, the Contractor shall provide additional on-site technical support all throughout AMC period without any additional cost to Employer.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

f) The Comprehensive AMC charges quoted by the Contractor shall include the cost of all spares, equipment, instruments, consumables & services including manpower, transportations of material, travel, lodging, insurance to take care of all preventive & breakdown maintenance activities during AMC period, as mentioned under Scope of AMC below.

g) ***Hardware Repair & Return:*** In the event of a hardware failure, the failed hardware shall be returned to Contractor for repair and replacement. Contractor shall follow the “Advance Replacement” service which provides for the replacement of a defective Hardware by an equivalent hardware upon request of replacement from Employer. Using this service, the Contractor from its warehouse/ factory will ship an equivalent unit (feature, function, fit compatible) in maximum 3 days without waiting for receipt of the defective module/ part(s). The defective module / part(s) will be sent to Contractor immediately.

h) For repairing, faulty hardware will be sent to Contractor from site locations of Employer. Accordingly, the FRU hardware shipment shall be made directly to respective Employer locations, from where the faulty hardware is received and all costs for this are to be borne by the Contractor.

i) Documentation Delivery Service and Software Updates: The Contractor will provide technical updates to Employer on regular basis. These updates will include the information on the latest software & firmware releases and anti-virus updates. The upgrade will be carried out by the Contractor or concerned OEM without any additional cost implication to Employer. However, any outage which would be necessary for the upgrade will be arranged by Employer.

j) The Contractor shall arrange for all spares, equipment, instruments, and consumables & services including manpower, transportations of material, travel, lodging, and insurance to take care of all above preventive & breakdown maintenance activities during AMC period without any additional cost to Employer.

G-3. Provision to discontinue AMC from any year

In case of dissatisfactory performance or any relevant reasons of the Contractor during AMC period, the Employer shall reserve full authority to discontinue AMC with the Contractor there after. However, Employer shall provide the Contractor regarding the decision to withdraw the AMC citing valid reasons for the same in a month’s advance before the start of the next year of AMC.

Thimphu: Bhutan
Office of the Bhutan Power System Operator

APPENDIX H

Substation-Lines Connectivity

H-1. Substations and Transmission Lines Connectivity Detail

Sl#	Substation	Connected to Substation	TL	Line (km)	Distance Protection	Remarks
	SMD Semtokha					
1	220kV Semtokha	220kV CHP	S/C	57.33	Main I&II	
		220kV Rurichhu	S/C	39.88	Main I&II	
		66kV Olakha	S/C	1.70	Main & Backup	
		66kV Dechencholing	S/C	14.33	Main & Backup	
		66kV Dochula	S/C	9.79	Main & Backup	
2	66kV Olakha	66kV Semtokha	S/C	1.70	Main & Backup	
		66kV Changgedaph u	S/C	26.63	Main & Backup	
3	66kV Dechencholing	66kV Semtokha	S/C	14.33	Main & Backup	
		66kV Damji	S/C	47.23	Main & Backup	
4	66kV Damji	66kV Dechencholing	S/C	47.23	Main & Backup	
6	66kV Changgedaph u	66kV Jemina	S/C	15.53	Main & Backup	
		66kV Olakha	S/C	26.63	Main & Backup	
7	66kV Dochula	66kV Semtokha	S/C	9.79	Main & Backup	
		66kV Lobeysa	S/C	16.06	Main & Backup	
8	66kV Lobeysa	66kV Dochula	S/C	16.06	Main & Backup	
		66kV Rurichhu	S/C	24.66	Main & Backup	
9	66kV Jemina	66kV Chumdo	S/C	14.77	Main & Backup	
		66kV Changgedaph u	S/C	15.53	Main & Backup	
10	66kV Chumdo	66kV CHP	S/C	38.63	Main & Backup	To be upgraded to 220kV substation with additional 4 Nos. of
		66kV Jemina	S/C	14.77	Main & Backup	
		66kV Olathang	S/C	25.83	Main & Backup	
		66kV Pangbisa	S/C	15.37	Main & Backup	

