SIACHEN ENERGY LIMITED

ENERGY FOR A BETTER TOMORROW

SEL/NEPRA/LPM/2020-0013

Date: 29 July, 2020

The Registrar,
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower Attaturk Avenue (East), Sector G-5/1.
Islamabad.

Subject: **Siachen Energy Limited ("Company") - License Proposed Modification of the Generation License Application**

Reference: **Generation License (SPGL/24/2017) dated October 10, 2017**

Respected Sir,

The Company was granted Generation License No. SPGL/24/2017 on October 10, 2017 (the "Generation License") by NEPRA, under Section 15 of the Regulation of Generation, Transmission and Distribution of Electric Power Act 1997, for its solar power generation facility at Deh Sukhpur/Bhalki Rayati/Morjhar Tapo Sukhpur/Karampur, Taluka Mirpur Sakro, District Thatta in the Province of Sindh (the "Project").

As mentioned in the Generation License, the Project was being designed with a capacity of 100 MWp based on 400,000 Polycrystalline PV Modules 250 Watt of model Sungrow SG2500U-MV.

The Company pursuant to Regulation 1.0(2) of the NEPRA Licensing (Application and Modification Procedure) Regulations, 1999 ("Regulations") hereby seeks to apply for a modification of the Generation License granted to the Company due to change in the design which is revised due to change in size and technology of modules and inverters. The proposed technology will be bifacial Mono-crystalline PV modules based on Passivized Emitter Rear Contact (PERC) technology which is the latest available technology for the solar power generation. According to the common design and documents provided to us by the EPC Contractor, we propose 200,016 pieces of 500Wp modules, for a total installed capacity of 100 MWp for the project.

In relation thereto, we certify that the documents in support attached with this application are prepared and submitted in conformity with the provisions of Regulation 10(2) of the Regulations and we undertake to abide by the terms and provisions of the Regulations. We further undertake and confirm that the information provided in the attached documents in support is true and correct to the best of our knowledge and belief.

A Pay Order No. 13841951 dated 28 July 2020 amounting to Rs. 246,160/- (Pakistani Rupees Two Hundred Forty Six Thousand One Hundred Sixty Only) drawn in favour of NEPRA, being the fee for the application, calculated in accordance with Schedule II to the Regulations is also attached herewith.

In light of the submission set out in this application and the information attached to the same, NEPRA is kindly requested to process the Licensee Proposed Modification of the Company's Generation License at the earliest.

Yours Sincerely,

Muhammed Sohail Shamsi
Chief Executive Officer

Siachen Energy Limited SEL

Encl:
1. P.O No. 13841951 for Rs. 246,160/- ifo NEPRA.
2. Affidavit
3. Board Resolution
4. Application for License Proposed Modification

SIACHEN ENERGY LIMITED

ENERGY FOR A BETTER TOMORROW

EXTRACTS OF THE MINUTES OF BOARD OF DIRECTORS MEETING **OF SIACHEN ENERGY LIMITED HELD** ON **JULY 25, 2020 AT THE HEAD OFFICE OF THE** COMPANY IN KARACIJI, PAKISTAN

RESOLUTION

"**RESOLVED THAT Siachen Energy Limited** ("Company"') be and is hereby authorized to file a License Proposed Modification of Generation License Application for submission to the National Electric Power Regulatory Authority for rnodification of the Company's Generation License and in relation thereto, enter into and execute all required documents, make all filings, attend all hearings, provide all required information and pay all applicable fees, in each case, of any nature whatsoever."

"**FURTHER RESOLVED THAT** in respect of the Licensee Proposed Modification of Generation License of the Company, Mr. Muhammed Sohail Shamsi being Chief Executive of the Company be and is hereby authorized and empowered for and on behalf of the Company to:

i. Review, execute, submit. and deliver the License Proposed Modification of Generation License and any related documentation required by National Electric Power Regulatory Authority for the award of Modified Generation License, including any contracts, documents, powers of attorney, affidavits, statements, letters. forms, applications. deeds, guarantees, undertakings, approvals, memorandum, amendments, letters, communications, notices, certificates, request statements and any other instruments of any nature whatsoever;

ii. Represent the Company in all negotiations, representations, presentations, hearings, conferences and/or meetings of any nature whatsoever with any entity (including, but in no manner limited to National Electric Power Regulatory Authority, any private parties, companies, partnerships, individuals, governmental and/or semi-governmental authorities and agencies, ministries, boards, departments, regulatory authorities and/or any other entity of any nature whatsoever);

iii. Sign and execute the necessary documentation, pay the necessary fees, appear before the National Electric Power Regulatory Authority as needed, and do all acts necessary for completion and processing of the award of Modified Generation License of the Company from the National Electric Power Regulatory Authority;

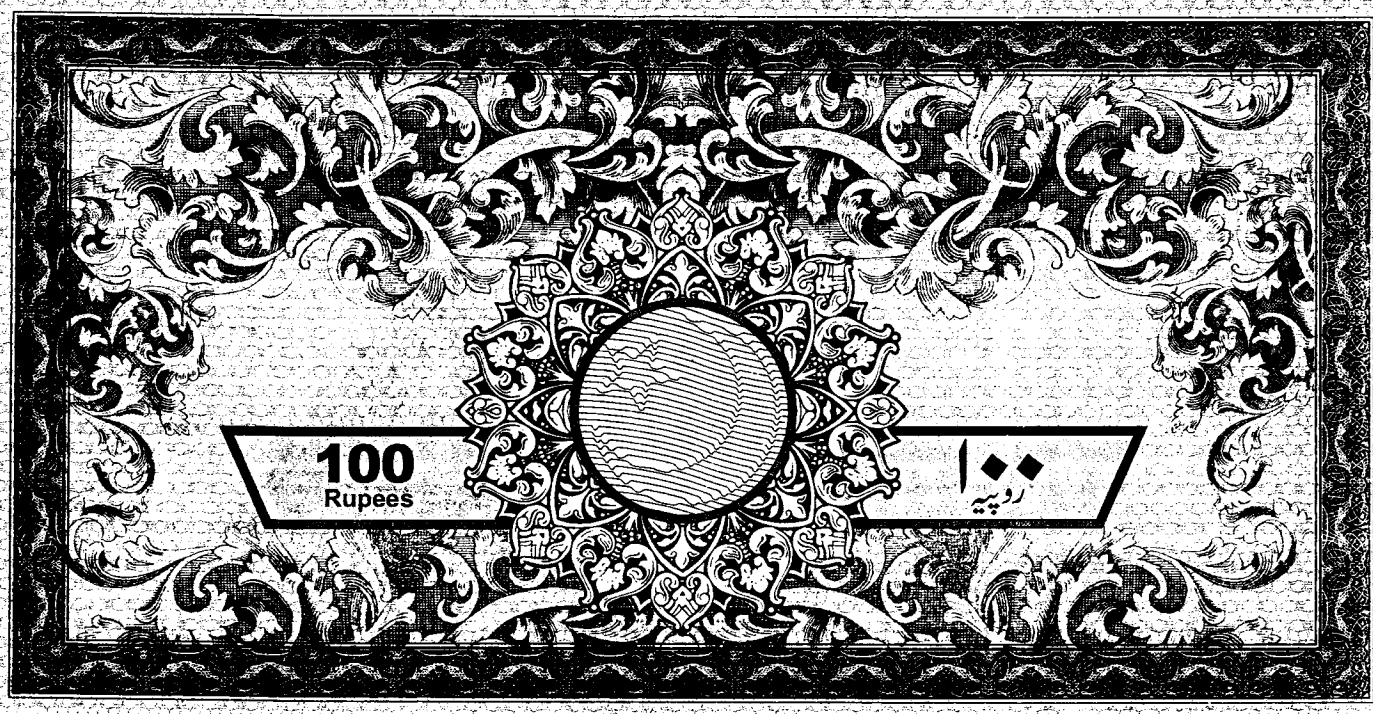
iv. Appoint or nominate any one or more officers of the Company or any other person or persons, singly or jointly, in their discretion to communicate with, make presentations to and attend any hearings in connection with the Licensee Proposed Modification of the Company's Generation License:

v. Do all such acts, matters and things as may be necessary for carrying out the purposes aforesaid and give full effect to the above resolutions.

CERTIFIED TO BE TRUE COPY

Company Secretary

Siachen Energy Limited SEL



RIAZ MUSTAFA RIZVI
mp Vendor Licence # 59,
Urdu Mehal Nazimabad, Karachi
4292
...ATE...
WITH ADDRESS Abdul Majeed Khan Advocate
ITH ADDRESS 27, Aziz Chambers Opp. City Courts, Kml.
...
...ATTACHED...
OR'S SIGNATURE...

(RUPEES ONE HUNDRED ONLY

27 JUL 2020

BEFORE THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

AFFIDAVIT

I, Muhammed Sohail Shamsi, Chief Executive Officer, Siachen Energy Limited, bearing CNIC number 42301-7052957-3, being duly authorized representative / attorney of Siachen Energy Limited, hereby solemnly affirm and declare on oath that the contents of the accompanying application for a licensee proposed Modification of Generation License of Siachen Energy Limited, including all attached documents-in-support, are true and correct to the best of my knowledge and belief, and that nothing has been concealed. I also affirm that all further documentation and information to be provided by me in connection with the ...lication shall be true to the best of my knowledge and belief.

Text of the Proposed Modification

SEL has selected Tier-1 PV Module "500 watt Bifacial Mono PERC Module" for its 100MW Solar Power Plant. It is considered as the state of the art in the Photovoltaic technology with the IEC 61215, IEC 61730, UL 61215, UL 61730 and IEC TS 62941 certification. It has 150 number of cells (maximum number by any solar project so far) and maximum voltage is promoted to 1500V and the module strings are extended by 50% which reduces the overall system BOS. This new technology adapts 4 busbar solar cell improve the efficiency of modules , offers a better aesthetic appearance, making it perfect for Grid Connected Systems. In addition it has higher module conversion efficiency (up to 20.4%) benefit from Passivized Emitter Rear Contact (PERC) technology. Furthermore, The PV module can pass maximum voltage 1500V PID testing under 60°C/ 85% RH condition to ensure the outdoor durability and energy output via high-voltage resistance technology. Also, its advanced glass and solar cell surface texturing allow for excellent performance in low-light environments. Hence, This PV Modules series is compatible with 1500V plant architectures, gives highly predictable energy in all climates and applications, and is independently certified for reliable performance in high temperature, high humidity, extreme desert and coastal environments.

The project mainly selects PV modules, and the PV modules are connected in series to form array strings. PV modules have advantages of high battery conversion efficiency, good stability, small size for equal capacity, etc. The PV modules with STC rated output (Pmpp) 500Wp are suggested for the project. In relation to the above please find attached the modifications required in Schedules I and II of the Generation License of the Company.

The Company Previously submitted SG2500 HV type Inverters having system voltage of 1500 V. Our inverters are 6.25MW with advanced three level technology and maximum inverter efficiency of 98.8%.

The new inverters have effective cooling with 1.1 overload capacity and has no derating up to 5ºC with degree of protection of NEMA 3R making it suitable for harsh environment conditions. In addition, it complies with the UL1741, UL1741 SA, IEEE 1547, Rule 21 and NEC code.

An all-in-one PC including two 3125kW inverters with 6250kW capacity is selected. By adopting variable structure PWM modulation algorithms and advanced MPPT control algorithms, the system loss can be reduced to the greatest extent, making the whole system efficiency highest, up to the maximum of 99.02%. At the same time, the inverter uses digital DSP control chips and dual power supply, increasing the reliability of the system. The inverter should have passed the TUV certification.

Statement of the reasons in support of the modification

The Company is a public limited company registered under the Companies Ordinance, 1984. The Company has been setup as a Special Purpose Company to setup and operate power projects.

The Company is seeking to develop, own and operate two solar power projects of 100 MW each in the province of Sindh. The Project is being developed pursuant to a Letter of Inte issued by the Sindh Alternative Energy Development Board ("SAEDB").

Siachen Energy L... SEL ...d

On October 10, 2017, NEPRA issued Generation License No. SPGL/24/2017 to the Company, which Generation License was based on PV Modules 250 Watt of model Sungrow SG2500U with a total capacity' of 100 MWp. This was the most advanced technology available for solar power generation at that time.

Since then, there has been great deal of changes happened in the technology and prices of the solar modules due to international demand and competition.

Further, the scope of the review on the Determination is established under paragraph XI that states:

> *"Projects that are going back for review of tariff will be asked to submit their applications on the basis of latest technology and technology related factors".*

Accordingly our EPC contractors have revised their Offshore and Onshore contracts for supply of equipment and construction of the project which reflects the latest technology. Hence, the Company seeks to incorporate those changes in the Generation License.

The Company has selected Power china International Group Limited as the equipment supplier for the Project. The engineering, procurement and construction works in relation to the Project will be undertaken by HDEC Engineering (Pvt.) Ltd, China. The said contractors have vast international experience in development and setting-up of power projects, including solar power projects.

The Company has already achieved the following key milestones in respect of the Project:

- All project approvals including LOI from SAEDB Government of Sindh along with latest extension, land documents, Environmental study, interconnection study and feasibility study;

- The EPC and O&M contracts in respect of the Project have been finalized;

- The Company has filed a new tariff with NEPRA on 25 June 2020 *(The earlier Tariff Determination expired on 18 November 2019)*

- Project debt financing has been arranged (on the basis of earlier debt equity structure approved by NEPRA in the Determination dated 18 November 2018) and lenders have taken their internal approvals, and sponsors have committed the required equity for the Project. Indicative term sheet to finance the project from industrial & Commercial Bank of China ("ICBC") is received as well.

  In view of the foregoing, the Company expects to achieve financial close in respect of the Project within the next few months. As part of its various milestones for achieving financial close, the Company desires to seek modification of its Generation License in order to reflect the change in technology of the PV Modules from 250 Watt of model Sungrow SG2500U to Tier-1 PV Modules "500 watt Bifacial Mono PERC Module" for its 100MW Solar Power Plant.

  The Company Previously submitted SG2500 HV type Inverters having system voltage of 1500 V. Our new inverters are 6.25MW with advanced three level technology and maximum inverter efficiency of 98.8%

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The Company hereby requests NEPRA to approve the proposed modification to the Generation License as such modification would allow the Company to proceed further with the Project and achieve financial close in a timely manner.

The present request is consistent with the guidelines set out in the Policy for Development of Renewable Energy for Power Generation, 2006 issued by the Government of Pakistan and the NEPRA (Application and Modification Procedure) Regulations. 1999.

We do hope NEPRA will consider our request and provide us the Modified Generation License based on the new Modules and Inverters as specified herein this application.

Statement of the impact on the tariff, quality of service and the performance by the licensee of its obligations under the license

The Company had previously awarded a Tariff Determination by NEPRA which expired on 18 November 2019 for reasons beyond our control. The Company filed a review motion with NEPRA for time extension in the Tariff which was declined on 27 March 2020 and we were advised to file a new Tariff based on latest technology and prevailing prices of the equipment.

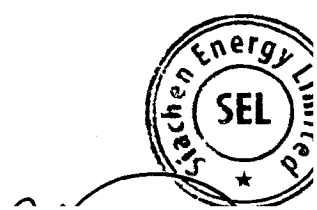
Therefore, the Company has filed a new Tariff on 25 June 2020. As all the changes in technology and equipment prices have already been incorporated in the tariff application. The proposed modification to the Company's Generation License will have no impact on the tariff awarded to the Company.

The Company hereby certifies that the tariff to be awarded to the Company will be acceptable to the Company and that the quality of service and the performance by the Company under the Generation License or tariff will not be affected by the proposed modification to its Generation License.

The Company has selected top quality Tier-1 PV Modules "500 watt Bifacial Mono PERC Module" for its 100MW Solar Power Plant and inverters of 6.25MW with advanced three level technology and maximum inverter efficiency of 98.8%.

The plant will be connected to the local transmission system and must comply fully with the most recent revision of the Local Grid Code. The Company shall actively comply with and demonstrate adherence to all relevant Pakistani and local (equivalent Chinese) standards and NTDC/HESCO requirements in the design, construction and commissioning of parts of the grid connection and will actively interface with NTDC/HESCO and all other relevant authorities to ensure acceptance of the design, construction and commissioning of parts of the grid connection.

