Book 1
Project Overview

Table of Contents

NOMENCLATURE

ADDC	Area Distribution Dispatching Center
AEPS	Alternative Energy Portfolio Standards
BESS	Battery Energy Storage System
BMS	Battery Management System
CAT	Communications Authority of Thailand
CSCS	Computer-Based Substation Control System
DCU	Data Concentrator Unit
DDIP	Distribution Dispatching Center Improvement Project
DG	Distributed Generator
DEDE	Department of Alternative Energy Development and Efficiency, Ministry of Energy
DER	Distributed Energy Resources which include distributed generation and energy storage
DMS	Distribution Management System
DNP over IP	Distributed Network Protocol over Internet Protocol
EMS	Energy Management System
FLISR	Fault Location, Isolation, and Service Restoration
FRTU	Feeder Remote Terminal Unit
GenSet	Diesel Generator Set
GHG	Green House Gas
HOA08	Feeder Number 8 from Hot Substation
HOA09	Feeder Number 9 from Hot Substation
MARS	Multiple Address Radio System
MGC	Microgrid Controller
MGDP	Microgrid Development Project at Mae Sariang District, Mae Hongson Province
OP	General Operations associate with the MGC
PCS	Power Conversion System
PEA	Provincial Electricity Authority
PCC	Point of common coupling reference point on the electric power system where the user's electrical facility is connected
PON	Passive Optical Network
RCS	Remote Control Switch
RE	Renewable Energy
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SNMP	Simple Network Management Protocol

SOC	State of Charge of Battery
SOH	State of Health of Battery
SW	Switch which is the complete set of the RCS and FDCU
TOT	Telephone Organization of Thailand
WDM	Wavelength Division Multiplexing

STANDARDS AND CODES

ANSI/IEEE Standard C2-2007	National Electrical Safety Code
ANSI C57.12.28-2005	Pad-mounted Equipment Enclosure Integrity
ANSI Z535.4-2002	Product Safety Signs and Labels
ANSI C62.41.2-2002	IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits
FCC Sections 15.109&15.209	FCC Code of Federal Regulations Radiation Emission Limits; General Requirements
IEC 61000	Electromagnetic compatibility (EMC)
IEC 61850-7-420	Communication networks and systems for power utility automation - Part 7- 420: Basic communication structure - Distributed energy resources logical nodes
IEC 61850-90-7	Communication networks and systems for power utility automation - Part 90- 7: Object models for power converters in distributed energy resources (DER) systems
IEC 61968	Common Information Model (CIM) / Distribution Management
IEC 61970	Common Information Model (CIM) / Energy Management
IEC 62786	Demand Side Energy Resources Interconnection with the utility grid
IEC 62109/UL 1973	Standard for Stationary Batteries
IEC 62619	Safety Requirements for Secondary Lithium Cells and Batteries
IEC62109/UL 1741	Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
IEC/TS 62898-2 Ed.1:	Technical requirements for operation and control of microgrids
IEEE Standard 519-1002	IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
IEEE Standard 1547.1-2005	IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
IEEE Standard 1547.3-2007	Guide for Monitoring, Information Exchange, and Control of Distributed Resources with Electric Power Systems
IEEE C37.90.2-2004	IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
IEEE Standard C37.90.1-2002	IEEE Standard for Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems (ANSI)
NERC CIP	North American Electric Reliability Corporation, Critical Infrastructure Protection
NISTIR 7628	Guidelines for Smart Grid Cyber Security

Overview of Microgrid Development Project at Mae Sariang District, Mae Hong Son Province Provincial Electricity Authority (PEA)

1. Introduction

PEA has an electric power network development plan according to economic and social development plan No. 11. The objective of this development plan is to develop electric power network that should be secured, sufficient supply and supplied throughout the country according to service quality standard. In addition, the electric power network is developed to support distributed generators and renewable energy resources, and efficient energy management technology in future. PEA has identified a development of a microgrid at Mae Sariang District, Mae Hongson Province project as one of the developments to transform electric power networks to be PEA smart grid within 15 years. The plan will improve reliability and quality of electric power network of PEA.

