RENEWX SOLAR UMPIRE PVT. LTD.

&

GRESSUS GREEN ENERGY SYSTEMS PVT. LTD.

Presents

A TECHNICAL REPORT On

20 MW(AC) Solar PV Plant At ZHADIMA VILLAGE, CHIEPHOBOZOU BLOCK, KOHIMA, NAGALAND

INDEX

ABBREVIATIONS

NSM	:	National Solar Mission
AD	:	AcceleratedDepreciation
BOP	:	BalanceofPlant
CDM	:	CleanDevelopmentMechanism
CEA	:	Central ElectricityAct
CER	:	Certifiedemissions reduction
CERC	:	Central ElectricityRegulatoryCommission
COD	:	Commercial OperationDate
DER	:	DebtEquityRatio
DISCOM	:	DistributionCompany
DPR	:	DetailedProjectReport
DSCR	:	DebtServiceCoverageRatio
DSRA	:	DebtServiceReserve Account
EA	:	ElectricityAct
EBIDTA	:	Earnings Before Interest,Depreciation,Tax& Amortization
ECB	:	External Commercial Borrowing
EOD	:	EventofDefault
EPS	:	Electric Power Survey
FACR	:	Fixed AssetCoverageRatio
FCL	:	ForeignCurrencyLoan
FI	:	Financial Institutions
GHG	:	GreenHouseGases
GoI	:	GovernmentofIndia
GoR	:	GovernmentofRajasthan
IDC	:	InterestDuringConstruction
IPP	:	IndependentPower Producer
PFS	:	PTC Financial Services
kWh	:	Kilowatt-Hour
LC	:	Letter ofCredit
LSHS	:	LowSulphur HeavyStock
Mn	:	Million

MNRE	:	MinistryofNew&RenewableEnergy
MoEF	:	MinistryofEnvironment andForest
MOP	:	MinistryofPower
MOU	:	Memorandum ofUnderstanding
MU	:	MillionUnits
MW	:	MegaWatt
NAPCC	:	NationalActionPlanfor ClimateChange
NEP	:	NationalElectricityPolicy
NG	:	NaturalGas
O&M	:	Operations &Maintenance
PAT	:	Profit AfterTax
PBT	:	Profit BeforeTax
PCB	:	PollutionControlBoard
PE	:	Private Equity
PIM	:	ProjectInformationMemorandum
PLF	:	PlantLoadFactor
PO	:	Purchase Order
PPA	:	Power PurchaseAgreement
R&D	:	ResearchandDevelopment
RE	:	RenewableEnergy
REC	:	RenewableEnergyCertificates
RoI	:	RateofInterest
RPO	:	RenewablePurchaseObligation
SCADA	:	SupervisoryControl andDataAcquisition
SEB	:	StateElectricityBoard
SERC	:	State ElectricityRegulatoryCommission
SLM	:	Straight LineMethod
SPV	:	SpecialPurposeVehicle
TNW	:	TangibleNetWorth
TOL	:	Total OutsideLiabilities
UNFCCC	:	UnitedNations Framework Convention onClimateChange
WC	:	WorkingCapital

Chapter 1

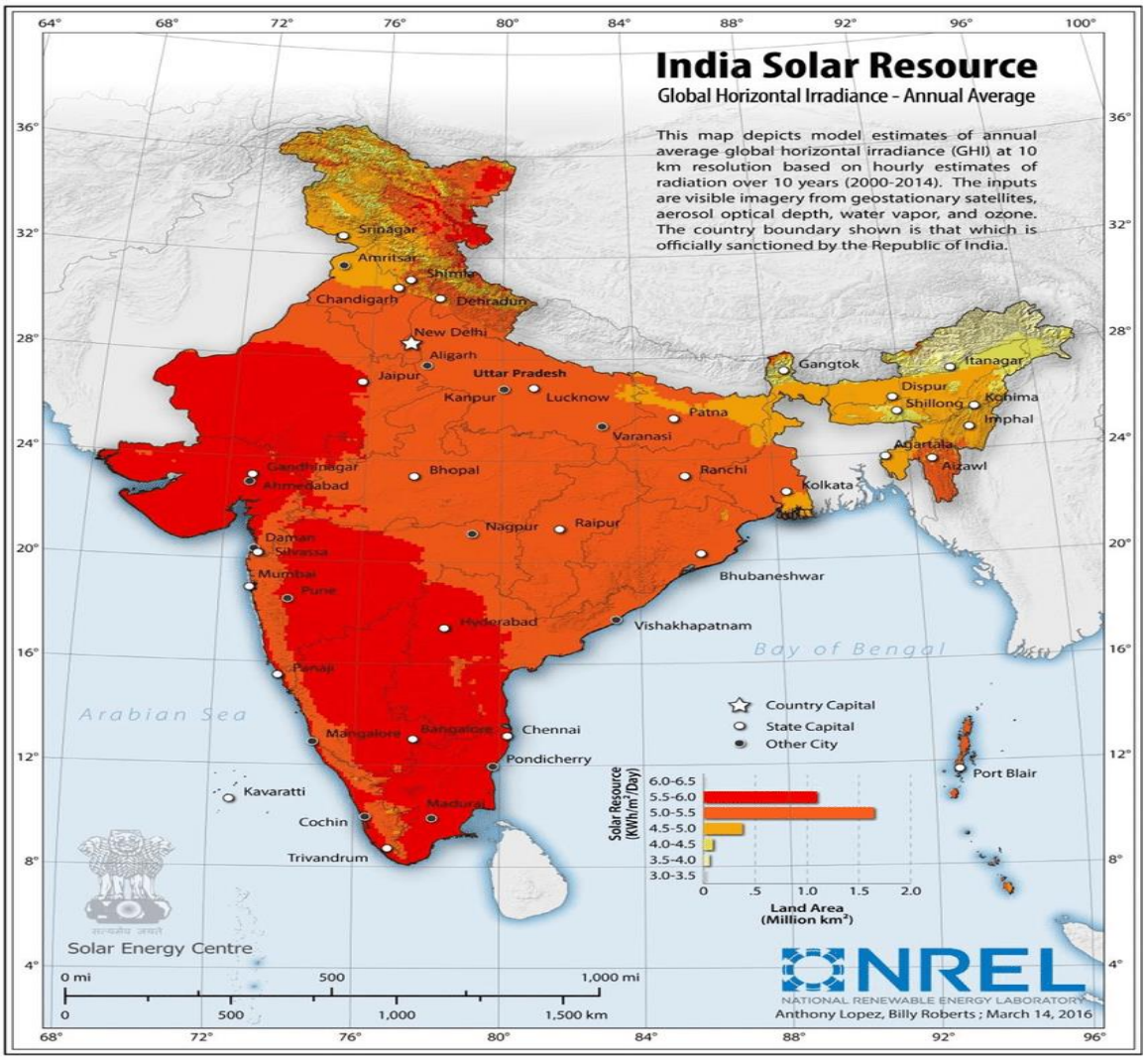
Solar Power in Nagaland

1.0 Introduction

According to a document by the Ministry of New & Renewable Energy (MNRE), India's Solar Potential is estimated to be about **748 GW** as per the report by *National Institute of Solar Energy in India.* The solar power potential has been estimate during the waste land availability data in every state and jurisdiction of India. The estimate is based on the assumption that only 3% of the total waste land available in a state is used for development of solar power projects. However, the tapped solar power output stands at a meager **1%**.

1.1 Solar Radiation over Nagaland

The daily average global radiation is around 5.0 kWh/m^2 in north- eastern and hilly areas to about 6.0 kWh/m^2in western regions and cold desert areas with the sunshine hours ranging between 2300 and 3200 per year. In most parts of India, clear sunny weather is experienced for 250 to 300 days a year. The annual global radiation varies from 1600 to 2200 kWh/m^2. Figure presents the global solar radiation map of India based on the measured data of Indian Meteorological Department.



1.1.1 Irradiation at Chiephobozou

The Solar Irradiation received at Chiephobozou site is estimated to be about **1632kwh/m^{2}per year.**

1.2 Climate of Nagaland

The climate is warm and temperate in Chiephobozou. In winter, there is much less rainfall in Chiephobozou than in summer. According to Köppen and Geiger, this climate is classified as Cwa. The average temperature in Chiephobozou is 22.6 °C | 62.6 °F. The annual rainfall is 1610 mm | 66.3 inch.

The driest month is December, with 15 mm | 0.6 inch of rainfall. With an average of 259 mm | 10.2 inch, the most precipitation falls in June.

The warmest month of the year is July, with an average temperature of 26.7 °C | 70.2 °F. January has the lowest average temperature of the year. It is 15.9 °C | 60.6 °F.

In July the highest number of daily hours of sunshine is measured in Chiephobozou on average. In July there is an average of 10.26 hours of sunshine a day and a total of 317.16 hours of sunshine throughout July.

In January, the lowest number of daily hours of sunshine is measured in Chiephobozou on average. In January there are an average of 7.2 hours of sunshine per day and a total of 254.16 hours of sunshine.

Around 3353.06 hours of sunshine are counted in Chiephobozou throughout the year. On average there are 110.23 hours of sunshine per month.

1.3 Energy Scenario at Nagaland:

As of March, 2023, the total contracted capacity for Nagaland is 226 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 43 %.

The fuel-wise contracted capacity as of March, 2023 is given in Table and Figure below:

Table 1 Fuel-wise Contracted Capacity as on March, 2023

Source	Contracted Capacity (MW)	Percentage (%)
Coal	52	23
Gas	76	34
Hydro	97	43
Solar	1	0.4
Total	**226**	**100**

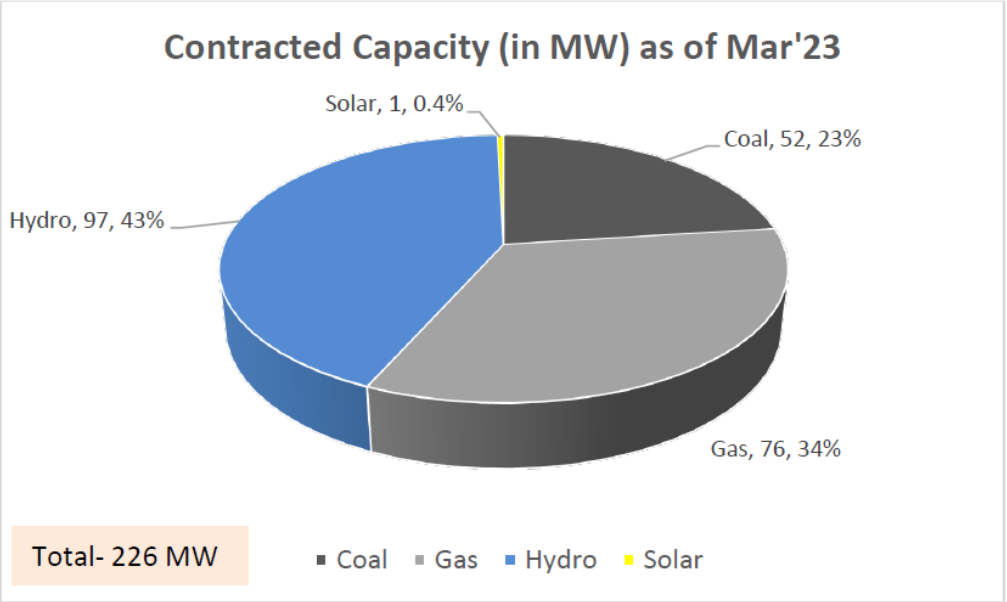
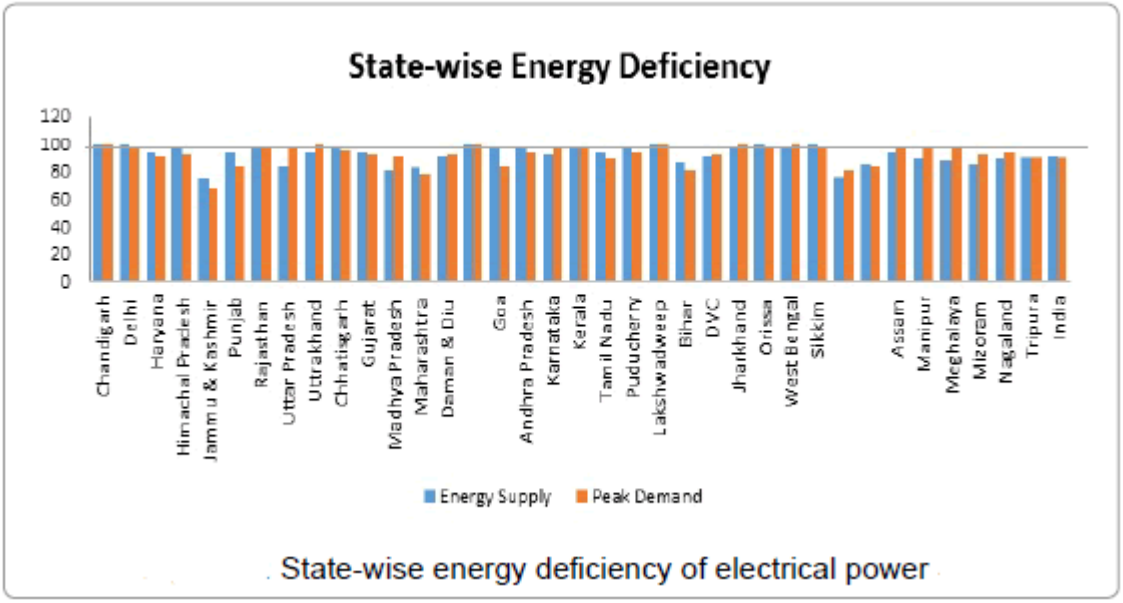


Figure 1 Fuel-wise Contracted Capacity (in MW) as on March 2023

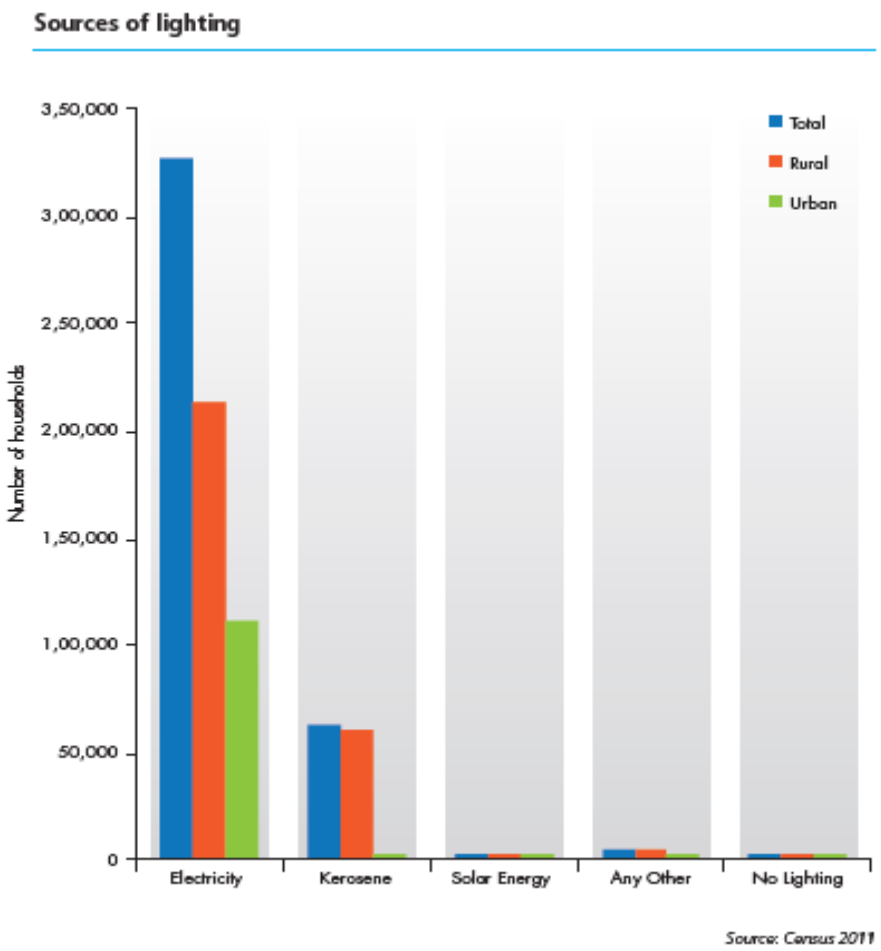
One of the seven states of India, Nagaland has a total installed capacity of 141 MW. Renewable energy, like most states in the region, refers only to SHP plants. The state has an untapped potential to harness seven GW of solar power. The state provides electricity to almost 70 per cent of its households; only 63,560 households do not have access to electricity in the state.

Right now Nagaland buying from the open market by tapping from the North East or National Grid to meet its energy demand.

During dry season, cost of electricity goes up since major energy/electricity is produced mostly from Thermal/Gas/Coal since hydro electricity generators run dry.



State-wise energy deficiency of electrical power



Solar power projects can be setup in a much shorter time frame when compared to conventional power projects. Also, the cost of solar power has become more economical.

The State government is keen to tap the solar potential and promote this clean source of energy to meet the rising energy requirements of the State. The following factors make Chiephobozouideal location for setting up Solar Power Projects:

Availability of about 300- 330 sunny days in a year.
Level of Solar isolation (4.4 -5.5 kWh/m2/day).
Average Rainfall.
Large demand of energy uses.

The Table given below shows the Sunrise, Sunset, dawn and dusk time for Nagaland (As on19th Aug' 2024)

(Source-www.gaisma.com)

Date	Sunrise	Sunset	Length	Dawn	Dusk	Length
Today	04:49	17:45	12:56	04:25	18:09	13:44
+1 day	04:49	17:44	12:55	04:25	18:08	13:43
+1 week	04:52	17:39	12:47	04:28	18:02	13:34
+2 weeks	04:54	17:32	12:38	04:31	17:55	13:24
+1 month	05:01	17:14	12:13	04:38	17:37	12:59
+2 months	05:14	16:43	11:29	04:51	17:06	12:15
+3 months	05:33	16:24	10:51	05:08	16:48	11:40
+6 months	05:47	17:08	11:21	05:24	17:32	12:08

The Figure given below shows the Graph for Sunrise, Sunset, dawn and dusk time for Nagaland (As on 19th Aug 2024)

1.4 Nagaland Solar Energy Policy:

1.4.1 Vision

To reduce the dependence on conventional sources of energy by promoting the development of non- conventional energy sources and most important, solar power there by enabling the State in attaining self-sufficiency in its energy needs. Aim is to create an enabling environment for installation of 25000 MW of solar power through State or Private Enterprises or through Public Private Partnership or through individual efforts.

