Independent Technical Evaluation
Patgram 5MW PV Power Plant
Lalmonirhat District
Bangladesh

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1、Introduction

1. Executive Summary

The climatic conditions of Bangladesh are ideal for solar energy technology. Indeed, stand alone PV plants are used in remote areas, grid connected systems however are not yet well enough considered. But Bangladesh Government has taken several initiatives to increase the solar energy supplies through having PPA, EPC or unsolicited project proposals.

The power supply system is suffering from lack of production forcing the distributor to practice regular load shedding. Therefore, using the energy production potential of grid connected PV plants could substantially contribute in making the national power supply system more diversified and independent, and more ecologically and economically sustainable.

Renewable energy encompasses a broad range of energy resources. Bangladesh is known to have a good potential for renewable energy, but so far no systematic study has been done to quantify this potential for power generation. This paper estimates the potential of renewable energy resources for power generation in Bangladesh from the viewpoint of different promising available technologies. The technical potential of gird-connected solar PV is estimated at 2000 MW. The renewable energy resources cannot serve as alternative to conventional energy resources, yet they may serve to supplement the long-term energy needs of Bangladesh to a significant level.

Due to present acute gas crisis in the country it is highly unlikely that ever growing energy and power demand and supply gap will be mitigated in the prevailing condition. In assessing the total energy demand for the entire Lalmonirhat District, the industry mixes and households demand as well considered are small to medium high energy intensive. At the same time, recently several enclaves have been handed over to Bangladesh by Indian Government which required more production of electricity to address the immediate need of those areas those were under dark for several decades.

In light of the above Patgram seriously has to consider to explore as many renewable and energy efficiency potential as possible. Considering the nationwide energy demand, **solar can be opted as one of the viable alternatives**. Although solar installation cost is way higher than diesel it has no fuel requirement as in the case of diesel and can be managed with little maintenance cost. To explore all potentials of solar energy efficiency the concept of **PV Power Plant - grid connected** could be a good option for Lalmonirhat District.

Even disposing of an extraordinary potential for Solar Power production, lack of investments, political instability and increase of energy demand have driven the country in a severe energy crisis, with as much as eight hours of load shedding a day during springtime 2009. The energy crisis has certainly find solutions and ways out through the diversification of electricity sources in order to increase the production capacity at short and long term, with –hopefully– careful consideration of global sustainability criteria.

The objective of this technical evaluation is to go through and check each and every elements of the design and see whether it has been done considering the all environmental and technical issues to make the project most efficient and viable or not?

2、 Electrical part evaluation

2.1.1、 Overview

The basic principle of design is to maximize the return on investment in power plant.

The actual installed capacity of the project is 5.7024MWp, consisting of 80 combiner boxes.

Each generating unit (Zone) consists of solar cell arrays in series and parallel. The solar modules are connected to the box type transformer by the inverter and the AC junction box. The inverter, combiner box and the step up transformer are distributed on the ground according to the unit distribution. Each power generation unit includes the photovoltaic array, it is composed of grid connected inverter, AC combiner box, box type transformer and corresponding monitoring and protection equipment.

In the management area, a 33kV substation is set up, and the 33kV side uses a single bus line connection. The project has a total of one 33kV circuit lines, and the switch station is connected to the power grid with one back 33kV line to meet the current photovoltaic project access. Finally, the power access is approved.

The power line cable is buried underground, and the collection line construction between blocks is responsible by the general contractor.

2.1.1、Electrical Primary Equipment

2.1.1、Photovoltaic system Primary Equipment

330Wp Polysilicon Photovoltaic module is used, each string consists of 18 modules, each inverter connects 12 strings and in total 80 inverters of 65kW rating are used. Every 4 sets of inverters connects an AC combiner box, a total of 20 AC combiner boxes are employed. Each 5 combiner boxes are merged into a 1600kVA box type transformer. There are total 4 box type transformers. The high voltage side of the transformer is connected to 33kV switchgear by a collection line.

Main PV system equipment selection

(1) Photovoltaic modules

The project consists of 17280 polysilicon 330Wp modules. Its main parameters are as shown in the following table

Table 1-1 PV module parameters

1	Rated output	Wp	330
2	Rated power deviation	W	0,+5
3	Component efficiency	%	17.0
4	Highest power voltage	V	39.25
5	Highest power current	A	8.41
6	Open circuit voltage	V	46.50
7	Short circuit current	A	8.78
8	Maximum system voltage	V	1000
9	Open circuit voltage temperature coefficient	%/℃	-0.410
10	Short-circuit current temperature coefficient	%/℃	0.070
11	Peak power temperature coefficient	%/℃	-0.550
12	Dimensions	mm	1956×992×40

(2) Inverter

In this project, 80 sets of Huawei string inverters of type SUN2000-65KTL-M0 are used. The main parameters are shown in the following table

Table 1-2 Inverter Parameter Table

1	Rated power (AC)	kW	65
2	Maximum input voltage	VDC	1100
3	Rated input voltage	V	720
4	MPPT voltage range	V	200～1000V
5	MPPT quantity	branches	6
6	Maximum output power	kW	72
7	Maximum input current	A	86.7
8	Rated output power	kW	65
9	Maximum inverter efficiency	%	98.9
10	European efficiency	%	98.7
11	Power Factor		0.8(leading) -0.8 (lagging)
12	Total current waveform deformity rate	%	<3% (rated power)
13	Allowed ambient temperature	℃	-40～55

(3) DC combiner box

This project used combiner box have 16 inputs and one 1 output, in total 61 combiner box are used.

PV array Inclination Angle

In order to receive more solar energy on the surface of the photovoltaic array, the surface of the square array is best to be mounted toward the equator (the azimuth is 0 degrees), and should be inclined to install. For the photovoltaic grid connected power station, the electric energy generated is fully used, so only the square array is made. The maximum radiation can be received throughout the year. This project uses the commonly used software PVsyst to calculate the amount of radiation on the tilting surface of the PV modules. The results are shown in the following table.

According to the PVSYST radiation curve, the annual total radiation received on the inclined plane reaches the maximum when the inclination angle is 20 degrees.

Photovoltaic array and parallel design

(1) Photovoltaic Array Design

For the 65kW string inverter of this project, refer to the parameters of the inverter in the above table. The MPPT voltage range is 200V~1000V. The open circuit voltage Voc of the polysilicon solar module is 46.5V, and the optimal operating point voltage Vpm is 39.25V. The open circuit voltage temperature coefficient is -0.410%/°C and the peak power temperature coefficient is -0.55%/°C.

Calculate the number of PV modules in series, using the following formula:

$$N \le \frac{V_{dc\max}}{V_{OC} \times [1 + (t - 25) \times K_v}$$

$$\frac{V_{mppt\min}}{V_{pm} \times [1 + (t' - 25) \times K'_v]} \le N \le \frac{V_{mppt\max}}{V_{pm} \times [1 + (t - 25) \times K'_v]}$$

Where: Vdcmax - maximum allowable DC input voltage (V)

Vmppt min - minimum MPPT voltage of the inverter (V);

Vmppt max - inverter MPPT voltage maximum (V);

Voc - PV module open circuit voltage (V);

Vpm - photovoltaic module operating voltage (V);

kV - photovoltaic module open circuit voltage temperature coefficient;

K'v- photovoltaic module operating voltage temperature coefficient;

T'- The maximum temperature limit (°C) of the PV module under working conditions;

t - the minimum temperature (°C) of the PV module under operating conditions;

Number of N-PV modules in series (N rounding).

The number of components in series should ensure that the inverter's DC MPPT voltage and maximum DC allowable voltage are met. This project chooses 65kW string Inverter. MPPT voltage tracking range are 200~1000V and maximum input voltage of 1000V. According to the local meteorological data, the project site area temperature is extremely high at 38°C and extremely low at 4°C. The photovoltaic module used in this project has an open circuit voltage of 46.5V, a working voltage of 39.25V, and an open circuit voltage temperature coefficient of -0.410%/°C; the open circuit voltage of the string at the lowest ambient temperature of 4°C should be lower than the maximum of the inverter. For the input voltage, the operating voltage of the module at 4°C and 38°C should be within the MPPT range of the inverter.

At a minimum ambient temperature of 4°C and a component of 38°C, when the photovoltaic string number is 9≤N≤18, the operating voltage of the module meets the MPPT operating voltage range of the inverter. When the minimum ambient temperature of the module is -25°C, the string open voltage is less than the maximum input voltage of the inverter 1000V under the condition of the number of strings N≤19. Considering the string arrangement of photovoltaic power plants and other comprehensive factors, the number of components in series is 18 blocks.

The quantity of the parallel placed 65kW generation units can be changed according to the design requirements.