With this latest technology and equipment, we are confident that we will able to provide both the quality of service and performance required by NTDC while adhering to comply with the applicable safety standards at the project site and the environment.



Modification in Schedule I

A. General Information:

Name of Applicant / Company	SIACHEN ENERGY LIMITED
Registered Office	74, J STREET OFF KHAYABAN E MUHAFIZ, PHASE-VI, DHA, KARACHI.
Plant Location	GHULAMULLAH ROAD, TALUKA MIRPUR SAKRO, DISTRICT THATTA, SINDH.
Type of Generation Facility	SOLAR POWER

B. Solar Farm Capacity & Configuration:

S. No.	Description	Stated in the Generation License	Proposed Modification
(i)	Solar Modules type. Make & Model	Polycrystalline PV Module 250 Watt Model Sungrow	Si-mono Mono-crystalline PV Module 500 Watt Model **JAM50D30-500/MB by** JA Solar
(ii)	Installed Capacity	100 MW	100 MW
(iii)	Number of Modules / Size of each Unit (kwh)	400,000 modules/ 1650 mm x 992 mm x 35 mm	200,016 modules / 2244*1112*35 mm
(iv)	Number of solar cells in each module	60 cells	150 cells (5 x 30)
(vi)	Inverter Model	1000CP XT	EP-3125-HA-UD

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C. Technical Details

ELECTRICAL SPECIFICATIONS	
STC rated output (Pmpp)*	500Wp
Rated voltage (Vmpp) at STC	42.75 V
Rated current (Impp) at STC	11.70 A
Module efficiency	20.0%
Types of solar PV cell	Mono-crystalline
Tolerance	0/+5W or better
Coefficient temperature	Less than -0.370%W/℃
cable	$4mm^2$
Connector type	MC4
NOCT	45+2,45-2
Frontal Glass	Single glass, 3.2mm coated tempered
Certifications	TUV/IEC/MCS/UL/ISO/TS/OHSAS
Warranty	First year 2% degradation, 2^{nd} to 25^{th} 0.55% linear degradation or less
Operating temperature	-40℃ to 85℃
Maximum voltage	1500V DC

RELATED PARAMETERS	
Cell type	Mono crystalline
Number of cells/cell arrangement	150/5*30
Packing unit	30 psc

MECHANICAL SPECIFICATIONS	
Outer dimensions(L*W*H)	2244*1112*35 mm
Frame technology	Anodized Aluminium alloy
Module composition	Glass/EVA/Back sheet(White)
Weight(module only)	32.5kg
Front glass thickness	3.2mm
Junction box IP rating	IP 68, three diodes
Cable diameter(UL/IEC)	$4mm^2$
Fire performance	UL Type 01 or 02
Connector type	MC type 4 compatible

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Inverter

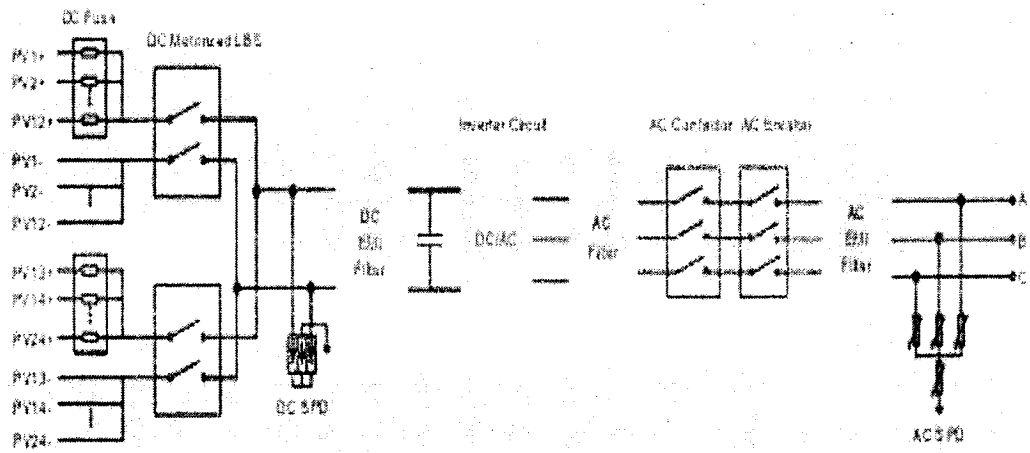
This project selects a grid-connected inverter with 3125kW capacity. By adopting variable structure PWM modulation algorithms and advanced MPPT control algorithms, the system loss can be reduced to the greatest extent, making the whole system efficiency highest, up to the maximum of 98.7%. At the same time, the inverter of this model uses digital DSP control chips and dual power supply, increasing the reliability of the system. The inverter of this model has passed the TUV certification, and it is suitable for Asian markets. Specific technical parameters are as follows:

Table inverter specification

Model	EP-3125-HA-UD
Input (DC)	
Max. PV input voltage	[illegible]
Max. input current	[illegible]
MPP voltage range for nominal power	[illegible]
Number of MPPT trackers	[illegible]
Number of DC inputs	[illegible]
Output (AC)	
Rated AC output power	[illegible]
Max. output power	[illegible]
Rated grid voltage	[illegible]
Grid voltage range	[illegible]
Rated output current	[illegible]
Max. output current	[illegible]
Rated grid frequency/range	[illegible]
THD (at nominal power)	[illegible]
DC current injection	[illegible]
[illegible]	[illegible]
Protection	
DC input protection	[illegible]
AC output protection	Circuit breaker
Overvoltage protection	[illegible]
[illegible]	Yes
Ground fault monitoring	Yes
Grid monitoring	Yes
[illegible]	Yes
[illegible]	Yes
[illegible]	Yes
[illegible]	Yes
[illegible]	Yes
Efficiency	
Max. efficiency	[illegible]
EU efficiency	[illegible]
General date	
[illegible]	[illegible]
[illegible]	[illegible]
Protection level	[illegible]
[illegible]	[illegible]
Cooling mode	Temperature controlled forced air cooling
[illegible]	[illegible]
Display	LCD
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Weight	[illegible]

Inverter Main Circuit

Circuit



Each DC input of inverter is protected by a DC circuit breaker, which can be controlled respectively; the current of each DC input is also under monitoring.

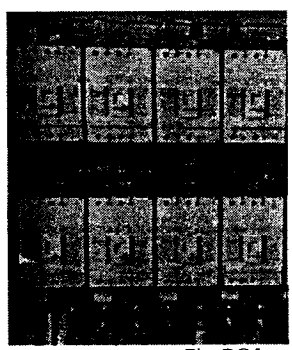


Fig. DC Inputs of Inverter and Zone Monitoring

The number of the DC inputs for a specific project may differ depending on the combiner boxes used; The combiner boxes are connected directly with the inverter, no need of using DC cabinets (or recombiner)

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Characteristic Curve

- Active & Reactive Power Control

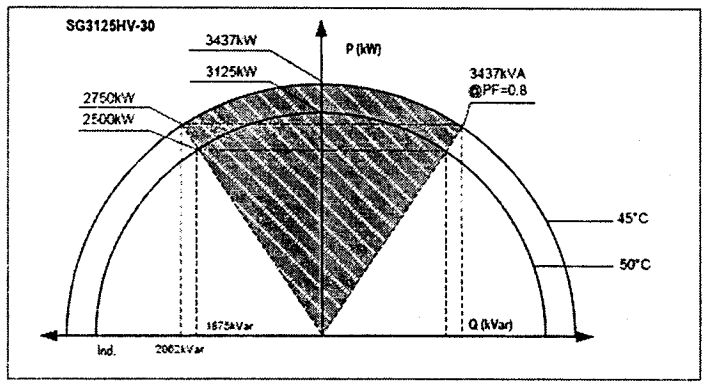


Fig. The P-Q Capability of SG3125HV (Pf mode)

The Pmax=3437kW, Smax=3437kVA. The Max. Q is +/-2062 kVar, when the power factor is +/-0.8, at 45℃; The Q is +/-1498 kVar, when the power factor is +/-0.9, at 45℃.

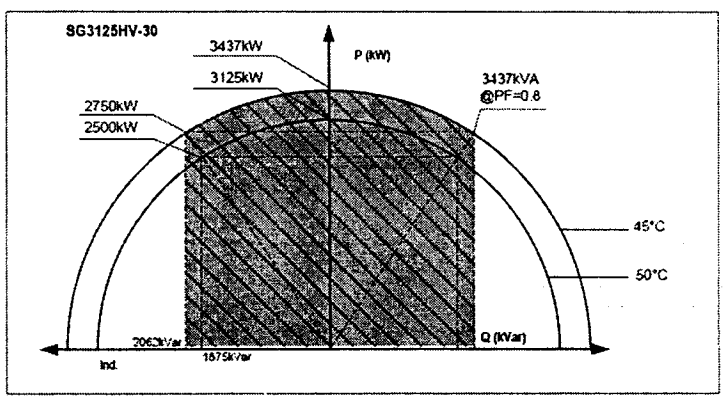


Fig. The P-Q Capability of SG3125HV (Q(t) mode)

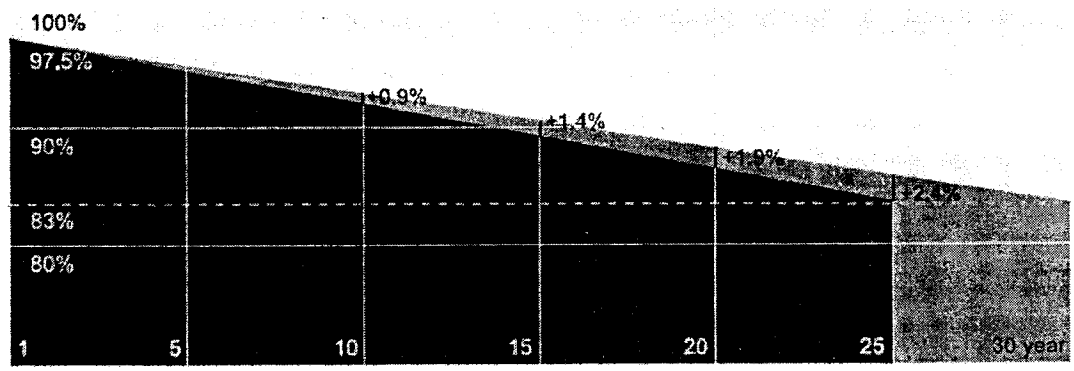
The Pmax=3437kW, Smax=3437kVA. The Max. Q is +/-2062 kVar, when the power factor is +/-0.8, at 45℃; The Q is +/-1498 kVar, when the power factor is +/-0.9, at 45℃.

D. Other Details

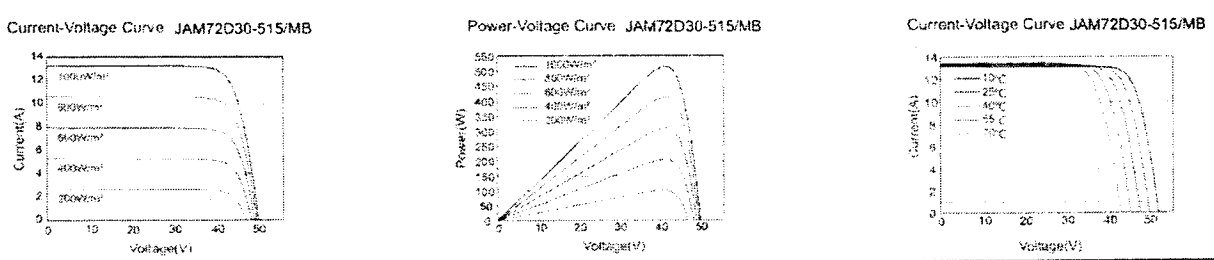
i.	**Expected COD of the Generation Facility / Solar Power Plant/ Solar Farm (Anticipated)**	**July 1, 2022**
ii.	**Expected Useful Life of the Generation Facility / Solar Power Plant/ Solar Farm (Anticipated) from COD**	**25 Years**