1.4.2 Objectives

a. Developing a centralized hub of solar power of 25 MW capacities to meet energy requirement of Nagaland.
b. Contributing to long term energy security of Nagaland as well as ecological security by reduction in carbon emission.
c. Providing a long-term sustainable solution for meeting energy needs and considerably reducing dependence on depleting fossil fuel resources like coal, oil and gas.
d. Generating direct and indirect employment opportunities in all activities related to the generation of solar power.
e. Envisaging a solar center of excellence that would work towards applied research and commercialization of nascent technologies to accelerate the march to grid parity**.**

1.4.3 Nodal Agency

State nodal agency Nagaland Renewable Energy Development/DOPN to act as Nodal Agency for Clearance of Projects-

a. Registration of projects.
b. Approval of projects.
c. Facilitating allotment of Government land (leased land)
d. Facilitating water allocation for Solar Thermal Power Plants.
e. Facilitating approval of power evacuation plan and allocation of bays etc.
f. Facilitating execution of PPA/ WBA with DISCOMS of Nagaland.
g. Accreditation and recommending the solar power project for registration with Central Agency under REC mechanism.

1.4.4 Grid Interactive Solar Power Projects

a. Setting up of Solar Power Plants sanctioned under guidelines of MNRE/ National Solar Mission (NSM):

The State will promote setting up of Solar Power Plants sanctioned under the guidelines of MNRE/ National Solar Mission (NSM).

b. Setting up of Solar Plants in Nagaland for sale to DISCOMS of Nagaland:

The State will promote setting up of solar power projects for sale to DISCOMS of Nagaland on the tariff determined by NERC through competitive bidding process to the extent of Renewable Purchase Obligation (RPO) target fixed by NERC.

1.5 Procurement of Land

a. Allotment of land to Solar Plant Developer:

Private land will be allotted to solar Plant Developer (on lease) for setting up of power plant based on Renewable Energy Sources.

b. For Setting up Solar Power Plant based on different technology, Maximum land which can be allotted to the Solar power producer shall be as follows:

S.No.	Technology	Maximum land required
1	SPV on Crystalline Technology	4-4.5 Acre /MW

1.6 Completion Time Schedule for the Projects

The completion time schedule for the Solar Power Plants will be as under:

Type of SPV Projects	Completion Time Schedule
Upto 20 MWp Capacity	Within 15-18Months from the Date of approval
More than 20 MWp and Upto 50 MWp Capacity	Within 17-20Months from the Date of approval
Upto 50 MWp Capacity	Within 24 Months from the Date of approval

1.7 Evacuation and Grid Interfacing

Evacuation of produced Solar Power shall be made through the transmission and distribution network being maintained by DISCOMS. For augmentation of Transmission/ distribution system to evacuate the power from receiving Sub-station, DISCOMS of Nagaland shall develop/ augment the necessary transmission/ distribution network within mutually agreed time frame.

Connectivity at EHV substation (400, 220 &132kV) and Distribution Substation (33/11kV and LT) shall be decided/ approved by DISCOM respectively in consultation with NREC. Minimum capacity and voltage level of Solar Power Project getting connected to NREC's receiving GSS shall be 5 MW at 33kV.

Grid interfacing shall be governed by CEA (Technical Standards for Connectivity to Grid), Regulations 2013 and the NERC (Nagaland Electricity Grid Code) Regulation, 2007with latest amendment.

Metering arrangement shall be made as per Central Electricity Authority (Installation &operation of Meters) regulations, 2006, the Grid Code, the metering Code and other relevant regulations issued by NERC/CERC in this regard.

****

Chapter 2

Project Location

2.0 Project at Glance

1	**General Details:**	
	Project	20 MW Solar Power Project
	Owner	RENEWX SOLAR UMPIRE PVT. LTD. & M/s GRESSUS GREEN ENERGY SYSTEMS PVT. LTD.
	Location of Plant	VILLAGE-ZHADIMA, BLOCK-CHIEPHOBOZOU, KOHIMA, NAGALAND
	Location details	N-25° 44'23.12", E-94° 02'09.13"
	Land Owner	Mr. K.T. Vilie
2	**Connectivity to Land:**	
	Access by Road	Connecting with NH-29 DIMAPUR TO ZHADIMA-90 KM
	Access by Rail	Nearest railway station- Shokhuvi railway station.
	Access by Air	Nearest Airport Dimapur Aiport (approx 90 km)
	Telecommunication	Proposed Airtel Tower on site(Proposal approved by state Airtel head)
	Land	Approx 110 acre (Private)
	Land Characteristics	Hilly terrain (underdeveloped)
	Source of Water	Water Ponds available (12 months natural water resource available)
	Nearest Police Station and distance	IRB camp(1km)
	Nearest Hospital and distance	Kohima-20 km
	Nearest Fire station and distance	Kohima-20 km
	Nearest Sea shore and distance	West Bengal (Digha- 1558 km)

3	**Climate:**	
	Climate	Monsoon Climate with high humidity
	General Weather condition- Min Temp, Max Temp	Min Temp:10-15*C & Max Temp:40-42 *C
	Rain fall pattern	May to September (Between 70 to 100 inches)
	Irradiation Details Considered	Approx 1687.3kwh/$m_2$per year
	Seismic Zone of region	Seismic Zone V
4	**Solar details:**	
	Type of PV module	Mono Crystalline Module
	Capacity of each module	>540 Wp
	Capacity of each Inverter	>250kVA
5	**Power evacuation details:**	
	Permission required for Power Generation: Yes/No	NO (NOC from State Department issued in our favour)
	33 KV or above transmission Network availability:	33KV/132 KV AVAILABLE
	a) Distance of supply point from the proposed site	Approx 3 km
	b) Distance of nearest substation from proposed site	Approx 3 km
	c) THE MODE OF EVACUATION	33 KV or above TRANSMISSION LINE is in the mode of evacuation
	d) Right of way requirement up to the delivery point	Available
	e) Construction power availability & identify source distance	Available
	f) Substation Load side voltage level (KV)	33/132/220 KV
	g) Check Space availability in substation to connect power output to the existing system (Bay area) and for extra transformer	Available
	h)Any transmission line/ communication line passing through proposed site	11 KV & 415VTransmission line passing through various land parcels.
	i) Check protection system details of Substation (Get complete substation SLD and Bay drawing if possible) :-	Available

6	**Others details:**	
	Nearest Industry: Category & distance	No Industry
	Availability of Labour and cost of labour	Available
	Can truck of Multi axel with 40-foot container reach site??	Yes
	Availability of vehicle for hiring / Cost per KM	Available

2.1 Site Description

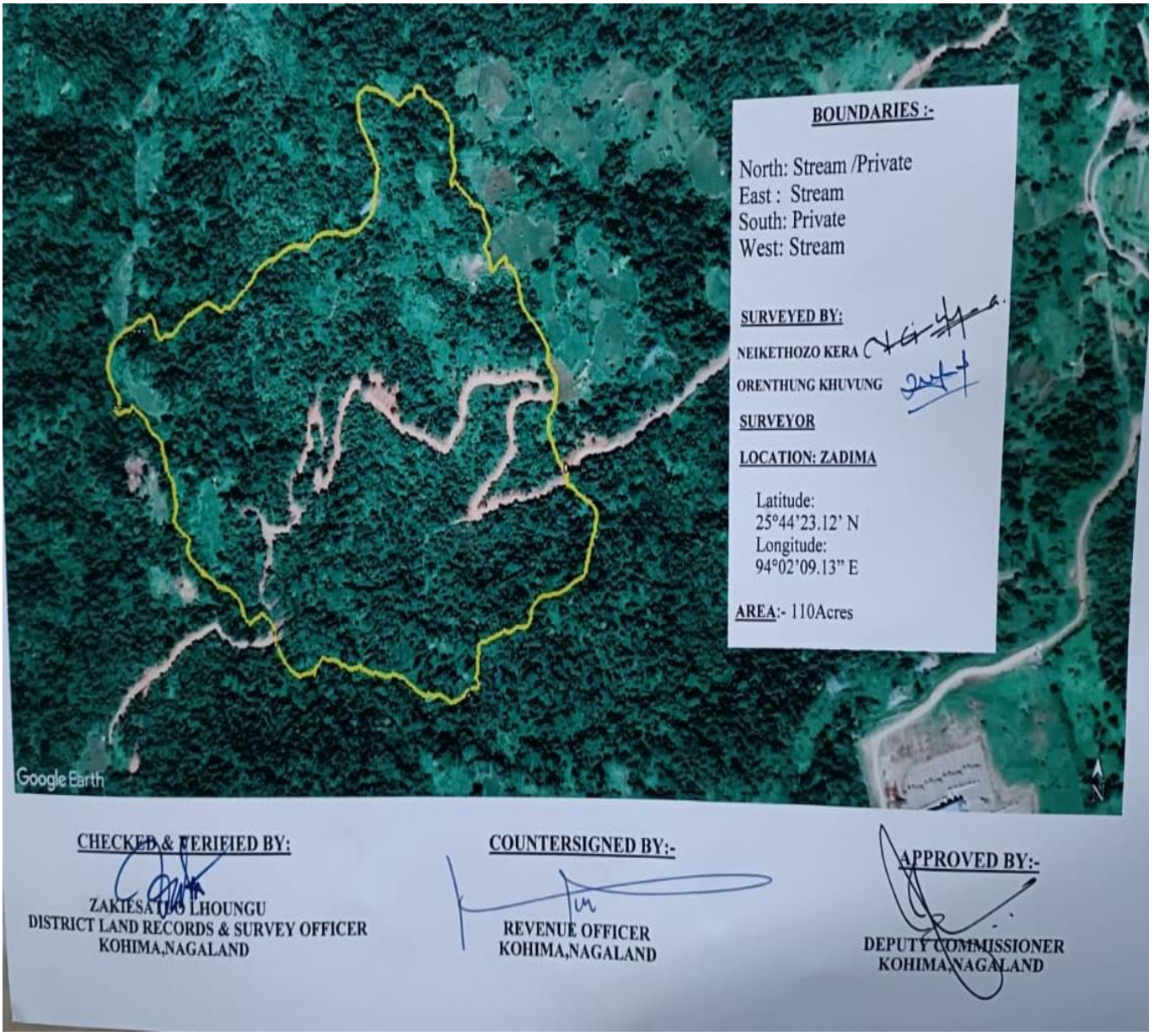
The Site is proposed to be 20 MW, Solar Power Project at Chiephobozou District is situated between latitude 25.7814° N and longitude 94.0985°E.

Fig.- Nagaland District Map showing Project Location

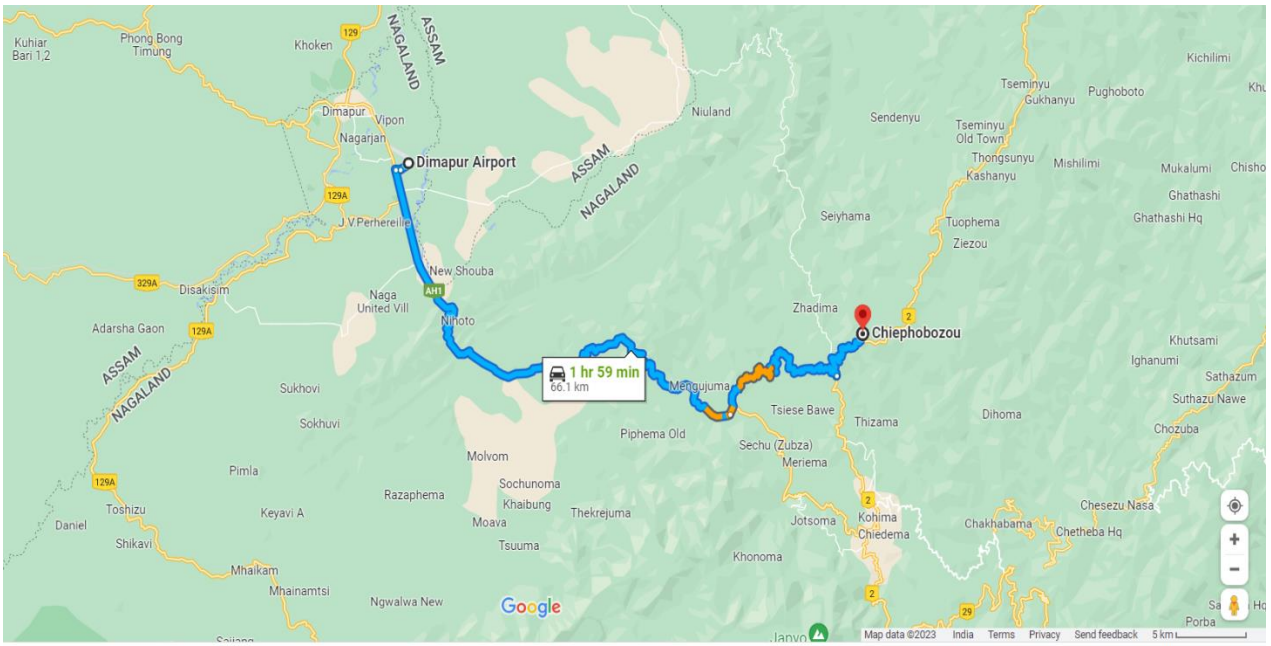
2.2 Land Location & Connectivity

Land details:

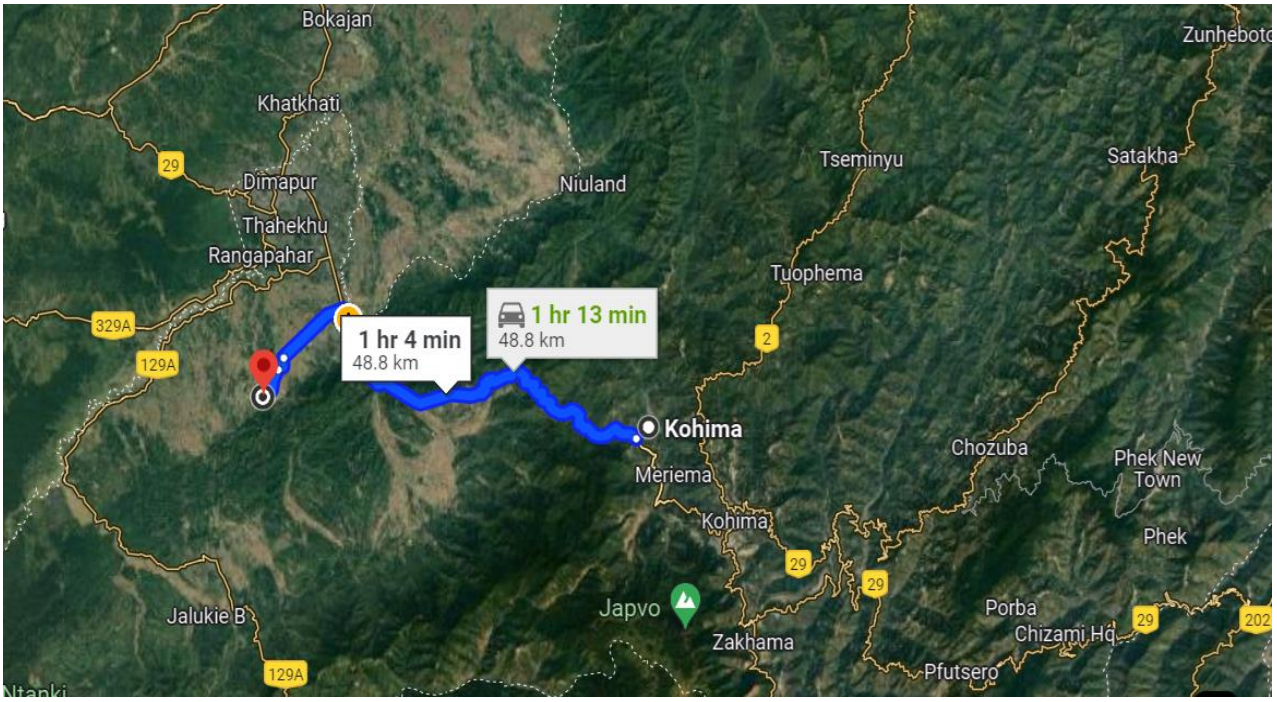
Proposed Solar Plant is to be developed on approx 100-acre vacant lands in Chiephobozou District in Nagaland.



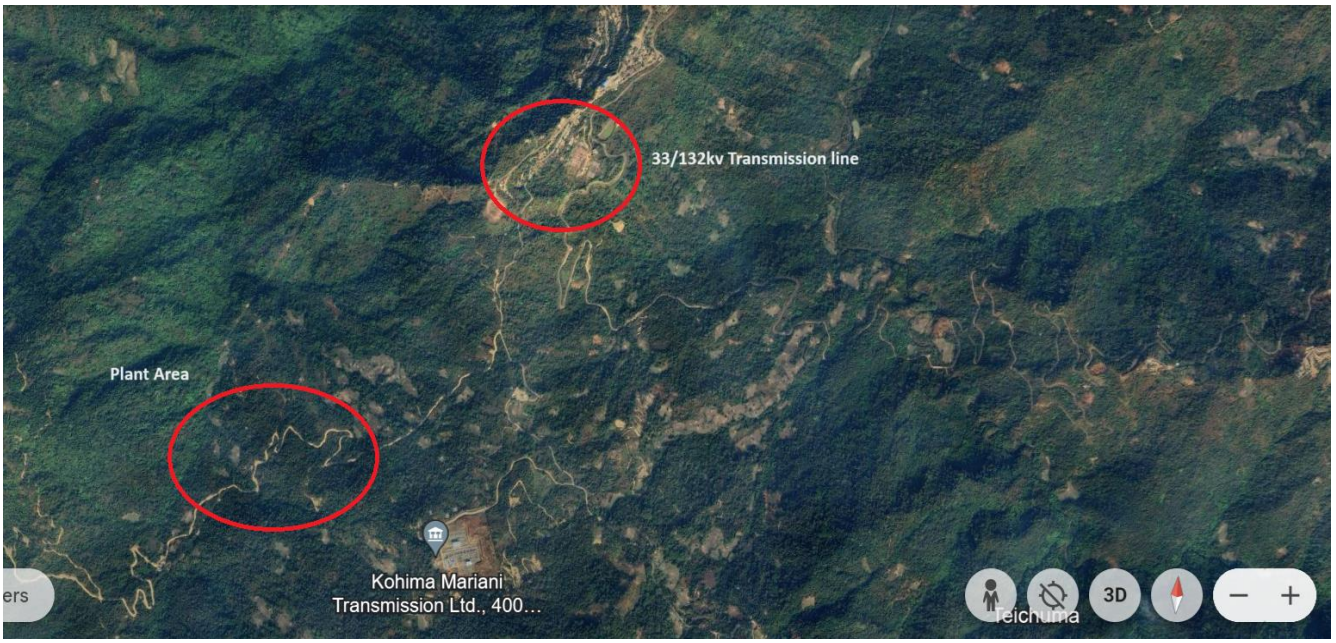
2.2.0 Nearest International Airport (Dimapur)- (90) km