The existing Mae Sariang District distribution system has faced many problems such as:

- The energy loss from long distribution line is about 19% or about 6.7 million kWh per year,
- The number of outage is more than 20 times per year caused by damaged equipment, maintenance, or weather related,
- During peak load, diesel generator has to run to support the voltage in the area,
- Solar farm cannot connect to the grid in some cases caused by voltage sag, over voltage, or unbalance voltage,
- The operation in this area still depends on the local operator due to the reliability of controlled equipment in SCADA system which are sometime low battery or loss of communication. Therefore, when the outage occurs, it will take about 20 minute to connect and disconnect equipment before diesel generator is able to supply to the load.

2. Target and Operational Area

This project will develop a micro grid system at Mae Sariang District, Mae Hongson Province as a target area as shown in Fig. 1. It has a long 22 kV distribution line from Hot substation about 110 kilometer. The distribution line also has to pass through the forest. Therefore, it has voltage sag and interruption problems. It also is difficult to find a cause of the interruption and take a long time to recover the line from interruption.

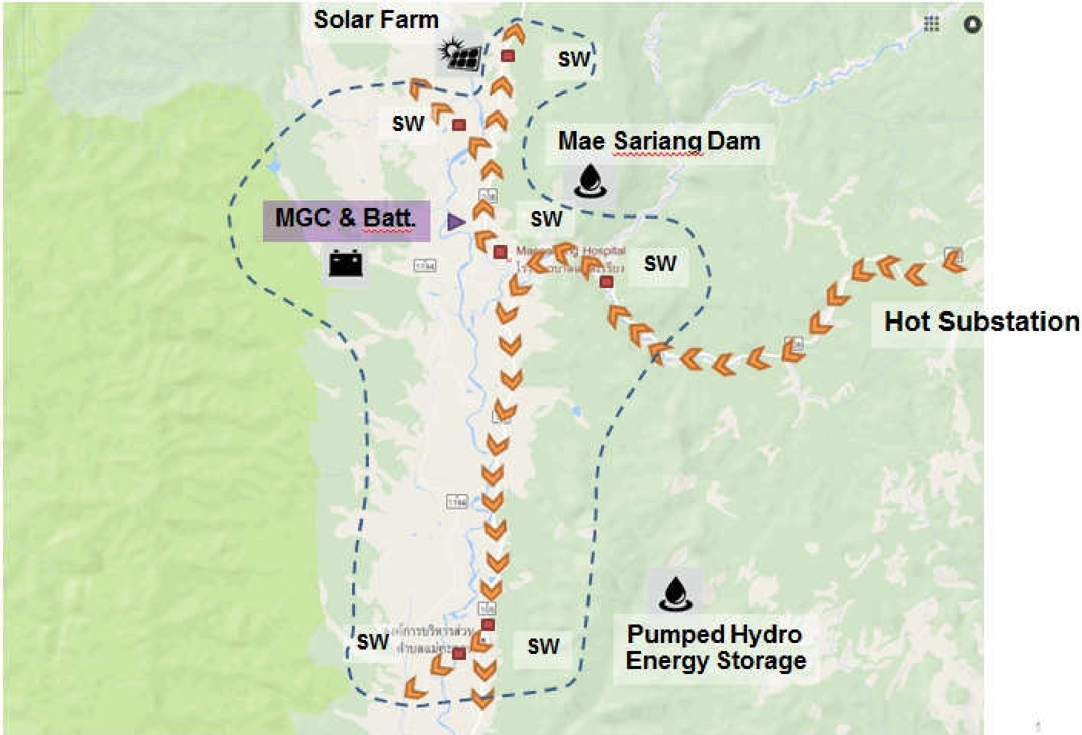

Figure 1 Microgrid Coverage area.

Therefore, the microgrid will be implemented in this target area. In the normal grid connected operation, the microgrid will operate to manage efficiency of energy usage in system. In addition, the microgrid also will manage the interruption in the grid or subsystem the coverage area. However, when the medium voltage distribution is interrupted, the coverage area will be supplied by energy sources from battery, diesel generator, Solar farm, or hydro power plant to form as islanding area in order to increase the reliability of the system. In the worst use case, the microgrid cannot support the system when it doesn't have any energy sources.