PV array operation

(1) Classification of photovoltaic array operation modes

In the design of photovoltaic power generation system, the operation mode of the PV module has a great influence on the total solar radiation received by the system, which affects the power generation capacity of the photovoltaic power supply system. The operation mode of the PV module has two types of fixed installation and automatic tracking.

(2) Selection of PV array operation mode

Fixed installation method is selected according to economic and technical requirements.

Layout of Photovoltaic Array

(1) Photovoltaic matrix spacing

In the northern hemisphere, the plane that corresponds to the maximum solar radiation receiving capacity is oriented to the south, and the inclined plane with the horizontal plane clipping angle equal to the local latitude, and the fixedly installed PV modules are installed at an optimal angle according to this inclination. After determining the angle of inclination of the array of squares, it is necessary to pay attention to a reasonable spacing between the north and the south and the front and back arrays to avoid shadowing before and after. The distance between the front and rear is: the winter solstice (the longest day in the shadow of the object in the sun during the year). 9:00 to 3:00 PM (Sun time). There is no shade between north and south PV modules. Fixed arrays do not adjust after installation.

Calculate the minimum spacing D between front and back arrays for the installation, as shown in the following figure:

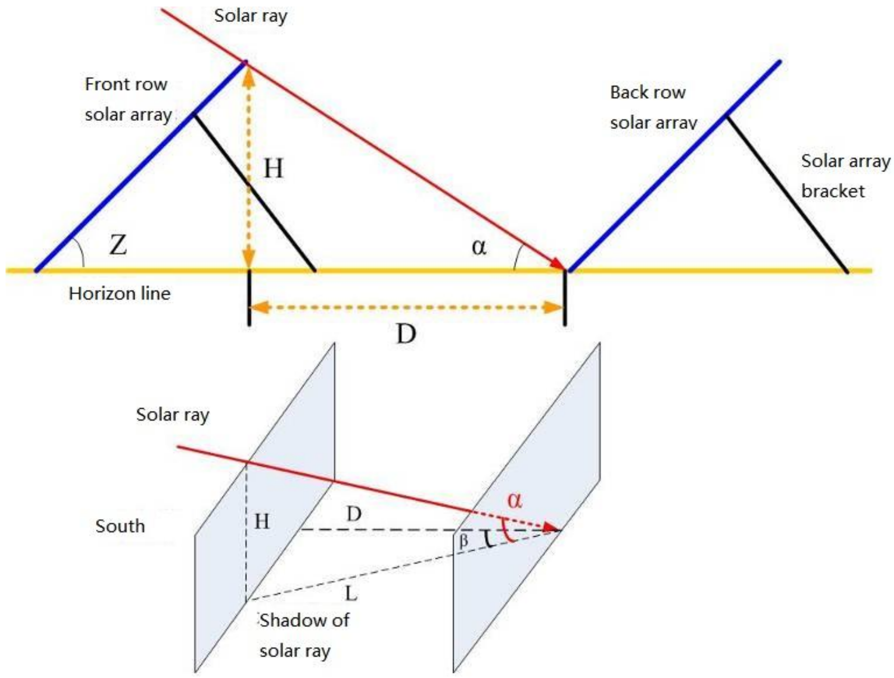

Figure 1-1 Shadow masking

General principle of determination: the winter solstice day 9:00 to 3:00 pm (solar time) PV array should not be obscured.

The calculation formula is as follows:

Solar elevation formula: sina=sinfsind+cosfcosdcosw

Solar azimuth formula: sinβ=cosdsinw/cosa

In the formula:

f is about 26.3° in the local latitude;

d is the declination of the sun, and the solar declination of the winter solstice is -23.45°;

w is the hour angle, and the hour angle at 9:00 am is -45°.

The solar elevation angle a at 9:00 a.m. on the local winter solstice day.

The solar azimuth β of the local winter solstice at 9:00 a.m.

D=cosβ×L，L=H/tana，a=arcsin(sinfsind+cosfcosdcosw)

which is:

$$D = \frac{\cos\beta \times H}{\tan[\arcsin(\sin\phi\sin\delta + \cos\phi\cos\delta\cos\omega)]}$$

According to the pre-used land topography and the local latitude, the distance between the front and rear rows should be designed so that the front and rear rows of the winter solstice will not be blocked between 9:00-15:00. *After calculation, the D value will be 2.2m.*

(2) System element sub-array design

The capacity of each power generation unit in this project is approximately 71.2 kWp, and there are total of 80 power generation units. Single power generation unit consists of 330Wp polysilicon PV module, 12 strings connected to inverter, each string is made of 18 modules, and there are total 80 inverters with 65kW power rating each.

(3) Photovoltaic module layout

According to the terrain condition of the project, the maximum capacity layout is optimized, and the 2×9 lateral arrangement is adopted

Cables, laying and fire protection

(1) Cable selection

1) PV-F-type cables are selected for the connection of PV modules to string inverters.

2) For Inverter to AC combiner box connection, YJV22-0.6/1kV-3x35 type cable is selected.

3) For AC junction box to box change connection, YJV22-0.6/1-3×240 type cable is selected.

(2) Cable laying

1) When the components are connected in series, the upper and lower rows of components must not be mixed. The string connection of the photovoltaic modules should be traced along the cross beam of the photovoltaic bracket. When the cross section (east-west direction) should cross the neutral between the two subunits, the overhead conductors should go through the galvanized steel pipe. Horizontal and vertical requirements, beautiful layout.

2) The part of the cable coming in and going out needs to be protected by galvanized steel pipe.

3) The depth of the direct buried cable is required below the frozen soil layer. The protection measures such as the galvanized steel pipe or the cable trench, such as crossing the galvanized steel pipe or the cable channel, etc., should be taken into full consideration for the corrosiveness of the local geological soil to the cable and to do the anticorrosion treatment.

4) The cable leading to the upper part shall not be exposed, and the bushing should be heated

2.1.2、Step up station Primary Equipment

Main electrical wiring

The project construction capacity is 5.7024MWp. The output AC voltage of 80, 65kW string inverters is three-phase voltage of 0.48kV. The output voltage of the inverter must be stepped up to 33kV and then sent to the 33kV switching station. The voltage transformer selects the American style box type transformer, each capacity is 1600kVA, and the voltage ratio is 33/0.48kV, the low voltage side is a double split winding. There are total 4 box type transformers, and output of the 5 combiner boxes is combined and connected to a low voltage side of the transformer.

33kV step-up substation adopts single busbar connection, and the distribution equipment adopts user-internal exchange metal-enclosed and removable high-voltage switchgear cabinets in total: 4 panels one outgoing cabinet, one PT cabinet, one grounding and station transformer and one current collecting line.

Neutral grounding

In order to compensate for the capacitive current, limit the over-voltage level, and improve the operational reliability, 33kV system grounding method is required to use small resistance grounding.

Short-circuit current level

The short-circuit current should be chosen according to the calculation result of the short-circuit current. The short-circuit level of the 33kV equipment should not be lower than 31.5kA.

Primary equipment selection

(1) 33kV high voltage Switchgear cabinet

Metal armored high-voltage switch cabinets are used. Circuit breakers are equipped with vacuum circuit breakers.

Rated voltage: 40.5kV

Rated current: 1250A

Rated breaking current: 31.5kA

Rated peak withstand current: 40kA

Rated short circuit duration: 4s

(2), grounding change and station transformer

DKSC-500/33-200/0.4kV is selected, the connection group is ZNyn11, Ud=6.5% dry earthing is changed, and it is placed outdoors with the grounding resistor complete set, in which the primary side is grounded and the capacity is 500kVA; The secondary side is used for station change and the capacity is 200kVA.

(3) Neutral grounding system

The 33kV side of this project adopts a neutral point small-resistance grounding method, and uses a grounding variable resistor device.

(4) Conductor selection

According to the specification of the conductor selection procedure, the TMY-80×8 type copper bus is selected for the 33kV bus.

Station Power Supply

(1) Station electrical wiring principle

The switch station is equipped with two stations with power supply, the grounding of the 33kV bus belt in a routing Step upstation and substation power supply, the other is powered by local electricity and two power supply is alternate. Considering the operating characteristics and power supply requirements, the station connection mode is a single bus connection.

(2) Station power equipment selection

There are 1 earthling stations in the station to change and station to use. The power supply is connected from the 33kV bus line and the other power is connected from the city power.

Primary equipment layout

The 33kV distribution device is arranged in the prefabricated cabin in the middle of the photovoltaic area. The primary equipment is arranged indoor in a single row and according to the space requirements: Outgoing line cabinet, the bus bar equipment cabinet, the grounding transformer and the electric circuit cabinet.

Insulation coordination, overvoltage protection and grounding

(1) Insulation coordination

The insulation coordination of this project is based on the characteristics of zinc oxide surge arresters. The insulation coordination of electrical equipment must meet the requirements of the relevant codes and regulations of the power industry.