2.2.1 Nearest Railway Station- Shokhuvi railway station. 48.8km

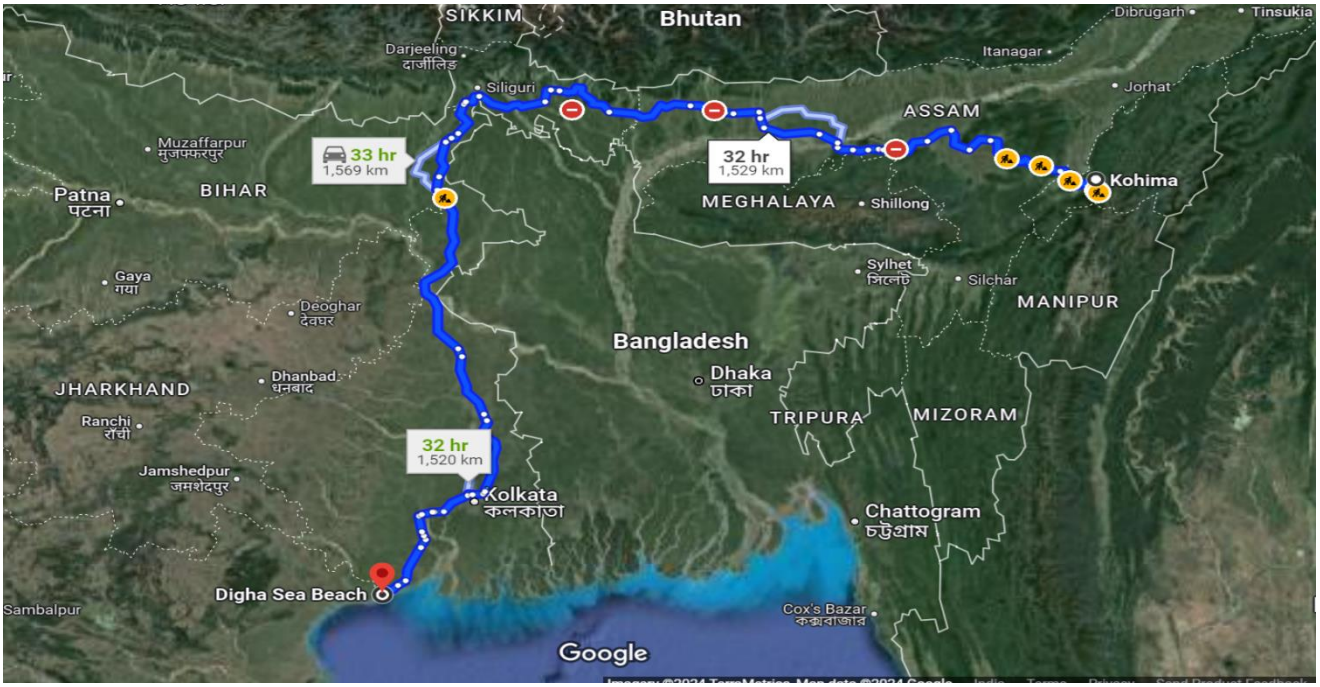


2.3 Transmission Connectivity



2.4 Road and Access facilities available: YES

2.5 Nearest Sea Shore: West Bengal (Digha)



2.6 SEISMIC MAP OF THE AREA

The maps how the various earthquake zones of Nagaland

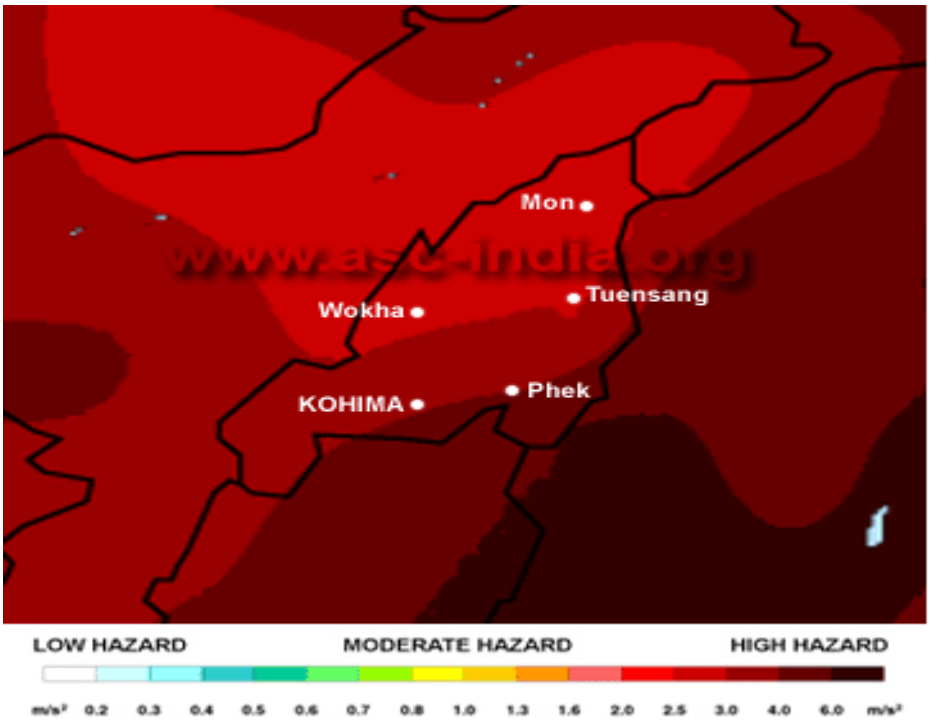


Figure: Earthquake zones of Nagaland

Chiephobozou District mostly falls under **seismic zoneV** having high seismic intensity

2.7 Meteorological Data

The Meteonorm 6.2.5 Global Climatological Meteo Database and Synthetic Weather Generator contain a database of ground station measurements of irradiation and temperature. If a site is over 20 km from the nearest measurement station, it calculates climatologic averages estimated using interpolation algorithms. If a site has no radiation measurement station within 300km, satellite information is used. If the site is between 50 km to 300 km from a measurement station, a mixture of ground and satellite information is used. The following table shows the data takenfor the proposed location of the Solar PV Power Plant.

Month	GlobHorkWh/m²	GlobInckWh/m²	GlobEffkWh/m²	T_Amb°C
January	127.2	165.9	156.3	11.25
February	123.6	148.7	140.2	13.17
March	162	178.9	168.7	16.43
April	163.6	166.4	156.5	18.81
May	142.2	136.5	127.7	20.87
June	133.4	125.1	117.2	21.93
July	132.6	125.7	117.5	22.49
August	125.4	122	114.1	22.57
September	134	141.5	132.9	21.28
October	138.3	157.3	148.3	19.4
November	122.3	153.8	145	15.01
December	126.6	173	163	11.91
	1631.3	**1794.7**	**1687.3**	**17.95**

These climatic conditions have direct impact on the output of any solar PV power plant. Generally, site-based station monitoring is the best source for data collection, if it is not available then data Meteonorm 7.2Meteo- Data base can be relied upon with a considerable amount of accuracy.

****

Chapter 3

Main Components of Solar Power Plant

3.1 Overview of Grid Connected Solar PV Power plant

Solar PV Modules: These convert solar radiation directly into electricity through the Photovoltaic effect which requires nonmoving parts and is a silent and clean process. A PV power plant contains many modules connected together to form an array and produce the required DC power output.

Module mounting rack system: These allow PV modules to be securely attached to the ground at a fixed tilt angle or on sun-tracking frame.

Inverters: These are required to convert the DC electricity to alternating current (AC) for connection to the utility grid. Many modules in series strings and parallel strings are connected to inverter via DC combiner box.

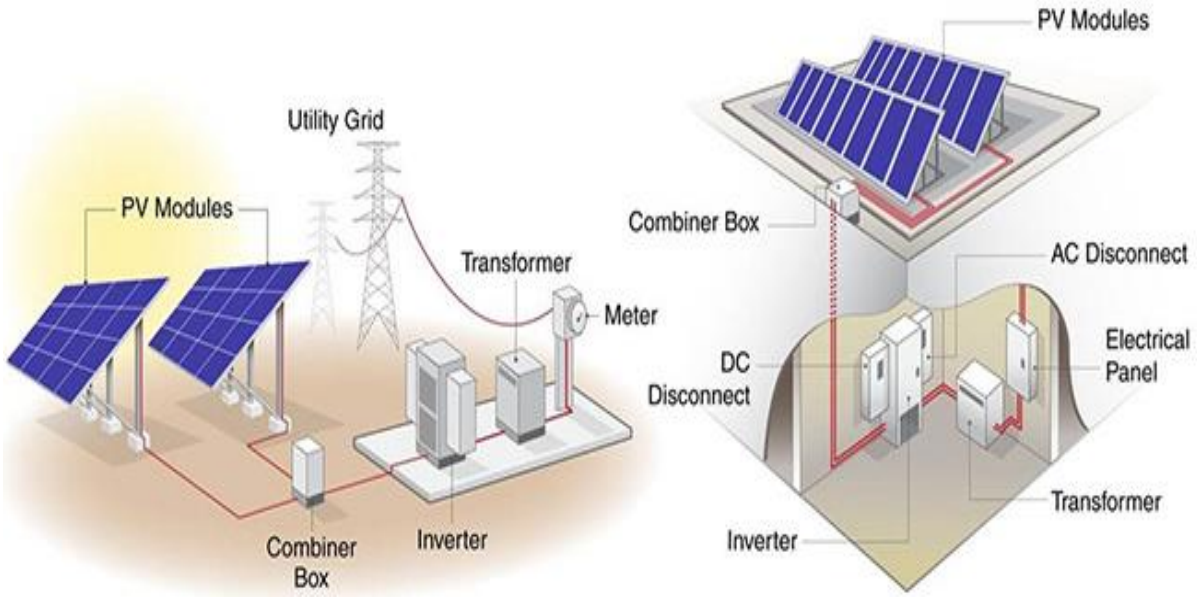
Control and Monitoring: The Control system and monitoring is required to ensure a control and effective operation of Solar PV Power Plant.

Step-up Transformers: The output from inverters generally requires a further step-up in the voltage to reach AC grid level. The step-up transformer takes the output from the inverters to the required grid voltage (i.e.11kV, 22KV, 33kV, 66kV, 110kV, 220kV etc., depending upon the level of power evacuation.

The grid connection interface:

The grid connection interface- This is where the electricity is exported into the grid network.

The Grid connection interface: This is where the electricity is exported into the Grid network. A switch yard is with required switchgear, control and protection of the PV power plant may be required for grid interfacing beside energy meters. The substation and metering points are often external to the PV power plant boundary and are typically located on the grid operator's property.



General Layout of a Solar PV Plant

3.2 Benefits of Grid Connected Solar Power plant:

(a) Power from sun is clean, limitless and free.
(b) PV generated electricity does not emit any emissions.
(c) Photo-voltaic is now a proven technology which is inherently safe in contrast to other fossil fuel-based electricity generating technologies.
(d) No fuel is required after the system has been installed and starts producing electricity.
(e) Solar power can be generated during peak hours.
(f) Increase the grid quality and reliability.
(g) Solar Powered Grid Connected Plants can act as tail end energizers, which in turn reduces the transmission and distribution losses.
(h) Provides a potential revenue source in a diverse energy portfolio.
(i) Assists in meeting renewable portfolio standards goals.
(j) Generation of electricity from Solar PV is totally free of Green House Gas emission.

3.3 Solar PV process

The power conversion source is via photovoltaic modules that convert light directly to electricity.

3.4 Components of Solar PV

The main Components of a Solar PV Include:

3.5 Solar PV Modules.
3.6 Module mounting (or tracking) systems.
3.7 Inverters.
3.8 Step-up transformers.
3.9 Data Monitoring/SCADA.
3.10 Evacuation System at, Zhadima Village.
3.11 The grid connection interface,

3.5 Solar PV Modules

Overview of PV Solar Module System and their technology

A PV Plant consists of a variety of components. The major components though remain the PV modules and Inverters. Due to continuous Research and Development (R&D) and growth of the global solar sector, these components have under gone considerable enhancement in technology over the past few years.

PV Modules

PV module is series and parallel combination of multiple PV cells grouped together. There are a wide range of PV cell technologies on the market today, using different types of materials, and an even larger number will be available in the future.
From traditional poly panels to mono & bifacial modules, we are continuously evolving. You might have heard of mono-crystalline panels mono-perc
Mono-perc is an advanced version of mono-crystalline panels that are considered to have higher efficiency even in low-light conditions.
Mono-perc solar panels are slightly different from the standard monocrystalline panels. PERC stands for Passivated Emitter & Rear Cell is a modern technology used to increase the efficiency of standard solar modules. This is done by adding a passivated layer in the rear of the cell.
Note: The passivated layer can be added in all types of PV modules (i.e. Poly, Mono & others). Since mono-perc are quite popular, thus we have only taken it into consideration. In Mono-perc modules, the same passivated layer is added in the back (rear) side of the solar cells.

In this project, we will use mono-perc half-cut solar panels, which have high efficiency and are capable of withstanding harsh weather conditions while maintaining energy generation. Some of such top Solar Panels Manufacturer name is:

1. Jakson
2. Waaree.
3. Goldi
4. Saatvik Solar
5. RenewSys
6. Bluebird Solar

TOPCon N-Type

TOPCON SOLAR PV MODULES WITH DUAL GLASS (WHITE GRID)

575-590Wp

JAKSON

ELECTRICAL DATA - STC* & NOCT**

Model	Unit	JN-575GW		JN-580GW		JN-585GW		JN-590GW	
Parameters		STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Capacity rating Wp	Pmax	575	432	580	436	585	440	590	443
Max. Power Voltage in V	Vpm	42.85	40.16	42.94	40.20	43.12	40.35	43.27	40.47
Max. Power Current in A	Ipm	13.42	10.77	13.51	10.85	13.57	10.91	13.64	10.97
Open Circuit Voltage in V	Voc	51.20	48.63	51.42	48.84	51.61	49.02	51.81	49.21
Short Circuit Current in A	Isc	14.25	11.50	14.36	11.59	14.43	11.64	14.50	11.70
Module Efficiency	%	22.28		22.47		22.67		22.86	
Power Tolerance	Wp	-0/+4.99							

*STC: Irradiance 1000 W/m^2, cell temperature 25°C, Air Mass AM 1.5 according to EN 60904-3. Average efficiency reduction of 4.5 % at 200 W/m^2 according to EN 60904-1. Measurement uncertainty ±3%

**NOCT irradiance 800 W/m^2, ambient temperature 20°C, wind speed 1 m/sec.

BI-FACIAL OUTPUT - REARSIDE POWER GAIN*

		JN-575GW	JN-580GW	JN-585GW	JN-590GW
10%	Power Output (W)	633	638	644	649
	Module Efficiency (%)	24.53	24.72	24.95	25.15
15%	Power Output (W)	661	667	673	679
	Module Efficiency (%)	25.61	25.84	26.08	26.31
20%	Power Output (W)	690	696	702	708
	Module Efficiency (%)	26.73	26.97	27.20	27.43
25%	Power Output (W)	719	725	731	738
	Module Efficiency (%)	27.86	28.09	28.32	28.59
Bifaciality Factor		80±5%			

MECHANICAL DATA

Dimensions (L x W x H)	MM: 2278 x 1133 x 35 | IN: 89.68 x 44.60 x 1.37
Weight	33 kgs | 72.75 lbs
Junction Box	Split JB, IP 68 with 3 bypass diodes
Cable	Solar Cable 4.0 mm² / 0.006 in², 400 mm / 15.75 in (Higher cable option available on request)
Front Superstrate	2.0 mm / 0.079 in, High Transmission, AR coated
Solar Cells	N-Type TOPCon - M10 (144 pcs Half Cut)
Cell Encapsulation	PID & UV Resistant
Back Substrate	2.0 mm / 0.079 in, Heat Strengthend Glass with White Grid
Frame	Anodized Aluminium Alloy
Mechanical Load Strength	5400 Pa (Snow Load), 2400 Pa (Wind Load)

TEMPERATURE RATINGS

Nominal Operating Cell Temperature (NOCT)	45°C (±2°C)
Temperature Coefficient of Voc	-0.25%/°C
Temperature Coefficient of Isc	0.046%/°C
Temperature Coefficient of Pmax	-0.3%/°C

PERMISSIBLE OPERATING CONDITIONS

Temperature Range	-40°C to +85°C
Maximum System Voltage	1500 V DC
Max. Series Fuse Rating	30 A

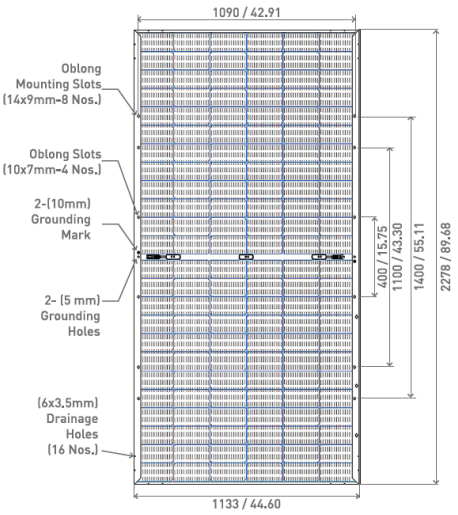
WARRANTY AND CERTIFICATIONS

Product Warranty	12 years Product Warranty
Performance Guarantee	30 year Linear Performance Warranty

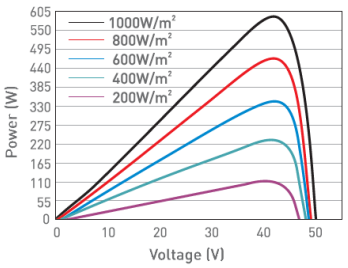
PACKAGING CONFIGURATION

Container Size	40' HQ
Modules per Pallet	31
Modules per Container	620

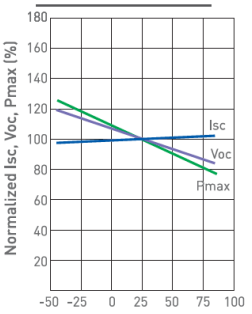
Dimension of PV Module
Unit: mm / in



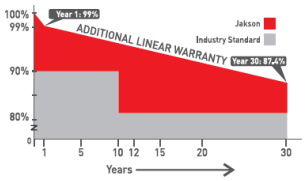
Power-Voltage Curve



Cell Temperature (°C)



Linear Performance Warranty



JAKSON ENGINEERS LIMITED

A-43, Phase-II Extn., Hosiery Complex, Noida-201305, U.P., India
Tel.: +91-120-4302600, 4526100 | Toll Free No. : 1800 103 2600
E-mail: customer.support@jakson.com ; solar-bu@jakson.com | www.jakson.com

144H-BFGW1400016BB-V02-123

AHNAY SERIES

Bi-68-645 to Bi-68-665

Framed Dual Glass Bifacial module

WAAREE®
One with the Sun

ELECTRICAL CHARACTERISTICS

Models	Pmax (W)		Vmp (V)		Imp (A)		Isc (A)		Voc (V)		Module Eff. (%)
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	
Bi-68-645	645	485.2	37.87	35.70	17.04	13.58	17.78	14.33	45.94	43.20	20.65
Bi-68-650	650	489.5	37.91	35.90	17.16	13.63	17.84	14.37	46.09	43.40	20.82
Bi-68-655	655	494.2	37.94	36.10	17.29	13.69	17.90	14.42	46.26	43.50	20.99
Bi-68-660	660	497.3	38.06	36.20	17.35	13.75	17.98	14.49	46.40	43.60	21.13
Bi-68-665	665	501.7	38.10	36.40	17.46	13.79	18.03	14.53	46.58	43.80	21.29

*Standard Test Conditions (STC) - 1000 W/m2 irradiance, Air Mass 1.5 and 25°C cell temperature. Nominal Operating Cell Temperature (NOCT) - 800 W/m2 irradiance, Air Mass 1.5, Ambient temperature 20°C and Wind speed 1 m/s. Average power reduction of 4.5% at 200 W/m2 as per IEC 60904-1. Measuring Uncertainty ± 3%.