- 12-year product warranty
- 30-year linear power output warranty

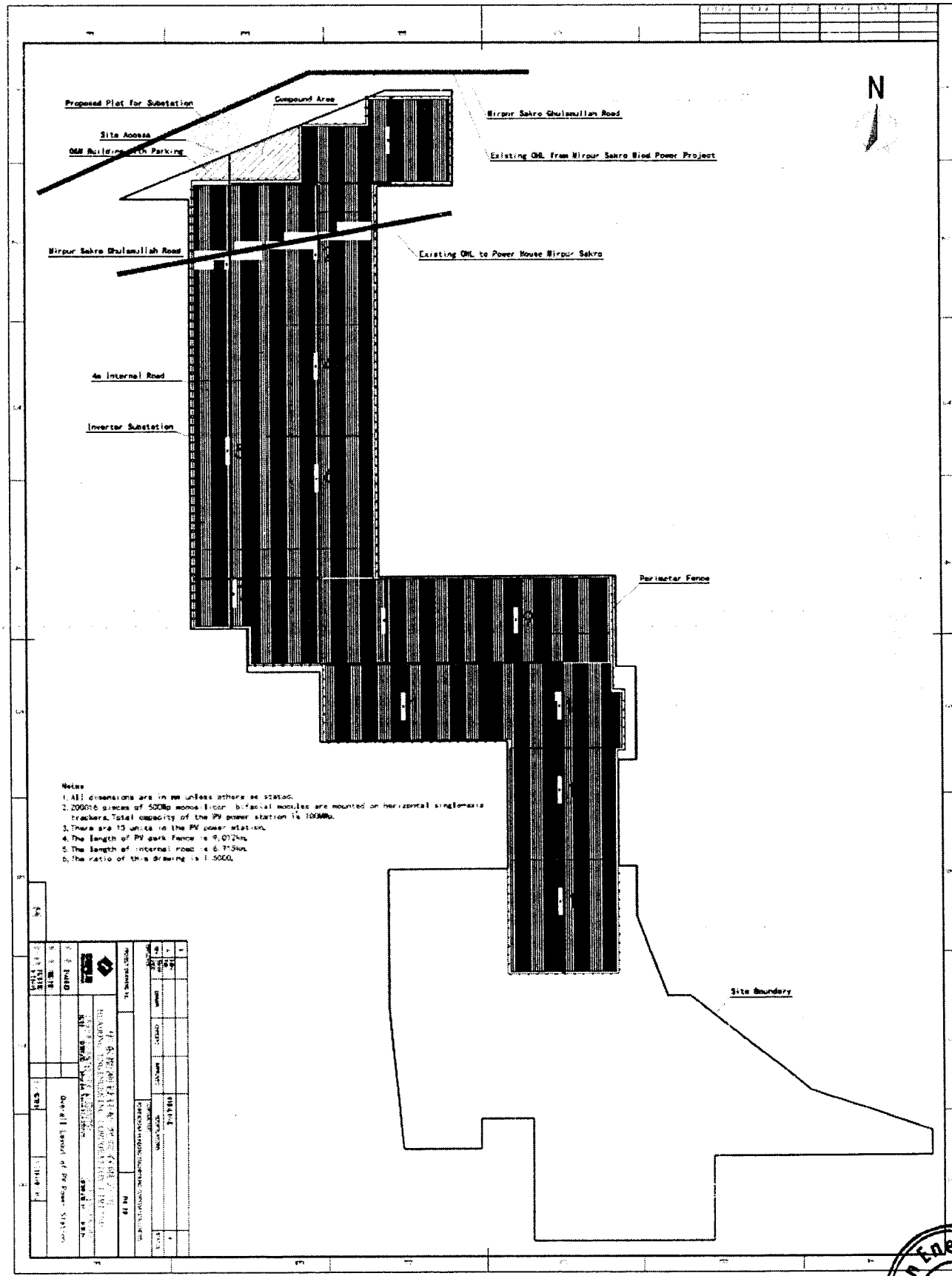
0.5% Annual Degradation Over 30 years



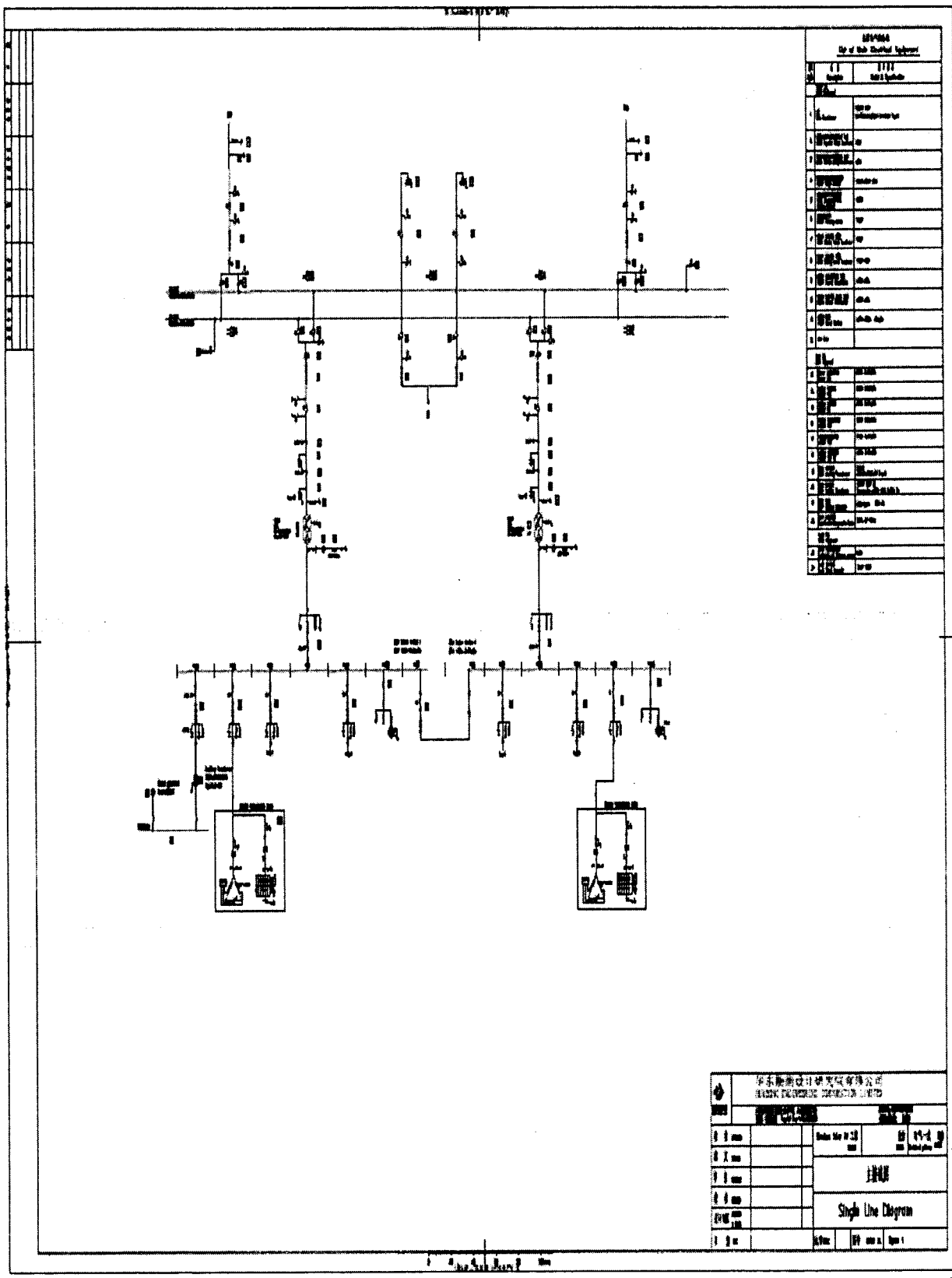
Power Curves



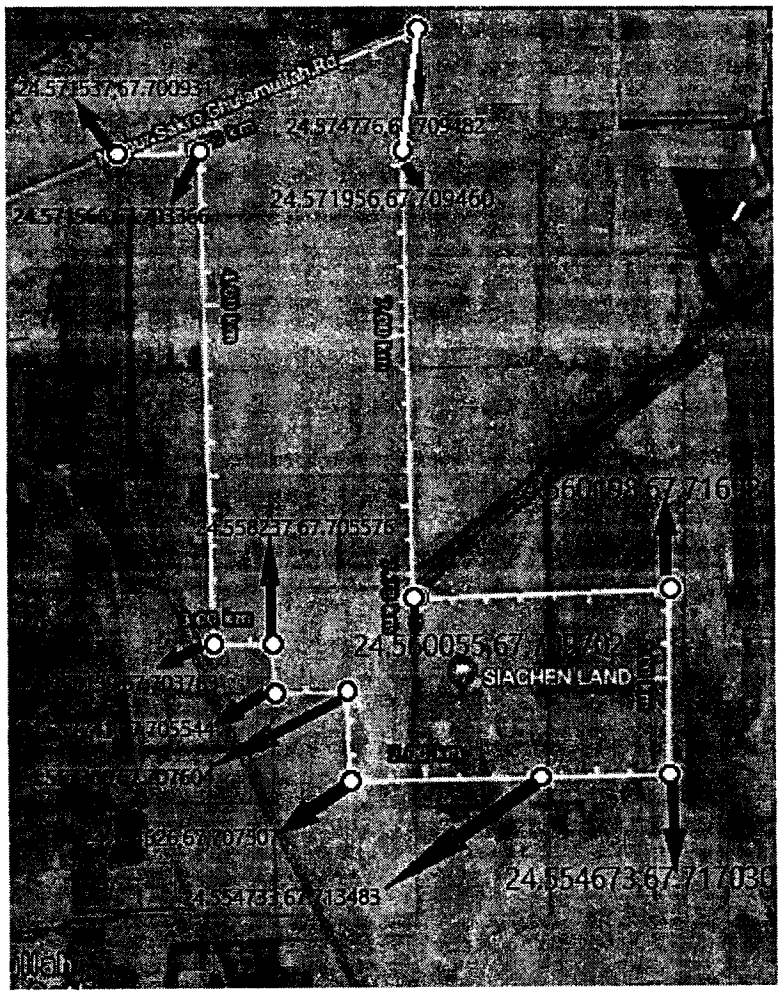
Solar Farm Layout



Single Line Diagram



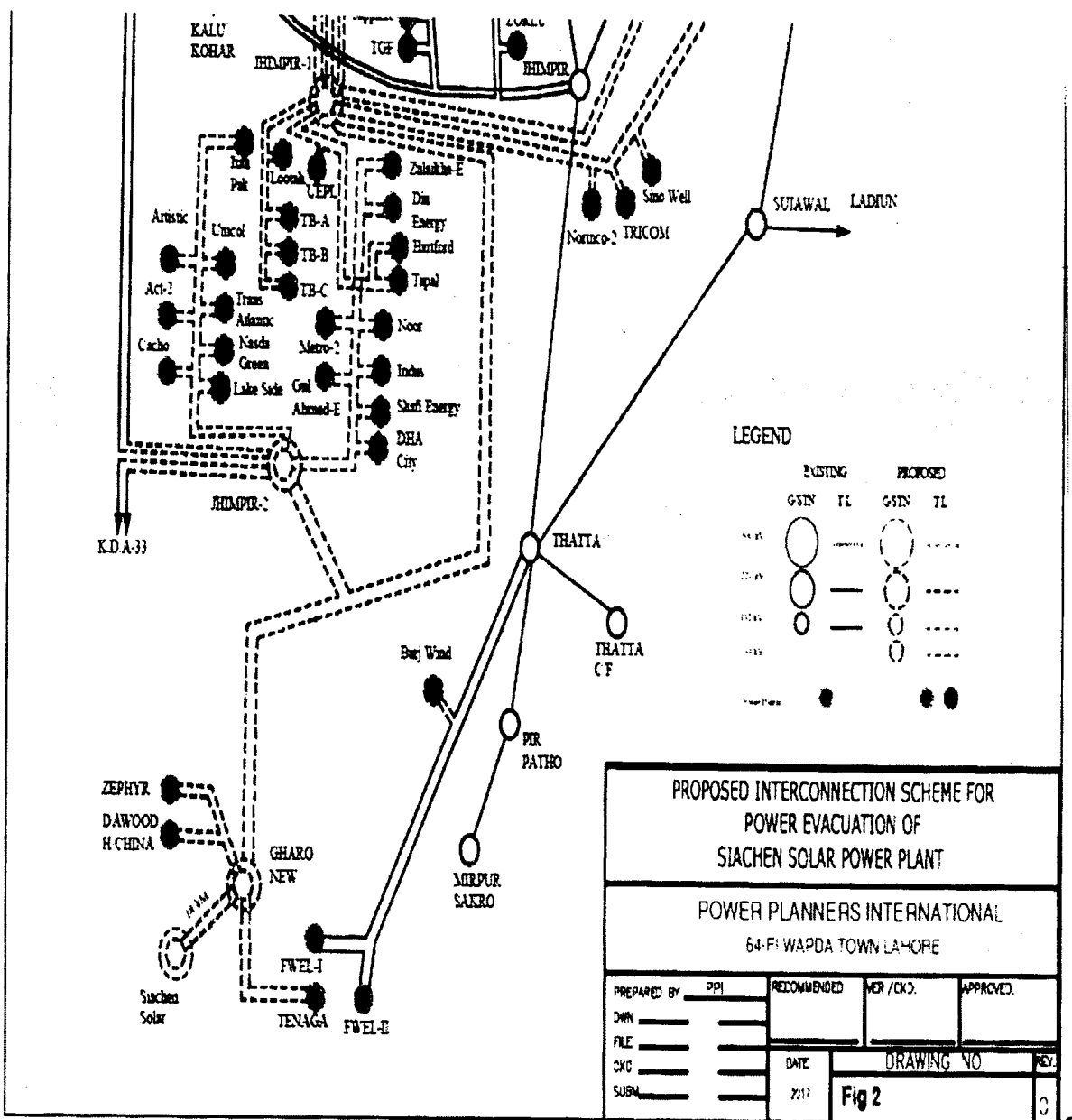
Solar Farm Coordinates



Proposed Interconnection Scheme

NTDC/MEPCO/Local Grid is responsible to install a new 132kV overhead line for grid connection of the Project. Note that this is yet to be installed. The Contractor shall be responsible for energizing of the grid connection in accordance with the Energy Purchase Agreement between the Employer and the grid operator, and to suit the programme for energizing the project complex.

Schematic Diagram of the Interconnection Arrangement/Transmission Facility for Dispersal of Power from th Generation Facility/Solar Power Plant /Solar Farm



Modification in Schedule - II

1	Total PV installed capacity of the Generation Facility	100.00 MWp
2	Average Sun Hour Available / Day (irradiation on inclined surface)	6.0 Hours
3	Days per year	330
4	PV plant generating capacity annually (as per simulation)	201,159 MWh/ year
5	Expected Total Generation in 25 Years life span of the plant	5,028,975 MWh
6	Generation per year from plant keeping 24 Hours working	100 x 24 x 365 = 876,000 MWh
7	Net Capacity Factor	**22.96%**

NOTE:

1. All the above figures are indicated as provided by the EPC contractors. The Net energy available to NTDC for dispatch will be determined through procedure contained in the Energy Purchase Agreement.

2. The detailed technical specifications as provided by the EPC Contractors are attached as annexures herewith in support of the application.

Annexure-I	**MODULE AND INVERTER SPECIFICATION**
Annexure-II	**CIVIL WORKS SPECIFICATION**
Annexure-III	**ELECTRICAL INFRASTRUCTURE WORKS**
Annexure- IV	**SCADA SPECIFICATIONS**

3. All other information not provided herein remains same as per the existing Generation license.

Respectfully submitted on the behalf of Petitioner.

Siachen Energy Limited

Dated: 29 July 2020

ANNEXURE-I

Siachen Energy Limited

Annex A Schedule 2

Module and Inverter Specification

Contents

1 INTRODUCTION

This specification provides details of the number and configuration of the circuits for the PV Module arrays Works to be provided under the EPC Contract for the construction of the Siachen 100MW Solar Project.

The entire PV power plant and grid connection Works shall be designed to operate in accordance with the relevant local grid code and distribution code and local technical and operational standards and requirements concerning embedded generation of this type and capacity.

2 SCOPE OF SUPPLY

2.1 OVERVIEW

The EPC Contract covers, but shall not necessarily be limited to, the engineering, procurement and construction, including the design, manufacture, supply, testing in factory works, insurance, packing, shipping, transport, delivery to site, unloading in site storage area, reloading and transport from storage area to final installed position, installation, erection, painting, testing, commissioning, warranty, performance and reliability testing and making good defects for the Employers interconnection works up to the interconnection point (the Complex boundary) as outlined below.

a) 132kV grid connection gantry from the PV power plant substation and interfacing with MEPCO/NTDC/Local grid connection interface point.

b) 132kV Substation Communication system which can be connected with the remote end grid substation..

c) Protection system for the 132kV line as required by the NTDC/MEPCO including associated measurement devices required at the project substation or interface point.

d) 132kV earth wire from interface with the NTDC/MEPCO equipment, to the project substation

e) Termination of overhead line at the project substation or grid connection interface point.

f) Provision of all necessary primary and secondary equipment required at project substation or grid connection interface including but not limited to switchgear, cables, termination, protection, CT's, VT's earthing, surge arrestors, lightning protection and metering to terminate the 132kV overhead line, to allow export of power to the national grid.

g) Gantries in project substation and their foundations for the above.

h) Two 100MVA feeders in 132kV substation enclosed compound, the latter including earthed fencing and trenching.

i) 132kV grid connection circuit breaker and disconnector, outdoor type AIS to be provided and associated protection systems at the project substation.

j) Project substation Main Transformer, associated switchgear and protection systems. This is to include supply of one power transformers with a nominal system voltage ratio of 132kV/33kV, exact ratio to be confirmed by NTDC/MEPCO/EPA, with, bund, automatic tap changer (+/- 8x1.25%), necessary protection (including unit differential protection).

k) Suitably rated and sized grounding transformer with resistor for earth faults protection. The requirement of resistor and grounding transformer shall be determined by the Contractor through calculations.

l) Reactive power compensation equipment, with voltage control as required to comply with Pakistan Grid Code and standards, NEPRA, NTDC, and MEPCO requirements

m) HV export/HV import/LV import metering and power quality monitoring.

n) Project substation SCADA interfaces and Network Control System including GPS satellite for time checking.

o) Telecommunications interfaces.

p) Project substation 33kV/400V transformers and auxiliary supplies, associated switchgear and protection systems.

q) Project substation 33kV switchgear and associated protection systems.

r) All project substation cables including but not limited to 132kV/33kV/ /400V/230V/110V DC/earthing/SCADA cabling.

s) PV power plant 33kV/550V transformers, size determined by contractor based on the design, housed in steel enclosures with associated switchgear and protection equipment.

t) Project cables including but not limited to MV/LV/earthing/SCADA cabling.

u) PV plant and substation lightning protection and earthing system.

v) Project substation power and lighting, fire fighting system

w) PV plant CCTV.

x) Temporary site power supplies for construction.

NTDC/MEPCO/Local Grid is responsible to install a new 132kV overhead line for grid connection of the Project. Note that this is yet to be installed. The Contractor shall be responsible for energizing of the grid connection in accordance with the Energy Purchase Agreement between the Employer and the grid operator, and to suit the programme for energizing the project complex.

2.2 APPLICATION OF CODES AND STANDARDS

The international standards(American/EURO/ equivalent Pakistan/equivalent Chinese) shall be adopted for this project. However, the Contractor may use relevant and equivalent Chinese standards and shall in that case internally establish the equivalence of such Chinese standards with relevant international standards.

2.3 PV MODULE

Main Design Criteria

The design of the Solar PV arrays to be provided will have an A-design assessment statement of compliance in accordance with relevant IEC standards, and will include site specific loads analysis for the solar PV farm based on the actual site conditions as per Site environmental conditions.