(2) Direct lightning protection

Photovoltaic modules are protected from lightning by means of assembly that is directly grounded. Independent lightning protection devices are not provided. The Step up station is protected by a separate lightning rod 15 meters high.

(3) Overvoltage protection

1) Zinc oxide surge arresters are installed in 33kV high-voltage switchgears as overvoltage protection.

2) Lightning arresters need to be installed in the grid-connected inverters, ac-communicators, and local step up boxes in the photovoltaic area.

(4) Grounding

1) PV area

Photovoltaic zone grounding grid adopts horizontally laid grounding trunks, and vertical earthling poles are supplemented to form a composite artificial grounding device. The horizontal grounding body of the main grounding grid and the grounding lead of the main equipment are hot-dip galvanized flat steel of -50X5. Vertical The grounding body uses DN40, L = 2500mm hot-dip galvanized steel pipe.

The brackets, component frames, and connectors of this project are all metal products. Each sub-matrix naturally forms an equipotential body. All sub-matrixes must be equipotential-bonded and reliably connected to the grounding grid through the down-lead and grounded. Welding points between bodies should be treated with antiseptic.

The photovoltaic zone requires that the grounding resistance is not greater than 4 ohms, and the life of the grounding grid is calculated as 30 years.

2) Step up station

The total station grounding grid adopts horizontally laid grounding trunks, and the vertical grounding pole is supplemented by a composite artificial grounding device. The horizontal grounding body of the main grounding grid and the grounding down conductor of the main equipment are -50X5 hot galvanized flat steel, vertical The grounding body uses DN40, L = 2500mm hot-dip galvanized steel pipe. For areas with high groundwater levels and severely corroded areas, use copper grounding bodies. For example, if the soil resistivity of the Step up station is relatively high, the corresponding resistance reducing agent, external grounding grid, and deep-well grounding shall be considered. When only the artificial grounding body is applied to the Step up station and it is difficult to satisfy the step potential and the contact potential, the use of a horizontal grid equalizing belt or a high-resistance insulation operating floor around the frequently operated equipment should be considered. A pressure equalizing belt connected to the grounding grid is arranged around the Step up station and adjacent to the road.

Separate lightning rods should be equipped with independent grounding devices. In non-high soil resistivity areas, the grounding resistance should not exceed 4Ω. When there is difficulty, the grounding device can be connected to the main grounding grid, but the underground connection point between the lightning rod and the main grounding grid must be no less than 15m along the length of the grounding body between the device and the underground connection point of the main grounding grid.

The boosting station grounding grid and the photovoltaic zone grounding grid must be reliably connected at no less than two points.

The boosting station requires a grounding resistance of $R \leq 2000/I$, a grounding resistance of no more than 0.5Ω, and a grounding grid life of 30 years.

Lighting and Maintenance

(1) Lighting power system

1) The work lighting is powered by the station's low-voltage distribution panel. The power supply trunk line adopts a three-wire and four-wire system. The grounding type of the power supply network adopts the TN-CS system.

2) The emergency lighting adopts the combination of ordinary emergency lighting and emergency lighting with its own battery. The ordinary emergency lighting is supplied by the AC/DC inverter switching device, and the emergency lighting with battery is normal by the working lighting network. Power supply, when the accident comes from its own battery, the emergency time is not less than 2 hours, AC / DC inverter switching device is arranged in the emergency lighting distribution box, its capacity is determined according to the emergency lighting load.

(2) Maintenance

33kV power distribution room is set to repair the power box, power supply from the station with a low-voltage distribution panel lead, repair power supply radius is not greater than 50m to consider.

Cables, laying and fire protection

(1) Cable selection

1) ZRC-YJY22-26 cable is selected for 33kV high voltage power.

2) ZRC-YJY22-0.6/1kV is selected as 380/220V low voltage power cable.

3) Control cable, use ZRC-KVVP22-0.45/0.75kV type cable, cable cross section is not less than 2.5mm2, in which current and voltage return cable cross section is not less than 4mm2.

4) 485 communication cable, use 2*2*1 shielded twisted pair cable.

5) Communication cable in the photovoltaic area, using 12-core single-mode armored

fiber.

(2) Cable laying

The cable for this project is buried underground, and the depth of direct burial is 0.6m. Protective measures such as galvanized steel pipes or cable trenches are adopted for roads, pipes, and trenches. The type of buried cables should fully consider the corrosion of local geological soil to the cable. Antiseptic treatment.

2.3、Electric Secondary Equipment

2.3.1、Automation System

PV Generation Monitoring System

(1) The monitoring system includes the following equipment: PV arrays, AC combiner boxes, grid-connected inverters, and 33 kV box-type substations.

(2) The monitoring configuration of photovoltaic power generation system is as follows:

1) The PV array modules in the photovoltaic power generation system does not have a separate monitoring device, but the data regarding it can be collected through the combiner box.

2) AC combiner boxes, grid-connected inverters, and 33kV box type transformer are all equipped with local monitoring devices to analyze, process, troubleshoot, and alarm the monitoring signals and discover the problems inherent in the equipment. The inverter room is equipped with a data acquisition device to collect real-time data of the monitoring device, and the collected data and processing results are transmitted to the substation by means of optical fiber communication, and the photovoltaic power plant operating personnel perform centralized remote monitoring and control.

(3) The monitoring function of the photovoltaic power generation system is as follows:

1) AC fuses, AC circuit breakers, surge protectors, etc. are installed in the combiner box. The combiner box monitoring device collects AC circuit breaker loading, various current and voltage signals, and monitors solar battery strings and AC lines.

2) Inverter monitoring function

Remote control inverter start and stop, power regulation, power factor adjustment.

The current display of the inverter can display parameters such as operation, real-time power, fault, and energy accumulation.

Inverter protection device is a complete set of equipment. The main protection are: grid over / under voltage protection, over / under frequency protection, over temperature protection, overload protection, over voltage protection, low voltage ride through function, anti-island protection, DSP fault protection and so on. After the protection device moves, it jumps the inverter circuit breaker and sends a signal.

Monitor the operating status of all inverters and use audible and visual alarms to indicate that the equipment is faulty. You can view the cause of the fault and the time of the fault.

An intelligent multi-function measuring instrument is installed in some DC cabinet. The on-off measurement and control device collects various switch states, DC current, voltage, power and other signals, and uploads them to the data acquisition device of inverter room.

In the box-type transformer, a measurement and control device is set up to send the high-side load switch operation signal, the low-side switch action signal, the high and low pressure switch position signals, the transformer temperature signal, the transformer oil temperature, and the oil level signals. The inverter room data collector realizes the interconnection with the switch station computer monitoring system and can remotely control the disconnection of the circuit breakers on the high and low voltage sides.

Control of Electrical Equipment in Switchgear

In the main control room of the switch station, a set of computer monitoring and control system is established in the switch station. This system is the communication hub of the integrated automation in the station. It is the comprehensive information point of the station. It is responsible for obtaining the measured data and state signals for the main equipment of the switch station, and collecting, analyzing, storing and reporting the output of the information, and also responsible for the information. The communication between the remote scheduling (control center) and the transmission of data, state quantity and control commands, in addition, it is also connected with other intelligent modules or devices such as electronic meter, DC power supply system and image monitoring system to complete the comprehensive management function of the whole station.

Through the operator workstation of the main control room, the operating personnel can centrally monitor and manage the 80 photovoltaic inverters and lines and other equipment of the power station. Station-level equipment can achieve the following functions:

Data collection and processing: Collect the status quantities of 80 photovoltaic inverters and switchgear lines and other equipment through the network, and use various application softwares for processing.

Safe operation monitoring: including status monitoring, over-limit alarm, trend analysis, event sequence recording, accident recall, and related quantity records. According to the processed information, the equipment status is determined, and the accident handling and recovery operation guidance can be proposed.

Real-time control: According to the mid-adjustment command, start and stop of each unit can be determined or the operator can manually control and adjust the unit and circuit breaker through various function keys or mouse.

Human-machine interface function: The operating personnel intervenes in the production process through human-machine interface devices such as keyboards, mice, screens, and printers, and obtains relevant information.

Data communication: According to the given communication protocol, establish data communication with the local computer. The data communication between the local control unit and the master-class equipment in the monitoring system is completed.

Substation operation and maintenance management: Accumulation of power station operation data provides a basis for improving the operation and maintenance level of switchyards and realizing condition maintenance.

System diagnostics: can be online or offline self-test computer software and hardware failures, and issued an alarm.

Software development: The system's application software can be edited, debugged and modified online or offline.

Training Simulation: Provide training for operating operators on operation or software development.

Multimedia function: The application of multimedia voice alarm system, telephone voice alarm connected to the value of personnel telephone.