System Voltage	1500 V

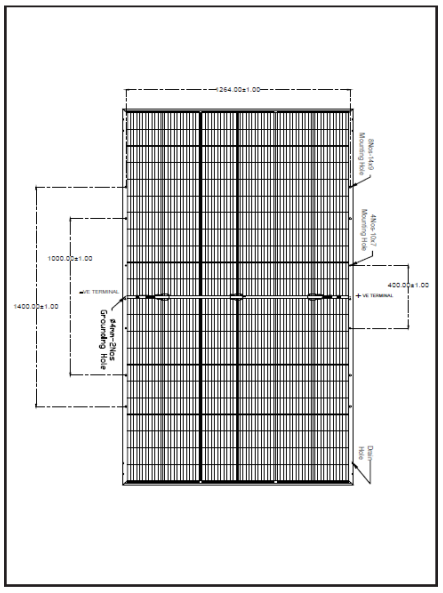
Series Fuse Rating	30 A

BI-FACIAL OUTPUT - BACKSIDE POWER GAIN*

		Bi-68-645	Bi-68-650	Bi-68-655	Bi-68-660	Bi-68-665
15%	Power Output (W)	742	748	753	759	765
	Module Efficiency (%)	23.74%	23.94%	24.13%	24.30%	24.49%
20%	Power Output (W)	774	780	786	792	798
	Module Efficiency (%)	24.78%	24.98%	25.18%	25.35%	25.55%
25%	Power Output (W)	806	813	819	825	831
	Module Efficiency (%)	25.81%	26.02%	26.23%	26.41%	26.62%
30%	Power Output (W)	839	845	852	858	865
	Module Efficiency (%)	26.84%	27.07%	27.28%	27.46%	27.68%

*The bifacial gains are dependant on the power plant design and location

DESIGN SPECIFICATIONS



THERMAL CHARACTERISTICS

Temperature coefficient of Current (Isc), α (%/°C)	0.04
Temperature coefficient of Voltage (Voc), β (%/°C)	-0.25
Temperature coefficient of Power (Pm), γ (%/°C)	-0.34
NOCT (°C)	43 ± 2
Operating temperature range (°C)	-40 to 85

MECHANICAL CHARACTERISTICS

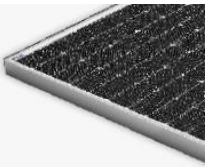
Length x Width x Thickness (L x W x T)	2400 mm (L) x 1302 mm (W) x 35 mm (T)
Weight	39 kgs
Solar Cells per Module (Units) / Arrangement	132 cells / (11x6 || 11x6)
Solar Cell Type & Size	Mono PERC Bifacial, 105 x 210 mm
Front / Back Glass (Material / Thickness)	2.0 mm Low Iron and Tempered glass
Encapsulate	PID Free & UV Resistant
Junction Box (Protection degree / Material)	IP68 / Weatherproof PPO
Cable & Connector (Protection degree / Type)	IP68 rated / MC4 compatible
Cable cross - section & Length	4 mm^2 & 500mm
Frame	Anodized Aluminium Alloy

Waaree Energies Ltd. is amongst the top Solar Energy Companies and has the country's largest Solar PV Module manufacturing capacity of 5 GW. In addition, it is committed to provide top notch EPC services, project development, rooftop solutions, solar water pumps and also in an Independent Power Producer. Waaree has its presence in over 325+ locations nationally and 68 countries globally.

12 Years Product Warranty • 30 Years Power Output Warranty

- The electrical data given here is for reference purpose only.
- Please confirm your exact requirements with the sales representative while placing your order.
- Refer installation Manual instructions & Waaree warranty statement for terms & conditions.
- Waaree Reserves the right to change the specifications without prior notice.z

BEST IN Grade Quality Class Results



TECHNICAL DATA

Electrical Parameter at STC	Bifacial Monocrystalline Module			
Module Type	GS10-T144-GF			
Capacity rating – Pmax(Wp)	555	560	565	570
Power Tolerance (W)	0~5			
Module efficiency (%)	21.48	21.67	21.87	22.06
Rated voltage - Vmp(V)	42.20	42.40	42.60	42.80
Rated current - Imp(A)	13.16	13.21	13.27	13.32
Open circuit voltage - Voc(V)	50.48	50.68	50.88	51.08
Short circuit current - Isc(A)	14.06	14.12	14.18	14.24

Under Standard Test Conditions (STC) of irradiance 1000 W/m², spectrum AM 1.5 and Module temperature of 25°C. Except Pmax, all other parameters have a tolerance of ±3%.

Electrical Characteristics with 10% rear side power gain#

Capacity rating – Pmax(Wp)	610	616	621	627
Rated voltage - Vmp(V)	42.20	42.40	42.60	42.80
Rated current - Imp(A)	14.47	14.53	14.59	14.65
Open circuit voltage - Voc(V)	50.48	50.68	50.88	51.08
Short circuit current - Isc(A)	15.46	15.53	15.59	15.66

Additional power gain from rear side compared to power of front side at STC depends on mounting structure (height, tilt angle etc.) and reflectivity of ground.
Bi-Faciality Factor : 80 ± 5 %

PERMISSIBLE OPERATING CONDITIONS

Temperature range	-40°C to + 85°C
Maximum system voltage	1500 VDC
NOCT	45± 2°C
Hail resistance	Max. diameter of 25 mm with velocity 23 m/s

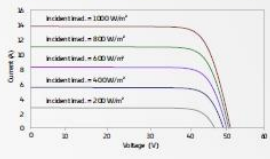
TEMPERATURE COEFFICIENTS (TC)

Temperature Coefficient (Voc)	-0.25% /°C
Temperature Coefficient (Isc)	0.045% /°C
Temperature Coefficient (Pmax)	-0.30% /°C

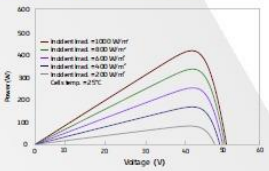
PACKAGING CONFIGURATION**

Number of Modules per Pallet	36
No of pallet	20
No of module, 40ft HC container	720

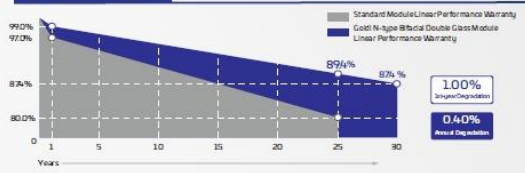
IV CURVE



PV CURVE



LINEAR GRAPH

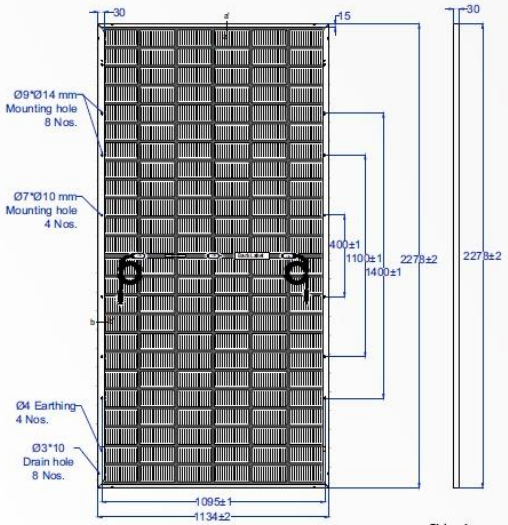


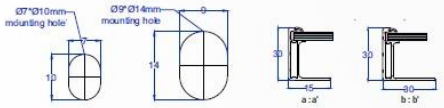
12 Years Product Material & Workmanship 30 Years Linear Performance Warranty

MECHANICAL SPECIFICATION

Solar cells	144 pcs TOPCon cell technology, Multi BB
Encapsulation	PID & UV resistance
Frame	Silver Anodized Aluminium Alloy
Front Glass	2.0 mm, High Transmission, AR Coated Semi Tempered Glass
Back Glass	2.0 mm, Heat Strengthened Glass
Dimensions	(L) 2278 mm x (W) 1134 mm x (H) 30 mm"
Weight	~32.5 Kg
J-box	IP 68 certified, 3 diodes, Split junction box
Series Fuse Rating	30 A
Cable	4 mm², Solar cable 400 mm/1400mm length or Customized length
Connectors	MC4 Type
Application Class	Class A
Electrical Safety	Class II
Fire Safety	Class C (Type 1)
Surface load	Snow load 5400 Pa, Wind load 2400 Pa

DRAWING (MEASUREMENTS ARE IN MM)





*Unspecified dimensions tolerance are according to ISO 2768-1, class m."

PRODUCT CERTIFICATIONS

*we have applied for below certification:

IEC 61215: 2021, IEC 61730: 2021, IS 14286:2010/IEC 61215:2005, IS/IEC 61730-1 & 2: 2004, IEC 61701, IEC 62716, IEC 60068-2-62, IEC CD 61215-2:2018, UL 61730-1 &2 , IEC 62804, CEC

MANAGEMENT SYSTEM CERTIFICATIONS

ISO 9001, ISO 14001, ISO 45001

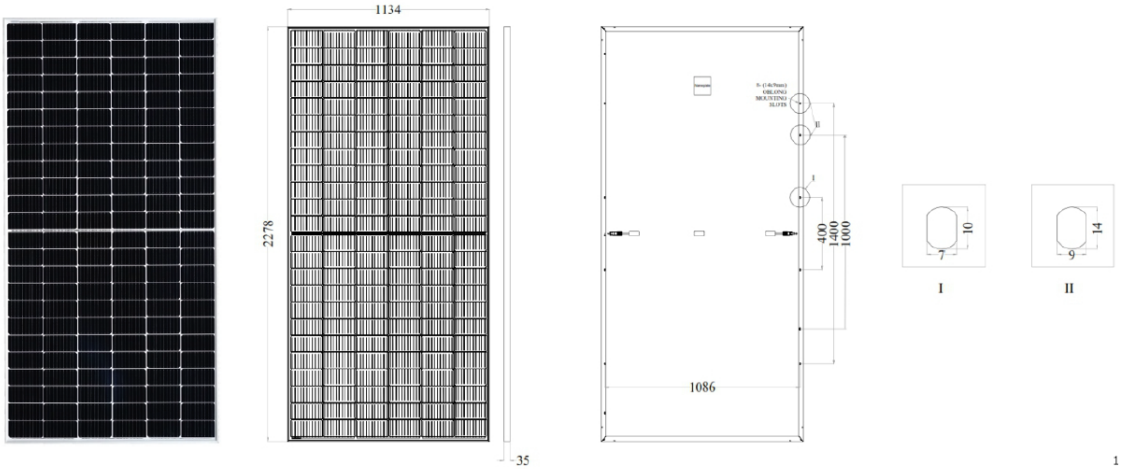
TDS-GS10T144GF-V1.3

UTILITY | INDUSTRIAL | AGRICULTURE | RESIDENTIAL | INSTITUTIONAL

- **Quantity of modules/container may get changed without prior notice. Confirm with our sales representative before placing order.
- For handling & installation instructions, refer to Goldi's installation manual available on the company website
- Before placing an order, confirm your requirements with our sales representative
- The electrical data provided here is for reference purposes only
- Dispose of a product as e-waste after the end of its working life
- Refer to Goldi's warranty document for terms and conditions
- Due to constant product modifications, Goldi reserves the right to amend the above specifications without prior notice
- Images in the datasheet are for representation purpose only

1800 833 5511
info@goldisolar.com
goldisolar.com

SAATVIK SOLAR
FOR A BETTER FUTURE



ELECTRICAL DATA PERFORMANCE

Module Type		525Wp		530Wp		535Wp		540Wp		545Wp		550Wp	
Conditions	**Unit**	**STC**	**NOCT**	**STC**	**NOCT**	**STC**	**NOCT**	**STC**	**NOCT**	**STC**	**NOCT**	**STC**	**NOCT**
Peak Power, Pmax (Wp)	W	525	390	530	393	535	397	540	401	545	405	550	408
Voltage at Maximum power, Vmp	V	41.31	39.00	41.48	39.16	41.64	39.31	41.77	39.43	41.96	39.61	42.12	39.76
Current at maximum power, Imp	A	12.71	9.99	12.78	10.05	12.85	10.10	12.93	10.17	12.99	10.21	13.06	10.27
Open circuit voltage, Voc	V	48.85	46.11	49.05	46.30	49.25	46.49	49.45	46.68	49.65	46.87	49.85	47.06
Short circuit current, Isc	A	13.35	10.78	13.42	10.84	13.50	10.61	13.59	10.98	13.65	11.02	13.74	11.10
Module Efficiency (%)		**20.32%**		**20.52%**		**20.71%**		**20.90%**		**21.10%**		**21.29%**	
Operating Temperature (℃)		-40°C~+85°C											
Maximum system voltage		1500 VDC											
Maximum series fuse rating		25A											
Power tolerance (Wp)		0~+3%											
Temperature coefficient of Pmax (γ)		-0.36%/°C											
Temperature coefficient of Voc (ß)		-0.28%/°C											
Temperature coefficient of Isc (α)		0.048%/°C											
Nominal operating cell temperature (NOCT)		45±2°C											
Fire Safety		Class-C											
Application		Class-A											
Safety Class		Class-II											

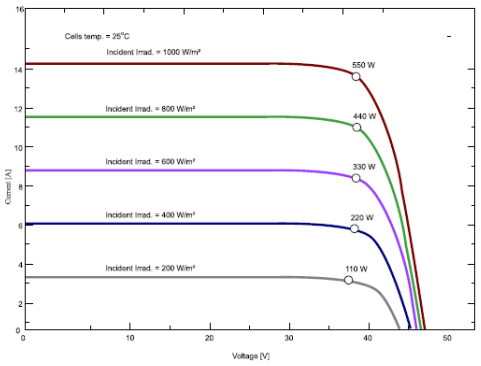
STC: Irradiance 1000W/m², module temperature 25°C, AM =1.5; NOCT: Irradiance 800W/m², ambient temperature 20°C, AM=1.5, wind Speed 1m/s. Average power reduction of 4.5% at 200W/m² as per IEC 60904- 1. Except Pmax, all other parameters have tolerance of +/-5%, measurement uncertainty +/-3%.

MODULE MECHANICAL DATA

SPECIFICATION DATA	
Cell Type	Half Cut-PERC Monocrystalline, 144Cells
Dimensions	2278X1134X35 mm
Weight	28 kgs
Front Cover	3.2 mm Tempered Glass
Backsheet	Composite Film
Frame Material	Silver Anodized Aluminium Profile,
J-Box	IP68, 3 diodes
Cable	350mm, 4mm²
Connectors	Mc4 Compatible Connector
Standard Packaging	31 Pieces/Pallet
Module Pieces per Container	620 pieces (40* HQ)

I-V Characteristics At Different Irradiations

PV module : "SGE550-144MHC"



- The specifications included in this datasheet are subject to change without notice.
- The electrical data given here is for reference purpose only.
- Please confirm your exact requirements with the sales representative while placing your order.
- Refer installation Manual instructions & Saatvik warranty statement for terms & conditions.

RenewSys
let there be light

Bifacial Dual Glass

Performance under standard test conditions (1000w/m², AM 1.5, 25 ºC)

DESERV

DESERV Extreme 144 Bi-Facial Gain @Different Albedo (%)

		Pm (Wp)	Vmp (V)	Imp (A)	Voc (V)	Isc (A)	Efficiency (%)	Pm (Wp)	Vmp (V)	Imp (A)	Voc (V)	Isc (A)	Efficiency (%)
	Front @STC	**565**	42.87	13.19	52.30	13.75	21.90	**570**	43.05	13.24	52.50	13.80	22.09
Bi-Facial Gain	5%	593.25	42.87	13.84	52.30	14.39	23.00	598.5	43.05	13.90	52.50	14.45	23.20
Bi-Facial Gain	10%	621.5	42.87	14.50	52.30	15.05	24.09	627	43.05	14.56	52.50	15.12	24.30
Bi-Facial Gain	20%	678	42.87	15.82	52.30	16.37	26.28	684	43.05	15.89	52.50	16.44	26.51
	Front @STC	**575**	43.28	13.29	52.78	13.85	22.29	**580**	43.50	13.34	53.03	13.89	22.48
Bi-Facial Gain	5%	603.75	43.28	13.95	52.78	14.50	23.40	609	43.50	14.00	53.03	14.55	23.61
Bi-Facial Gain	10%	632.5	43.28	14.61	52.78	15.17	24.52	638	43.50	14.67	53.03	15.21	24.73
Bi-Facial Gain	20%	690	43.28	15.94	52.78	16.50	26.75	696	43.50	16.00	53.03	16.55	26.98
	Front @STC	**585**	43.74	13.38	53.27	13.93	22.68	**590**	43.93	13.44	53.51	13.97	22.87
Bi-Facial Gain	5%	614.25	43.74	14.04	53.27	14.59	23.81	619.5	43.93	14.10	53.51	14.63	24.01
Bi-Facial Gain	10%	643.5	43.74	14.71	53.27	15.26	24.94	649	43.93	14.77	53.51	15.30	25.16
Bi-Facial Gain	20%	702	43.74	16.05	53.27	16.59	27.21	708	43.93	16.12	53.51	16.64	27.44
	Front @STC	**595**	44.16	13.48	53.75	14.01	23.06	**600**	44.37	13.53	54.00	14.05	23.26
Bi-Facial Gain	5%	624.75	44.16	14.15	53.75	14.67	24.22	630	44.37	14.20	54.00	14.71	24.42
Bi-Facial Gain	10%	654.5	44.16	14.82	53.75	15.35	25.37	660	44.37	14.87	54.00	15.39	25.58
Bi-Facial Gain	20%	714	44.16	16.17	53.75	16.69	27.68	720	44.37	16.23	54.00	16.74	27.91

NOCT (Wp) at 45 ± 2 ºC @800 W/m²	565	570	575	580	585	590	595	600
Pmax (W)	420.49	424.21	427.93	431.65	435.38	439.10	442.82	446.54
Max. power voltage (Vmp), V	39.21	39.38	39.58	39.78	40.00	40.18	40.39	40.58
Max. power current (Imp), A	10.74	10.78	10.82	10.86	10.89	10.94	10.97	11.01
Open circuit voltage (Voc), V	48.63	48.82	49.08	49.30	49.53	49.76	49.98	50.21
Short circuit current (Isc), A	11.23	11.27	11.31	11.34	11.38	11.41	11.44	11.47

Bi-faciality factor: 80 ± 5%

Mechanical Characteristics

Cable	No. 12 AWG, 4mm
PV Connectors	MC4 Compatible
Frame	Anodized Aluminum Alloy
Junction box	IP68 Split junction
Glass (front)	2.0mm AR Coated Semi Tempered Glass
Glass (back)	2.0mm Semi Tempered Glass.