PV MODULES

The project mainly selects PV modules, and the PV modules are connected in series to form array strings. PV modules have advantages of high battery conversion efficiency, good stability, small size for equal capacity, etc. The PV modules with STC rated output (Pmpp) 500Wp (above) are suggested for the project, and the PV modules are proposed to be installed in each solar PV farms. The main technical parameters are as follows:

Table 8.1-2 PV modules electrical specification

ELECTRICAL SPECIFICATIONS	
STC rated output (Pmpp)*	500Wp (above)
Rated voltage (Vmpp) at STC	42.75 V
Rated current (Impp) at STC	11.70 A
Module efficiency	20.0%
Types of solar PV cell	Mono-crystalline
Tolerance	0/+5W or better
Coefficient temperature	Less than -0.370%W/℃
cable	$4mm^2$
Connector type	MC4
NOCT	45+2,45-2
Frontal Glass	Single glass, 3.2mm coated tempered
Certifications	TUV/IEC/MCS/UL/ISO/TS/OHSAS
Warranty	First year 2% degradation, 2^{nd} to 25^{th} 0.55% linear degradation or less
Operating temperature	-40℃ to 85℃
Maximum voltage	1500V DC

FIG 8.1-1 Photovoltaic Panel

RELATED PARAMETERS	
Cell type	Mono crystalline
Number of cells/cell arrangement	150/5*30
Packing unit	30 psc

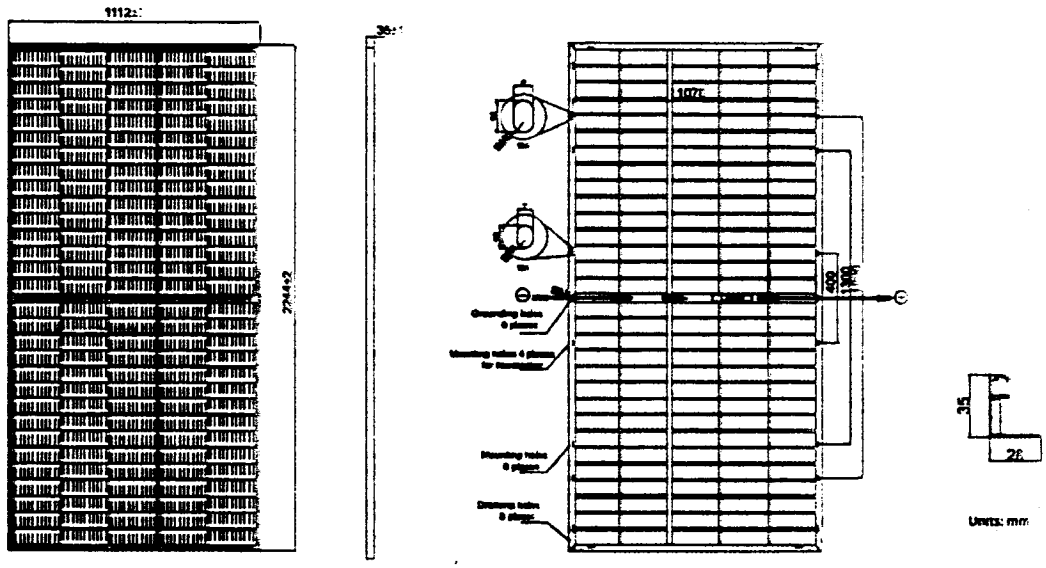
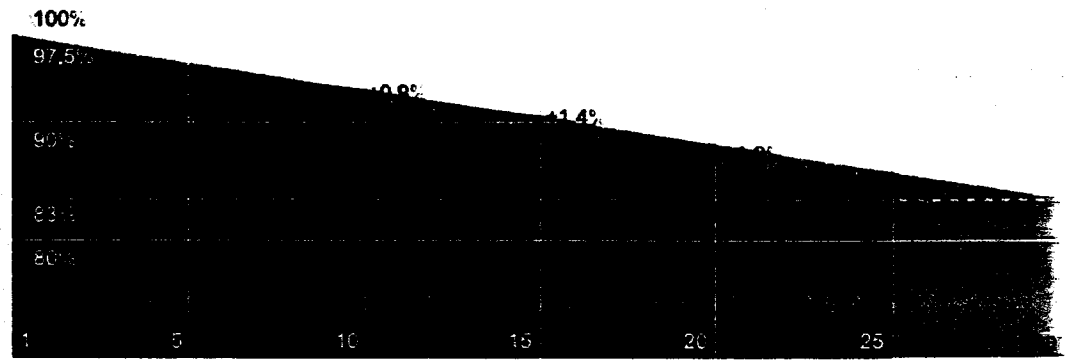


FIG 8.1-2 Module Dimension Details

Table 8.1-3 PV modules mechanical specification

MECHANICAL SPECIFICATIONS	
Outer dimensions(L*W*H)	2244*1112*35 mm
Frame technology	Anodized Aluminium alloy
Module composition	Glass/EVA/Back sheet(White)
Weight(module only)	32.5kg
Front glass thickness	3.2mm
Junction box IP rating	IP 68, three diodes
Cable diameter(UL/IEC)	4mm^2
Fire performance	UL Type 01 or 02
Connector type	MC type 4 compatible

- 12-year product warranty
- 30-year linear power output warranty



Please refer to the annex 1-PV modules specification for more details.

2.4 INVERTER

This project selects a grid-connected inverter with 3125kW capacity. By adopting variable structure PWM modulation algorithms and advanced MPPT control algorithms, the system loss can be reduced to the greatest extent, making the whole system efficiency highest, up to the maximum of 98.7%. At the same time, the inverter of this model uses digital DSP control chips and dual power supply, increasing the reliability of the system. The inverter of this model has passed the TUV certification, and it is suitable for Asian markets. Specific technical parameters are as follows

Table inverter specification

INVERTER SPECIFICATIONS		
DC Parameter	Maximum DC Voltage	1500V
	Operating Voltage Range	875V ~ 1300V
	Maximum DC Current	3997A
	DC Inputs	18 Inputs
Ac Parameter	Rated Output Power	3125kW
	Maximum Output Apparent Power	2.75MVA
	Rated Grid Voltage	600V
	Allowable Grid Voltage	510 ~ 660 V
	Maximum Output Current	3308 A
	Rated Grid Frequency	50 Hz (60Hz Optional)
	Allowable Grid Frequency	45~55Hz(55~65Hz Optional)
	Adjustable Range of Power Factor	>+0.99,0.8 Leading.-0.8 Lagging
	Total Current Waveform Deviation Factor	<3%
	Maximum Efficiency	99.0%

	Euro Efficiency	98.7%

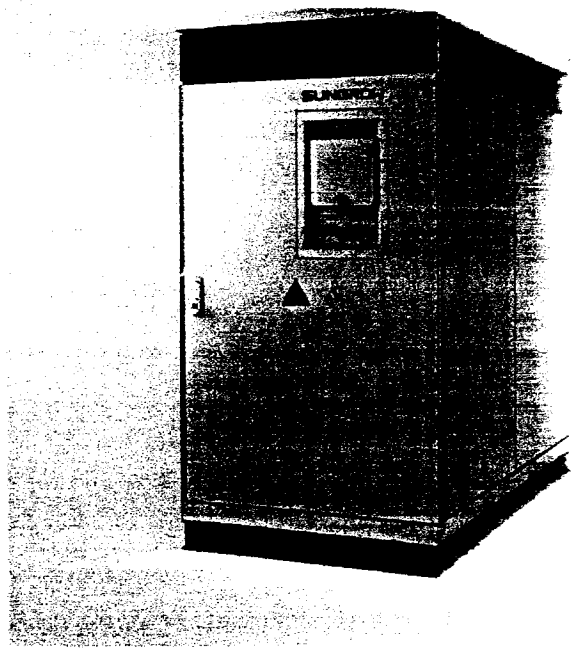


FIG 3125kW central inverter

1) Inverter Main Circuit

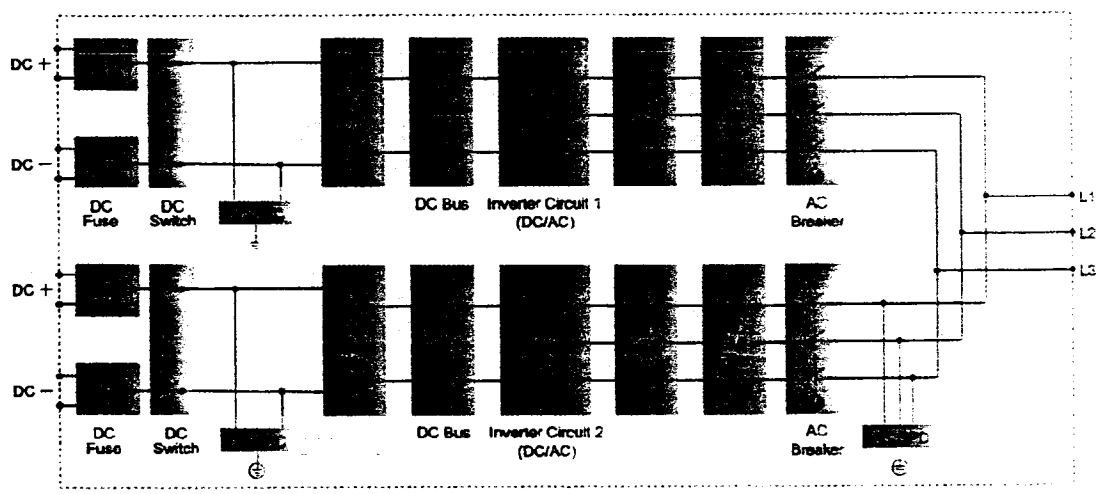


Fig. Main Circuit of SG3125HV

the DC current from PV arrays comes in, going through the DC breakers, DC EMC filter, reaches the IGBT modules, where the DC power is converted into AC and further trimmed through the AC filter circuit, followed by a AC main contactor used for protection;

2) DC Distribution and Zone Monitoring

Each DC input of inverter is protected by a DC circuit breaker, which can be controlled respectively; the current of each DC input is also under monitoring.

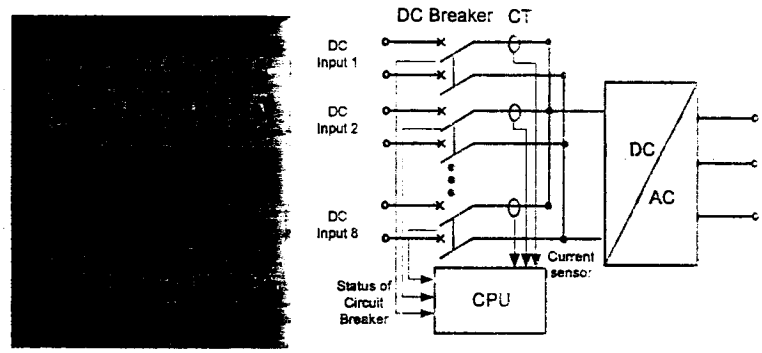


Fig. DC Inputs of Inverter and Zone Monitoring

the number of the DC inputs for a specific project may differ depending on the combiner boxes used;

the combiner boxes are connected directly with the inverter, no need of using DC cabinets (or recombiner);

3) Characteristic Curve

- Active & Reactive Power Control

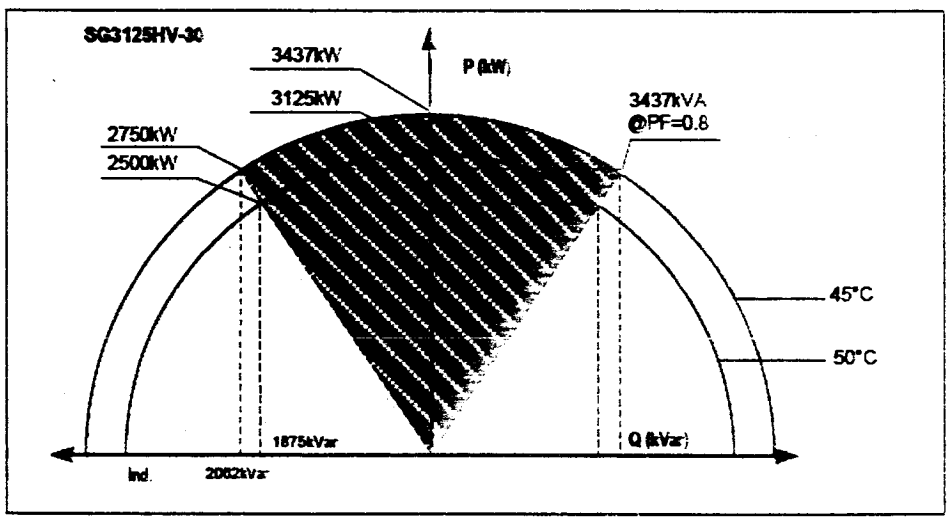


Fig. The P-Q Capability of SG3125HV (Pf mode)

The Pmax=3437kW, Smax=3437kVA. The Max. Q is +/-2062 kVar, when the power factor is +/-0.8, at 45°C; The Q is +/-1498 kVar, when the power factor is +/-0.9, at 45°C.

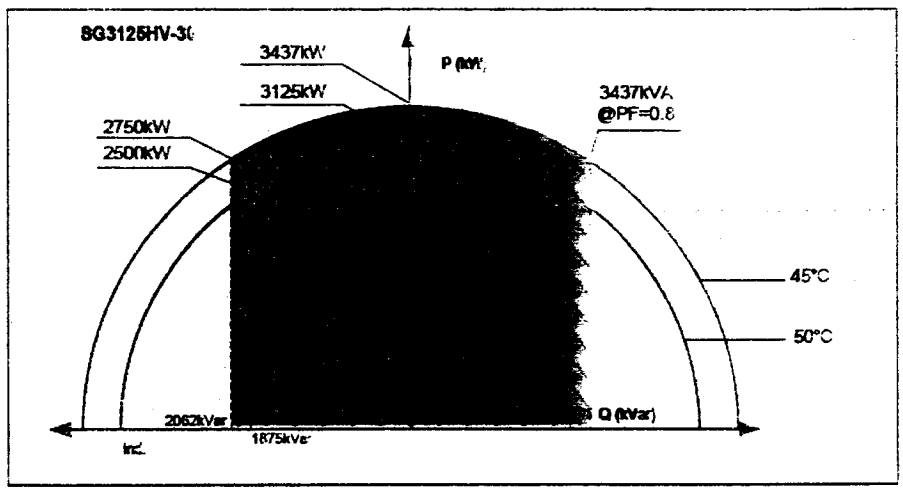


Fig. The P-Q Capability of SG3125HV (Q(t) mode)

The Pmax=3437kW, Smax=3437kVA. The Max. Q is +/-2062 kVar, when the power factor is +/-0.8, at 45°C; The Q is +/-1498 kVar, when the power factor is +/-0.9, at 45°C.

4) Other Function descriptions

a) DC over-voltage protection
b) AC Over/under voltage protection
c) Over/under frequency protection
d) Over-temperature protection
e) Over load protection
f) DC Insulation resistance monitoring
g) Soft start-up&Shutdown
h) Anti-islanding protection
i) Negative grounding for PID proof on request(2 inverters in parallel at DC side)
j) Frequency dependant active power control on request.
k) Other functions, if not specified by the customer, are Sungrow standard.

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ANNEXURE-II

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Annex A Schedule 3
CIVIL WORKS SPECIFICATION

Contents

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1 GENERAL

This specification provides details of the requirement for the civil infrastructure Works to be provided under the EPC Contract for the construction of the Siachen Solar Power Plant. A general description of the Project, the Site, and the required Works is in included in Schedule 4 Annexe 1 (*General Description*).

The Contractor shall ensure he has understood the nature of the potential risks and statutory quality, health, safety and environmental requirements. The Contractor shall be responsible for undertaking further investigations and risk assessments as he deems necessary prior to mobilising on the Site.

2 SCOPE OF SUPPLY

The scope of supply for the civil infrastructure Works includes but is not limited to:-

Design and construction of:

a) All civil works associated with the solar panel foundations;

b) All civil works associated with the medium voltage Transformers

c) All civil works associated with the provision of temporary and permanent internal roads on the site with suitable drainage arrangements;

d) All civil works associated with on Site electrical cabling and equipment;

e) All civil works associated with the solar power plant substation buildings, and permanent offices;

f) All civil works associated with the solar power plant substation enclosed compound including earthed fencing, and trenching;

g) All civil works associated with the solar power plant substation and internal roads;

h) All civil works associated with the 132kV grid connection cable up to the interconnection point (the Complex boundary) with the Energy Purchasers interconnection facilities; and the fibre optic cable from the solar power plant substation up to the interconnection point (the Complex boundary) with the Energy Purchasers interconnection facilities.

i) All of the above civil works with suitable drainage arrangements.