2.3.2、Relay protection and automation device

The photovoltaic power station adopts a microcomputer type relay protection device, and the configuration of various protection devices shall meet the requirements of Bangladesh Power Grid Corporation.

(1) 33kV outgoing line protection

A set of differential protection main protection is configured, and the current protection connected to the sum of the two circuit currents shall be used as the backup protection for the simultaneous operation of the two lines and the primary and backup protection after the disconnection of one line.

(3) 33kV bus protection

Configure 1 set of special bus differential protection.

(4) 33kV line protection monitoring device

Each 33kV line is equipped with a set of integrated protection and monitoring devices, and is equipped with current quick-break protection, over-current protection, and zero-sequence current protection.

(5) 33kV station transformer (grounding transformer) protection

Microcomputer type three phase interphase current protection, zero sequence current protection and body protection shall be configured to protect the circuit breaker of each side of the transformer.

(6) Fault Recorder

The switch station is temporarily equipped with a set of fault recorder equipment. The fault recorder shall have networking functions, complete analysis and communication management functions, remote transmission functions, analysis software, and complete master station functions. The recorded waveform information may be sent to the power system dispatch department. The current and voltage collected by the fault recording device are taken from the secondary winding of the protection stage of the transformer.

2.3.3、Telecontrol system

(1) The configuration of dispatching automation shall be subject to the approval of access system.

(2) Telecontrol system

According to relevant regulations, the computer monitoring system used can collect the running status and parameters of buses, lines, circuit breakers, etc. The remote measurement acquisition adopts AC sampling, the sampling accuracy is less than 0.2%, and it has four remote functions and scheduling. Data network access functions, etc. The telemetric information is sent to the grid dispatcher simultaneously through the scheduling data network and the point-to-point channel.

(3) Telecontrol information

Telemetry:

The 33kV transmission line active power, reactive power, active power and current, voltage, frequency.

Telesignalling:

All circuit breaker position signals.

33kV line main protection signal.

All the fault information signals.

(4) Billing system

The charging point of the electrical energy gate of this project is based on the approval of the access system, and the charging point of the electric energy gate is set at the 33kV line side of the switch station. The metering device is set up according to Class I, and the 0.2S class main and auxiliary devices are installed. At the same time, the metering point was set on the high-voltage side of the 33 kV external power grid station. In the 33kV outlet line, reactive power outlet line and station outlet line, metering devices shall be installed according to Class II, and a 0.2S class meter shall be installed as a measurement assessment point. According to the requirements of the technical regulations of the electric energy metering device configuration technology, special grade 0.2, current 0.2S class transformers or special secondary windings shall be provided for Type I and Type II metering devices.

A set of remote terminals for electric energy is set to complete the functions of information collection, data processing, time-sharing storage, long-term storage, and remote transmission for each electric energy charge point and electric energy checkpoint. The device communicates with the station's power meter via the RS485 serial port and collects the power information of the entire station. The device uses the power data network as the main channel to communicate with the master stations of the dispatching center's electric energy metering systems at all levels. At the same time, the public/dedicated telephone automatic dialing mode is considered as the standby channel. The device communicates with the switch station computer monitoring system via RS485 interface or network. When the remote terminal of the electric energy communicates with the provincial electricity and electricity billing system for real-time computer data communication, it needs to support the IEC60870-5-102 communication protocol.

(5) Scheduling data network access equipment

A set of dedicated access devices for scheduling data networks, including switches and routers, shall be configured and implemented in accordance with the overall technical system of the Bangladesh Grid Company's dispatch data network.

(6) Secondary equipment safety protection equipment

According to the basic principles of "security partition, network-specific, horizontal isolation, vertical authentication", configure a set of secondary security protection equipment.

2.3.4、Operating power system

In order to provide reliable power supply for control, relay protection, signals, integrated automation devices, and accident lighting devices, the 33kV switchyard is set up to operate the power system, including the DC and AC uninterruptible power supply (UPS) systems.

(1) DC system

The DC power supply voltage is 220V. The battery pack is made of maintenance-free valve-regulated lead-acid batteries. The battery pack screen is placed in the secondary room. According to the preliminary statistics on the DC load, a set of 200Ah batteries can be used to meet the discharge capacity of the switch station and the maximum impact load capacity at the end of the accident.

The wiring of the direct current system adopts single bus line connection and floating charge operation mode. Charging and floating charge using high-frequency switching charging device.

(2) UPS system

The 33kV switchyard microcomputer monitoring system is equipped with a set of UPS power supply with a capacity of 5kVA to provide continuous uninterrupted AC power supply for the load.

2.3.5、CCTV and Anti-theft Alarm System

A set of CCTV system and anti-theft alarm system is established in the switch station. The system is mainly used for remote monitoring of the gates, secondary equipment rooms, power distribution rooms and other equipment of substations. The on-site conditions are regularly patrolled, security is safeguarded, and video surveillance scenes can be recorded to facilitate accident analysis.

CCTV system consists of control station, camera, video cable, control cable and other components. Control station consists of digital video surveillance host, monitor, keyboard and other equipment. The cameras are placed in the main control room, 33kV power distribution unit, and the main wall entrance. Each camera and the control station are connected by a coaxial cable and a control cable. The digital video monitoring host has a computer communication port that can receive fire signals at any point in the fire alarm control system within the switch station to achieve video linkage of image monitoring, system monitoring screens and fire signals, and improve the monitoring level of the switch station.

In order to monitor the environmental parameters and images of switchyards, in order to be able to understand and master the conditions of the switchgear in real time, and respond to the conditions in time, the video surveillance system adopts FE(4M) as a way of comprehensive data. The network uploads data to the dispatch center.

2.3.6、Fire Alarm System

Substation fire alarm and fire control system adopts regional alarm working method. In the prefabricated cabin, a wall-mounted fire alarm controller (linkage type) is installed to monitor the fire signals of the fire detectors. The automatic linkage control of relevant parts such as fans, fire vents and fire dampers can be implemented according to the requirements of fire protection. The fire alarm controller has a running status indication and manual operation buttons of the controlled device. Fire monitoring objects are important equipment, main control rooms and other places. According to the environment and different fire combustion mechanisms, different kinds of smart detectors such as smoke and temperature are selected. The detectors are mainly installed in places such as the main control room, and manual alarm buttons and audible and visual alarms are installed in each fire partition. When the detector or manual alarm button is activated, the fire alarm controller emits an audible and visual alarm and displays the address of the alarm point, the print alarm time, and the alarm point address. At the same time, according to the pre-programmed logic, control instructions are issued to automatically stop the relevant parts of the fan, close the fire vents and fire dampers, and activate the audible and visual alarms. The on-duty personnel may also perform remote manual operations on the fire alarm controller.

The fire alarm controller comes with a backup power supply. The normal operating power supply AC 220V is powered by the UPS uninterruptible power supply. When the AC power disappears, it automatically switches to the DC backup power supply to ensure the normal operation of the system. The cable adopts flame-retardant shielded control cable and flame-retardant shielded double-color twisted-pair wire. The cable is laid on the cable bridge or in the cable trench. The wire is protected by a metal pipe or laid in a slot.

The regional fire alarm controller sends fire signals at any point in the fire alarm control system to the switchyard image monitoring system to realize video linkage between the image monitoring screen and the fire alarm signal, and to increase the monitoring level of the switch station.

2.3.7、Solar power prediction system

The photovoltaic power station is equipped with a photovoltaic power forecasting system, capable of forecasting the output power of the power station in ultra-short term (0 to 4 hours), short-term (0 to 24 hours), and long-term (0 to 72 hours) at a time interval of 15 minutes, facilitating power dispatching. The department adjusts the scheduling plan in time, and the system can access the computer monitoring system of the power station and the dispatching system of the power grid company, and transmits the forecast information to the upper-level dispatcher.

2.3.8、Power Quality Online Monitoring

According to the relevant requirements of the grid company's photovoltaic power grid access technology and the load characteristics of photovoltaic power plants, effective power quality control measures should be taken to limit the harmonics and negative sequences injected into the grid within the allowable range.

This project is equipped with a set of on-line monitoring devices for power quality, which can monitor the voltage deviation, frequency deviation, three-phase unbalance, negative sequence current harmonics, flicker, voltage fluctuation, voltage sags, temporary lift, short time interruption, which may be caused by the photovoltaic power station

2.3.9、Active power control and voltage regulation system

Photovoltaic power plants should have active power regulation capability and be able to control their active power output according to part of the grid dispatch instructions. The photovoltaic power station shall realize the function of active power control, be able to receive and automatically execute the dispatch of active output control signals dispatched according to the grid frequency value, and the photovoltaic power station inverter power adjustment unit shall adjust its active power output through software calculation to ensure that the photovoltaic power station The maximum output power and rate of power change do not exceed the given value of the schedule to ensure stability of the power system during grid faults and special modes of operation.