Operating Conditions

Temperature, ºC	-40 to +85
Max. system voltage, Vdc	1500
Hail impact velocity, m/sec	23
Max. surface load capacity, Pa	5400
Max. wind speed capacity, Pa	2400
Series fuse rating, A	30

Physical Parameters

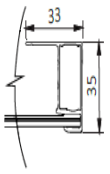
No. of cells	144
Module dimension (mm)	2277 X 1133 (± 2)
Module thickness (mm)	35
Approximate weight (kg)	31.5

Cell Temperature Coefficient	Bi-Facial
Open circuit voltage	-0.2764 % / ºC
Short circuit current	+0.0572 % / ºC
Peak power	-0.2915 % / ºC

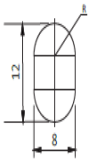
Test uncertainty for Pmax ± 3%

Bi-facial gain subject to mounting structure specifications and albedo % of ground

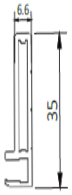
Frame Cross Section



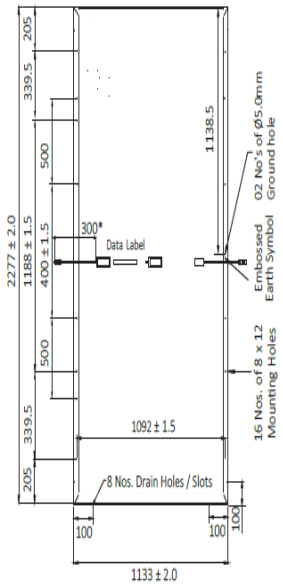
Mounting Hole



Width flangeless

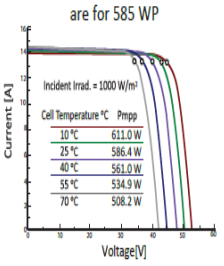


Module Dimension Diagram (mm)

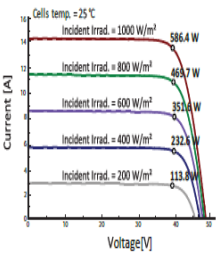


IV Curves

Cell temperature sensitivity chart are for 585 WP



Incident irradiance sensitivity chart are for 585 WP



-Please refer to the installation manual for detailed information.

*Due to continuous product updation, specifications may change without notice. Kindly refer to the website for latest information: www.renewsysworld.com

*Recycle Responsibily/RenewSys recommends recycling in accordance with local government e-waste notifications.

*Standard frame : Width side frame cross section is flange less, Flange is available on request.

TECHNICAL DATA

Module Series	Mono Half-cut					
	BBS24MC525	BBS24MC530	BBS24MC535	BBS24MC540	BBS24MC545	BBS24MC550
Electrical Characteristics at STC:						
Maximum Power Pmax (Wp)	525	530	535	540	545	550
Maximum Voltage Vmpp (V)	41.35	41.48	41.65	41.78	41.93	41.90
Maximum Current Impp (A)	12.70	12.78	12.85	12.93	13.00	13.13
Open Circuit Voltage Voc (V)	49.20	49.35	49.50	49.65	49.80	49.70
Short Circuit Current Isc (A)	13.47	13.53	13.60	13.68	13.76	13.83
Module Efficiency (%)	20.34	20.53	20.73	20.92	21.12	21.31

STC:1000W/m2 irradiance, 25°C cell temperature, AM1.5G spectrum according to EN 60904-3
Average relative efficiency reduction of<5% for every 200W/m reduction in Irradiance, according to EN 60904-1

Electrical Characteristics at NOCT:						
Maximum Power Pmax (Wp)	392.70	396.44	400.30	404.00	408.30	412.20
Maximum Voltage Vmpp (V)	38.44	38.56	38.64	38.74	38.84	38.94
Maximum Current Impp (A)	10.22	10.28	10.36	10.43	10.51	10.59
Open Circuit Voltage Voc (V)	46.00	46.14	46.37	46.55	46.70	46.83
Short Circuit Current Isc (A)	10.85	10.90	10.97	11.03	11.09	11.15

NOCT:800W/m2 irradiance, 20°C ambient temperature, Wind Speed 1m/sec

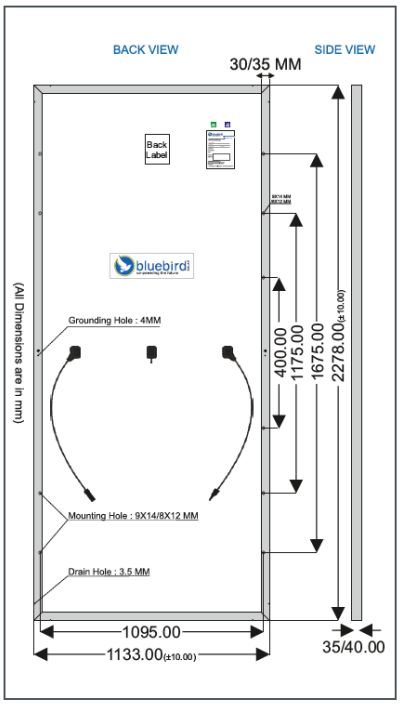
Temperature coefficient (Tc) and permissible operating conditions

Tc of Open Circuit Voltage (β)	-0.27%/°C
Tc of Short Circuit Current (α)	0.050%/°C
Tc of Power (γ)	-0.35%/°C
NOCT	45 ± 2°C
Maximum series fuse ratings	25A
Temperature Range	-40°C to +85°C
Maximum System Voltage	1500 V DC

Mechanical Data

Dimension (LxWxH)	2278mm x 1133mm x 35/40mm
Weight	28 Kg
Solar Cells (PID Free)	144 (12 x 6 x 2)Mono Cut Cells, 10BB, (91x182mm)
Junction Box	IP68, Split Junction Box with individual bypass diodes
Cables & Connectors	400 mm (+ve) and 400 mm (-ve) lenght cables, MC4 Compatible or MC4 Connectors
Superstrate	3.2 mm high transmission low iron tempered glass, AR coated
Cell Encapsulant	PID Free EVA (Ethylene Vinyl Acetate) - FC/UFC
Backsheet	Composite Film - White (Black & Transparent optional)
Frame	Silver Anodized Aluminum frame with twin wall profile
Application Class	Class A (safety class II)
Mechanical Load Test	Sustain heavy static load (2400 Pa & 5400 Pa)
Packaging	Standard 30 Modules per Pallet

**Refer to Bluebird Solar's warranty documents for terms and conditions.
Specification and electrical data included in this datasheet are subject to change without notice. Please confirm your requirements with the company representative while placing your order.
Note: It is mandatory to make negative grounding of modules in all installation to avoid PID Issue.

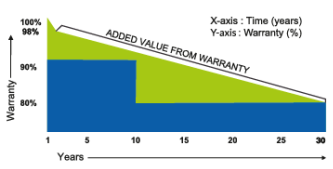


Approvals and certifications	
Products:*	ALMM, BIS, IEC 61215/IS 14286, IEC 61730-I & II, IEC 61701, IEC 61853, IEC 62804, IEC 62716
Manufacturing:	ISO 9001:2015, ISO 14001: 2015 ISO 45001:2018

*some certifications are under process

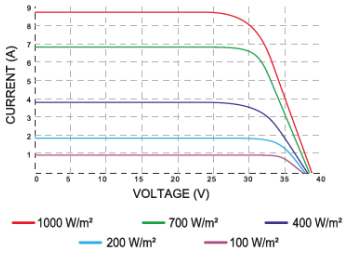
Packaging Information			
Truck Type	**Pallet/Truck**	**Modules/Truck**	**KW/Truck(Approx)**
19 ft.	10	300	162
22 ft.	12	360	194.4
32 ft.	18	540	291.6
40 ft.	22	660	356.4
Container Type	**Pallet/Truck**	**Module/Truck**	**KW/Truck(Approx)**
40 HQ	22	660	356.4

Warranty Graph



Product Warranty: 12 Years
Performance Warranty: Linear Power Warranty for 30 years with 2% for 1st year degradation and 0.55% from year 2 to 30 year

I-V Curve (for different irradiance)



Above quantities are subject to variation depending on miscellaneous Factors | Trucks under consideration are all open body trucks. | Customized packaging available.

CORPORATE OFFICE
70, Rajasthani Udyog Nagar Industrial Area, G.T. Karnal Road,
(Oppsite Jahangirpuri Metro Station) Delhi-110033

WORKS
Plot No.5, Ecotech, Udyog Vihar, Greater Noida,
Uttar Pradesh-201306

3.6 Module Mounting Structure or tracking System:

According to electrical design restrictions and requirements of civil and architectural design aspects, the most important mechanical design work is to create the optimal mounting structure carrying the PV modules and the cabling. It has to correspond with the electrical design in respect of module count and module orientation.

To achieve the highest energy yields, solar plants must adjust their module surface optimally to the current position of the sun.

Solar PV modules can be mounted on mechanical structure with fixed/tracking/seasonal tilt, as per site conditions.

Other important criterion is the stability of the mounting systems against wind load, hurricanes, tornados and other hazards happening on the site. Material selected will mostly be aluminum and stainless steel in order to reach durability of mounting systems for a predicted life time of more than 25 years.

Modules are mounted on non-corrosive support structures known as module mounting structures. It is important to choose a suitable tilt angle that optimizes the annual energy yield from the SPV modules according to the latitude of the site and the annual distribution of solar resource. The MMS is mainly of the following three types:

3.6.1 Fixed Tilt Module Mounting Structure.

3.6.2 Seasonal Tilt Module Mounting Structure.

3.6.3 Single axis trackers.

3.6.4 Dual axis trackers.

3.6.1 Fixed Tilt base Module Mounting Structure

Fixed mounting structures shall support and tilt solar PV modules at a fixed angle determined by the latitude of the site, the requirements of the applicable loads and the availability of sunlight & keep the rows of modules at a fixed tilt angle.
The fixed tilt module mounting structure is mechanically simple, hence lower installation and maintenance costs.

Fixed Tilt Based Module Mounting Structure

3.6.2 Seasonal Tilt based Module Mounting Structure

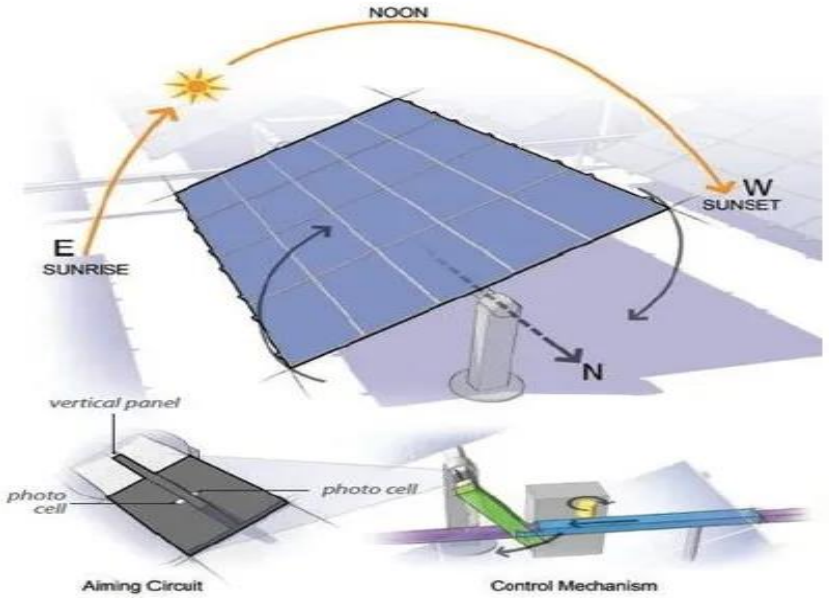
Seasonal tilt ground mounting structure addresses the need to exploit at its best the output of the solar project by maximizing the total annual incident irradiation on the panel's surface. This is carried out with a seasonal change of the structural tilt, typically 2 or more times during the year, allows the module to be tilted manually on a seasonal basis and it is possible through a very simple mechanism that allows one of the fastest and least expensive O&M in the industry. Forged with resistant and durable materials, the Fixed Adjustable ground mounting structure was designed by keeping in mind to make its implead effective. This innovative structural BOS component is today one of the most cost effective alternatives to maximize financial benefits from solar investments.

Seasonal tilt based mounting systems, have three angular positions are specified namely latitude angle, latitude angle -15 degree and latitude angle +15 degree.

Seasonal Type Based Module Moduting System

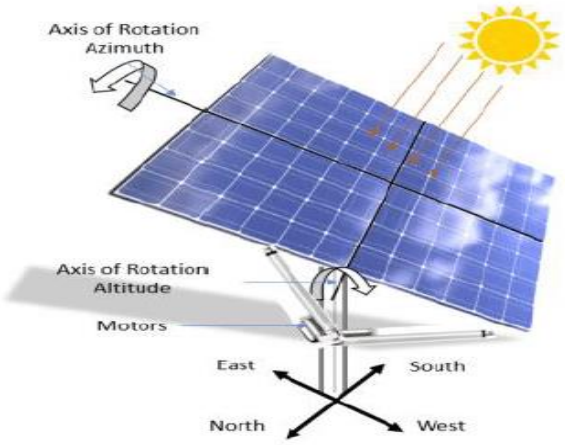
3.6.3 Single axis trackers

Single axis tracker shave one degree of freedom that acts as an axis of rotation. The axis of rotation of single axis trackers is typically aligned along a true North meridian. It is possible to align them in any cardinal direction with advanced tracking algorithms.



3.6.4 Dual axis trackers

Dual axis trackers have two degrees of freedom that act as axes of rotation (alter both orientation and tilt angle). These axes are typically normal to one another. The axis that is fixed with respect to the ground can be considered a primary axis. The axis that is referenced to the primary axis can be considered a secondary axis.
Dual axis trackers typically have modules oriented parallel to the secondary axis of rotation. Dual axis tracker sallow for optimum solar energy levels due to their ability to follow the sun vertically and horizontally. No matter where the sun is in the sky, dual axis trackers are able to angle themselves to be indirect contact with the sun.



3.6.5 Tracker type selection

The selection of tracker type is dependent on many factors including installation size, electric rates, government incentives, land constraints, latitude, and local weather.

Considering all these parameters and the site conditions, we have decided to use a fixed-type module mounting structure. With a fixed tilt, our solar panels will be able to generate energy throughout the year at a single angle of orientation.

3.7 Inverters:

Inverters are solid state electronic devices that convert DC electricity generated by the PV modules into AC electricity, suitable for supply to the grid. In addition, inverters can also perform arrange of functions to maximize the output of a PV plant
The technical name for a grid-tied inverter is "grid-interactive inverter". Such inverters may also be called synchronous inverters. Grid-interactive inverters typically cannot be used in standalone applications where utility power is not available.

Typical operation

- Feeds the inverted AC power into the grid.
- Synchronizes the frequency of AC with that of the grid (e.g.50Hz) using a local oscillator and limits the voltage to no higher than the grid voltage.
- Sense the current AC grid waveform, and output a voltage to correspond with the grid.
- Grid-tied inverters are also designed to quickly disconnect from the grid if the utility grid goes down. This is a requirement that ensures that in the event of a blackout, the grid-tied inverter will shut down to prevent the energy the PV System produces from harming any workers who fixing the power grid.
- GTIs have a fixed unity power factor, which means its output voltage and current are perfectly lined up, and its phase angle is within 1 degree of the AC power grid.

Inverters can be further classified into 2 types:

Central Inverters
String Inverters

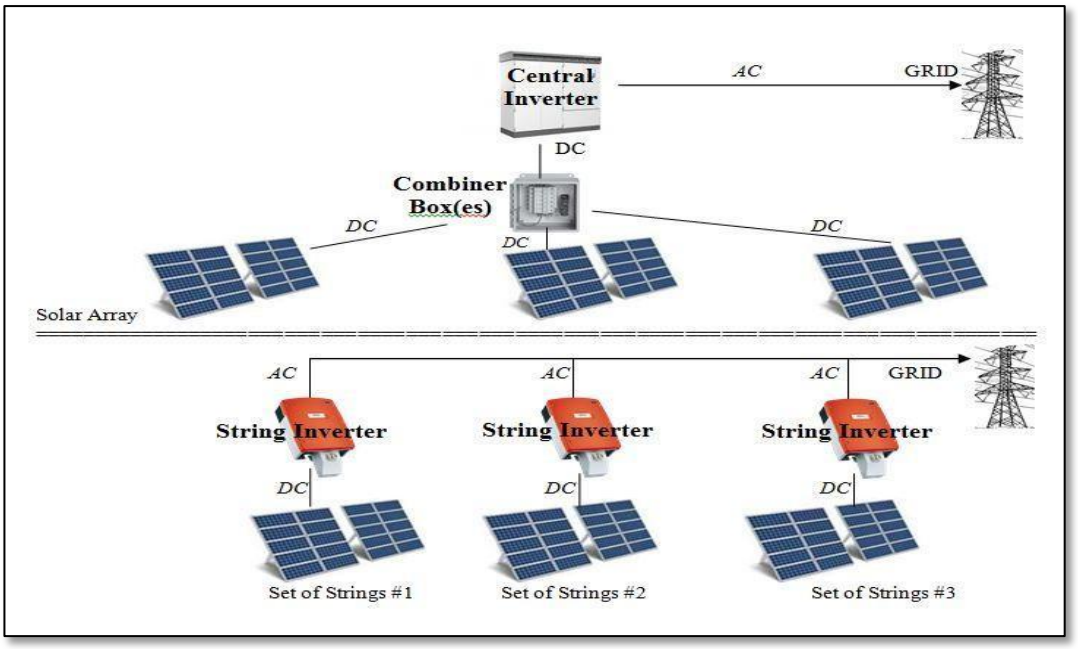


Figure showing Central and String Inverters

Central inverters are connected to a number of parallel strings of modules. String inverters are connected to one or more series strings. While numerous string inverters are required for a large plant, individual inverters are smaller and more easily maintained than a central inverter.
While Central inverters remain the configuration of choice for most utility-scale PV projects, both configurations have their pros and cons. Central inverters offer high reliability and ease of installation.

String inverters, on the other hand, are cheaper to manufacture, simpler to maintain and can give enhanced power plant performance on some sites.

The String Inverter proposed for this project according to conditions are:

1. Sungrow.
2. Growatt.
3. Solis
4. Hitachi, etc.

The obtain the maximum yield, some of top Inverter manufacturer are choose for this project after analysing them against different parameter for selection of Inverter.