						220kV TL connections.
11	66kV Olathang	66kV Chumdo	S/C	25.83	Main & Backup	
12	66kV Pangbisa	66kV Chumdo	S/C	15.37	Main & Backup	
		66kV Haa	S/C	25.87	Main & Backup	
13	66kV Haa	66kV Pangbisa	S/C	25.87	Main & Backup	
	SMD Phuentsholing					
14	400kV Malbase	400kV THP	S/C	26.90	Main I&II	LILO arrangement at Malbase.
		400kV Siliguri	S/C	125.00	Main I&II	
		220kV CHP	S/C	33.68	Main I&II	
		220kV Birpara	S/C	40.77	Main I&II	
		220kV Singhigaon	S/C	1.21	Main I&II	
		220kV Dhamdum	S/C	43.40	Main I&II	
		66kV Phuentsholing	S/C	10.20	Main & Backup	
15	220kV Singhigaon	220kV Malbase	S/C	1.21	Main I&II	
		220kV Dhamdum	S/C	44.63	Main I&II	
16	220kV Damdhum	220kV Malbase	S/C	43.40	Main I&II	
		220kV Singhigaon	S/C	44.63	Main I&II	
		66kV Gomtu	D/C	17.00	Main & Backup	
17	66kV Phuentsholing	66kV Gedu	S/C	18.83	Main & Backup	
		66kV Malbase	S/C	10.20	Main & Backup	
		66kV Gomtu	S/C	29.00	Main & Backup	
18	66kV Gedu	66kV CHP	S/C	20.23	Main & Backup	
		66kV Phuentsholing	S/C	18.83	Main & Backup	
19	66kV Gomtu	66kV Phuentsholing	S/C	29.00	Main & Backup	
		66kV Dhamdum	S/C	17.00	Main & Backup	
	SMD Jigmeling					
20	400kV Jigmeling	400kV MHP-I	D/C	91.00	Main I&II	
		400kV MHP-II			Main I&II	

		400kV MHP-III	D/C	91.50	Main I&II	
		400kV MHP-IV			Main I&II	
		400kV Alipurduar-I	D/C Quad Moose	162.20	Main I&II	
		400kV Alipurduar-II			Main I&II	
		220kV Dharjey	S/C	34.50	Main I&II	
		220kV Dagapela	S/C	57.20	Main I&II	
		132kV Tintibi	S/C	54.60	Main I&II	
		132kV Gelephu	S/C	19.00	Main & Backup	
21	220kV Dagapela	220kV DHP	S/C	9.00	Main I&II	
		220kV Jigmeling	S/C	57.20	Main I&II	
22	220kV Dharjey	220kV Rurichhu	S/C	52.50	Main I&II	
		220kV DHP	S/C	20.20	Main I&II	
		220kV Jigmeling	S/C	34.50	Main I&II	
23	132kV Gelephu	132kV Jigmeling	S/C	19.00	Main & Backup	
		132kV Salakati	S/C	50.00	Main & Backup	
24	132kV Tintibi	132kV Jigmeling	S/C	54.60	Main I&II	
		132kV Yurmoo	S/C	34.80	Main & Backup	
		132kV Nganglam	S/C	83.50	Main & Backup	
25	132kV Yurmoo	132kV Tintibi	S/C	34.80	Main & Backup	
		132kV MHP-Nikachhu	D/C	20.48	Main & Backup	
	SMD Deothang					
26	132kV Kilikhar	132kV KHP	S/C	13.50	Main & Backup	
		132kV Corlung	S/C	48.50	Main & Backup	
27	132kV Corlung	132kV Kilikhar	S/C	48.50	Main & Backup	
		132kV Kanglung	S/C	55.20	Main & Backup	
28	132kV Kanglung	132kV Corlung	S/C	55.20	Main & Backup	
		132kV Phuntshothang	S/C	52.20	Main & Backup	
29		132kV KHP	S/C	34.90	Main & Backup	