The photovoltaic power station is equipped with a set of reactive voltage regulation system, with reactive power and voltage control capabilities. According to the instructions of the dispatching department of the power system, the photovoltaic power station automatically adjusts the reactive power it emits (or absorbs) to achieve the control of the voltage at the grid point.

2.3.10、Environmental Monitoring System

The system is equipped with a set of environmental monitoring devices to monitor the environmental conditions at the site. The device consists of a wind speed sensor, a wind direction sensor, a solar radiation meter, a temperature probe, a control box and a support, and can measure parameters such as ambient temperature, wind speed, wind direction and radiation intensity. The RS485 communication interface can be connected to the monitoring of the grid monitoring device. The system records environmental data in real time.

2.3.11、Anti-Islanding

Photovoltaic power plants must have the ability to rapidly monitor islands and immediately disconnect from the grid, and their anti-islanding protection should be compatible with grid-side line protection. The anti-islanding protection of photovoltaic power plants must have both active and passive types, and at least one type of active and passive island protection should be provided.

2.3.12、Low voltage ride through

Photovoltaic power plants should have a certain low voltage withstand capability. When an electric power system accident or disturbance causes the voltage drop at the photovoltaic power station's network connection point, the photovoltaic power station can ensure continuous operation without disconnection within a certain voltage drop range and time interval. Specific requirements are as follows;

(1) When the grid-connected voltage of the PV power station drops to 0, the PV power station shall not run off the grid for 0.15 s continuously;

(2) When the PV voltage of the PV power station falls below curve 1, PV power stations can be removed from the grid.

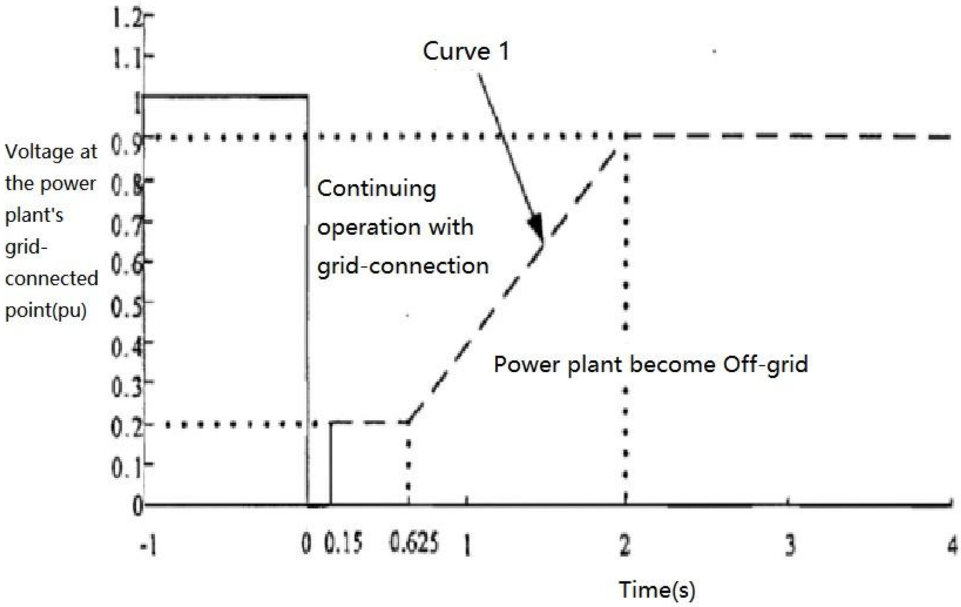

Figure 1-2 Low voltage ride through

2.3.13、Electrical secondary equipment layout

Photovoltaic power station secondary equipment and high voltage switchgear are arranged in the same prefabricated cabin.

2.4、Communications

The photovoltaic system communication system of this photovoltaic project mainly includes system communication, field communication and communication power.

2.4.1、System Communication

The system communication provides a communication channel for the superior departments to provide communication channels for the production scheduling and modern management of photovoltaic power stations, and provides information transmission channels for relay protection, telecontrol and computer monitoring and control systems. The switch station 33kV delivery line is equipped with 2 16 core OPGW optical cables, and recommends 1 sets of 155M SDH light transmission equipment, 2 STM-1 light interface boards, 1 sets of PCM access network equipment, and the final system communication scheme is based on the opinion of the Power Grid Corp approval access system.

2.4.2、Field communication

The field communication is to provide service for the operation, dispatch and operation of the photovoltaic power station, the operation and management of the administrative office system and the communication and communication between the various functional departments of the administrative office system, and it is divided into the field production and dispatching communication and the administrative communication.

Photovoltaic power station from the inverter room to the 33kV switch station along the 33kV collection line laying 12 core directly buried optical cable, the two sides set up photovoltaic special optical communication and monitoring device.

A direct dial call is set up in the switchboard. Set up a local telephone for external liaison, and at the same time as a standby means for dispatching and communication of PV power stations, no SPC exchanges will be set up.

The communication mode of overhaul and patrol in power station mainly adopts the communication mode of high-power wireless walkie talkie, and supplemented by public network mobile phone communication mode.

2.4.3、Communication Power Supply

The power supply of communication equipment is integrated with the DC power supply used in the station operation. The DC power supply used in the station operates through a DC220V/DC48V inverter and provides 48VDC for the communication power supply. The AC power supply is powered by the AC uninterruptible power supply UPS.

3. 1、Civil engineering part evaluation

3. 1、Photovoltaic area

3. 1.1、General layout

1) All equipment in the site shall be arranged within the red line of the plan approved by this project.

2) There are altogether 1 plots in the PV area, and the roads are connected to each other

according to the surrounding environment and original roads to facilitate maintenance.

3) The spacing between electrical equipment and structures shall comply with the relevant requirements of GB 50229-2006 "Code for the design of fire protection for thermal power plants and substations".

3. 1.2、Site Levelling

1) According to the process requirements and combined with natural terrain, the main building and construction foundation treatment, comprehensive balance of earth and rock work volume, internal water level, site drainage, and road and pipeline interface coordinates higher standards.

2) Photovoltaic station area is located on the impact sandbar north of Dharala River, and the ground elevation is 60.0m~61.0m above sea level. Since the station area is located on the river bank, it is necessary to consider the effect of a 50-year flood level. The station site should be combined with the topography, a drainage ditch should be built, and the rainwater should be led to the ditch to be imported into the Dharala River. In this project, solar photovoltaic panels are arranged along the topography, and the lowest margin of the bottom of the PV modules is not less than 2.0m, which ultimately meets the government acceptance requirements.

3. 1.3、Pipeline layout

The layout of the trench should proceed from the whole, plan in an integrated manner, coordinate with each other in the plane and vertical direction, combine the distance far and near, and have reasonable spacing to reduce crossover. At the same time, consideration should be given to convenient maintenance and expansion.

In the PV area, the power cables from the battery board combiner box to the inverter to the grounding transformer, prefabricated module and box type transformer are mainly installed. When the buried cable needs to be buried and passes through roads and other areas that may be mechanically damaged, protective measures such as wearing galvanized steel pipes or cable channels shall be adopted. After the excavation is completed, the bottom of the tank shall be cleaned and compacted, and the cables shall be installed up and down. Side each shop 100mm fine sand, and do the cement board protection on the upper side of the cable. Directly buried cable selection should fully consider the corrosion of local geological soil to the cable, and do anti-corrosion treatment.

3. 1.4、Road way

1）The gravel roads are used in the PV area and in the section connecting roads. The width of the road surface is 4.5m and the turning radius is not less than 6m. The prefabricated cabin, outdoor grounding transformer and box type transformer are connected, and the total length is about 247m.

2）As far as possible outside the control point at the road surface elevation, it is arranged along the natural slope of the site. The longitudinal slope of all roads combined with the terrain design, the lateral slope is 1.5%~2%.

3) The technical indicators of the road are implemented according to the national fourth-grade highway standards.

3. 1.5、Site treatment

The necessary site leveling is performed according to the process requirements and in combination with natural terrain. The photovoltaic area site does not need to do a large-scale formation. It is only necessary to make a small-scale formation of the surface with a large partial slope, and the overall terrain and land type will not be destroyed, and the flatness and height requirements of the foundation installation and the support installation can be satisfied.

3. 1.6、Slope protection and retaining wall

Set necessary slope protection and retaining walls according to the actual situation on site.