This project will develop the coverage area to be secured and sufficient power supply and supplied throughout area according to service quality standards. In addition, this project also develops electric power network to be ready to support distributed generators and renewable energy, and be able to manage efficiency of energy usage.

3. Objectives of Project MGDP

3.1 to improve the reliability and quality of power in the Mae Sariang coverage area,
3.2 to replace other types of peaking generation to meet growth in peak demand,
3.3 to reduce power losses in distribution line and overcome constraints in the development of new transmission line,
3.4 to support the expansion of Renewable Energy (RE) in the area (government policy)
3.5 to reduce the Green House Gas (GHG) and carbon dioxide (CO2),
3.6 to implement the first smart microgrid system in PEA power system.

4. Microgrid System at Mae Sariang District, Mae Hongson Province

From engineering study and design of microgrid system for Mae Sariang District, Mae Hongson Province, the microgrid system from Feasibility study has defined configuration and connection as shown in Fig. 2. The medium voltage distribution line from HOA08 has connected to feeder F1 and F5. While the medium voltage distribution line from HOA09 has connected to feeder F2, F3, and F4. The most critical loads in coverage area are in feeder F2 and F3.

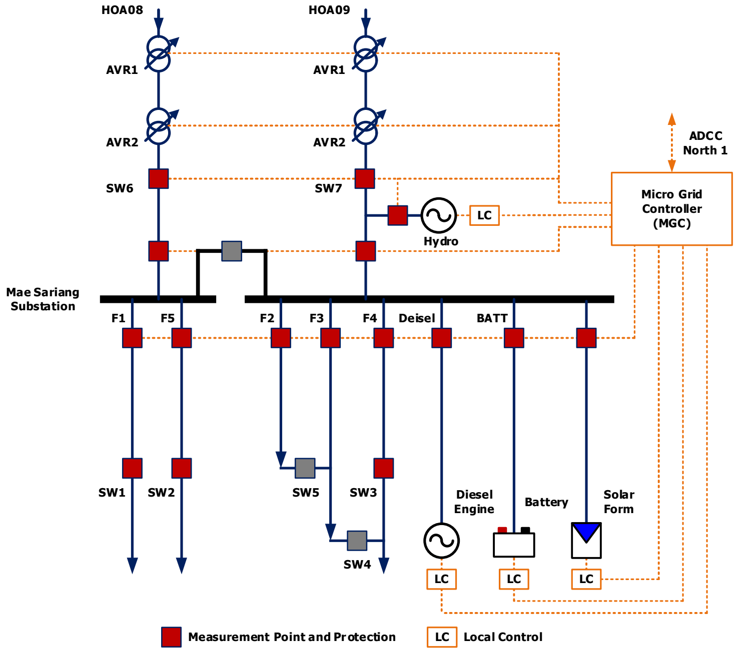

Figure 2: Connection diagram of the Microgrid at Mae Sariang District, Mae Hong Son Province according to feasibility study.

However, the configuration and connection of distribution system as current existing system have been modified from configuration in feasibility study. The medium voltage distribution line from HOA08 has connected to feeder F2 and F3. While the medium voltage distribution line from HOA09 has connected to feeder F1, F4, and F5. According to feasibility study, the most critical loads in coverage area are in feeder F2 and F3. The connection of the battery and diesel engine should be the same bus with critical load in order to supply to these load immediately when it has outage from medium distribution line. Therefore, the configuration and connect of microgrid system should be connected as shown in Fig. 3.