Thimphu Bhutan
Office of the Bhutan Power System Operator

	132kV Nangkor	132kV Deothang	S/C	26.90	Main & Backup	
		132kV Nganglam	S/C	36.30	Main & Backup	
30	132kV Deothang	132kV Nangkor	S/C	26.90	Main & Backup	
		132kV Motanga	S/C	13.90	Main & Backup	
31	123kV Motanga	132kV Deothang	S/C	13.90	Main & Backup	
		132kV Phuntshothang	D/C	23.30	Main & Backup	
		132kV Nganglam	D/C	35.00	Main & Backup	
		132kV Rangia	S/C	46.40	Main & Backup	
32	132kV Phuntshothang	132kV Kanglung	S/C	52.20	Main & Backup	
		132kV Motanga	D/C	23.30	Main & Backup	
33	132kV Nganglam	132kV Nangkor	S/C	36.30	Main & Backup	
		132kV Motanga	S/C	35.00	Main & Backup	
		132kV Tintibi	S/C	83.50	Main & Backup	

H-2. Generating Plants (GENCOS) Connectivity Detail

Sl#	Generating Plants	Connected to Substation	Transmission Line	Line (km)	Distance Protection	Remarks
1	Chhukha Hydropower Plant (CHP)	220kV Semtokha	S/C	57.33	Main I&II	
		220kV Malbase	S/C	33.68	Main I&II	
		220kV Birpara-I	D/C	36.80	Main I&II	
		220kV Birpara-II			Main I&II	
		66kV Chumdo	S/C	38.63	Main & Backup	
		66kV Gedu	S/C	20.23	Main & Backup	
2	Tala Hydropower Plant (THP)	400kV Siliguri-I	D/C	146.00	Main I&II	
		400kV Siliguri-II			Main I&II	
		400kV Malbase	S/C	26.90	Main I&II	
		400kV Siliguri-IV	S/C	149.40	Main I&II	
3		220kV Semtokha	S/C	39.88	Main I&II	

	Basochhu Hydropower Plant (BHP)	220kV Dharjey	S/C	52.50	Main I&II	
		66kV Lobeysa	S/C	24.66	Main & Backup	
4	Manggdechhu Hydropower Plant (MHP)	400kV Jigmeling-I	D/C	91.00	Main I&II	
		400kV Jigmeling-II			Main I&II	
		400kV Jigmeling-III	D/C	91.50	Main I&II	
		400kV Jigmeling-IV			Main I&II	
		132kV Yurmoo	D/C	20.48	Main & Backup	
5	Kurichhu Hydropower Plant (KHP)	132kV Kilikhar	S/C	13.50	Main & Backup	
		132kV Nangkor	S/C	34.90	Main & Backup	

H-3. Interconnecting Transmission Lines to India

Sl#	Substation in India	Connected to Plant/ Substation in Bhutan	Trans-mission Line	Line (km)	Distance Protection	Remarks
1	Birpara, WB	220kV CHP-I	D/C	36.80	Main I&II	
		220kV CHP-II			Main I&II	
		220kV Malbase	S/C	33.68	Main I&II	
2	Siliguri, WB	400kV THP-I	D/C	146.00	Main I&II	
		400kV THP-II			Main I&II	
		400kV THP-IV	S/C	149.40	Main I&II	
		400kV Malbase	S/C	26.90	Main I&II	
3	Salakati, Assam	132kV Gelephu	S/C	50.00	Main & Backup	
4	Rangia, Assam	132kV Motanga	S/C	46.40	Main & Backup	
5	Alipurduar, Assam	400kV Jigmeling-I	D/C Quad Moose	162.20	Main I&II	
		400kV Jigmeling-II			Main I&II	

APPENDIX I

Project Implementation Plan

Project Implementation plan is as follow:

Project Implementation Schedule - 13 months (Months after Letter of Award-LOA)														
Sl/ No.	**Task Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Site surveys, Engineering, Documents, Submissions and Approvals													
2	Inspection, Type Test and Factory Testing of Equipment													
3	Supply, Installation, and Integration of Equipment													
4	Site Acceptance Test													
5	Network Stability Test, Trial Run and Commissioning													