The technical data sheet are as follows:

1. **Sungrow**

SG250HX

Type designation	SG250HX
Input (DC)	
Max. PV input voltage	1500 V
Min. PV input voltage / Startup input voltage	500 V / 500 V
Nominal PV input voltage	1160 V
MPP voltage range	500 V – 1500 V
MPP voltage range for nominal power	860 V – 1300 V
No. of independent MPP inputs	12
Max. number of input connector per MPPT	2
Max. PV input current	30 A * 12
Max. DC short-circuit current	50 A * 12
Output (AC)	
AC output power	250 kVA @ 30 ℃ / 225 kVA @40 ℃ / 200 kVA @ 50 ℃
Max. AC output current	180.5 A
Nominal AC voltage	3 / PE, 800 V
AC voltage range	680 – 880V
Nominal grid frequency / Grid frequency range	50 Hz / 45 – 55 Hz, 60 Hz / 55 – 65 Hz
THD	< 3 % (at nominal power)
DC current injection	< 0.5 % In
Power factor at nominal power / Adjustable power factor	> 0.99 / 0.8 leading – 0.8 lagging
Feed-in phases / connection phases	3 / 3
Efficiency	
Max. efficiency	99.0 %
European efficiency	98.8 %
Protection	
DC reverse connection protection	Yes
AC short circuit protection	Yes
Leakage current protection	Yes
Grid monitoring	Yes
Ground fault monitoring	Yes
DC switch	Yes
AC switch	No
PV String current monitoring	Yes
Q at night function	Yes
Anti-PID and PID recovery function	Yes
Overvoltage protection	DC Type II / AC Type II
General Data	
Dimensions (W*H*D)	1051 * 660 * 363 mm
Weight	99kg
Isolation method	Transformerless
Ingress protection rating	IP66
Night power consumption	< 2 W
Operating ambient temperature range	-30 to 60 ℃
Allowable relative humidity range (non-condensing)	0 – 100 %
Cooling method	Smart forced air cooling
Max. operating altitude	5000 m (> 4000 m derating)
Display	LED, Bluetooth+App
Communication	RS485 / PLC
DC connection type	MC4-Evo2 (Max. 6 mm², optional 10mm²)
AC connection type	OT/DT terminal (Max. 300 mm²)
Compliance	IEC 62109, IEC 61727, IEC 62116, IEC 60068, IEC 61683, VDE-AR-N 4110:2018, VDE-AR-N 4120:2018, EN 50549-1/2, UNE 206007-1:2013, P.O.12.3, UTE C15-712-1:2013
Grid Support	Q at night function, LVRT, HVRT,active & reactive power control and power ramp rate control

*: Only compatible with Sungrow logger and iSolarCloud

2. Growatt

Datasheet	MAX 185KTL3-X HV	MAX 216KTL3-X HV	MAX 250KTL3-X HV	MAX 253KTL3-X HV
Input data (DC)				
Max. DC voltage	1500V			
Start voltage	500V			
Nominal voltage	1080V			
MPP voltage range	500V-1500V			
No. of MPP trackers	9	9	12	15
No. of PV strings per MPP tracker	2			
Max. input current per MPP tracker	30A			
Max. short-circuit current per MPP tracker	50A			
Output data (AC)				
AC nominal power	185KW	216KW	250KW	253KW
Max. AC apparent power	185KVA@30°C 175KVA@40°C 160KVA@50°C	216KVA@30°C 200KVA@40°C 192KVA@50°C	250KVA@30°C 230KVA@45°C 220KVA@50°C	253KVA@30°C 230KVA@45°C 220KVA@50°C
Nominal AC voltage (range*)	800V (640-920V)			
AC grid frequency (range*)	50/60 Hz (45-55Hz/55-65 Hz)			
Max. output current	133.5A	155.9A	180.4A	182.6A
Adjustable power factor	0.8leading ...0.8lagging			
THDi	<3%			
AC grid connection type	3W+PE			
Efficiency				
Max.efficiency	99.0%			
European efficiency	98.7%	98.7%	98.7%	98.5%
MPPT efficiency	99.9%			
Protection devices				
DC reverse polarity protection	Yes			
DC switch	Yes			
AC/DC surge protection	Type II / Type II			
Insulation resistance monitoring	Yes			
AC short-circuit protection	Yes			
Ground fault monitoring	Yes			
Grid monitoring	Yes			
Anti-islanding protection	Yes			
Residual-current monitoring unit	Yes			
String monitoring	Yes			
AFCI protection	Optional			
Anti-PID function	Optional			
LVRT	Yes			
HVRT	Yes			
Night SVG	Optional			
General data				
Dimensions (W / H / D)	1070/675/340mm			
Weight	95kg	95kg	99kg	109kg
Operating temperature range	-30°C ... +60°C			
Nighttime power consumption	< 1W			
Topology	Transformerless			
Cooling	Smart air cooling			
Protection degree	IP66			
Relative humidity	0-100%			
Altitude	4000m			
DC connection	Staubli MC4/Amphenol UTX			
AC connection	OT Terminal connectors (Max. 300mm²)			
Display	LED/WIFI+APP			
Interfaces: RS485/USB / PLC/4G/GPRS	Yes/Yes/Optional/Optional/Optional			
Warranty: 5 years / 10 years	Yes /Optional			
CE, IEC62116/61727, IEC60068/61683, IEC60529, PEA, MEA, VDE0126, Greece, NRS097-2-1:2017, CEA2019				

* The AC voltage range and frequency range may vary depending on specific country grid standard.
All specifications are subject to change without notice.

SHENZHEN GROWATT NEW ENERGY CO., LTD. A: 2nd & 3rd Floor,Building 4,Jiayu Industrial Zone,Xibianling,Shangwu Village,Shiyan,Baoan District,Shenzhen
T: + 86 755 2747 1900 F: + 86 755 2749 1460 E: info@ginverter.com

3. Solis

solis
www.solisinverters.com

DATASHEET

Solis-(215-255)K-EHV-5G

Models	215K-PLUS	255K	255K-PLUS
Input DC			
Max. input voltage		1500 V	
Rated voltage		1080 V	
Start-up voltage		500 V	
MPPT voltage range		480-1500 V	
Max. input current	9*30 A	14*26 A	12*30 A
Max. short circuit current	9*50 A	14*40 A	12*50 A
MPPT number/Max. input strings number	9/18	14/28	12/24
Output AC			
Output power	215 kVA@30°C / 205 kVA@40°C / 195 kVA@50°C	255 kVA@30°C / 235 kVA@40°C / 220 kVA@50°C	
Rated grid voltage		3/PE, 800 V	
Grid voltage range		640-920 V	
Rated grid frequency		50 Hz	
Max. output current	155.2 A	184.0 A	
Power factor		>0.99 (0.8 leading - 0.8 lagging)	
THDi		<3%	
Efficiency			
Max. efficiency		99.0%	
EU efficiency	98.8%	98.7%	98.8%
Protection			
DC reverse-polarity protection		Yes	
Short circuit protection		Yes	
Output over current protection		Yes	
Surge protection		DC Type II / AC Type II	
Grid monitoring		Yes	
Anti-islanding protection		Yes	
Temperature protection		Yes	
Strings monitoring		Yes	
I/V Curve scanning		Yes	
Night time SVG function		Yes	
Integrated PID recovery		Yes	
Integrated DC switch		Yes	
General Data			
Dimensions (W*H*D)		1125*770*384 mm	
Weight	109 kg	113 kg	
Topology		Transformerless	
Self-consumption (night)		<2 W	
Operating ambient temperature range		-30 ~ +60°C	
Relative humidity		0-100%	
Ingress protection		IP66	
Cooling concept		Intelligent redundant fan-cooling	
Max. operation altitude		4000 m	
Grid connection standard		EN50549, G99, AS4777.2, VDE0126, IEC61727, VDE4110, CEA 2019	
Safety/EMC standard		IEC/EN 62109-1/-2, IEC/EN 61000-6-2/-4	
Features			
DC connection		MC4 connector	
AC connection		OT terminal (max. 300 mm^2)	
Display		LCD	
Communication		RS485, Optional: PLC	

4. Hitachi

Technical Specifications

Solar String Inverter - 250 kW to 255 kW (3Ph.)

Hiverter Si Series Three Phase		Si-250K-HV	Si-255K-HV
Input (DC)	Max. input voltage	1500V	
	Rated input voltage	1160V	
	Start-up voltage	550V	
	MPPT operating voltage range	500V- 1500V	
	Full power MPPT voltage range	800V-1300V	
	Number of MPP trackers	12	
	Number for DC inputs	24	
	Max. input current per MPPT	30A x 12	
	Max. input short circuit current per MPPT	50A x 12	
Output (AC)	AC output power	250kVA@30°C / 235kVA@40°C / 220kVA@50°C	255kVA@30°C / 235kVA@40°C / 220kVA@50°C
	Max. output current	180.5A	184A
	Nominal grid voltage	3/PE, 800Vac	
	Grid voltage range	640Vac-920VVac	
	Nominal frequency	50/60Hz	
	Grid frequency range	45~55Hz / 55~ 65Hz (According to local standard)	
	Active power adjustable range	0-100%	
	TH Di	<3%	
	Power factor	1 default (adjustable±0.8)	
Performance	Max. Efficiency	99.02%	
	European weighted efficiency up to	98.70%	
Protection	DC reverse polarity protection	Yes	
	Anti-islanding protection	Yes	
	Leakage current protection	Yes	
	Ground fault monitoring	Yes	
	PV-array string fault monitoring	Yes	
	Zero voltage ride through	Yes	
	DC switch	Yes	
	Anti-PID protection	Optional	
	AFCI	Optional	
	Protection class/Overvoltage category	I/II	
	Input/Output SPD	PV: type II standard, AC: type II standard	
Communication	Communication	RS485 /USB /Bluetooth, Optional: WiFi /GPRS /PLC	
General Data	Ambient temperature range	-30°C ~ +60°C	
	Self-consumption at night	<2W	
	Topology	Transformer less	
	Degree of protection	IP66	
	Allowable relative humidity range	0-100%	
	Max. operating altitude	4000m	
	Noise	≤75 dB	
	Weight	99kg	
	Cooling	Smart forced air cooling	
	Dimension (L*W*H)	1100.5 x 713.5 x 368mm	
	Display	LCD & Bluetooth + APP	
Standard	EMC	IEC 61000-6-2, IEC 61000-6-4, IEC 61000-3-11, IEC 61000-3-12	
	Safety standard	IEC62109-1/2, IEC62116, IEC61727, IEC-61683, IEC60068 (1,2,14,30)	

Hitachi Hi-Rel Power Electronics Private Limited

Registered Office: B-52, Corporate House, Near Judges Bunglow, Bodakdev, Ahmedabad-380054, Gujarat, India.
Tel: +91-79-6604 6200, Fax: +91-79-6604 6243

Manufacturing Works: Plot No. SM 3 & 4, Sanand GIDC II, Industrial Estate, Bol Village, Sanand-382 110, Gujarat, India.
Tel: +91-2717-678 777, Fax: +91-2717-678 700

Gandhinagar Facility: B-14/1 & 171, GIDC Electronics Zone, Sector - 25, Gandhinagar - 382 028, Gujarat, India.
Tel: +91-79-6170 0500

Helpline No.: (080) 6112 0800 (For Sales & Service Support) contact@hitachi-hirel.com www.hitachi-hirel.com

e-gallery

/company/hitachihirel
/hitachihirelindia
/hitachihirelindia
/hitachihirel

Ver2.2/2023/GTSS250 I Spotlight

3.8 Step up Transformers

The AC power supplied from the inverters is stepped up with step up transformers preferably to 33kV for pooling and transmission purpose.

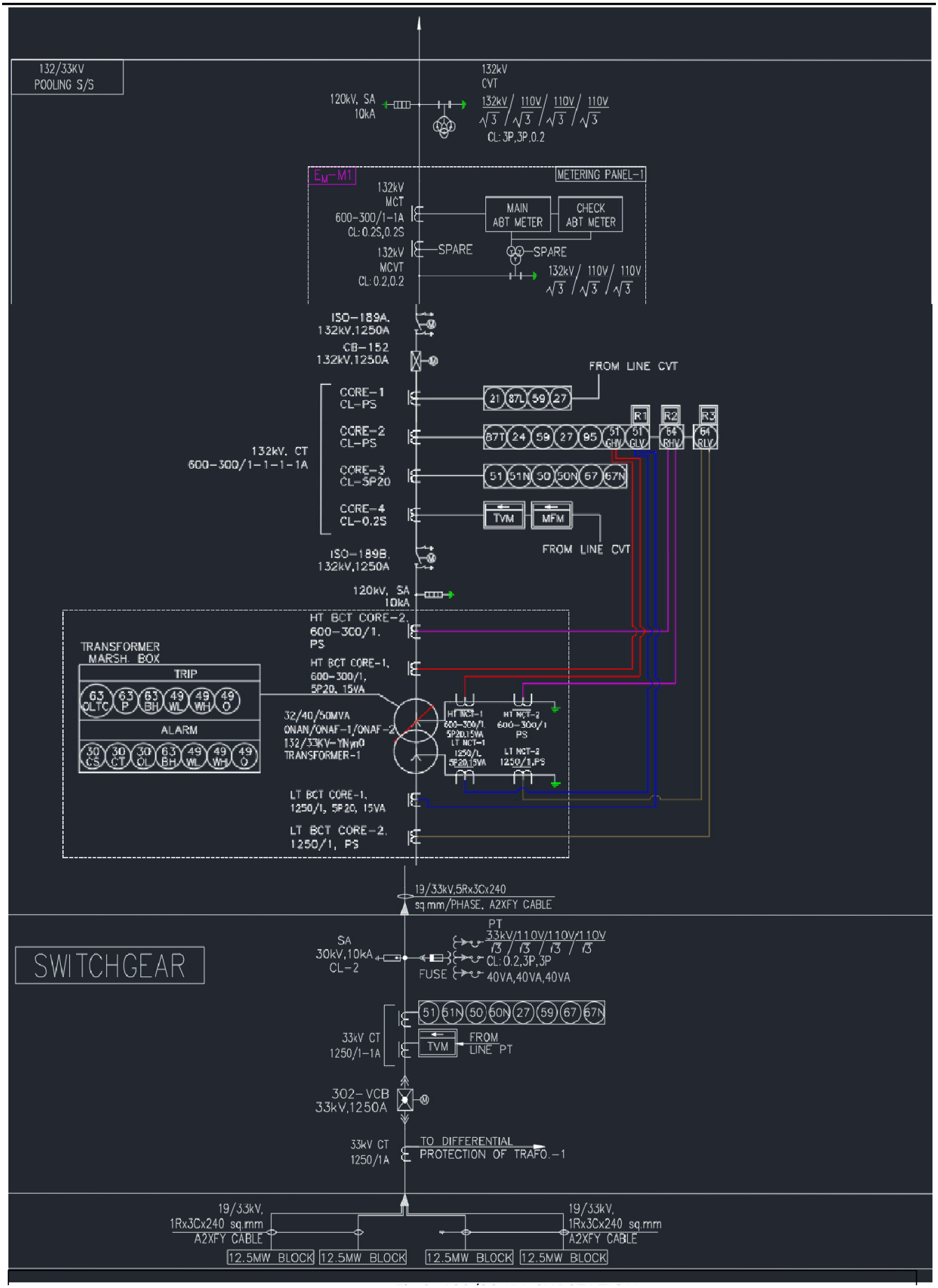
3.9 Data Monitoring/SCADA

Data Monitoring/SCADA - (Supervisory Control and Data Acquisition) SCADA Systems provide control and status indication for the items across the solar plant. Reliable sensors of solar radiation, temperature and electrical parameters will be supplied with the data logger unit.

SCADA systems perform the following operations: Measurement and recording of-
• Ambient air temperature
• Module temperature
•Wind speed at the level of array plant
• Solar radiation incident to the array plant
• Inverter output
• System frequency
• Energy delivered to the grid in kWh.

3.10 Evacuation System at, Zhadima Village

The process of collecting the power and dumping it into the desired load center is known as power evacuation. The Evacuation of 20 MW generated at solar power plant at Zhadima village at >= 33 kv using switch yard and then dumped into the state grid at 220/132/33 KV Grid Sub-Station. Zhadima village (Chiephobozou Block). The cost of evacuation included end equipment at sending station, power transmission line in lattice structure and receiving end 220/132/33 KV Sub-station, Zhadima, Block-Chiephobozou(Fig 1) Transmission Line 132 KV Transmission line from the generating Sub-station to the receiving Sub-station is 3 Km (Appx.) Transmission Line will be design according to the site condition. Lattice structure and Panther Conductor is use in the transmission line.


132/33KV
POOLING S/S
132kV
CVT
120kV, SA
10kA
132kV/√3 / 110V/√3 / 110V/√3 / 110V/√3
CL: 3P,3P,0.2
METERING PANEL-1
132kV
MCT
600-300/1-1A
CL: 0.2S,0.2S
MAIN
ABT METER
CHECK
ABT METER
SPARE
SPARE
132kV
MCVT
CL: 0.2,0.2
132kV/√3 / 110V/√3 / 110V/√3
ISO-189A,
132kV,1250A
CB-152
132kV,1250A
FROM LINE CVT
CORE-1
CL-PS
CORE-2
CL-PS
CORE-3
CL-5P20
CORE-4
CL-0.2S
132kV, CT
600-300/1-1-1-1A
21 87L 59 27
87T 24 59 27 95 51 GHV 51 GLV 64 RHV 64 RLV
R1 R2 R3
51 51N 50 50N 67 67N
TVM
MFM
FROM LINE CVT
ISO-189B,
132kV,1250A
120kV, SA
10kA
HT BCT CORE-2,
600-300/1,
PS
HT BCT CORE-1,
600-300/1,
5P20, 15VA
TRANSFORMER
MARSH. BOX
TRIP
63 OLTC 63 P 63 BH 49 WL 49 WH 49 O
ALARM
30 CS 30 CT 30 OL 63 BH 49 WL 49 WH 49 O
32/40/50MVA
ONAN/ONAF-1/ONAF-2
132/33KV-YNyn0
TRANSFORMER-1
HT MCT-1
600-300/1,
5P20,15VA
HT MCT-2
600-300/1
PS
LT MCT-1
1250/1,
5P20,15VA
LT MCT-2
1250/1,PS
LT BCT CORE-1,
1250/1, 5P20, 15VA
LT BCT CORE-2,
1250/1, PS
19/33kV,5Rx3Cx240
sq.mm/PHASE, A2XFY CABLE
SWITCHGEAR
SA
30kV,10kA
CL-2
PT
33kV/110V/110V/110V
√3 / √3 / √3 / √3
CL: 0.2,3P,3P
FUSE
40VA,40VA,40VA
51 51N 50 50N 27 59 67 67N
33kV CT
1250/1-1A
TVM
FROM
LINE PT
302-VCB
33kV,1250A
33kV CT
1250/1A
TO DIFFERENTIAL
PROTECTION OF TRAFO.-1
19/33kV,
1Rx3Cx240 sq.mm
A2XFY CABLE
19/33kV,
1Rx3Cx240 sq.mm
A2XFY CABLE
12.5MW BLOCK
12.5MW BLOCK
12.5MW BLOCK
12.5MW BLOCK

3.11 The grid connection interface:

The grid connection interface- This is where the electricity is exported into the grid network. The substation will also have the required grid interface switchgear such as circuit breakers and disconnects for protection and isolation of the PV power plant as well as generation and supply metering equipment**.**

****

Chapter 4

Analysis of Solar Radiation

4.1 Methods of Analysis of Solar Radiations

Meteonorm- The Meteonorm global Climatological database and synthetic weather generator contains a database of ground station measurements of irradiation and temperature. If a site is over 20km from the nearest measurements on it calculates climate logic averages estimated using interpolation algorithms. If as it has no radiation measurement station within 300km, satellite information is used. If the site is between 50 and 300km from a measurement station, a mixture of ground and satellite information is used. The following table shows the data taken for the proposed location of the Solar PV Power Plant.