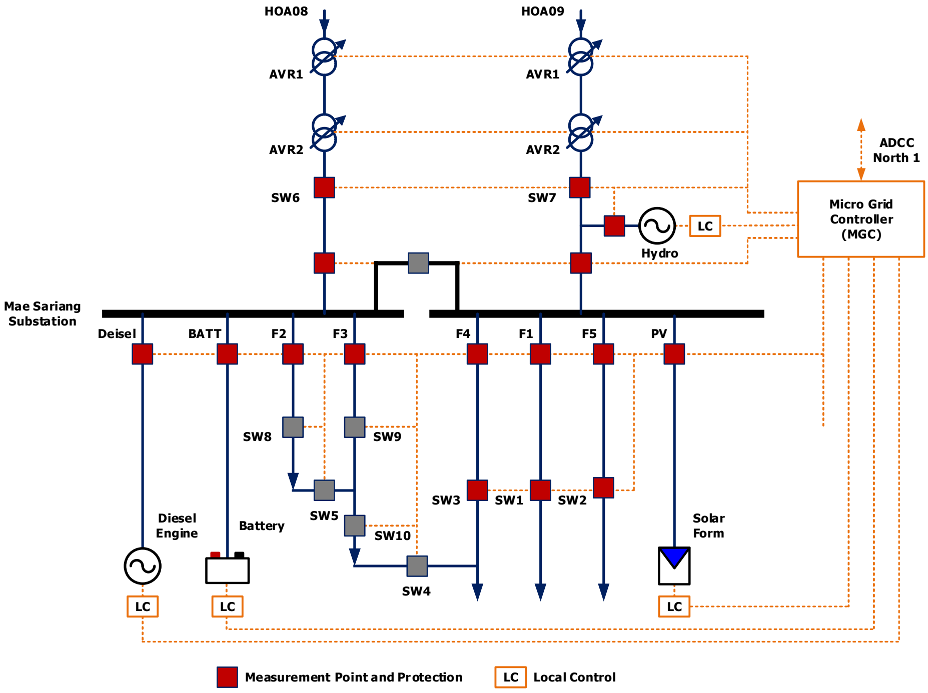

Figure 3: Connection diagram of the Microgrid at Mae Sariang District, Mae Hong Son Province according to current existed distribution system.

PEA has planned to build new substation in Mae Sariang substation to support new 115 kV transmission line. The 115 kV transmission line will take a few year to complete construction between Hot substation an Mae Sariang substation. It will be finished construction after the implementation of microgrid system. So, it will not be considered in the microgrid system at this phase. However, the building of new substation for 115 kV/22 kV at Mae Sariang substation has already awarded contracted to contractor. Therefore, the new substation can be used as a bus for microgrid system without 115 kV transmission line. The recommended configuration and connection at new substation at Mae Sariang for using in microgrid system can be configured as shown in Fig. 4. It should have 10 circuit breaks at substation for all feeders which is included incoming feeder from HOA08 and HOA09 in order to connect/disconnect these feeders as a function requirement in microgrid controller. The feeder from solar farm should be connected directly to the bus without the load in the feeder which will need additional circuit breaker. Because the operation of microgrid controller may has to connect/disconnect the solar farm according to the use case of the system. It should be connected to the same bus with battery in order to use battery in many operations such as PV smoothing, peak shaving, energy management, etc. Therefore, the connection of those feeders directly to bus will help to operation of microgrid controller more effectively.