Provision of the following Facilities:

a) Construction of temporary offices area, temporary Works area and parking areas;

b) Site security including temporary substation fencing;

Completion of the following studies and investigations:

a) All studies and Site investigations necessary for designing and constructing the civil Works;

b) Identification, location, protection, re-routing of existing services on the Site during the construction period;

c) Topographic survey and soil investigation.

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1.1 SITE CONDITIONS

The Contractor shall accept the risk of encountering adverse ground conditions or environmental conditions at the Site and shall be responsible for commissioning and undertaking any further investigations and analysis of the area as he considers may be necessary for the execution of the design and construction work. The design shall be suitable for the ground conditions at the Site and the design life of the solar power plant, and the environmental conditions at the Site which may be encountered over the design life of the solar power plant.

The interpretation, accuracy and acceptability of the information, provided for use in the design of the civil works, shall be the sole responsibility of the Contractor. The Contractor shall acknowledge that the risk of encountering adverse Site conditions, environmental conditions, ground conditions, existing structures or artificial obstructions (of any kind) during the execution of the Works shall be borne by the Contractor who shall not be entitled to any additional payment or extension of time in respect thereof. The Contractor shall bear the entire risk of any inadequacies or other failings (including omissions) in the preparation of the Contractor's proposals.

The Contractor shall be responsible for the location, protection and bear expenses on design revisions where re-routing of the grid connection and fibre optic cabling between the grid connection interface point and the solar power plant substation proves necessary.

The Contractor has to take due consideration of elements of water stagnation after rainfall and ensure that the minimum height of foundation base and plinth levels at safe heights above the estimated level of water accumulation which may possibly occur during the rainy season and/or the monsoons. The final design level of foundations and plinth levels of civil structures will be decided during the design stage.

1.2 CODES AND STANDARDS

The design of the civil infrastructure works shall comply with all current Pakistani regulations, and international/Pakistani design codes and standards. The Contractor shall be responsible for compliance with the provisions of any order or regulation that may apply to the temporary and permanent buildings erected on the Site.

1.3 REQUIREMENTS FOR FOUNDATIONS

1.3.1 GENERAL

The Contractor shall be responsible for the design and construction of all reinforced concrete foundations required to support all solar panels, all solar power plant electrical equipment, substation, and buildings.

The solar panel foundations shall be designed and constructed according to the requirements of the manufacturer and with reference to the specific climatic conditions of the site and the ground conditions.

Notwithstanding the requirements of the solar panel manufacturer, the solar panel foundations shall be designed to take into account the following:-

a) The foundation loads;

b) Allowable stresses for the supporting soils;

c) The stability of the foundation;

d) Bending and shear in the foundation;

e) The presence of groundwater (buoyancy effects);

f) Load transfer reinforcement to transfer loads into the foundation;

g) Fatigue in the embedded foundation insert and reinforcement;

h) Crack control in the reinforced concrete;

i) The density of the backfill over the base and its control and achievement on site;

j) The need to safely access and construct the foundation at all stages of its construction.

In designing the foundations, it is not permissible to assume that the local groundwater is lowered by any drainage that the Contractor may choose to install, or that drainage will prevent submerged conditions. The Contractor is to consider the worst case ground water level within his design for all foundations i.e. groundwater level is taken at ground level, unless instructed or agreed otherwise.

Cast-in items such as foundation inserts, templates and bolts are supplied by the contractor, and the Contractor is required to install these to orientations and tolerances given in the solar panel specification contained in Schedule4 Annex 3a (*Module and Inverter Specification Specification*).

The *Module and Inverter* foundation designs shall be certified and warranted to be suitable for the operational life of the solar power plant. No *Module and Inverter* shall be erected on any foundation until the Contractor is satisfied that the foundation quality and strength has been verified.

During construction, the Contractor shall carry out appropriate methods of confirming compliance with the *Module and Inverter* foundation design requirements.

1.3.2 Position of Module and Inverter and Equipment Foundations

Accurate surveying equipment shall be used by the Contractor on all aspects of the construction of the solar power plant. The type of surveying equipment used by the Contractor shall be agreed by the ER and in order to satisfy the ER it achieves a satisfactory level of accuracy.

The height of the ground above datum at each *Module and Inverter* location shall be measured accurately by the Contractor before construction work commences at that location. The surveying equipment used to check that these tolerance criteria are met and also to locate the *Module and Inverter* positions for construction shall be accurate to within 10mm.

1.4 Concrete Works

1.4.1 General

The Contractor shall be responsible for the design and construction of all reinforced concrete foundations required to support all *Module and Inverter*, all solar power plant electrical equipment and substation buildings.

The Contractor must submit his proposals for sourcing concrete for the project detailing whether it will be Site batched or ready-mixed. If Site batched, details are required to be submitted as to how quality control will be achieved. The Contractor will be responsible for gaining all necessary consents for establishing a batching plant at the Site. The location of any batching plant on the Site must be agreed with the ER and should be positioned such that its shelter from adverse weather conditions is optimised.

Concrete works on the project must comply in all respects with the requirements of international or Pakistani recognised standards equivalent to Chinese, European and, British Standards.

1.4.2 HOT WEATHER WORKING

It is important that the Contractor takes into account the weather conditions that can prevail on site particularly taking into account seasonal hot weather conditions. Consequently it is important that due consideration is given to the design, detailing, specification and workmanship of all concrete works to ensure that the lifetime requirements of this specification are achieved.

The Contractor shall continually monitor climatic conditions occurring and forecast so as to identify periods when adverse weather may affect the progress of the Works, may have or has affected the adequacy of the Permanent Works.

The Contractor shall use all reasonable means and aids to prevent and minimise the effect of extremely hot weather. At air temperatures above 25°C the Contractor shall put in place appropriate precautions to protect the concrete Works from the adverse effects of hot weather. These precautions may include some or all of the following:

a) Moisten sub-grade, steel reinforcement, and formwork prior to concrete placement.

b) Erect temporary wind breaks to limit wind velocities and sunshades to reduce concrete surface temperatures.

c) Cool aggregates and mixing water added to the concrete mixture to reduce its initial temperature.

d) Protect the concrete surface during placement with plastic sheeting or evaporation retarders to maintain the initial moisture in the concrete mixture.

e) Provide sufficient labour to minimize the time required to place and finish the concrete, as hot weather conditions substantially shorten the times to initial and final set.

f) Consider fogging the area above the concrete placement to raise the relative humidity and satisfy moisture demand of the ambient air.

g) Provide appropriate curing methods as soon as possible after the concrete finishing processes have been completed.

h) In extreme conditions consider adjusting the time of concrete placement to take advantage of cooler temperatures, such as early morning or night time placement.

Notwithstanding the adoption of the above precautions the Contractor shall not be permitted to add quantities of water to freshly batched concrete. The Contractor shall follow best industry practice for hot weather working and shall make-good any damage caused by hot weather irrespective of the cause of damage.

1.4.3 CURING

Curing and protection should start immediately after the compaction of the concrete to protect it from:

a) Premature drying out, particularly by solar radiation and wind;

b) Leaching out by rain and flowing water;

c) Rapid cooling during the first few days after placing;

d) High internal thermal gradients;

e) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

Wnere members are of considerable bulk or length and the cement content of the concrete is high and the surface finish is critical, special or accelerated curing methods are to be applied. The method of curing should be specified in detail in the design submissions of the Contractor.

Where differences occur between this specification and the specifications noted above then the more onerous condition will apply.

Within four weeks of the Commencement Date, the Contractor shall make a full submission of the mix designs he proposes to use for the duration of the works. A testing programme shall be agreed with the ER for all concrete works prior to the commencement. This will include the requirements for standard slump tests to be carried out and for sample concrete cubes to be taken from all concrete used on site and the arrangement of independent compressive tests to be carried out in accordance with Chinese or Pakistan equivalent.

A testing programme shall be agreed with the Employer for all concrete works prior to the commencement. This will include the requirements for standard slump tests to be carried out and for sample concrete cubes to be taken from all concrete used on site and the arrangement of independent compressive tests to be carried out in accordance with BS 1881/ACI-211-1/ASTM-C-39 or Pakistani.. For structural concrete six (6) concrete cubes to be taken every 100m^3, for testing after 24 hours, 7 days and 28 days. One will be kept as a permanent record. Each test certificate shall specify the component into which the concrete was poured. For all other works six (6) concrete cubes shall be taken every 100m^3, for testing after 7 days and 28 days. Where concrete is proposed to be Site batched it is expected that these requirements will be more rigorous until such time that the ER is satisfied that concrete quality is assured. Test certificates shall be made available to the Employer in a timely manner and as a minimum requirement the 7 day test certificates must be available prior to the commencement of solar panel assembly.

In advance of the works being carried out, the Contractor shall submit a detailed method statement indicating exactly how and with what resources he proposes to carry out these works. Specific reference should be made to hot weather concrete working. Due allowance shall be made in the EPC Contract for all costs resulting from the method of working including any double handling of materials which may occur at this time.

The workmanship of concrete construction by the Contractor shall be in strict accordance with the requirements of the relevant design and construction guidelines.

1.5 Lightning Protection and Earthing

1.5.1 General

The electrical lightning protection and earthing requirements are specified in Schedule 4 Annex 3c (*Electrical Infrastructure Works*). The Contractor shall undertake all associated civil works.

1.6 Roads

1.6.1 Site Access and Site Roads

The Contractor shall design, supply, construct and test new or upgraded internal roads for the purposes of constructing, operating, repairing and maintaining the solar power plant suitable for a 20 year operational lifespan, including the required passing points.

The Contractor shall be fully responsible for the design of the roads. Road network drainage suitable for the Site and weather conditions shall be designed, supplied, constructed and tested by the Contractor.

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As a minimum, access roads shall be designed for 4m wide useable width. A slope of 2.5% shall be provided from the axis of the roads to either side for drainage of rainwater or a similar crossfall. No ponding on the running surface shall be permitted. All road layers must be properly compacted by suitable machinery. Road surfaces must be suitable for transporters having ground clearance as low as 100mm.

Where the underlying soil is unsuitable for supporting any transportation loads, the unsuitable material shall be removed and replaced with suitable compacted fill.

1.6.2 DRAINAGE

The Contractor is to undertake any necessary further site investigations to establish the existence of drainage networks associated with current land management activities. The Employer requires that any existing drainage network be maintained in good working order throughout the execution of the EPC Contract. The Contractor shall design the Works and provide additional drainage Works such that the effect on the existing drainage at any part of the Site is minimised due to the execution of the Works.

Flows will be managed to allow for potential extreme rainfall or flood events, and so as to minimise erosion of channels and effects on the natural hydrology of the area.

1.7 ELECTRICAL POWER AND COMMUNICATIONS CABLES

1.7.1 GENERAL

The requirements for electrical power and communications cables are specified in Schedule4 Annex 3c (*Electrical Infrastructure Works*).

The Contractor shall undertake all associated civil works including the design and installation of the cable trenches and cable ducts or buried cables, and foundations and supports for overhead lines.

1.7.2 GRID CONNECTION INTERFACE

The Contractor will be required to install the equipment that makes up the Sellers Interconnection Facilities up to the interconnection point which will interface with the Energy Purchasers interconnection facilities at the interconnection point. The interface between Contractor and Employer is the Gantry of Substation.

The Employer is to liaise with the NTDC to determine the requirements for the Sellers Interconnection Facilities.

1.8 SUBSTATION BUILDING AND COMPOUND

1.8.1 GENERAL

The Contractor with the Employer's assistance is required to fully liaise with the grid operator, ER and Employer's operations personnel during the detailed design to ensure that the substation building includes all requirements. The Contractor is required to allow for adequate computer flooring/cable trenching and foundations for the substation switchgear and also to allow for adequate access to the 132kV and 33kV switchroom(s) for the switchgear equipment. The floor level of the building will be approximately 200mm above existing grade

The Contractor shall undertake the submission of all drawings and documents for the purposes of obtaining all necessary approvals, including all applicable building regulation approval and fire authority approval. The substation building should be classified as a manned installation. The Contractor will therefore be required to submit all the necessary information (calculations and drawings) in a timely fashion to allow the appropriate submission to be made to the appropriate authorities.

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1.8.2 EARTHWORKS

The Contractor shall carry out all earthworks and grading of the entire Site within the EPC Contract to the extent required to construct the Works, including the substation building and adjacent area, in accordance with the specification.

No material, natural to the solar power plant Site, shall be removed from the Site. The Contractor shall arrange a Site reconnaissance with the ER prior to construction. The ER may accept the invitation to attend the Site reconnaissance with the Contractor.

1.8.3 ENTRY OF BURIED CABLES

All buried power and communication cables shall enter the building below ground and shall be out of sight and inaccessible from outside the substation building. Special attention shall be given to preventing the ingress of ground water into any trenches inside the building, and for draining any water which may accumulate in these trenches.

1.8.4 SUBSTATION BUILDING PARTICULAR REQUIREMENTS

The appearance of the substation building and the type and colour of materials used to build the substation shall comply with the requirements of the appropriate authority before construction commences. The layout of the building shall be reviewed by the ER prior to construction

The substation shall consist of;

a) High and medium voltage switchroom(s)

b) Low voltage switchroom

c) SCADA room or control room

d) Battery room

e) Metering room

f) Three offices

g) Meeting room

A separate Residential block for Operational Staff suitable to accommodate bachelors quarters for ten persons. The residential block of 10 staff to accommodate 6 operational, 3 maintenance, 1- trained fire-fighting staff.,

h) Canteen area sufficient for the proposed operational personnel

i) Toilets and washroom facilities sufficient for the proposed operational personnel

j) Storage area of a minimum of 100m^2 for the storage of spare parts, this should contain

   i. Racking for the storage of small parts

   ii. Bounded area for the storage of oils and chemicals

   iii. Climate controlled area for parts that require specialist storage conditions

   iv. Air conditioning for storage of electronic equipment, devices, components

Rooms shall be fitted with the following as appropriate:

a) Power and lighting (including a minimum of two 240V and two 110V standard power sockets above that specified for other equipment within this document).

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b) Suspended ceiling (for control building lobby, relay-protection room, main control room and office).

c) Emergency lighting.

d) Fire detection and alarm system in accordance with Chinese Standard or equalized Pakistani for linking to SCADA system.

e) Ventilation, designed to minimise rainwater or sand ingress.

f) Durable floor covering.

g) Phone sockets as required (control room, and office space)

h) Network sockets as required (control room and office space).

The Contractor shall ensure ventilation and environmental requirements are met in the room which accommodates the battery system.

All aspects of the building shall comply with relevant Pakistani building regulations, Pakistani (or equivalent Chinese) standards and good practice.

All external doors shall be theft proof and comply with the relevant Pakistani (or equivalent Chinese) standards. Three sets of keys for all doors shall be provided.

Doors and frames are to be chemically treated to ensure maximum paint adhesion and primed and finished with a high-performance external painting system.

The floor of the buildings shall comply with Pakistan standards. Trench covers shall be sized to allow lifting by a single operative. Trench covers shall be from concrete or other material proposed by the contractor and shall comply with Pakistan standards.

A minimum 2.5m wide concrete apron ramp slab will be provided externally to each build entrance to the building and shall be no narrower than the doorway opening. This shall provide transition from the external ground level to the building floor level and be suitable for the use of wheeled trolleys and pedestrian traffic.

The Contractor shall assist the Employer to liaise with the relevant authorities to ensure that all building approvals and warrants required for the substation are completed in a timely fashion.

The solar power plant substation area shall have appropriately rated external lighting to ensure that during hours of darkness operators, staff, Contractors and visitors have sufficient and safe lighting to enter, exit and visit other buildings, equipment and parking areas in the surrounding area of the substation.