3. 2、Walls and gates

The entire area of the red line of the photovoltaic zone is completely enclosed with wire fence, and the fence height is not less than 1.8 meters. The fence length is set to be 1393m according to the red line and the layout of the components

3. 2.1、Assembly and Brackets

Component brackets/Assebmlies are designed in accordance with the current specifications such as GB 50797-2012 "Specifications for Photovoltaic Power Plant Design", GB 50009-2012 "Load Code for Building Structures", and GB 50017-2003 "Design Code for

Steel Structures". For load and accidental loads, the design service life of the assembly bracket is 25 years, and the safety level is 3. The wind loads, snow loads, etc. are taken as the value of the load in the case of the 50-year load in the “Load Code for Building Structures”.

The total installed capacity of this project is 5MW, and the assembly supports are all fixed steel brackets. The minimum height of the assembly from the ground is about 2.0m (the specific principle is not lower than the requirements of the contractor's equipment specification). The bracket assembly 2 × 9 horizontal layout, using a fixed installation, tilt angle of 37 degrees. The arrangement of the brackets follows the trend of the slope and is consistent with the overall gradient. The detailed dimensions of the brackets need to be adjusted according to the topography.

3. 2.1、Assembly Bracket Basics

The component support base is designed based on the detailed survey report of engineering geological survey and GB51101-2016 "Technical Specifications for Braced Foundation of Solar Power Station" and other current specifications, and reasonably selects the basic type of support and performs basic calculation.

The foundations of the component brackets of this project are all prefabricated pipe pile foundations, and the design of the foundations should fully consider load, wind load, settlement, corrosion and other measures according to the 25-year service life. According to the preliminary calculation results, the pile diameter is 300mm, the length of the pile foundation is taken according to the bracket type, and the length of the pile foundation is 4.0m (tentative). The assembly support column is connected with the hoop and the pipe pile, and the detail of the photovoltaic support is shown in Figure 4. Above the foundation of the support, load tests are required before construction, and the depth of pile foundation will be determined based on the test results.

3. 2.2、AC combiner box installation

The AC combiner box and inverter are mounted on the PV module bracket.

3. 2.3、Prefabricated cabin, Box type transformer, Grounding transformer

The prefabricated cabins and the box bases are all made of reinforced concrete lab foundations. The reinforced concrete sidewalls are built on the floor to facilitate the installation and overhaul of the equipment. Full consideration is given to the cold-start in winter, heat dissipation in the summer, wind protection, waterproof and anti-humidity, Corrosion and so on. The box-change foundation should be designed with a maintenance platform, and the basic top elevation should not exceed 0.9m in principle..

If there is a weak stratum in the area of the photovoltaic field, foundations of the box foundation and the foundation of the inverter must be treated with foundations. The detailed design needs to be based on the detailed survey report of the engineering geological survey.

3. 2.4、Rainwater discharge in photovoltaic area

Photovoltaic areas are partially drained in accordance with the topography of the site.

3. 2.5、Photovoltaic fire protection design

Each box is equipped with two 5kg portable dry powder fire extinguishers, and two 5kg portable dry powder fire extinguishers are installed on the grounding transformer.

4、Transmission Line Part

4. 1、Project construction scale and design scope

From the 33kV outgoing frame of Patgram substation, the wire adopts the LGJ-120/20 type steel core aluminum strand, the whole line considers the erection of double ground wire, the ground wire adopts the GJ-30 steel strand, and the new route of the new overhead line is 1.71km

3. 2、Transmission Line route

4. 2.1、 Path planning principles

(1) In accordance with the system planning and arrangement, consider the unified planning of the line corridor in the scope of the substation in and out of the line;

(2) Avoid the farms, towns and planning areas to meet the planning requirements;

(3) Keep as close as possible to existing roads and make full use of all rural roads to facilitate construction operations;

(4) Try to shorten the route and reduce the construction cost; try to adopt double-arrangement on the same tower to reduce the channel occupancy and reduce the

impact on the environment;

(5) Avoid Class I communication lines, radio facilities and radio stations as much as possible;

(6) Avoid the mining area, factory area and military facilities as much as possible;

(7) Avoid forest areas, protect natural ecological environment, and reduce the cost of forest logging. (8) Try to avoid large houses.

In addition to the above, full consideration should be given to the influence of factors such as topography and geological conditions on the safety, reliability, and economics of the transmission lines. After comprehensive analysis and comparison, the best path plan is selected.

4. 2.2、 Transmission Line Route Solution

According to the actual situation of the region and the above-mentioned route planning principles and data collection, combined with on-site survey situation, the route scheme is unique, and the route scheme is as follows:

The line exits from the 33kV outlet structure of the Patgram substation. The total length of the route is about 1.71 kilometers, and the zigzag coefficient is 1.03. The route is located at an altitude of 300 meters. The terrain along the line is a flat area.

(1) Topographic division: 100% flat land.

(2) Geological division: 20% for ordinary soil, 50% for loose sand, and 30% for rock.

(3) Transportation: Main roads and rural roads along the route can use rural roads and tractor farms.

(4) Car and manpower distance situation: The average car transport distance across the line is 5 kilometers and the average manpower distance is 0.6 kilometers.

4. 2.3、 Crossway planning

A 33kV substation will be newly built in this project, and there will be no intersection between the 33kV and 11kV incoming and outgoing lines.

4. 2.4、 Natural conditions along the line

The line is located in Patgram, Bangladesh. The alignment of the route is from south to north. The elevation is 300 meters, the relative elevation is 0-100 meters, the terrain gradient is 0-15 degrees, and the basic earthquake intensity is VI degree. Along the line, the overall trend of the terrain is gentle, the terrain conditions are good, and the hills and flat lands are the main factors. The line did not cross the large forest area.

Most of the land along the line is cultivated land, most of which are fields of water and dry land, and there are many sporadic trees around the cultivated land; the trees on the slopes of the mountainous terrain are denser, the trees are mainly miscellaneous trees, and the top of the slope is cultivated land, because the tower is generally at the top of the slope. Therefore, most of the trees in the mountain terrain segment can take appropriate measures to increase the tower to minimize cutting.

The area along this line is densely populated, with high density of houses and irregular distribution. There are many bamboo forests and economic forests behind the house. In the next stage of the design process of this project, the route will be further optimized to minimize Sprawl across houses and trees to reduce project costs.

All terrain classification: 100% flat land.

4. 2.5、 Geological conditions along the line

Along the line, the geological structure is simple, the stratum is smooth, the rock dip angle is small, no deep and large fault zones pass through the path area, and the regional stability is good. There are no geological structures that affect the establishment of the line path. The basic earthquake intensity in the area is VI degrees.

Along the line, the geological lithology is purple red sand, mudstone and residual product, residual slope accumulation clay and other strata, all of which can be used as the natural foundation of the tower. In the inter-mountain depressions, individual towers are located in soft soil, and special consideration can be given to flat-plate foundations or refilling methods. The design of the next stage is based on the actual situation as a flat-plate foundation. There is no adverse geological phenomenon across the tower.

Groundwater along the line mainly consists of bedrock fissure water and loosely packed pore water. The bedrock fissure water groundwater has a deeper burial depth, which has no influence on the foundation and its excavation. The loosely-packed pore water has a shallow depth and a relatively abundant amount of water, and the foundation pit support and drainage measures should be strengthened when the foundation of the line is excavated. The type of groundwater is dominated by heavy calcium carbonate, with low salinity and no corrosion to concrete.

Geological division: 20% for ordinary soil, 50% for loose sand, and 30% for rock.

4. 2.6、 Important facilities along the route

(1) The radio facilities in the vicinity of the route include a television transmission station and a mobile communication base station, all of which are outside the scope of the line. The impact on the communication lines along the line satisfies the regulatory requirements.

(2) The line crosses and spans, and the distance across the clear space shall meet the design regulations.

(3) Basically, farmland, dry land and hillsides along the line. Most of the towers are on the slopes. During the deforestation of the passageways, the cypresses, bamboo forests, and other miscellaneous trees that grow in the hilly terrain are relatively high. For the trees on the slopes of the mountains, the towers are located. The top of the slope, so most can cross without cutting (to meet the clearance distance requirements).

(4) The houses along the line are dense and there are more demolition.

(5) There are no other flammable or explosive facilities such as explosive storages, oil depots, firecrackers, etc. within the scope of the line.

4. 3、 Project tentative Plan

4. 3.1、 Weather Conditions

The Patgram area in Bangladesh is a subtropical monsoon climate with hot and humid conditions. The year is divided into winter (November to February), summer (March to June) and rainy season (July to October). The annual average temperature is 26.5°C. Winter is the most pleasant season of the year, with a minimum temperature of 4°C, a summer maximum temperature of 45°C and an average rainy season temperature of 30°C. 85% of the country’s land area is in plains, and hilly areas are in the southeast and northeast. The highest peak is the Keokula East Peak, which is 1,229 meters high.