NASA- NASA's Surface Meteorology and Solar Energy data set records satellite derived monthly data for a grid of 1°x1°covering the globe for a twenty-two year period from 1983 to 2005.

NREL- NREL's Climato logical solar radiation model uses primary data from geo stationary satellites. These satellites provide information on the reflection of the earth- atmosphere system and the surface and atmospheric temperature, which is useful in determining cloud cover. The model calculations are verified with ground-based data to ensure quality of the measurements

4.2 Analysis of Solar PV Radiations

Global irradiation at the Zhadima site was computed from Meteonorm 7.1. The detailed results of the programmed analysis are located in subsequent sections.

Sr. No.	Data Source	Global Irradiation	Temperature
1.	Meteonorm7.1(1981-2010)	1632.0kWh/ m2	24.20ºC

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	119.0	44.08	16.73	164.5	152.4	3375499	2796409	0.680
February	118.1	54.62	19.55	143.8	133.9	2935000	2329195	0.648
March	154.8	78.44	23.22	170.5	158.0	3428051	3232992	0.758
April	146.6	88.75	24.44	144.1	132.1	2879618	2717484	0.754
May	150.2	86.02	26.77	135.3	123.3	2663184	2507182	0.741
June	142.7	88.56	27.87	126.1	114.2	2473545	2329021	0.739
July	136.7	88.33	28.70	122.5	110.7	2391214	2249337	0.734
August	147.1	87.93	28.97	139.0	126.9	2731523	2574525	0.741
September	137.3	69.70	27.81	142.2	130.9	2804948	2467841	0.694
October	131.1	67.28	26.13	151.3	140.0	3017235	2813990	0.744
November	130.1	40.02	21.67	178.0	165.0	3572487	3364817	0.756
December	118.2	36.12	18.28	172.7	158.9	3493983	3291579	0.762
Year	1632.0	829.85	24.20	1790.0	1646.4	35766287	32674372	0.730

Since, the estimate of radiation by Meteonorm 7.1 source is spread over 30 years which is longest duration in comparison with NASA and PVGIS. The result from Meteonorm 7.1 is found to be minimum the same shall be used for further analysis of generation of Solar Photovoltaic Power with simulations for different types of module mountings.

4.3 Generation Analysis

Annual energy yield for the proposed site is estimated using simulation software's. Some losses were considered (as per the details given in losses section) within the software whereas some were applied externally based on experience.
The final energy yield is summarized below**:**

Summary for 20 MW Solar PV Power Plant Mounting Type : Fixed Tilt, Inverter: Sungrow Inverter Solar Panel: Jakson Solar	
First Year Estimated Generation after losses	32674372 kWh/year
Specific Production	1307 kWh/kWp/year
Mounting type	Fixed
Performance Ratio	73.01%
CUF-AC	18.64%
CUF-DC	14.91%

****

Version 7.4.8

PVsyst - Simulation report

Grid-Connected System

Project: New Project

Variant: New simulation variant

Unlimited sheds

System power: 25.00 MWp

ZHADIMA VILLAGE, CHIEPHOBOZOU BLOCK, KOHIMA, NAGALAND - India

Author

PVsyst V7.4.8
VC5, Simulation date:
21/08/24 00:02
with V7.4.8

Project summary

Geographical Site
ZHADIMA VILLAGE, CHIEPHOBOZOU BLOCK, KOHIMA, NAGALAND
India

Situation

Latitude	25.82 °N
Longitude	94.03 °E
Altitude	260 m
Time zone	UTC+5.3

Project settings
Albedo 0.20

Weather data
ZHADIMA VILLAGE, CHIEPHOBOZOU BLOCK, KOHIMA, NAGALAND
Meteonorm 8.1 (1991-2000), Sat=100% - Synthetic

System summary

Grid-Connected System

Unlimited sheds

PV Field Orientation

Sheds	
Tilt	30 °
Azimuth	15 °

Near Shadings
Mutual shadings of sheds

User's needs
Unlimited load (grid)

System information

PV Array

Nb. of modules	45456 units
Pnom total	25.00 MWp

Inverters

Nb. of units	80 units
Pnom total	20.00 MWac
Pnom ratio	1.250

Results summary

Produced Energy	32674372 kWh/year	Specific production	1307 kWh/kWp/year	Perf. Ratio PR	73.01 %

Table of contents

General parameters

Grid-Connected System

Unlimited sheds

PV Field Orientation

Orientation		Sheds configuration		Models used	
Sheds		Nb. of sheds	500 units	Transposition	Perez
Tilt	30 °	Unlimited sheds		Diffuse	Perez, Meteonorm
Azimuth	15 °	**Sizes**		Circumsolar	separate
		Sheds spacing	6.80 m		
		Collector width	3.81 m		
		Ground Cov. Ratio (GCR)	56.0 %		
		Top inactive band	0.02 m		
		Bottom inactive band	0.02 m		
		Shading limit angle			
		Limit profile angle	28.8 °		

Horizon	Near Shadings	User's needs
Free Horizon	Mutual shadings of sheds	Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	Generic
Model	JH-550M
(Original PVsyst database)	
Unit Nom. Power	550 Wp
Number of PV modules	45456 units
Nominal (STC)	25.00 MWp
Modules	1894 string x 24 In series
At operating cond. (50°C)	
Pmpp	23.03 MWp
U mpp	914 V
I mpp	25209 A

Inverter

Manufacturer	Generic
Model	SG250-HX
(Original PVsyst database)	
Unit Nom. Power	250 kWac
Number of inverters	80 units
Total power	20000 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	1.25
Power sharing within this inverter	

Total PV power

Nominal (STC)	25001 kWp
Total	45456 modules
Module area	117321 m²

Total inverter power

Total power	20000 kWac
Number of inverters	80 units
Pnom ratio	1.25

Array losses

Array Soiling Losses
Loss Fraction 2.5 %

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 29.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 0.95 mΩ
Loss Fraction 2.4 % at STC

LID - Light Induced Degradation
Loss Fraction 2.0 %

Module Quality Loss
Loss Fraction 1.0 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 1.0 %

IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

System losses

Unavailability of the system
Time fraction 3.0 %
10.9 days,
3 periods

Auxiliaries loss
Night aux. cons. 50.0 kW

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage 800 Vac tri
Loss Fraction 4.94 % at STC
Inverter: SG250-HX
Wire section (80 Inv.) Alu 80 x 3 x 185 mm²
Average wires length 600 m

MV line up to HV Transfo
MV Voltage 0.8 kV
Wires Alu 3 x 100000 mm²
Length 8 m
Loss Fraction 0.01 % at STC

HV line up to Injection
HV line voltage 33 kV
Wires Alu 3 x 300 mm²
Length 150 m
Loss Fraction 0.04 % at STC

AC losses in transformers

MV transfo
Medium voltage 0.8 kV
Transformer parameters
Nominal power at STC 24.75 MVA
Iron Loss (24/24 Connexion) 24.75 kVA
Iron loss fraction 0.10 % at STC
Copper loss 247.51 kVA
Copper loss fraction 1.00 % at STC
Coils equivalent resistance 3 x 0.26 mΩ

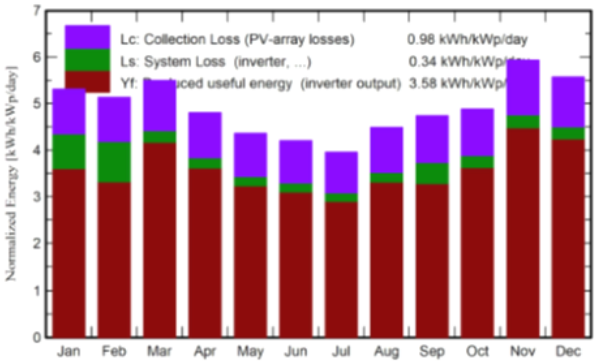
HV transfo
Grid voltage 33 kV
Transformer from Datasheets
Nominal power 20000 kVA
Iron Loss (24/24 Connexion) 1.00 kVA
Iron loss fraction 0.01 % of PNom
Copper loss 1.00 kVA
Copper loss fraction 0.01 % at PNom
Coils equivalent resistance 3 x 0.00 mΩ

Main results

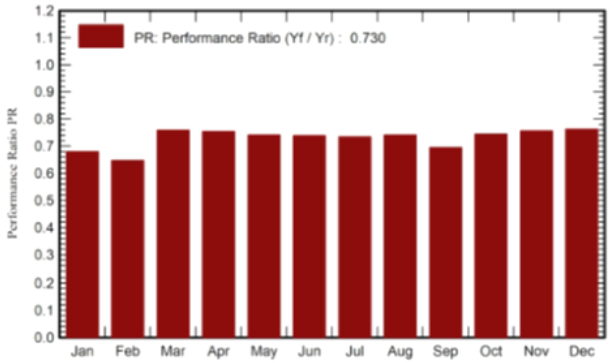
System Production

Produced Energy	32674372 kWh/year	Specific production	1307 kWh/kWp/year
		Perf. Ratio PR	73.01 %

Normalized productions (per installed kWp)



Performance Ratio PR



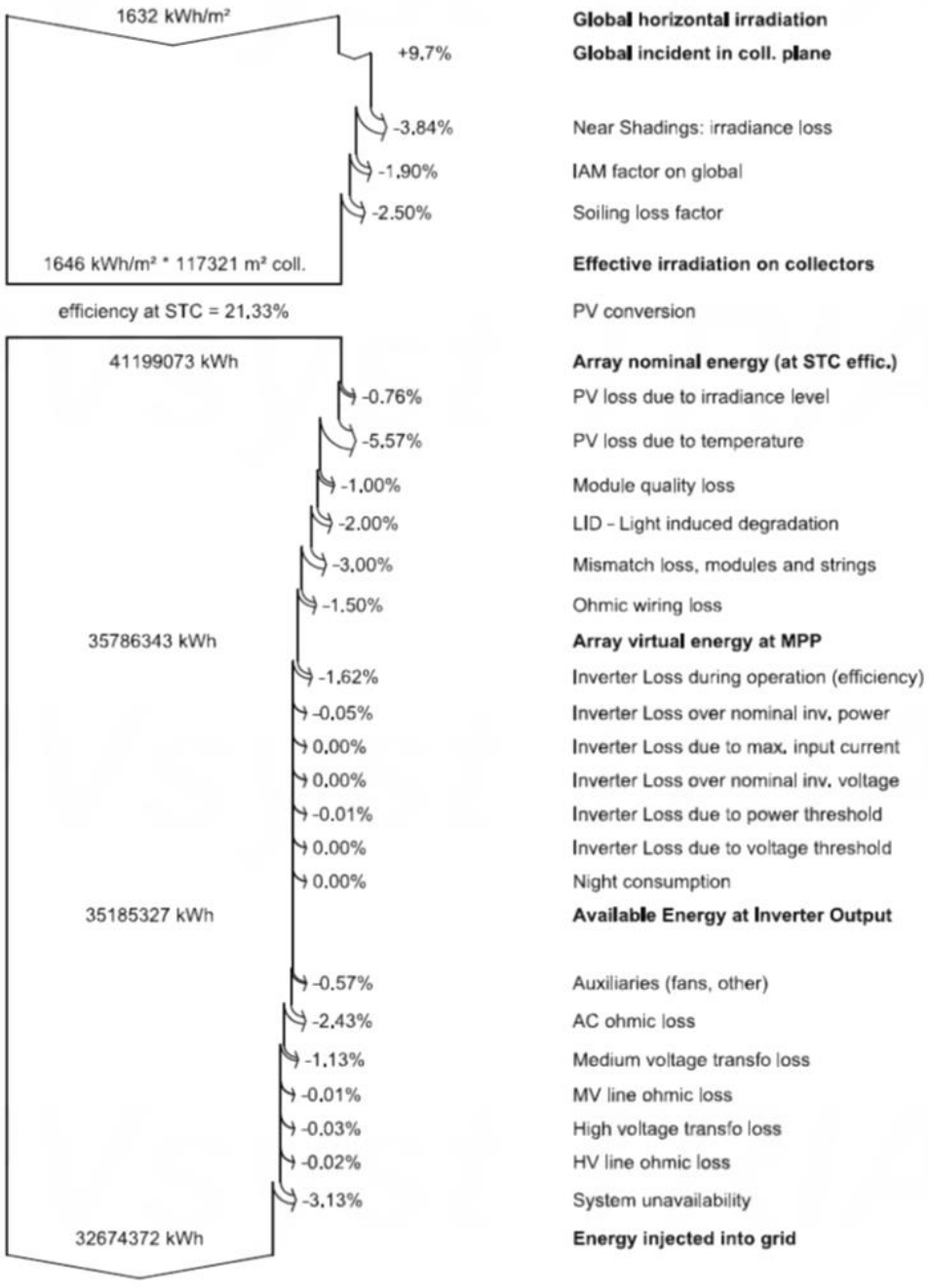
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	119.0	44.08	16.73	164.5	152.4	3375499	2796409	0.680
February	118.1	54.62	19.55	143.8	133.9	2935000	2329195	0.648
March	154.8	78.44	23.22	170.5	158.0	3428051	3232992	0.758
April	146.6	88.75	24.44	144.1	132.1	2879618	2717484	0.754
May	150.2	86.02	26.77	135.3	123.3	2663184	2507182	0.741
June	142.7	88.56	27.87	126.1	114.2	2473545	2329021	0.739
July	136.7	88.33	28.70	122.5	110.7	2391214	2249337	0.734
August	147.1	87.93	28.97	139.0	126.9	2731523	2574525	0.741
September	137.3	69.70	27.81	142.2	130.9	2804948	2467841	0.694
October	131.1	67.28	26.13	151.3	140.0	3017235	2813990	0.744
November	130.1	40.02	21.67	178.0	165.0	3572487	3364817	0.756
December	118.2	36.12	18.28	172.7	158.9	3493983	3291579	0.762
Year	1632.0	829.85	24.20	1790.0	1646.4	35766287	32674372	0.730

Legends

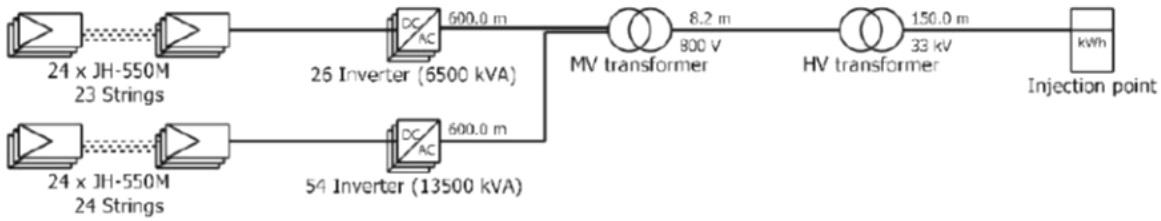
GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Loss diagram



Single-line diagram

PVsyst V7.4.8
VC5, Simulation date:
21/08/24 00:02
with V7.4.8



PV module	JH-550M
Inverter	SG250-HX
String	24 x JH-550M

	New Project	
	VC5 : New simulation variant	21/08/24

Chapter 5

Civil Aspect and Infrastructure

5.0 Civil Engineering Aspects

The Construction and Infrastructure aspects are detailed as follows:

5.1 Fencing

The entire Solar PV Plant area shall be properly fenced for protection and to avoid any intrusion by unauthorized persons, cattle and other stray animals etc.

5.2 Leveling and Drainage

The entire area shall be leveled and provided with suitable lope/ drainage to ensure effective drainage of rain water and avoid any accumulation within the solar farm premises. Drainage can be by way of natural drainage or drains constructed with trapezoidal sections and may be strengthened at appropriate places using brick work. The area shall be then divided into suitable land pockets to accommodate the Solar PV Arrays and switchyard.

5.3 Roads and Walkway

Proper arrangement for movement within the solar farm area shall be provided by way of service roads/ pathways. The construction work shall be done with reinforced cement concrete unless otherwise specifically provided for.

5.4 Pipe Grid

A water pipeline grid shall be laid to supply water for washing of Solar Panels.

5.5 Switchyard Control Room Building:

The Control building is envisaged with an area of 200m^2.
It shall have following components:

- Panel Room with suitable cable trench.
- Battery Room.
- SCADA Room with Air Conditioning.
- Service Area
- Store Room
- Circulating space, pantry, Toilets etc.

5.6 Reinforced Concrete Structure

5.6.1 Grade of Concrete

The following Grades of concrete as per IS–456 will generally be considered for civil work**.**

Grade of Concrete	Civil Work
M-25	For all Load Bearing Structures- Beams, columns, Slabs, Suspended Floors, Chhajja etc.
M-20	Grade Slab and other Horizontal concrete members supported on ground, Plinth protection, Non- Suspended Slabs
M-10	Mud Mat
M-7.5	Mud Mat

Non–Suspended ground floor shall consist of the following minimum specification unless otherwise specified.

a. 230 mm rubble soling binded with murrum / sand over thoroughly compacted earthfill.
b. 50 mm thick lean concrete(M-7.5) over soling.
c. 150 mm thick lean concretes lab of grade M-20 (adequately reinforced) over lean concrete.
d. Proper slope will be provided for adequate draining of ground floor slab.
e. All expansion/ separation joints in slabs shall be filled with premoulded joint filler sealed with approved mastic sealing compound**.**

5.6.2 Reinforcement Steel

Reinforcement Bar	Specification
Mild Steel	As per IS-432 (Grade-1)
High Strength Deformed Bars	As per IS- 1786

5.7 Architecture

Architectural Concepts of structure should offer its own identity and be aesthetically blended to give pleasing appearance. Functional needs of each building will be maintained but without entailing expensive architectural treatment.

5.7.1 Walls

Walls if main control room shall be brick work 230 mm thick except toilet partitions; where same shall be 115 mm thick & 2100 mm tall ofton top.

5.7.2 Doors and windows

Aluminum glazed doors and windows shall be provided for access to the building. Rolling shutters shall also be provided for the panel room for maintenance purpose.
The Battery Room shall be provided with Acid resistant treatment, PVC Door and Exhaust fan.

5.7.3 False Ceiling

Gypsum board ceiling fixed to suitable Galvanized Iron/ Aluminum frame work and suspended from steel/ R.C beams shall be provided for all air- conditioner spaces. The illumination and duct grills in this area shall match the overall aesthetic.