1.8.5 SUBSTATION COMPOUND

An enclosed compound including earthed fencing, and trenching will be required for the electrical equipment, refer to Schedule 4 Annex 3c (*Electrical Infrastructure Works*). The Contractor shall be responsible for the civil and electrical design and construction.

ANNEXURE-III

Siachen Energy Limited

Annex A Schedule 4

Electrical Infrastructure Works

Contents

1 INTRODUCTION

This specification provides details of the requirement for the electrical and instrumentation infrastructure Works to be provided under the EPC Contract for the construction of the [Project Name].

The number and configuration of the circuits for the PV Module arrays will depend upon the PV Module selection as described in Schedule 4 Annex 3a Module and Inverter Specification.

The entire PV power plant and grid connection Works shall be designed to operate in accordance with the relevant local grid code and distribution code and local technical and operational standards and requirements concerning embedded generation of this type and capacity.

The grid connection system design and supply includes the grid interconnection study shall be provided by the Employer.

2 SCOPE OF SUPPLY

2.1 OVERVIEW

The EPC Contract covers, but shall not necessarily be limited to, the engineering, procurement and construction, including the design, manufacture, supply, testing in factory works, insurance, packing, shipping, transport, delivery to site, unloading in site storage area, reloading and transport from storage area to final installed position, installation, erection, painting, testing, commissioning, warranty, performance and reliability testing and making good defects for the Employers interconnection works up to the interconnection point (the Complex boundary) as outlined below.

a) 132kV grid connection gantry from the PV power plant substation and interfacing with HESCO/NTDC/Local grid connection interface point.

b) 132kV Substation Communication system which can be connected with the remote end grid substation..

c) Protection system for the 132kV line as required by the NTDC/HESCO including associated measurement devices required at the project substation or interface point.

d) 132kV earth wire from interface with the NTDC/HESCO equipment, to the project substation

e) Termination of overhead line at the project substation or grid connection interface point.

f) Provision of all necessary primary and secondary equipment required at project substation or grid connection interface including but not limited to switchgear, cables, termination, protection, CT's, VT's earthing, surge arrestors, lightning protection and metering to terminate the 132kV overhead line, to allow export of power to the national grid.

g) Gantries in project substation and their foundations for the above.

h) Two 100MVA feeders in 132kV substation enclosed compound, the latter including earthed fencing and trenching.

i) 132kV grid connection circuit breaker and disconnector, outdoor type AIS to be provided and associated protection systems at the project substation.

j) Project substation Main Transformer, associated switchgear and protection systems. This is to include supply of two 80/100 ONAN/ONAF1/ONAF2 power transformers with a nominal system voltage ratio of 132kV/33kV, exact ratio to be confirmed by

NTDC/HESCO/EPA, with, bund, automatic tap changer (+/- 8x1.25%), necessary protection (including unit differential protection).

k) Suitably rated and sized grounding transformer with resistor for earth faults protection. The requirement of resistor and grounding transformer shall be determined by the Contractor through calculations.

l) Reactive power compensation equipment, with voltage control as required to comply with Pakistan Grid Code and standards, NEPRA, NTDC, and HESCO requirements

m) HV export/HV import/LV import metering and power quality monitoring.

n) Project substation SCADA interfaces and Network Control System including GPS satellite for time checking.

o) Telecommunications interfaces.

p) Project substation 33kV/400V transformers and auxiliary supplies, associated switchgear and protection systems.

q) Project substation 33kV switchgear and associated protection systems.

r) All project substation cables including but not limited to 132kV/33kV/ /400V/230V/110V DC/earthing/SCADA cabling.

s) PV power plant 33kV/550V transformers, size determined by contractor based on the design, housed in steel enclosures with associated switchgear and protection equipment.

t) Project cables including but not limited to MV/LV/earthing/SCADA cabling.

u) PV plant and substation lightning protection and earthing system.

v) Project substation power and lighting, fire fighting system

w) PV plant CCTV.

x) Temporary site power supplies for construction.

NTDC/HESCO/Local Grid is responsible to install a new 132kV overhead line for grid connection of the Project. Note that this is yet to be installed. The Contractor shall be responsible for energizing of the grid connection in accordance with the Energy Purchase Agreement between the Employer and the grid operator, and to suit the programme for energizing the project complex.

2.2 Application of Codes and Standards

The international standards (American/EURO/ equivalent Pakistan/equivalent Chinese) shall be adopted for this project. However, the Contractor may use relevant and equivalent Chinese standards and shall in that case internally establish the equivalence of such Chinese standards with relevant international standards.

2.3 General Requirements for Electrical Installation

2.3.1 HIGH VOLTAGE INSTALLATIONS

The project electrical power installation shall comply with Pakistani equivalent standards or the common rules for installations exceeding 1kV covered in IEC 61936 part1. The installation shall also generally comply with Pakistani equivalent standards.

2.3.2 *ELECTROMAGNETIC INTERFERENCE*

The Contractor shall ensure that the level of electromagnetic emissions / interference generated by the Solar PV plant shall be no more than the maximum specified in relevant IEC or Pakistani standards.

2.3.3 *HV SWITCHGEAR*

HV switchgear shall comply with the latest editions of IEC 60298, ISO 60694, IEC 62271-100, IEC 62271-102 and IEC 62271-203, IEC 60265 – 1 standards for equipment of this type or the relevant Pakistan.

2.3.4 *HV CABLING*

HV cabling shall comply with the latest edition of IEC 60840/BS7870-4.10 or the relevant Pakistan standards, and relevant Pakistan regulations.

2.3.5 *SWITCHBOARDS*

Each main component mounted in a switchboard shall be separately labelled according to the corresponding drawings. Internal wiring must be ferruled and numbered in accordance with circuit diagrams. All front-mounted equipment shall be marked with plan identification and functional designation.

Switchboards shall have a method of preventing condensation, such as inclusion of anti-condensation heaters. The switchboard(s) shall have an internal light and a power socket outlet to the relevant Local Standard. Where test equipment has to be used, for example a laptop computer, the panel will incorporate a foldable shelf into the back of the panel door.

When switchboards and other sensitive electrical equipment has to be stored on site and installed prior to commission, the manufacturer's instructions regarding storage and heating must be fully implemented, and particularly regarding condensation prevention and protection against high temperatures and blowing sand.

2.3.6 *LV CABLES*

The Contractor shall ensure that all LV cabling complies with the relevant international/ Pakistan standards and relevant Pakistan regulations.

2.4 GRID CONNECTION INTERFACE

The plant will be connected to the local transmission system and must comply fully with the most recent revision of the Local Grid Code. The Contractor will have overall responsibility for ensuring Grid Code compliance.

Grid Connection details shall be provide by the Employer.

Project shall be designed for 100 MW total capacity PV modules. The main transformer and grid connection shall be designed to export the capacity of 100 MW of PV modules at rated power factor.

The project shall be connected to the local 132kV network at the 132kV incoming circuit breakers (substation breakers).

The project connection (project complex), will have a maximum export capacity of approximately 100 MW, with a power factor operating range in accordance with the relevant Pakistani Grid Code (or equivalent).

The Contractor will make provision to manage the project engineering interface with the Grid Operator for the 132kV circuit breaker and dis connector and associated protection system.

The point of connection between the grid and the project substation infrastructure shall at the 132kV incoming line circuit breaker(s) terminal (s).

The Contractor will be responsible for the design, engineering, routing, procurement, manufacture, construction, testing and commissioning of the grid connection interface works to connect the project to the power grid.

The Contractor shall actively comply with and demonstrate adherence to all relevant Pakistani and local (equivalent Chinese) standards and NTDC/HESCO requirements in the design, construction and commissioning of parts of the grid connection not supplied by the NTDC/HESCO.

The Contractor will actively interface with NTDC/HESCO and all other relevant authorities to ensure acceptance of the design, construction and commissioning of parts of the grid connection not supplied by NTDC/HESCO. This includes, but is not limited to, gantry design, earthing, terminations, communications system, and protection schemes as applicable.

The Employer requires the Contractor to provide the following facilities for grid connection:

- Provision shall be made for a secure area within the substation building dedicated to housing the grid connections switchgear and associated equipment
- Suitable road access to the project substation building for installation of 33kV switchgear and associated equipment and to enable future maintenance of Grid Operator's equipment
- Access will also be required for the HV system meter operator.

2.5 132 KV ELECTRICAL SYSTEM AND MAIN TRANSFORMER

As stated in the Scope of Supply, the Contractor shall provide the following:

a) Not used.
b) Two 100MVA feeders in plant substation enclosed compound, the latter including earthed fencing and trenching.
c) 132kV grid connection AIS and associated protection systems at the substation, 100 MW.
d) Substation Main Transformer, associated switchgear and protection systems. This is to include supply of two 80/100MVA ONAN/ ONAF1/ONAF2 power transformers with a nominal system voltage ratio of 132kV/33kV, exact ratio to be confirmed by NTDC/HESCO, at the plant with, bund, automatic tap changer (+/- 8x1.25%), necessary protection (including unit differential protection).
e) A suitably rated neutral earth fault grounding transformer and resistor at MV side for the above.
f) A reasonable fire alarm system (including mobile fire extinguishers and relays, which comply with IEC Standards) for 132 KV Transformers.

2.5.1 132KV EQUIPMENT DESIGN FAULT LEVEL

The Contractor shall confirm with NTDC/HESCO, the scope of supply for the 132kV protection systems and the technical requirements for the protection equipment and equipment design fault level.

2.5.2 132KV PROTECTION EQUIPMENT

The Contractor shall confirm with NTDC/HESCO, the scope of supply for the 132kV protection systems and the technical requirements for the protection equipment and equipment design fault level.

2.6 PROJECT SUBSTATION SWITCHGEAR

The HV switchboards shall be type approved by the Grid Operator to which they will be connected and to ensure connection to the local 132kV system.

All MV and LV switchgear shall comply with the relevant Pakistan standard or the latest edition of the relevant part of the IEC 60947 standards for this type of device.

Switchboards installed within the project substation shall have a method of preventing condensation, an internal light and a power socket outlet to Pakistan standards or IEC 60309-2 equivalent.

2.6.1 REACTIVE POWER COMPENSATION AND VOLTAGE CONTROL EQUIPMENT

The reactive power compensation shall be supplied, as required to comply with local grid code, NTDC/HESCO or national standards, with all necessary control and protection equipment, housings and compound, and shall be designed to fully integrate with the control system.

It is the responsibility of the Contractor to ensure that:

a) The reactive power compensation is sized correctly to provide the required reactive range for the project, substation and 132kV grid connection line from the project substation to a point on the grid to be agreed with the grid operator.

b) The reactive power compensation and voltage control scheme interacts correctly with the network control system.

c) The overall connection is compliant with all relevant aspects of the Pakistan Grid Code.

2.6.2 METERING

The Contractor will supply power for the meters inside the project substation. The metering system (including the backup metering system) and associated equipment shall comply with the relevant codes and NTDC requirements.

Metering and Backup metering system should be in compliance with the NTDC requirements. Main meter will be provide by the NTDC and not in the Contractor's scope.

The metering equipment shall be installed within the substation building and should allow access by the appointed meter operator and viewing by the plant operators.

The meter reading equipment will be supplied and installed within the metering panels by the Contractor and meter data shall interface with the SCADA system and shall be transmitted in the way required by the NTDC.

2.6.3 POWER QUALITY MONITORING EQUIPMENT

The HV power quality meters (PQM) shall either be a power measurement or shall be to the Grid Operator's specification, as appropriate and as determined at the commencement of the project.

The PQM meter shall be installed in the fascia of the respective outgoing/incoming HV panels, complete with shorting link terminals for the CT inputs. Terminals (Weidmuller or equal) shall also be provided for the VT required to form a complete, functional installation.

2.7 AUXILIARY POWER SUPPLIES

2.7.1 DC SUPPLIES

All 132kV and 33kV switchgear protection and control/tripping system shall be rated for 110V DC. The Contractor will therefore provide a suitable 110V DC system for the substation and project protection and control/tripping system.

For the telecommunication systems a 48 V DC system will be provided.

For protection and control/tripping system the 110V DC supplies shall be designed and sized for one hour on full load.

The Contractor shall make further provision for the project substation 48 V DC and 110V DC systems which shall consist of batteries, charger and distribution board for supplying the control, protection and telecommunications system for 8 hours.

The Contractor shall ensure ventilation and environmental requirements are met in the room which accommodates the battery system. The battery system shall be provided with an earth reference.

2.7.2 LV AC AUXILIARY SUPPLIES

The LV AC supplies shall comprise 400V 3-phase and 220-240V single phase supplies at the project substation.

The Contractor will provide LV AC auxiliary supplies derived both from the substation and with standby from the Emergency diesel generator. substation shall be through one auxiliary transformer, suitably rated for 33kV/400V. To cover long duration system shutdowns associated with the Main Transformer, and to provide a supply independent of the auxiliary transformer, provision shall be made at 400V from the Emergency diesel generator, typically rated at 200kVA 400V.

One Standby emergency diesel generator typically rated at 200kVA, the rating of which shall be further reviewed during detailed engineering phase, shall be supplied complete with local control system, and weather proof and sound proof canopy.

The LV AC supplies will provide power, but not be limited to the following services: substation, accommodation, offices, communication systems, security, fire alarm and protection system and garages.

A LV AC distribution board to provide all substation LV AC supplies equipment (including lighting and other small power requirements) shall be supplied by the Contractor.

The Contractor shall supply LV AC devices including LV AC distribution board for the 132kV equipment LV AC supplies.

The Contractor shall make provision for power supplies to the HV export, HV import and LV meters.

2.8 33KV ELECTRICAL SYSTEM

2.8.1 33KV EQUIPMENT DESIGN FAULT LEVEL

All 33kV equipment shall comply with the following minimum design fault level:

- Phase to Phase – 31.5kA for 1.0 second.
- Phase to Earth – 31.5kA for 1.0 second (resistance earth).

The fault levels will comply with the requirements of NTDC/HESCO and will be confirmed in the system studies and design and specification of equipment. It is incumbent upon the EPC supplier to supply equipment that can exceed designed or specified fault levels.

2.8.2 33KV PROTECTION EQUIPMENT

The Contractor shall be responsible for the design, supply, delivery, installation, testing and commissioning of the 33kV protection equipment associated with the project. The design of the protection equipment shall comply with all relevant IEC/Pakistan/Chinese standards and engineering recommendations and would be expected to include as a minimum over-current, earth fault and under/over voltage.

The Contractor shall make provision for 33kV protection equipment associated with each of the PV array 33kV feeder circuits of the substation. The 33kV protection CTs and VTs will form an integral part of the 33kV switchgear to be supplied by the Contractor. The Contractor shall specify the required CT's and VT's to be supplied with the switchgear.

The protection equipment will be installed within the project substation building. All protection, control and tripping DC supplies shall be powered by the site 110V DC battery system.

2.8.3 PV ARRAY CONNECTION SCHEME

The PV modules will consist of 4 independent circuits (arrays or array sections), each one will consist of the number of PV modules indicated below and the Contractor will offer the PV configuration after the Commencement Date considering the Employer's requirement.

2.9 MEDIUM VOLTAGE CABLES AND OVERHEAD LINES

2.9.1 MEDIUM VOLTAGE CABLES

The Contractor shall be responsible for the design, installation and testing of the 33kV cables connecting the plant transformers to the 33kV switchgear in the project substation. The cable system can be either direct buried power cables or bare ACSR (aluminium conductor steel reinforced) overhead lines. For the avoidance of doubt interconnection by buried cables is preferred to overhead lines and is specified elsewhere in the Employer's Requirements.

The 33kV cable system shall be designed to comply with the PV modules rated output (taking account of the power factor required by the Grid Code) and fault level rating of the 33kV network.

2.9.2 CABLE SPECIFICATION

All 33kV cables and associated installation shall comply with the relevant IEE and BS standard as appropriate or the relevant Pakistan standard.

Similar specifications, with suitable rating changes shall also apply to 132kV cables unless specified otherwise by the Grid Operator or in the Grid Connection Agreement. For the avoidance of doubt the latter will take precedence shall apply.