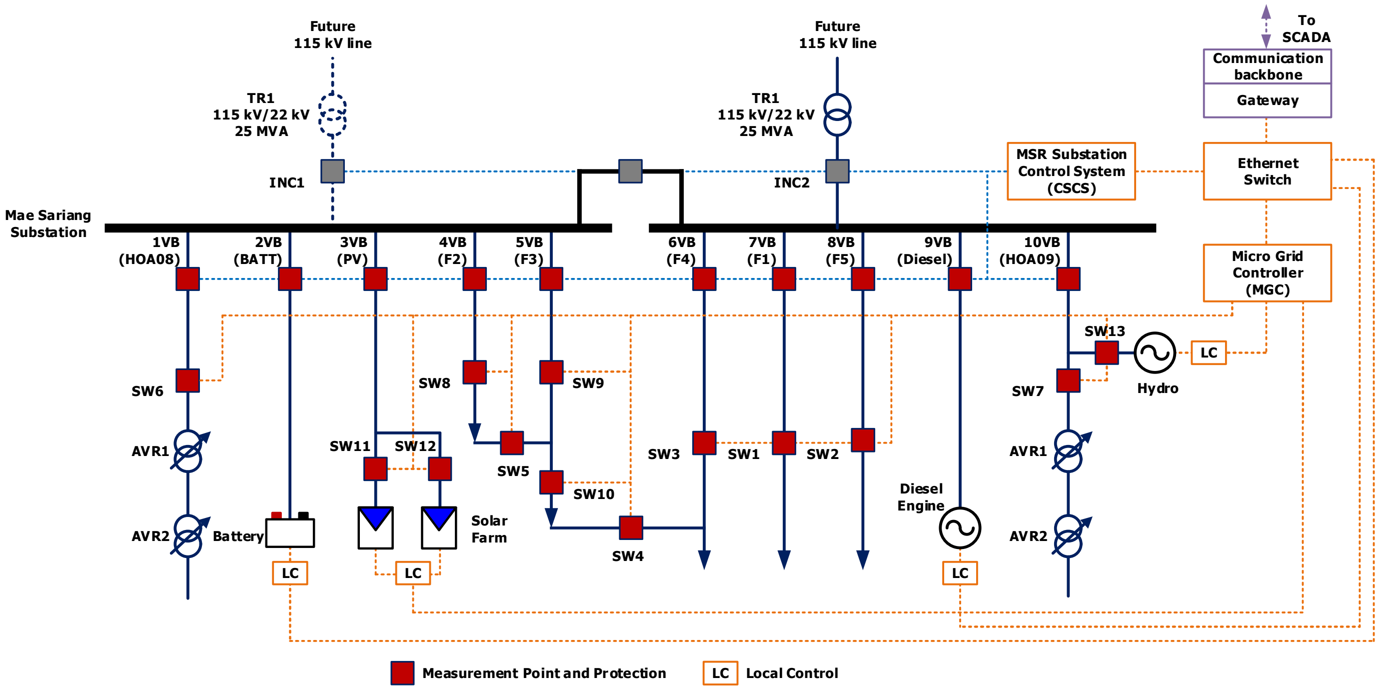

Figure 4: Connection diagram of the Microgrid at Mae Sariang District, Mae Hong Son Province according to new substation.

Microgrid system at Mae Sariang District consists of the following equipment:

1) Microgrid Controller : The main function is data processing and issuing commands to control system as per specified performance requirements. The specification of microgrid controller is described in Book 2: Technical and Specification of Microgrid Controller.

2) Converters for Solar Farm : These converters can control active and reactive power in order to delivery power or reactive power from solar cell to power grid and also control voltage of distribution system. However, PEA cannot control the converter of solar farm. Because this solar farm is belongs to VSPP's private company. However, if PEA needs to control these converters, the communication link between microgrid controller is needed to send command to these converters. If PEA is able to control these converters, it will help PEA to control both active and reactive power to support the operation of PEA. In

addition, if PEA can switch on/off to connect/disconnect these converters, the microgrid controller can switch on these converters back to microgrid at appropriated time or as needed.

3) Energy Storage : Lithium Ion battery is chosen for this project. This battery is used to supply power to distribution system within short time during failure in distribution system. As the battery technology has been developed very fast since feasibility study. However, as review battery technology recently, the technology of lithium ion battery is still appropriated to this project. The specification of energy storage is described in Book 3: Technical and Specification of Battery Energy Storage System (BESS).

4) Diesel Engine : This diesel engine will supply power to distribution system when failure in medium voltage distribution line occurs. However, it cannot delivery power instantaneously, because starting diesel engine takes time at least 5 minutes to be ready for delivery power. The specification of modification of diesel engine is described in Book 5: Technical and Specification of Modification of Diesel Generator.

5) Hydro Power Plant : This hydro power plant will delivery power to medium voltage distribution system. This power plant can also delivery power during medium voltage distribution line outages. This hydro power plant is available in season manner. This hydro power plan is belong to Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy.

6) Communication System : Communication system is crucial for microgrid as continuously communication between microgrid controller and devices in microgrid system is required. Therefore, the reliability of communication system is a key of success of microgrid system. The specification of communication system is described in Book 4: Technical and Specification of Communication System.

7) Measurement System : It measures electrical quantities to show the operation performance of the system such as current, voltage, power, position of tap changer, etc.This information is used to make decision by microgrid controller.