According to the site data, reference is made to the classification of typical meteorological regions in the country, combined with the line route, elevation, topography, and topography, and a comprehensive analysis is performed to determine the temperature of the project using the following design data:

Table 3-1 Weather Conditions

Highest temperature (°C)	40

The lowest temperature (°C)	5
Annual average temperature (°C)	27
Average annual thunderstorm day (days)	100

(3) Maximum design wind speed

The maximum design wind speed of the transmission line in the mountainous area, if there is no reliable data, should be increased by 10% according to the statistics of the nearby plain areas. The maximum design wind speed of 66kV and below overhead power lines shall not be less than 23.5m/s, and reference shall be made to the design parameters of nearby voltage class lines to ensure that the maximum design wind speed for this project is 30m/s.

(4) Design ice coating values

The area covered by the route is a subtropical humid climate zone with a mild climate. The annual average temperature is around 27°C, the extreme minimum temperature is 5°C, and elevation is 300 meters. According to the currently-designed meteorological data and operational experience of the circuit in the area, there are no ice hazards or ice-coverage on the lead and ground lines. Therefore, the line and ground lines of the line are considered to be a combination of meteorological conditions for 0 mm ice-covered design.

Table 3-2 Combination of Weather Conditions

condition / project	temperature (℃)	Wind speed (m/s)	Ice thickness (mm)
Highest temperature	40	0	0
Lowest temperature	-5	0	0
The annual average temperature	27	0	0
Maximum ice coverage	-5	10	0
Maximum wind speed	10	30	0
External overvoltage	15	10	0
Internal overvoltage	15	15	0
Installation situation	0	10	0
Thunder Day in the whole year	100		
Specific gravity of ice (g/cm^3)	$0.9g/cm^3$		

4. 3.2、 Conductor selection

(1), Conductor model selection

According to the system transmission capacity and checking; the conductor is made of steel-cored aluminum stranded wire JL/G1A-120/20 to meet the requirements.

(2), Ground conductor model selection

The ground wire is selected as OPGW-9-40-1, and the other one is GJ-30.

(3) Line conductor and ground conductor design and protection

The safety coefficient of the guide and ground line design and the safety factor of the use condition are not less than 2.5, and the average operating stress is not more than 25% of the failure stress of the wire. The safety factor of the suspension point is not less than 2.25, and the safety factor of the suspension point is not less than 2.25.

The vibration that endangering the normal operation of wires is mainly because of the wind

Anti-vibration measures widely used for high-voltage transmission lines are using vibration dampers, damping wires and pre twisted wires to prevent vibration. The vibration control hammer has great damping effect on low frequency vibration due to the larger weight of the unit, which is the main anti vibration measure of the overhead line, but its unit load is generally far larger than the wire. It is easy to cause damage to its own and wire when the wire is jumping or dancing, and the damping line can make use of the damping property of its material. The vibration energy is consumed, so the effect of restraining the high frequency vibration is better. The pre straining wire can enhance the rigidity of the conductor and reduce the bending stress of the wire outlet of the clamp.

The annual average operating stress of the project and ground lines is relatively high. Combined with the actual conditions of this project and the design experience of other projects, the design recommends that the project use pre-twisted wire protection lines and anti-vibration dampers/

(3) Line and ground conductor swing prevention measures

There is no need for the swing protection for this project.

4. 3.3、 Insulation coordination

(1) Climate conditions along the line

The area covered by this project is Patgram in Bangladesh. The weather is hot and the rainfall is abundant, but the rainfall is mainly concentrated in the rainy season. There is less rainfall in winter, but the air is moist and foggy. Each time the fog lasts for a long time and the water content is relatively large, these are the condition which cause pollution flashover (arc).

(2) Pollution sources along the line

According to field investigations, most of the line is located in hills and mountains. There are many trees and bamboos, and the vegetation is good. There are no concentrated sources of pollution around, and there are only some small pollution sources such as small brick factories. However, they are still subject to comprehensive pollution of the surrounding climatic conditions in cities. And the adverse effects of highway dust, farmland fertilization, and pesticides.

(3) Division of the Polluted area

The line of this project is a class d soil area. Considering the importance of the line and the industrial development factors of the city, the design recommends that the entire line should be insulated according to the upper limit of the class d soiling zone.

(4) The altitudes of the sections of this project that pass by are all below 1000m. No special considerations need to be taken to increase the air gap. The values of air gaps taken from this project are as follows:

Table 3-3 Air gap values

Operating conditions	Lightning overvoltage	Internal overvoltage	Operating voltage
Air gap (m)	0.45	0.25	0.10

Note: For work on hotlines should also consider the range of human activity 30~50cm.

(5) Insulator selection

At present, there are three major types of insulators: porcelain, glass, and synthetic. 33kV lines mainly use porcelain and glass insulators, and composite insulators are used in some areas.

Porcelain insulators have long lifetime.

Glass insulators have the advantages of zero self-explosion, reduced maintenance inspection workload, strong anti-fouling ability, high pollution flash voltage, and stable electromechanical performance. At present, major insulator manufacturers can produce high quality glass insulators.

The composite insulator has the characteristics of excellent anti-fouling performance, zero measurement, light weight, and easy installation, but the lightning resistance level is relatively poor.

The transmission lines of this project are mostly located in the outskirts of cities and towns, and the conditions for operation and maintenance are good, so as to facilitate operation and maintenance. This project uses porcelain insulators.

Table 3-4 Electromechanical Characteristics of Porcelain Insulators

insulator model	Main dimensions				Mechanical and electrical properties		Mechanical failure load (kN)
	Height (mm)	Disk diameter (mm)	Creepage distance (mm) ≥	Connection tag	Power frequency impact tolerance Voltage (kV)	Power frequency shock tolerance Voltage (kV)	
U70BP/146-1	146	280	450	16	45	120	70
U70BP/146D	146	280	450	16	45	120	70

(6) Insulation coordination

Table 3-5 Electromechanical Characteristics of Porcelain Insulators

String type	Insulator model	mechanical strength (kN)	Monolithic leakage distance (mm)	Insulator height (mm)	Insulator number and leakage ratio (mm/kV)
					Graded soiled area
Suspension string	U70BP/146-1	70	450	146	5 (88.7)
Suspension string	U70BP/146D	70	450	146	5 (88.7)
Strain string	U70BP/146-1	70	450	146	5 (88.7)
Strain string	U70BP/146D	70	450	146	5 (88.7)
Jumper string	U70BP/146-1	70	450	146	5 (88.7)
Jumper string	U70BP/146D	70	450	146	5 (88.7)

4. 3.4、 Lightning protection and grounding

The average annual lightning time for this line is 100 days and it is an area with more lightning activities. According to the operation of the surrounding 33kV, the probability of a 33kV line being struck by lightning is also very high. To ensure the reliability of the line, double line lightning protection lines are installed across the line to prevent Thunder protection. One OPGW-9-40-1, the other with GJ-30. The tower is grounded at four points, and the cement rod is grounded by means of external lead grounding, which is connected by a lightning conductor and a grounding net.

The protection angle of the ground-to-side conductor is no more than 20 (the distance between the two grounds of the tower shall not exceed 5 times the vertical distance between the ground and the conductor; at a temperature of 15°C, under the condition of no wind, the central conductor of the span The spacing of the ground satisfies the requirement of S ≥ 0.012L + 1m.

The number of insulators for conductors can be chosen to meet overvoltage requirements.

The grounding body is used (10 round steel, bent wire used (12 round steel, all required hot-dip galvanizing. According to Sichuan Electric Technology (2005) 147 documents, with the design rules GB50061-2010 and over-voltage regulations DL/T620- In accordance with the provisions of 1997, in order to improve the performance of lightning protection, the frequency-to-ground resistance of grounding resistance during the lightning season must not exceed the following values:

Table 3-6 Power frequency grounding resistance limits

Soil resistivity (Europe m)	≤100	100~500	500~1000	1000~2000	>2000
Power frequency grounding resistance (Europe)	10	15	20	25	30

4. 3.5、 Conductor transposition and commutation

The longest route for this project is 1.71km, and the conductor does not need to be replaced or commutated.

4. 4、 Communication protection

Lines have no effect on telecommunication lines, radio stations and other communications facilities.

4. 5、 Other facilities

There are no other special facilities on this line.

4. 6、 Tower planning

Combining regional hydrological, meteorological and topographic features, and practical conditions of towers, based on the principle of economy and reasonableness, the single-circuit tower of 35B17 module in the “General Design of Power Transmission and Transformation Engineering of the State Grid Corporation of China” is selected for this project. The standard module tower type is a relatively mature tower type. Selecting a standard module tower type can improve the safety of the line operation and make the circuit design more economical and reasonable.