5.7.4 Roof Drainage Systems

The system will be provided for removal of water from roof surface to avoid Damage to the roof structure of all building and shall consist of the following-

(i) Roof drain Heads.
(ii) Rain Water Down comers.
(iii) Fixtures

5.7.5 Building Finishes

Brick Works- internal and external: 230 mm thick with 1:6 Cement Sand mortar.
Half brick partition walls– 115 mm thick can be provided for internal partition walls of toilets with 1:4 Cement Sand mortar.
Panel room shall have IPS floor finish and other rooms shall have vitreous tile finish except Battery Room

5.7.6 Roof

All roofs shall be provided with extra heavy duty water proofing treatment comprising often courses using four layers of Hessian based bitumen felt and Five layers of bitumen felt and Five layers of bitumen paint finishing with 20 mm thick Pre cast concrete tiles on

15 mm thick (1:4) cements and mortar under bed. Water proofing treatment shall be laid over 75 mm thick foam concrete/ 25 mm thick expanded polystyrene Insulation.

5.7.7 Painting

External masonry surface of all building shall have Exterior Quality

Emulsion Paint.
Acrylic plastic emulsion paint shall be provided for control room, control equipment room, computer room. UPS room and air- conditioned area including entrance lobby over smooth wall prepared with a layer of white cement putty and

Primer
Ceiling surfaces shall be provided with White Wash in general Area and acrylic emulsion in false ceiling area.

5.8 Materials

5.8.1 Structural Steel

All structure steel for array shall be tested for quality and shall conform to IS 2062 and the IS standard with galvanized coating.

5.8.2 Electrodes

Mild steel electrodes shall conform to IS: 814. The contractor shall furnish to the Engineer a certificate issued by the manufacturer to the effect that the electrodes supplied are in accordance with the above specification. For welding in any particular position, the electrodes used shall be those recommended by the manufacture for use in that position.

5.8.3 Other Materials

Other materials used in association with steel work shall comply with the appropriate Indian standard specification**.**

5.9 Project Infrastructure

5.9.1 Site Organization- It is recommended to put in place as in team to position since the beginning. An organization Structure is enclosed in Annexure

5.9.2 Clear Workable Site- It is understood that clear workable site is already available with boundary wall of SEZ.

5.9.3 Internal/ Periphery **Roads** could play a critical role in installation of large-scale power plants. Proper roads make the site easily approach able of all installation purposes/ vehicle movement/ earthmoving vehicle movement etc. Further, these roads will be later utilized for proper O&M of the plant.

5.9.4 Permissions & Clearance– The Project team shall immediately start taking action on the permissions and the clearances required.

5.9.5 Construction Water/ Power is required during installation and need to address before commencement of work at site. There could be a temporary Power line also or permanent like can be planned in such a manner to cater the auxiliary power (if allowed) during operation of the plant. In case of unavailability of construction power proper arrangements for generators is required and necessary fuel storage facility within the site.

Water will be required for all civil and other works for construction of the solar PV power plant, thus proper arrangements need to be considered. However, this requirement can have met by ponds and water tankers, but it's recommended to have a permanent arrangement of water supply at site.

During Operation & Maintenance, water will be required for cleaning of PV Modules. Generally, 5 Ltr of water is required to clean one PV module in one cycle.

The Overall Water requirement will vary between Approximately 160 kLtr to 240 k Ltr per day depending upon the occurrence of dust storms, initial rains.

The above figures are based on water requirement of 2.5 mm to 5 mm thickness over the module area per week.

The actual washing requirement will depend upon SCADA report.

It is proposed to use water from the canal for this purpose. However, if adequate quantity from the canal is not available, Ground water through Bore wells shall be used.

A scheme of water pipe grid is already considered in the estimate and suitable pumping/ purification is provided for.

5.9.6 Site office/Warehouse facility is to be created at site to store all the incoming material, like PV Modules, Inverter, structures etc. This store can be further utilized to store spares like drives, fuses, connectors etc. at site.

5.9.7 Communication Facilities: The Site office shall be equipped with Internet connection and Printing facilities for quick transmittal and implementation of the Project activities.

5.9.8 Workforce

It is recommended to plan the workforce and their requirements well in advance before commencement of construction of the plant. Accommodation is required for the construction labor at site, so proper site camp needs to be arranged.

5.10 Contingency Requirements

Provision has been made in the estimate in infrastructure works, miscellaneous and contingency for creation of different infrastructure facilities.

****

Chapter 6

Operation and Maintenance

6.0 Station Operation Philosophy

Necessary software and hardware features are required for effective operation and maintenance management system.
Software system manages and provides the information needed to manage day to day operations, improve labor productivity, reduce maintenance costs, and monitor preventive and predictive maintenance programs.
Through more effective, scheduled and preventive maintenance, the costs associated with emergency breakdown scan be greatly reduced. This includes savings from reduced payroll overtime, fewer defective products and reduced down time losses from disrupted production schedule**.**

6.1 Operation and Maintenance Management System

The operation of solar power plant is relatively simple and restricted to daylight hours in a day. With automated functions of inverter and switchyard controllers, the maintenance will be mostly oriented towards better up keep and monitoring of overall performance of the system. The solar PV system requires least maintenance among all power generation facility due to the absence of fuel, intense heat, rotating machinery, waste disposal, etc. However, for keeping PV panels in good condition, continuous monitoring and faults detection and correction in the connected equipment and cabling are still required for optimization of plant to get maximum energy from the plant. A maintenance schedule needs to be planned as per service/ guarantee terms of supplier to maintain optimum availability of plant at all times. The maintenance functions of a typical solar PV power plant can be categorized as given below-

6.1.1 Preventive Maintenance

6.1.2 Scheduled Maintenance

6.1.3 Unscheduled (Emergency) Maintenance

6.1.1 Preventive Maintenance

Preventive Maintenance, which covers routine checking and minor refurbishment activities to be performed according to operation manuals of components equipment in operating conditions.

6.1.2 Scheduled Maintenance

Scheduled maintenance is carried according to maintenance plan, which should be discussed and optimized according to the needs of the customer / client.
The maintenance plan is based on scheduled outages for the following components:

(a) Cleaning of Solar Module
(b) Power Processing System
(c) Switchyard equipment

6.1.3 Unscheduled (Emergency) Maintenance

Emergency maintenance, which is corrective maintenance to be performed when a significant failure occurs. To minimize forced outages duration, an effective Emergency Maintenance must be supported by:

(a) A proper stock of spare parts
(b) Permanent monitoring and diagnostic systems for main components.

6.2 Operations for Scheduled Maintenance

6.2.1 Ordinary Maintenance

Description	Freq.	Time	Notes
Care and management of landscaping.	-	WN	To avoid vegetation causing shading of the modules.
Fencing	1	A	Cleaning the water passages of buildings and roads (manual)

6.2.2 Inspections

Description	Freq.	Time	Notes
Production system (Panels)	1-2	W	Cleaning of Panels (Generally 5 ltr. Of water is required to clean one PV module in one cycle).
	1	M	Visual analysis, to carry out Corrective Maintenance, if necessary. Check the integrity of the modules, plugs, frames and glass.
	4	A	Check of the readability and status of the strings and Panels labels. Sample thermal imaging of modules in lowest 10% performing strings. Thermal imaging of junction boxes and inverters.
Support and anchorage system (Module Mounting Structure) in Case of fixed tilt system	2	A	Visual analysis, to carryout Corrective Maintenance, if necessary. Sample check of the tightness of the bolts and nuts.

Support and anchor age System (Module Mounting Structure) in case of tracker system	-	WN	To carry out visual inspection and periodic Maintenance according to the specifications of the manufacturers. Lubricate tracker by inserting grease with grease gun into appropriate grease caps per manufacturer maintenance recommendation. Check voltages inside the controller box. Check the calibration and positioning of the inclinometers. Check array for signs of part shitting or rubbing other parts.
Conversion system (Inverters).	-	WN	To carry out periodical maintenance according to the specifications of the manufacturers of the inverters.
	3	A	Fault analysis of monitoring system, to carry Out corrective maintenance if serial faults are apparent.
		A	Visual analysis, to carry out Corrective Maintenance, if necessary.
Transport system (cables)	6	A	Visual analysis, except for under-ground Cables. To carry out Corrective Maintenance, if necessary.
Earth system	4	A	Periodical earth resistance measurements according to the Applicable Law Check of the tightness of the connections. Check of the continuity of Primary Earth connections. Earth resistance test if inverter earth resistance values are unusual.
Transformation and continuity system (transformers, generators, UPS)	-	WN	To carry out periodical maintenance of the transformers according to the type of transformer and the manufacturer's recommendations and specifications.
Cables	4	A	Visual analysis, to carry out Corrective Maintenance, if necessary. Check of absence of electrical discharges Check of the proper tightness of the power cables. Tests on the thermal protections.
Connection system (DC/AC connector block, equipotent bars etc.)	12	A	Visual analysis, to carry out Corrective Maintenance, if necessary. Check of the status of the fuses and surge arresters.
	4	A	Check of the proper screwing of the cables On boards.

All disconnection devices (handle, keys, circuit breakers etc.)	4	A	Visual analysis, to carry out Corrective Maintenance, if necessary.
Lighting system (external and in technical areas)	4	A	Visual analysis, to carry out Corrective Maintenance, if necessary.
IT system and data transfer (PC, modem, lines, etc.)	12	A	Visual analysis, to carry out Corrective Maintenance, if necessary. Required hardware and software updates (excluding changes in design). Periodical back-up of database.
Sensor systems (Irradiation, Temperature)	1	M	Visual analysis, to carry out Corrective Maintenance if necessary.
	1	5A	The calibrated irradiation sensors will be Changed every 5years.
LV/ MV cabins	-	WN	Maintenance according to manufacturers' Recommendations and specifications.
	2	A	General check and internal cleaning, replenishment of required safety tools (gloves, fire extinguishers, safety signs).
LV and MV Panels	-	WN	Maintenance according to manufacturers' Recommendations and specifications.
	1	A	Visual check. Check of the protection equipments against direct contacts and interlocking devices. Check of the tightness of the nuts. Check of the continuity of the earth connection. Check of the interlocking devices against direct access to energized parts. Tests of opening and closing of main breaker. Verifications of electrical protection settings.
Energy Meters	1	A	Support for the utility company for the performance of inspections by allowing access to the site.

6.2.3 Data Acquisition

Through the Data Acquisition System, the Tele Control System and the Video Surveillance System:

Recording and storage of alarm information	Real Time	-	Information coming from sensory equipment.
Recording and storage of Production information	Real Time	-	Information coming from Inverter and energy meters.
Recording and storage of Irradiation information	Real Time	-	Information coming from sensory equipment.
Recording and storage of video digital images from security cameras	Real Time	-	Information coming from closed circuit cameras.

6.2.4 Data Management (through the Monitoring and Video Surveillance systems)

Description	Freq.	Time	Notes
Alarms	Real Time	-	Analysis in real time.Intervention.
Production	1	A	Comparative analysis with historical/ statistical reference.
Radiation	1	A	Comparative analysis with historical/ statistical reference data. Record in log.
Data Back Up	4	A	Off-site data back-up of relevant alarms, faults, production, including solar irradiation.
Images from security cameras	-	WN	Real time alarm for on Site security in the event of an alarm caused by Video Surveillance System.

6.3 Operations for Unscheduled Maintenance

6.3.1 Corrective or Reactive Maintenance

Corrective or reactive maintenance addresses equipment break downs after their occurrence and, as such, is instituted to mitigate unplanned down time. The current industry standard, this break-fix method allows for low upfront costs, so brings with it a higher risk of component failure and accompanying higher costs on the backend (putting a premium on negotiating beneficial warranty terms). Though a certain amount of reactive maintenance will likely be necessary over the course of a plant's lifetime, it can be lessened through more proactive PM and condition-based maintenance (CBM) strategies.

Within seven (7) days from the time upon which the SCADA System reveals (or either Party otherwise discovers) a failure, breakdown of malfunction affecting the proper performance of the plant without disconnection of complete combiner boxes or inverters Minor Defect, the Contractor shall inspect the PV Plant and repair the Minor Defect.

Sr. No.	Major element of Corrective or Reactive Maintenance (For All components)	Frequency	Time
1.0	On-Site Monitoring/ Mitigation	Variable	WN
2.0	Critical Reactive Repair (Critical reactive repairs address production losses issues)	As Needed (High Priority)	WN
3.0	Non-Critical Reactive Repair (Non-critical reactive repairs address production degradation issues)	As Needed	WN
4.0	Warranty Enforcement	As Needed	WN

6.3.2 Condition Based Maintenance

Condition based maintenance uses real-time data to prioritize and optimize maintenance and resources. Though largely incipient, an increasing number of third party integrators and turnkey providers are developing CBM regimes to offer greater O&M efficiency. The increased efficiency, however, comes with a high upfront price given the communication and monitoring software and hardware requirements. Moreover, the relative novelty of CBM can produce maintenance process challenges caused in part by monitoring equipment malfunction and/ or erratic data connection**.**

S.No	Major element of Condition Based Maintenance	Frequency
1.0	Active Monitoring—Remote and On-Site Options	Continuous
2.0	Warranty Enforcement (Planned and Unplanned)	As Needed
3.0	Equipment Replacement (Planned and Unplanned)	As Needed

On the whole, the PV power plants require O&M approaches that promote greater oversight and management capability. Based largely on budgetary constraints and the relatively low level of importance assigned to PV production (which represents a small fraction of the generation portfolio), utilities are employing either directly or via a third- party a combination of PM and reactive maintenance strategies. However, CBM is anticipated to play a larger role as PV assets proliferate, associated information technology and deployment costs fall, and the over arching cost benefit equation improves. Somewhat unsurprisingly, nascent CBM efforts are being predominately developed by third-party monitoring and services providers whose livelihoods have historically been more closely aligned with PV system performance metrics.

Legend: *W=Week, H=hourly, D= daily, M= monthly, A= annually; WN= when necessary, Real Time = according to the sampling and storage frequency of the Monitoring / Data Acquisition System or the Tele control System or the Video Surveillance System.*

6.4 Man Power Deployment& Training for O& M

A solar PV plant does not require constant attention when in operation. A part time plant manager, one account cum administrative personnel, one site engineer assisted by two trained and skilled technician can monitor and look after its periodic inspection and maintenance. The plant manager will be responsible for overall functioning, maintenance; revenue collection and expense control for operation and maintenance of the power plant and will report to the management. He will monitor the power plant remotely from headquarter. The site engineer will be located in the site and will be fully responsible for day-to-day operation, maintenance and up keep of the power plant. He will be assisted by site technician sand will report to the plant manager. Unskilled man power will be required for scheduled cleaning and other civil and structural maintenance work. The same could be out sourced from external agencies.

6.5 Security Personnel

Required security personnel to be placed on shift and could also be outsourced from security service agencies. All heavy maintenance jobs and those of capital nature will be contracted out. While estimating manpower, it has been considered that the maintenance personnel will have multi disciplinary skills so that occasional minor repairs and adjustments in all systems could be carried out without waiting for specialists.

****

Chapter 7

Project Financial

Activity of 20 MW AC Solar Power Plant			
SL. NO.	**Activity**	**Approximate Cost**	**Considering normal site conditions. Many items are not mentioned which may require after survey as per site condition.**
1	**Land Lease, Tree Cutting and Clearing, Land Cutting/Grading, Boundary Mapping, Contour Mapping, Geo-Technical Investigation, Construction for supply of Power & Water, Access/Approach Road to Site, Camp office,Control room/Godown**		
	Land Lease for 30 years	3,72,00,000	
	land compensation for Posts' ROW	73,50,000	
	Tree cutting & clearing, Land cutting/grading	4,45,51,000	Tree cutting & clearing, Land cutting/grading/ Land Development
	Approach/Access Road construction. Construction of permanent pathways for O&M activities	3,63,68,000	Security gate at access & exit points on the road for Plant safety
	Construction for supply of power & water(camp)	15,00,000	
	Camp Office/ Quaters permanent structure	1,50,00,000	
	Godown(4K sq ft)	20,00,000	Construction of Godown for material storage
	Solar Plant Boundary Chain Link Fencing	4,50,00,000	
	HR remuneration	2,00,00,000	
	PURCHASE OF VEHICLES	60,00,000	3-4 vechicle need to purchase for erection and maintenance
	INSURANCE	1,24,00,000	
	ADMINISTRATION COST	20,00,000	Team daily logistics and accomodation, fuel costs,etc
2	Power Plant Design & Layout	1,25,00,005	
3	Boundary Mapping, Contour Mapping		Included in Power Plant Design & Layout
4	Geo-Technical Investigation		Included in Power Plant Design & Layout
5	Site Survey/technical variation input		Included in Power Plant Design & Layout
6	Solar Panels	38,75,00,155	25MW DC side.
7	Inverter	4,40,00,000	20MW AC side.
8	MMS including Mounting accessories	10,00,00,040	Ground Mount Structure as per design.
9	Civil Work	2,50,00,010	Civil Foundation work of MMS Structure
10	DC Cables	1,36,50,000	
11	DC Side Earthing	30,00,000	
12	Weather Monitoring system	3,50,000	
13	Lightening Arrestor	11,00,000	
14	Plant Remote Monitoring System (DC side)	16,00,000	
15	LT/HT Power Cables & LT/HT Panels	5,00,00,000	
16	AC Side Earthing	16,00,000	
17	Control & Communication Cables	20,00,000	
18	Plant Remote Monitoring System (AC side)	3,50,000	
19	ABT Meter	10,00,000	
20	Power Transformers	87,00,000	
21	Transmission Line (132 KV)	3,00,00,000	

22	GSS Bay including meter	2,75,00,000	
23	MMS Foundation (AC side)	50,00,000	
24	Inverter Rooms, Control Room	62,50,003	
25	Foundation & Fencing of Outdoor Equipment	62,50,003	
26	Double pole structure with foundation & Civil Works	75,00,000	
27	Module Cleaning System - Piping works	70,00,000	
28	Plant Illumination near Inverter, Control Panel	4,00,000	
29	Accessories	50,00,000	
30	Security Cabins	10,00,000	
31	Water Storage Tanks	10,00,000	
32	Fire Safety Equipment (Extinguishers & Sand Buckets)	5,00,000	
33	Plant Security – CCTV	25,00,000	
34	Transportation & Loading/Unloading	1,02,00,000	TRAIN/TRUCKING
35	EPC Consultant renumeration	1,50,00,000	
36	Installation & Commissioning	5,00,00,000	Labour cost and machinery cost for piling, civil work of structure, trench work, MCR work, etc.
37	Cable Trenches for AC/DC, HT/LT, C&C Cables		Included in I&C
	Total excluding GST	**1,05,68,19,215.00**	
	Total including GST	**1,21,31,37,664.40**	**12% GST on Inverter and Solar Panels** **18% GST on rest BOS/work.** **No GST on Land Lease and Land Compensation**
The prices indicated are tentative for cost estimations.			

-