Quantity:	To be determined by EPC Contractor
Primary Manufacturing Specification:	IEC 60502, IEC 60840 / BS7870-4.10 or relevant Pakistan standard
Installation Method:	Direct buried cable
Ground Conditions:	To be determined by Contractor
Number of Conductors per Cable:	Three
Rated Voltage (U_m):	36,000 V

Power Frequency:	50 Hz
Conductor cross sectional area (CSA)	To be determined by Contractor (based on loading and short circuit rating)
Conductor Material:	Aluminium
Conductor Construction:	Stranded Wire
Longitudinal Conductor Water-Blocking:	Required
Insulation Material:	Triple Extruded XLPE or EPR
Semi-Conducting Conductor Screen Type:	Fully Bonded
Semi-Conducting Insulation Screen Type:	Fully Bonded
Screen CSA	To be determined by Contractor (based on loading and short circuit rating)
Screen Material:	Copper
Screen Construction:	Stranded Wire
Armouring:	To be determined by Contractor
Longitudinal Core Water-Blocking:	Required
Outer Sheath Material:	MDPE
Outer sheath colour:	Black

2.9.3 *LAYING DIRECT IN THE GROUND*

The electrical network for the complete Solar PV plant shall consist of underground cables installed in accordance with BS, EN and IEC Standards or the relevant Pakistan standard. All cable trench excavation and back-filling will be carried out under the EPC Contract. Sand for cable bedding and cover and marker tape shall be supplied and installed by the Contractor prior to back filling of the trench. Cables shall be buried at least 700 mm below ground level and the Contractor shall be responsible for all of the excavation required, including excavation in soft and hard rock.

Buried cables shall be at a sufficient depth to avoid damage from traffic and from agricultural processes such as ploughing. Due account shall be taken of the need to pass under streams, culverts, drainage ditches, field drains, channels and existing buried pipes and cables where these exist.

Where the nature of the ground is such that there is a risk of the cables sinking under their own weight, suitable measures shall be taken to prevent this.

Before the cables are laid, the bottom of the trench shall be lined with sifted soil or with approved soft sand well tamped down to a minimum depth of 100 mm to form a bed. After the cables are laid, the first cover of backfill shall consist of a layer of sifted soil or approved soft sand with a minimum thickness of 100 mm above the cable after having been well tamped down, over which cable protective covers shall be placed.

Marker tapes of non-corrodible material, bright yellow in colour and indelibly marked in black with the words "DANGER – 33kV ELECTRIC CABLE", in English and Urdu, shall be placed in the trench after back-filling to a level approximately 150mm below the final surface level after reinstatement. In addition, before back filing, a wide marker tape (equal in width to the excavated trench) shall be laid 200 mm above the cables. This marker cable shall also be of non-corrodible material, bright yellow in colour and indelibly marked in black with the English and Urdu words "DANGER – 33kV ELECTRIC CABLE". In areas subject to uncontrolled third party excavation, a layer of strong plastic mesh shall be laid 200mm above the cable covers for the full width of the trench. The voltage shall be stated as applicable.

Cable marker posts shall be supplied and installed under the EPC Contact. These shall be concrete/ compressed wooden posts with an appropriate sign on each and installed above

ground for underground cables. There shall be at least one marker for every 50m, a minimum of three markers per cable run, additional markers indicating changes of direction where they occur and where cable joints have been made are required. A marker is also required near the start and finish of any cable run.

2.9.4 DUCTED CABLES

Cable protective covers (where required) shall be of reinforced concrete and unless otherwise approved will be 300 mm wide, 50 mm thick and 500 to 1000 mm long. They shall be designed for interlocking one with the other both vertically and laterally. Special covers shall be provided where required for short radius bends.

Alternatively, the joints between the cable covers may be overlapped with a third shorter cover and this procedure can be used to form bends. Cable covers shall laterally overlap the cable by at least 50mm on each side.

Where cable routes need to cross roadways, areas of hardstanding, other services or obstacles they shall be installed in suitable ducts.

Where sufficient depth exists, the ducts may be buried in the road structure of bridges, otherwise the ducts shall be supported by a structure attached to the bridge parapets and suitably protected from accidental or malicious damage.

Buried ducts shall normally be in the form of PVC ducts. Buried ducts should also be suitably sized and installed to support expected loadings. Above ground – e.g. attached to bridge parapets – ducts shall be of galvanized steel construction.

It shall be permissible to install a three phase trefoil group in a single duct. However, no more than one project MV or HV power cable circuit shall be drawn into each duct, and each pipe shall have a nominal internal diameter of not less than 100mm or at least 35mm greater than the diameter of the core or trefoil group to be installed.

Ducts placed under streams or drainage ditches shall be covered with a 150mm reinforced concrete slab to protect them from damage due to drainage clearance/improvement Works.

Ducts buried in the ground shall extend at least one meter beyond the edge of the crossing. PVC ducts shall be completely embedded in concrete with a minimum 150mm thickness of concrete surrounding the ducts on all sides. All ducts shall be sealed at each end with split plugs and bitumen or other approved means to prevent the ingress of water or access by vermin. Sealants required for ducting shall be supplied and installed by the Contractor.

If nose pulling is required, pulling eyes shall be fitted to the cables at the manufacturer's Works. The pulling eyes shall be attached to the conductors and the armour wires. Pulling eyes shall be designed to minimize any tension on the metallic sheath. Cable stockings may be used for smaller power cables where approved by the cable manufacturer. A sufficient number of rollers over which the cable can ride shall be provided to ensure that the cable does not rotate or twist on its longitudinal axis during the pulling operation.

2.9.5 OVERHEAD LINES

If the Contractor opts for to install overhead 33kV power lines they must comply with the following conditions.

The overhead line will be an ACSR bare conductor supported by suitably steel lattice or precast concrete towers.

Consideration of any overhead line routes must be cognizant of vehicle access

2.9.5.1 Design:

The Contractor shall supply as a minimum details of the following,

a) Detailed layout and routing of the overhead line circuits showing gantry, tower and pylon positions; gantry, tower and pylon types, ACSR type and size used at each section.

b) Design drawings of all types of gantries, pylons and towers used.

c) Details of all foundations proposed.

d) Earthing and earth wire

e) Calculations of conductor sag including consideration for all environmental and electrical conditions.

f) Conductor sizing and specification.

g) Insulators, and post insulators details

The design and all applicable calculations shall ensure, that as a minimum, they cover all the following conditions

a) The maximum operating temperature of the cables does not exceed 75degC or the manufacturers' and national recommendations.

b) Maximum wind velocities as per national regulations and local site conditions, whichever is higher.

c) Solar radiation/heat

d) Rainfall

e) Humidity

f) Altitude

g) Ice and snow loading, in conjunction with maximum wind velocities.

h) Atmospheric pollution

i) Soil characteristics

j) Lightning

k) Seismic factors

l) Mechanical cable loading

m) Electrical, steady state and fault conditions loading.

The routing and height of the overhead line should ensure adequate clearances over all natural and man-made obstacles; it shall exceed the minimum standards for clearance.

The pylons or supports for the cable shall have sign's in English and local language, with the wording "DANGER – 33kV OVERHEAD LINE" the voltage being stated as applicable, and a graphical symbol indicating the hazard in accordance with ISO 7010:2003.

All gantries, towers, pylons or supports shall have anti-climb devices to discourage unauthorised people from climbing the supports.

If required by local and national regulations the pylons or supports shall have bird scaring devices.

The termination method at the project substation and MV PVs transformers or to cables shall be submitted to the employer and employer's representative or technical advisor for review.

The Contractor shall provide details of the all calculations and standards applied as well as specifications and sizing calculations for key components.

2.9.6 *Cable Routes*

Cable routes shall remain within the project area, with the possible exception of the cable connection to the grid connection interface.

The Contractor shall endeavour to design cable routes whereby cables are installed in direct buried trenches adjacent to Site access roads to minimize the overall disturbance to the Site.

Any requirement for overhead lines or cables within the project plant will require approval by the Employer.

Any requirement for overhead lines or cables outside the project will require approval by the Employer, the landowner, the local grid operator and all relevant authorities.

2.9.7 *Cable Jointing and Terminating*

The Contractor shall be wholly responsible for the MV or HV cable straight jointing and terminating into switchgear cable termination boxes/chambers supplied under the EPC Contract. The Contractor shall also be responsible for terminating MV or HV cables into switchgear associated with the circuit grid connection.

The Contractor shall design all MV or HV cables route lengths to minimize the requirement for straight joints, all joints shall be identified above ground by cable markers and accurate GPS positions marked on 'As Constructed' drawings.

Jointing of cables shall not be permitted except where it is absolutely necessary and technically feasible to do so. Approval for all positions of inline joints shall be sought from the Employer.

All cable jointing shall be carried out in line with manufacturers approved procedures. All cable jointing materials shall be compatible with the associated switchgear and the design of the associated cable. The detailed procedure of how the cables will be jointed and terminated shall be available prior to any work taking place.

All cable jointing and terminating shall take into account all environmental factors, temperature, dust, precipitation, humidity etc and minimize workmanship errors.

A record shall be kept of all MV or HV cable jointing and terminating. This record shall include the names of the terminator and mate, the cable drum numbers, the date making the terminations, the date of testing them and weather conditions. Four copies of the record signed by the Contractor shall be provided to the Employer. One photocopy shall be included in each of the operating and maintenance manuals.

2.9.8 *Fibre Optic Cable System*

The Contractor shall design, supply, install and test and commission the fibre optic network connections. The Contractor shall be similarly responsible for fibre optic cable interconnections for the grid connection, NCS and GMS SCADA systems (as applicable) and to the telecommunications systems. The Contractor shall follow the advice, and seek the input of the specialist telecommunications Contractor and comply with the requirements of the local grid operator. This will include, as required the termination to SC or ST type fibre optic connectors in splice boxes or 19" rack mount splice trays. The design, layout and type of fibre optic network will require approval by the employer.

The Contractor shall ensure that the power losses (dB) of the fibre optic network design are calculated.

The Contractor shall ensure that the fibre optic network is tested in line with the tests on completion, i.e. bidirectional OTDR and power loss.

The communication network will typically follow the 33kV cabling routes. All fibres shall be buried according to fibre manufacturer's specification. Technical specifications of fibre optics, to which the Contractor shall be procure and install fibre optics, shall be supplied by the SCADA supplier or specialist Telecommunications Contractor. The fibre optic cable shall be in appropriate protection pipe in order to provide mechanical and chemical protection and protection from vermin. If laid adjacent to power cables the fibre cable should be non-conductive.

All joints in the fibre optic system below ground shall be located in a jointing pit to allow for ease of inspection. The cable placement shall be in accordance to the cable manufacturer's recommendations.

The Contractor shall design, supply, install, test and commission the fibre optic network, and connecting the network control system (if required and located in the project substation) to the grid connection interface point, which may be at the marshalling enclosure within the project substation, at the gantry for the overhead line, or at the telecommunications station. The grid connection should comply with the Energy Purchase Agreement.

It is incumbent upon the Contractor to supply, install and commission the fibre optic communication system as required by NTDC/HESCO. The foliowing equipment may typically be recommended.

- OPGW Optical cable.
- Model: G652
- [Project name] optical transmitter and receiver.
- [Project name] to configure a pair of PCM's to receive low frequency audio and data information from Grid Operator's control and monitoring station.
- [Project name] to install a pair of PCM's as a reserve backup communication.

2.9.9 PV MODULE MV TRANSFORMERS

The interconnection network for the PV modules will operate at 33KV. The step up from the generated voltage shall be done using one transformer, which shall be optionally located.

The transformers are to be suitably sized to operate in the ambient conditions as specified in Schedule 4 Annex 5f [*Site Environmental Conditions*].

Each individual transformer shall be equipped with the following main items; A steel enclosure will house a three phase transformer with a 550V AC primary and a 33kV secondary, and a 33kV switch disconnector with integral earth switch also housed in the steel enclosure.

The transformer shall include a 550V feeder, a frame type circuit breaker, a 33kV Circuit Breaker on the 33kV Transformer side as well as relevant control, metering and protection equipment.

The equipment shall be suitably rated for the connection and have the capability to make the inrush current and break the magnetizing current associated with step-up transformer operation.

The earth switch shall be configured to provide a 3 phase earth associated with the 33kV cable connection to the step-up power transformer.

Each 550V to 33kV step-up transformer shall be suitably rated for the PV modules array output. The transformer shall be a three phase naturally air cooled, oil-immersed (ONAN) construction with a delta connected HV (33kV) winding and star connected LV (550V)

winding. The star point neutral shall be connected to the system earth, by suitably sized and rated cables. The transformer shall comply with the relevant requirements of IEC 60076 or the relevant Pakistan/Chinses equivalent.

2.9.10 RING MAIN UNITS (RMUS)

The 33kV Ring-Main-Unit of SF6 gas insulated type (each MV cable connection with load switch and transformer connection with circuit breaker) shall have relevant control, metering and protection equipment. The equipment shall be suitably rated for the PV modules connection and have the capability to make the inrush current and break the magnetizing current associated with step-up transformer operation.

An earth switch shall be integrated and configured to provide a 3 phase earth associated with the 33kV cable connection to the step-up power transformer. HV load switches form an integral part of the switching disconnector and shall protect the 33kV connections associated with the inverter. HV circuit breaker will require to grade with the upstream protection devices, including the protection installed on each feeder at the 33kV circuit protection at the substation.

2.9.11 EARTHING AND LIGHTNING PROTECTION

The Contractor shall be responsible for designing, installing, and testing all earthing for the PV plant, including the ground earthing for the PVs.

The earthing and lightning protection systems for the PVs and ancillary equipment shall be designed to comply with the relevant IEC standards, European Norms, or Pakistan/Chinese Standards. Where IEC standards or European Norms conflict with the corresponding Pakistan Standards, the Contractor shall notify the ER.

- All earthing conductors shall be copper.
- Lightning protection systems shall comply with IEC 62305, IEC 61643, IEC 61663,EN 50122 and IEEE standards.
- Earthing systems shall comply with IEC 60364 and IEC 61936.
- Calculations for lightning protection shall be in accordance with IEC 61024.
- Calculations for earthing shall be in accordance with EN 50122 or IEEE 80.

2.9.12 PV ARRAY AND SUBSTATION LIGHTNING PROTECTION AND EARTHING

The PVs, Substation and associated equipment shall be suitably protected against lightning damage.

The combination of the lightning protection system together with the earthing system shall prevent harm or danger to people in the immediate vicinity of the PVs, or other equipment. These systems shall also prevent fire within the PVs, substation, and equipment; and prevent mechanical damage.

The electrical, SCADA and communications systems, including the control computers, power electronics, and electromechanical devices shall be protected against voltage transients by suitably rated and located surge arresters in accordance with appropriate IEC standards or their Pakistan equivalent.

The Contractor shall carry out soil electrical resistivity tests to the extent necessary to establish the actual values upon which earthing calculations can be based.

The Contractor shall prepare and submit detailed calculations and designs for the PV modules earthing, the substation earthing.

Calculations for lightning and earthing protection shall be in accordance with the latest editions of the following standards or the relevant Pakistan/Chinese equivalent standard or recommendation:

- IEC 60479 - Effects of current on human beings and livestock.
- IEC 61024 - Protection of structures against lightning.
- BS 7430 – Code of Practice for Earthing.
- ER S34 – A Guide for Assessing the Rise of Earth Potential at Substation Sites.
- Technical Specification 41/24 – Guidelines for Design, Testing, Installation and Maintenance of Main Earthing Systems in Substations.

Note: details of all applicable relevant or equivalent Pakistan standards that are used shall be submitted to the employer.

After system commissioning the Contractor shall submit lightning and earth protection test results, performed using an approved test meter, to the ER.

No extra costs will be allowed or approved in the event the actual earthing is more extensive or more substantial than the earthing included in the EPC Contract Price. Any risk associated with the possibility of increased cost in this regard shall be borne by the Contractor.