8) Protection System : Protection system is able to operate in 2 modes, normal mode and islanding mode. In normal mode, the distribution system is connected from medium voltage distribution line from Hot substation. In islanding mode, the medium voltage distribution line is out of service. As each mode may have a different fault level, therefore, the protection system should be able to adapt according to mode of operation. The specification of protection system is described in Book 7: Technical and Specification of Protection System.

9) Switching Devices : They will be used to disconnect the short circuit part of distribution line and to adjust electric power network to supply continuity and affect least customers. Theses switching devices will be used in Fault Location Isolation & Supply Restoration (FLISR) function. The specification of switching devices are described in Book 6: Technical and Specification of Remote Control Switch.

10) Interface Devices and Connection : These will improve physical configuration of Mae Sariang substation to meet the standards. The configuration will have all connections at one point and will also support automatic operation of the microgrid system as shown in Fig. 4.

5. Microgrid System Performance

5.1 General Requirements

5.1.1 Overall life expectancy of the system and the life expectancy of critical system parts and components of the microgrid shall be provided.

5.1.2 The microgrid system shall be designed for an expected average life time of at least 10 years. An accelerated aging/stress test shall be provided to demonstrate the test environment and the corresponding life time.

5.1.3 The expectancy support for spare parts shall be provided with a guarantee period of no less than ten years from the date of the latest delivery of equipment containing these parts or assemblies.

5.1.4 Notification shall be provided at least six months in advance if any part or assembly becomes unavailable for purchase. However, the vendor shall cover the guarantee according to 5.1.3.

5.2 Microgrid System Availability

5.2.1 The system availability evaluation methodology, assumptions, and calculation results, including expected number of microgrid system failures per year, of the proposed design shall be documented and provided for PEA's review. Proven track records through a number of customer references for like systems (including contact information for persons who can provide authentic testimony) will carry greater weight than purely theoretical calculations. A greater number or references will dispel the concern of cherry-picking customer references. A system approach that does not require routine maintenance is preferable by PEA.

5.2.2 The availability of the system is defined as the probability that the system will be available when required, or as the proportion of total time that the system is available for use. Annual availability of the system, defined as the ratio of the system uptime and total operating time, shall be 99.95% or better on average (IEC 60870-4, Table 2 – Class A3). This requires that system downtime be less than 262 minutes per year.

5.3 Reliability

5.3.1 The reliability of the system is defined as the probability that a piece of equipment or component will perform its intended function satisfactorily for a prescribed time and under stipulated environmental conditions. The system reliability evaluation methodology, assumptions and calculation results shall be provided to PEA for verification and validation.

5.3.2 The expected failure modes for the system and the components shall be declared. Preferably, the failure mode and effect analysis (FMEA) shall be based on IEC 60812.

5.3.3 The system and component failure rates shall be provided to PEA for verification and validation.

5.3.4 The worst-case event estimation and consequences shall be provided to PEA for verification and validation.

5.3.5 The system shall be free from design flaw and design error. Design error shall be detected and tested out before installation and commissioning.

5.3.6 The system shall be free from deviation from a desired or intended state.

6. Project Responsibilities

Both the Authority and Contractor shall take responsibility for different tasks as described in the following sub-clauses.

6.1 Contractor Responsibilities

The Contractor shall supply, install, and commission the specified quantity of equipments for microgrid system are in a contract so that they are in good clean working order, fit for their intended purpose, and fully integrated with the corresponding existing Authority's SCADA system. In this respect, the Contractor's responsibilities shall include, but shall not be limited to:

1) Ensuring the microgrid controller is designed and engineered to meet the Authority's requirements fully and completely in coordination with the existing Authority's SCADA.
2) Supplying all necessary materials and performing all necessary fabrication, testing, wiring, and interconnection work during the process of assembling or otherwise producing the microgrid system.
3) After contract awarded, completing all relevant type testing as well as factory acceptance testing (FAT) shall submit to PEA for reviewing and approval. Completing all relevant type testing as well as factory acceptance testing (FAT) prior to delivering each component of microgrid system to its assigned site. FAT shall include use of all necessary Contractor-supplied test equipment.Contractor shall submit Full Function Test & Factory Routine Test report to PEA.
4) Provide transportation and accommodation for members of the Authority's acceptance committee to the factory where they will inspect each component of microgrid system and witness the test procedures.
5) Work plans and drawings for installing the microgrid system and all other relevant equipment such as Lay-Out of Equipment, control circuits and etc. at their installation sites.
6) Provision of all necessary test equipment
7) Transportation of all components of microgrid system and all accessories to their assigned sites.
8) Site acceptance testing (SAT) of every components of the microgrid system. SAT shall include Contractor use of the test sets in order to demonstrate the readiness of the microgrid system be end-to- end tested with the existing Authority's SCADA.
9) End-to-End testing (ETE) of every components of the microgrid system. In this respect, Contractor personnel shall be readily available to identify and resolve related microgrid system problems. This shall include any necessary modifications or adjustments to the installed microgrid system.
10) Participation in project meetings, such as design and progress review meetings, and submission of all necessary transmittals related, for example, to items such as meeting agendas, meeting minutes, progress reports, etc.
11) Ensuring and periodically demonstrating that the work is progressing according to the approved schedule. In this respect, the controller, the battery energy storage, the switching devices, communication system and others components shall be installed and tested for readiness well before they are required to perform any of the overall end to-end system tests.

12) Provision of preliminary and as-built drawings, functional design documents, operation and maintenance manuals, test plans, test procedures, and test reports.
13) Training Authority staffs so that they will be self-sufficient in monitoring, testing, and maintaining the microgrid system's equipment. This includes provision of all necessary training equipment and materials.
14) Maintaining the microgrid system's equipment until acceptance and start of the corresponding warranty period.
15) Providing and implementing all warranty services that relate to the microgrid system's equipment.

6.2 Authority Responsibilities

Authority responsibilities will include supervision and support of all Contractor activities as follows:

1) Provision of Site installation including with x-y coordination GPS, drawings such as schematic diagrams of remote controlled switch and pea's standard general arrangement drawing for remote control switch installation.
2) Review and approval of Contractor-supplied drawings, manuals, design documents, training materials, test procedures, and other required documentation.
3) Providing appropriate 22 kV power sources at sites.
4) Providing water supply at sites.
5) Participation in Contractor-provided training courses. This will include Authority auditing of these courses to ensure the training objectives are met.
6) Witnessing of factory and site acceptance tests.
7) Review and approval of Contractor-supplied work plans for installing the microgrid system.
8) Inspection and approval of goods and materials both before and at time of delivery.
9) Coordination and supervision of the Contractor's on-site work.
10) Switching and blocking of primary power system equipment as required by the approved work plan.
11) Inspection and approval of completed the microgrid system installations.
12) Preparing all databases for the existing Authority's SCADA and personal to identify and resolved the SCADA problem during End-to-End testing.

7. Technical Proposal Format and Content

The Proposer shall structure the Technical Proposal as follows:

7.1 Describe past experiences of proposer on microgrid system, this section should describe at least on concept, architecture, performance characteristics.

7.2 Proposed Methodology, Approach and Implementation Plan - this section should demonstrate the Proposer's response to the Terms of Reference by identifying the specific components proposed, how the requirements of the microgrid system shall be addressed, as specified, point by point; providing a detailed description of the essential performance characteristics proposed; identifying the works/portions of the work that will be subcontracted; and demonstrating how the proposed methodology meets or exceeds the specifications. The proposal shall cover at least 2 main critical parts: microgrid controller and BESS. The methodology and approach in proposal shall be a part of contract of the work.

7.3 Expertise of Firm/Organization - this section should provide details regarding management structure of the organization, organizational capability/resources, and experience of organization/firm, the list of projects/contracts (both completed and ongoing, both domestic and international) which are related or similar in nature to the requirements of this TOR, and proof of financial stability and adequacy of resources to complete the project.

7.4 Management Structure and Key Personnel - This section should include the comprehensive curriculum vitae (CVs) of key personnel that will be assigned to support the implementation of the proposed methodology during entire project period, clearly defining the roles and responsibilities compared with the proposed methodology. CVs should establish competence and demonstrate qualifications in areas relevant to the TOR.

7.5 Other Information as may be relevant to the Proposal.