Table 3-7 List of Use of Towers and Towers

Tower type	Horizontal span (m)	Vertical span (m)	Turn angle (°)	Ruling span (m)	The minimum KV value	Nominal Height (m)	Calculated height (m)
35B17-Z1	300	450	0	600	0.8	12~30	27
35B17-Z2	450	700	0	600	0.75	12~30	27
35B17-Z3	600	900	0	600	0.7	12~36	33
35B17-J1	300	450	0°~20°	450	/	9~24	24
35B17-J2	300	450	20°~40°	450	/	9~24	24
35B17-J3	300	450	40°~60°	450	/	9~24	24
35B17-J4	300	450	60°~90° and 0°~90° terminal	450	/	9~24	24

The above towers are all self-supporting angle steel towers connected by anchor bolts. The conditions of use of each tower type and the call for high energy meet the needs of this project.

4. 6.1、 Tower Material and Others

(1) Need to comply with relevant local documents and policy requirements

(2), iron tower anti-corrosion

All components and bolts of the tower are hot-dip galvanized.

(3), tower bolt anti-theft and anti-loose

The bolts under the lower leg of the tower 8 meters (for the short leg tower according to the shortest leg) are bolts (including the diaphragm), and all the bolts on the 8m are used in the case of a joint plate or joint. In addition to other parts, bolts are installed on loose bolts (except for bolts with double caps). When the double cap is used, the screws need to be buckled or buckled.

(4) the grounding of the tower

All the four legs of the tower are reserved for 1 diameter 17.5 grounding holes, and the earth support is reserved for the earth wire grounding holes.

(5), other

All poles and towers require installation of pole numbers (including line names) and warning boards. Terminal towers require installation of phase sequence cards. The specific requirements are subject to the requirements of the owners' units or operation units

4. 6.2、 Basic selection

According to the terrain, geological features and selected tower type of this project, the recommended basic types are as follows:

(1) Plate foundation

The foundation is a shallow foundation, and the series of foundation slabs and columns are equipped with steel reinforcement. The large slab foundation is used for shallow burial, the large slab is subjected to lower pressure, the foundation stress is small, and the large slab increases the upward soil to withstand the pull-out force. It is mainly used in seasonal frozen ground areas and towers with relatively high groundwater level near the river bed. Due to the shallow depth of the foundation type, there is no difficulty in the construction of large dredging puddles. The construction is simple and can meet the needs of this project.

(2) Bored pile foundation

This type of foundation refers to the use of special machines for drilling (drilling) into deeper holes, head pressure or head pressure and mud retaining walls, placing reinforcing steel skeletons and pile foundations for underwater pouring of concrete, which is a deep type of foundation. The type is suitable for foundations with high groundwater level, such as cohesive soil and sandy soil, especially for crossing rivers.

All of the above foundations are in site casting.

4. 6.3、 Basic materials

Basic Concrete: C25

Foundation cushion and protective cap concrete: C15

Basic reinforcement: Ordinary steel bar HRB400 (II) grade, HPB300 (I) grade;

Anchor bolt: No. 35 quality carbon steel.

The basic steel is HPB300 and HRB400 steel.

The steel used for the anchor bolts is No.35 high-quality carbon steel. .

Portland cement or ordinary portland cement is used for cement. The type and grade of cement shall meet the strength rating of the concrete or cement mortar specified in the design.

Sand, stone and other materials must meet the requirements of construction and acceptance procedures and be inspected by local quality inspection stations. Stones require good gradation, between 20mm and 40mm in diameter. The content of mud and other harmful impurities in sand and stone should meet relevant regulations.

4. 7、 Universal design and "Two types of three new" applications

The selection of poles and towers, insulator strings, conductors, and ground wires in this project all use the common design of the State Grid.

4. 8、 Natural Disaster Resiliency measures

Engineering construction will inevitably change and influence the environment. Careful design and standardized construction can minimize the change and influence of geological environment. Protecting the natural environment within the base of the tower is not only an important measure to ensure the safe operation of the line, but also our duty to care for nature and protect nature. Therefore, it is particularly important to design the tower foundation according to local conditions and protect the natural environment of the tower area.

(1) Avoid the foundation surface of large excavation foundation, protect natural topography and landform.

In the design, the micro topography of the tower should be fully considered. The height difference between the foot and the terrain of the tower should be adjusted with the length of the leg and the high and low foundation of the tower, so as to reduce the open square of the base surface and protect the stability of the slope. After the completion of construction, the restoration of natural terrain and vegetation will be done.

(2) Excavation of foundation pit

All excavations can be excavated by replacing the bottom template with pit wall instead of excavation. The excavation volume can be reduced as much as possible. For the tower located in steep rock and poor geological conditions, blasting is not allowed. Artificial excavation is needed.

(3) Surface protection of rock mass

For strong weathering, bare rock and broken surface, it is easy to be pushed by rainwater scouring the tower. The M7.5 mortar surface is used to protect the topsurface debris. The scope of protection is the surface damage area of the tower surface.

(4) Dump the soil

The steep slope of the tower is strictly prohibited. It is strictly forbidden to place the abandoned soil on the ground and the excavation of the foundation in the direction of the downslope of the tower.

(5) The slope protection moves and destroys the natural landform in the downhill direction of the tower, and the safety of the critical tower foundation.

In the upper slope of the upper slope of the upper slope of the lower slope, the "dry lining and the slope protection" should not be used for the upper slope of the lower slope slurry.

For better rock slopes, slope treatment is carried out according to relevant regulations and geological conditions. For the tower legs located on the lower slope, if the slurry block stone retaining dam is needed, the method of replacing the foundation pit with rubble concrete is generally replaced. In the foundation pit excavation, the "bottom wall" is used instead of the foundation bottom formwork.

For the tower position in the steep slope terrain and the nonresidential area, the excavation of the ground ditch does not form a closed ring to avoid the excavation of the ground ditch along the vertical direction, thus forming the safety of the gully endangering the tower side slope.

(6) The drainage of the tower base

The tower base surface should be made of a flat slope to facilitate natural drainage on the slope that needs to be excavated on a small platform.

4. 9、 Energy Analysis

Both sides of the substations use iron towers to save access.

4. 10、 Environmental protection

The environmental impact of high voltage transmission lines includes electromagnetic interference and regional environmental impact. In order to ensure the construction quality of the project and ensure the least impact on the environment, the purpose of protecting the environment is achieved by fully investigating and investigating the investigation and path coordination, and controlling the impact of the line on the environment in accordance with relevant regulations. In order to minimize the adverse impact on the environment, this project intends to adopt the following measures:

(1) When the power transmission line cuts through the forest area, the width of the channel shall not be less than twice the height of the main tree species in the forest area. In order to protect the limited forest resources, in order to avoid massive tree felling and destroying the ecological balance, the forest has been avoided as far as possible when selecting the path of the project; when the line passes through dense trees, the trees are not cut or cut down, and the tower is properly raised to use the tower. The way. After considering the natural growth height of the trees, trees with a clear distance between the wire and the tree greater than 4.5m will not be cut down, and bushes with a natural growth height of no more than 2m will, in principle, not be felled.

(2) The use of a single-strand-arranged iron tower for the conductors to reduce the width of the circuit's operating channels will save space.

(3) In order to ensure the normal activities of the personnel below the line, the integrated electric field strength under the line is designed to be less than 4kV/m. In a sunny day, the 0.5-m radio interference is less than 46dB at a distance of 20m from the sideline projection, and the daytime audible noise is less than 60dB. (A) Noise at night is less than 50dB (A).

(4) Design communication protection for the relevant communication lines and radio facilities along the line.

(5) Conduct line route coordination work to avoid urban planning areas, development zones, densely populated areas, military facilities, factories and mines and other important areas, and control the impact on the environment to a minimum.

(6) Avoid nature reserves, scenic areas, etc. to protect the ecological environment.

When formulating the path plan, forest areas, bamboo forests, and private houses were avoided as far as possible, and the scenic spots along the line were avoided.

(7) Change the traditional construction organization design. Under the premise of guaranteeing the construction period, the time for relocation will be arranged after the crop is harvested to reduce the damage to the crops, and tension shall be used to reduce tree felling in the construction channel.

(8) In the construction, the blasting method shall be used to disable the pressure guide and ground wire, and noise elimination measures shall be taken when the rock foundation is excavated.

(9) Farmland rehabilitation and restoration of vegetation

The site occupied during the construction process can be resumed after the completion of construction. In forested areas and areas where the surface is dominated by grasses and shrubs, after the construction is completed, the surface vegetation shall be restored as far as possible, and grass seeds shall be sowed. In order to protect the original landforms and vegetation of the tower base site, grass seeds are sown on the slopes and abandoned lands of the construction wounds.

5、 Drawing

Figure 1: General layout of the electrical field in the photovoltaic field

Figure 2: Schematic diagram of distributed power grid connection

Figure 3: Main electrical wiring diagram of 33kV switchyard

Figure 4: Photovoltaic stent detail