The earthing design shall be such that the effect of ground potential rise and current levels will not endanger the safety of people or equipment under normal and fault conditions, while ensuring continuity of service. If the Site is classified as a 'hot site' then protection activities shall be taken by Contractor for the safe operation of the equipment.-

2.9.13 Earthing, Grounding and Bonding

All electrical equipment shall be connected to earth. Earth circuits must use copper conductors. All mechanical services made of metallic materials shall be bonded to the earthing terminal in accordance with the relevant standards. Bonding shall also be carried out between earthed metal and extraneous metalwork with which people may accidentally come in contact. Extraneous metalwork includes, but is not limited to:

- Ladders and access equipment.
- Accessible structural steelwork.

Fences and gates shall be earthed in accordance with the relevant Pakistan standard.

All equipment supplied shall have relevant and suitable earthing terminals in line with the above standards or Pakistan equivalent and BS 7671, for earthing system design.

The following text in English shall be reproduced on warning signs that shall be clearly and permanently fixed to earth electrodes:

SAFETY ELECTRICAL CONNECTION – DO NOT REMOVE

2.9.14 *Low Voltage Cables*

The LV cables and conductors shall be identified by colour, by characters, or by both. Cable and conductor markers shall be durable and shall not fade with solar radiation, or effects of the ambient weather conditions.

After installation and termination, but prior to connection to the respective items of equipment, the Contractor shall perform:

a) Insulation resistance tests on each length of cable, at the following voltage levels:

Circuit Nominal Voltage	Test Voltage dc (V)	Minimum Insulation Resistance (MΩ)
SELV an	250	0.25
Up to and including 500V, but excluding the above.	500	0.5
Above 500V	1000	1.0

b) A conductor continuity and phase identification test.

c) Earth loop impedance measurements.

The cable tests results shall be recorded, in accordance with requirements ETCI 1012004 National Rules for Electrical Installations and shall be included in the O&M manuals.

2.10 Substation Building And Compound

2.10.1 *General*

The General Requirements for the substation building and compound are described in Schedule 4 Annex 3b Civil Works Specification.

2.10.2 *Substation Building Particular Electrical Requirements*

The substation building shall comprise the following areas for installation of the electrical, control, and communications equipment detailed in these Employer's Requirements, and other equipment as required by the Grid Operator and the project design developed by the Contractor:

- 33kV Middle voltage switchroom, housing the Employer's MV switchgear panel.
- Low voltage switchroom/SCADA room or control room, housing the communications equipment, the Control Building mimic panel, the Employer's metering and instrumentation, the protection relay panel(s), the building services panels and the SCADA system operator station.
- Battery room, housing the related battery and battery charger.
- Metering room / cupboard, housing the Utility's metering equipment, protection relay panel(s).
- Stores / workshop area and a toilet.

urther to the design and construction of the substation building and installation of the electrical, control, and communications equipment, the EPC Contract shall also provide:

- Adequate power and lighting, including emergency lighting, for the substation in accordance with Pakistan standards.
- Fire detection and alarm system.

2.10.3 SUBSTATION COMPOUND PARTICULAR ELECTRICAL REQUIREMENTS

The substation compound shall contain the following electrical equipment and other equipment as required by the Grid Operator and the project design developed by the Contractor:

- 132kV feeder(s) from grid connection
- 132kV switchgear
- Main Transformer
- Capacitor bank (if not located within the Substation Building)
- Pre-insertion resistor (if required)

2.11 CCTV

A CCTV system will be installed with cameras to provide coverage of:

- The 132kV Switchyard, substation building (equipment rooms and control rooms), compound and main gate
- PVs, covering the view of MV Transformer/RMU.
- The grid connection where it enters the site

The control unit for the CCTV system will be located within the SCADA / control room of the substation. The system will be operated locally and remotely. A dedicated monitor will not be required within the substation but camera images will be viewed on the existing computer monitor when required.

2.12 TEMPORARY SITE POWER SUPPLIES FOR CONSTRUCTION

2.12.1 SITE CONSTRUCTION & TEMPORARY COMMISSIONING LVAC SUPPLIES

The Contractor shall make provision for suitable LVAC supplies during site construction of the project, for all temporary accommodation, construction, and commissioning activities for the Contractor, Employer's offices and PVs array construction and on-site project management team. This is expected to be up to 250kVA(It shall be finalized during construction of TSF CAMP).

The Contractor shall provide permanent power supplies during the period of commissioning. This detail shall be included within the commissioning procedures.

13 CALCULATIONS AND STUDIES

Prior to placing any orders for equipment, as part of his scope the Contractor shall carry out calculations and studies to the stated standards or Pakistan/Chinese equivalents, as necessary, including but not limited to the following:

a) Fault calculations per IEC 60909 covering all HV , MV, and LV systems

b) Protection studies and relay settings covering all HV,MV, LV and DC systems

c) Electrical system studies performed on E-TAP software or such other software as may be mutually agreed between the Parties(Grid study will be provided by the Employer for reference)

d) Cable sizing and electrical losses calculations (including economic optimisation) per IEC 60287

e) Lightning Protection calculations per IEC 61024 – Protection of structures against lightning

f) Substation earthing calculations:

   i. IEC 60479 – Effects of current on human beings and livestock

   ii. BS 7430 – Code of Practice for Earthing

   iii. ER S34 – A Guide for Assessing the Rise of Earth Potential at Substation Sites

   iv. Technical Specification 41/24 – Guidelines for Design, Testing, Installation and Maintenance of Main Earthing Systems in Substations

   v. IEEE Standard 80

   The Earthing design of the substation and consequent installation shall ensure that the effect of ground potential rise and current levels will not endanger the safety of people or equipment under normal and fault conditions, while ensuring continuity of service.

g) Battery and battery charger sizing per Pakistan standards or IEEE 485.

h) UPS and battery sizing per Pakistan standards or IEEE 485.

i) Lighting calculations per Pakistan standards or CIBSE Standards or EN 12464

2.13.1 PROTECTION STUDIES

The Contractor is responsible for ensuring correct protection co-ordination within the PV power plant site, from the MVPVs transformer switch protection device through to the grid incomer protection settings except those related to grid connection system.

The protection study shall include but not be limited to the following elements:

- Over-current, directional over-current and earth fault relay co-ordination with grading curves.
- Overload protection
- Differential protection
- Unit protection
- Overvoltage and under-voltage protection.

Over-frequency and under-frequency protection studies and system studies shall cover all equipment and systems including but not limited to MV transformers, 33kV system including

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switchgear and cabling, reactive compensation equipment (if required), main transformers and HV switchgears.

2.14 Spare Parts And Special Tools

The Contractor shall list and supply the spares required for the commissioning of the Works. A full inventory of these spare parts shall be ready for use and stored either on Site or locally.

One set of special tools necessary for proper installation, operation, maintenance and monitoring of the proposed shall be provided by the Contractor. In addition, the Contractor shall supply one complete set of electrician's tools, each including a high quality multi-meter (Fluke) and housed in a suitable tool chest or cabinet inside the substation store/workshop room.

ANNEXURE-IV

Siachen Energy Limited
Annex A Schedule 5
SCADA Specifications

Contents

1 INTRODUCTION

The Contractor shall be responsible for detailed design, supply, installation, testing and commissioning of the entire SCADA system and associated network components and equipment within the Solar PV power project.

The Solar PV power project's control room shall have (a) a Solar PV array SCADA system for control and monitor the PVs within the plant and; (b) a BOP SCADA system for control and monitor the required systems and components not included in the Solar PV array SCADA system.

For information, this shall include:

- Solar PV array monitoring units
- BOP monitoring unit (monitoring the substation switchgear and MV transmission system)

The SCADA server shall be located in the project substation control room of the substation building.

2 SCOPE OF WORK

The PV plant is monitored and controlled through a SCADA system built in substation control room, which will be used for online operation, monitoring, processing of user-defined reports and statistics as well as remote monitoring of entire PV Plant for operation & maintenance purpose.

2.1 DATA ACQUISITION

The SCADA system in normal operation shall;

i. 24h/15m Log

The data available in the 24h/15m log are a group of analogue data stored as average values of 15 minutes over the latest 24 hours. In the menu of the controller, it can be configured and is available for presentation.

ii. Production Overview Log.

The Production Overview Log provides information on energy produced by monitoring of PV arrays during certain period.

iii. Availability Log

The Availability Log allows information on amount of time PV array has been available for production during a certain period. It is measured in percentage and is calculated through the ratio between the amount of time a PV array produced energy and the total amount of time in the given period where the irradiation is above or equal to a defined value.

iv. Plant Overview

An Overview screen gives a current data list view over all PV arrays in the Complex.

v. Weather Station Data

The weather station (six sets) panel shows weather conditions at the Complex site.

The EPC Contractor shall be responsible to arrange all the equipment and material brand new from internationally reputable manufacturers in compliance with the relevant international standards. The provision, installation and commissioning of SCADA equipment at the Substation to receive data from the Complex shall also be the responsibility of EPC contractor.

2.2 SOLAR PV PLANT CONTROL

The Employer shall have access to all PV modules via the Solar PV array SCADA system which shall be used in the normal operation of the solar PV power plant. It will capable of control of all relevant components of the plant including the individual PV array, Inverters, MV transformers, groups of transformers. The plant control functions will include but not be limited to:

a) switching on and off Inverters/ MV transformers.
b) setting power for a single PV array, a selection of PV arrays and for the whole PV arrays
c) Substation equipment control

2.2.1 ALARMS AND EVENTS

The SCADA system shall record an error list, each error listed with error number and downtime associated with error. Alarm data shall be recorded and made available. There should be a description included with each error. It should also be possible on the error list to enter text into a field. This would facilitate an operator putting in a brief description of the error and how the problem was rectified i.e. part repaired / part replaced / awaiting Inspection etc. this data would be stored with the error list and linked to the specific error.

If any array of PV modules is switched off or has a fault, it should be shown on the SCADA System. This event, in turn, will cause the processing of data from this PV array to be suspended utility is running again.

The software shall provide a priority alarming system, such that each alarm may be assigned a priority by the user and each priority shall have a unique display message. It shall also be possible to filter alarms based on priority this shall allow, for example, separation of alarms which cause the Inverters to stop from those that do not.

Each fault in the system shall generate a log file, where all data is recorded to the highest possible resolution for 5 minutes before and 5 minutes after the fault.

An alarm notification system shall be provided which alerts operation and maintenance staff if any part of the project requires attention via SMS and also has the capability of notifying the relative people via email, if applicable.

The SCADA system shall provide remote indication of the Substation status and alarms; these indications must include but not be limited to;

- Earthing Switch Position
- Circuit Breaker Position, and Fault Status
- Miniature circuit breaker tripped (as a group signal)
- Protection activated (as a group signal)
- No busbar voltage
- Voltage Transformer MCG tripped (as a group signal)
- Low SF6 Gas Pressure
- Positive / Negative ground fault detection indication

2.2.2 *SECURITY*

Appropriate security is required on the SCADA system. The security policies should include a hierarchy of access allowing control over the functions available to different operators. This security system shall also include firewalls and virus protection.

2.3 DISPLAY

The user interface for the SCADA system will allow operators to see the entire plant at one time by displaying a map and diagrams of the PVs, MV transformers/RMUs and Substation. It shall be possible to view specific elements of the plant in more detail- e.g. individual inverters, major equipment etc- via different screens in the supervisory system.

2.4 COMMUNICATIONS

The communications network shall connect to all the main equipment, the equipment of the electrical infrastructure such as the Substation and other facilities of the plant, up to and including the point of disconnect, via industry standard data communication hardware and software.

2.5 GENERAL OPERATION

Should the SCADA system fail, the PVs. the inverters, the MV transformers and other electrical systems shall continue in operation unless such operation compromises the safety of the equipment.

The SCADA system shall be traceable and transparent in operation. It shall be structured in such a way as to provide maximum data integrity.

The SCADA system shall be able to facilitate interfacing to a maintenance management system and to forecasting tools.

2.6 NETWORK CONTROL SYSTEM

The Contractor shall be responsible for the design, supply, delivery, installation, testing and commissioning of the network control system (NCS) to monitor and control the all substation equipment (including substation auxiliary supplies switchgear), reactive power compensation and grid connection equipment.

The Contractor shall be responsible for the design, supply, installation, testing and commissioning of the communication system between the substation and the grid to allow data exchanging with regional and central grid operators.

The Contractor shall provide all necessary signal connections between the NCS equipment and switch room, control room and substation equipment including but not limited to connections to; 132kV and 33kV intelligence control measurement (switchgear) and protection panels, substation auxiliary power supplies switchgear, metering and power quality measurement panels, measurement CTs and VTs, DC power supplies, UPS, other monitored equipment as necessary, as well as all connections to the external telecommunication data links.

The Contractor shall provide a detailed list of all digital and analogue inputs and outputs that are available for the Network Operator. This signal list needs to be agreed with the local Network Operator.

2.7 GRID INTERFACE SIGNAL LIST

All signals to and from the Energy Purchaser's control centre have to be interfaced at the project site and this needs to be clearly defined by the Grid Interface Signal List for the project. The Grid Interface Signal List will be finalised at a future date between all parties i.e. Employer, Contractor and Transmission System Operator (TSO). The Contractor shall participate in meetings with the Employer and TSO to discuss and agree a finalised Signal List.

2.8 SOFTWARE

All software, licences, keys and dongles etc for the configuration, management and administration shall be provided. Two sets of all the appropriate software and licences shall be provided.

2.9 TELECOMMUNICATIONS SYSTEM

The Contractor shall design, supply, install test and commission equipment that complies with the minimum requirements for the telecommunications connection to the plant. Since the project is a power station, this will be classed as a 'Hot Zone' for telecoms.

The Contractor shall design, supply, install, test and commission the required telecommunications links (including provision of all ADSL and PSTN terminal equipment, telephone handsets, and all voice and data connections) from the SCADA servers to the telecommunications utility equipment.

The Contractor shall provide the telecommunications connections. The scope of work shall include the provision of voice and data communications. Sufficient communication facilities are required to satisfy the requirements of the SCADA.

The Contractor shall make an application to the telecommunications utility's terminal points on behalf of the Employer for the provision and commissioning by telecommunications utility's terminal points of the required telephone lines above including all associated hardware, handsets and equipment. As part of his scope of supply, the Contractor shall bear all costs, including but not limited to costs associated with the application for telephone lines and any and all costs levied by telecommunications utility's terminal points for the design, supply, installation, testing and commissioning of the required lines and associated hardware, handsets and equipment including all cabling to the Site from the point of connection to the telecommunications utility's terminal points network. All cabling within the Site from the various equipment to the telecommunications utility's terminal equipment shall be designed, supplied, installed, terminated and commissioned by the Contractor.

2.10 METERING SYSTEM AND BACKUP METERING SYSTEM

A Metering system and a Backup Metering system must be installed that complies with the requirements of NTDC Specification P-199:2008 and Specification P-201:2008 and the requirements of the EPA for determining the Complex Net Delivered Energy.

The procurement and supply of the Main Metering system is carried out by the Energy purchaser.

The procurement and supply of the Backup Metering system is included within the scope of work of the Contractor.

The Metering system and Backup Metering system must be supplied with valid calibration certificates, and be capable of being sealed such that adjustment of the calibration cannot be made without removing the security seal.

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2.10.1 Enclosure and Security

The Metering System and Backup metering system must be located within a separate air-conditioned room within the substation building. the installation shall be designed such that it is possible to carry out local reading of both metering systems without entering a restricted HV environment, and allows for installation of the metering system in upright panels with appropriate channels, and ducting for the cable installation.

2.10.2 Data Recording and Telecommunications

The Metering System and Backup Metering System must be designed as class 0.2 in accordance with NTDC Specification P-201:2008 with an inbuilt telemetry system that is capable of monitoring the Net Delivered Energy and;

a) maintaining records for a minimum of 90 days

b) providing a telemetry feed of the readings to the Control room

c) complies with the requirements of the EPA

3 INSPECTIONS AND TESTING

SCADA system acceptance tests will be performed by the Contractor to demonstrate to the Employer the proper functioning of the SCADA system.

The Contractor shall provide a program, and detailed test document for comment at least 4 weeks prior to tests. This document shall describe the procedure for carrying out the SCADA system acceptance tests and other relevant details of the tests required.

The Contractor must ensure that the tests carried out on the Metering System and Backup Metering system comply with the requirements of the EPA. The Employer reserves the right to witness these tests and to carryout independent testing of the Metering System and Backup metering System.

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