TVAKSAS
RENEWABLE PVT. LTD.

To,
Shri Er. MOA AIER,
Engineer – in - Chief,
Department of Power, Kohima
Government of Nagaland

August 8, 2023

Subject: Covering letter for the submission of Detailed Techno – Commercial Project Report (**DPR**) on 100 MWp Grid Connected Solar PV (photovoltaic) Project in Nagaland.

Ref: Lt. No.PWR/SOLAR-TIZIT-02/23/186; Kohima, 17th July, 2023.

Respected Sir,

With reference to the subject cited above and ref, we M/s. Tvaksas Renewable Pvt. Ltd. Pune is submitting the "DETAILED TECHNO – COMMERCIAL PROJECT REPORT (DPR)" on 100 MWp Solar PV power plant herewith.

We seek your support of consideration procedure in this regard and request you to issue the necessary registration or issuance the tariff or PPA rate for 100 MWp solar photovoltaic power generations proposal in the state of Nagaland.

We are pleased to attach the following documents

1. Covering letter
2. Detailed Techno – Commercial Project Report (**DPR**)

Kindly consider our keen interest to work with Dept of Power, Government of Nagaland for achieving Prime Minister's India's Solar mission 500 GW by 2030.

Thanking you and further do the needful.

Please acknowledge the same

Yours Faithfully,

Tvaksas Renewable Pvt Ltd

TVAKSAS RENEWABLE PVT. LTD.

Director
Pune,
Maharashtra

TVAKSAS RENEWABLE PVT. LTD.

+91 99245 29926 | +91 75675 18350 director@tvaksas.in Pune, Maharashtra
CIN No.: U40100PN2021PTC200852 GST No.: 27AAICT6048C1ZB

Detailed Techno – Commercial Feasibility Project Report on 100 MWp Grid Connected Solar PV (photovoltaic) project in Nagaland proposed by

M/S. TVAKSAS RENEWABLE PVT LTD PUNE

At proposed site location Takun, Tizit, Nagaland; State – Nagaland

Under PPA – IPP mode (Sale to EB, Govt. of Nagaland)

TVAKSAS RENEWABLE PVT LTD

Tvaksas Group Company
Pune Office
Amanora Park Town, Pune – 411028
Tel: +91 7567518350; +91 9924529926
Email: director@tvaksas.in ; bhakti.arkaips@gmail.com

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PREAMBLE:

Government of India has set as ambitious target of 500 GW for generation of power from Renewable Energy sources by 2030, wherein 200 GW target has been set for generation of power from solar energy. With the spirit of Government of India's National Solar initiative, Government of Nagaland has also estimated potential as per MNRE of 7200 MW solar capacity additions in State.

As a part of national solar movement, M/s. Tvaksas Renewable Pvt Ltd. is in the business of EPC of solar projects and IPP, has proposed to set up 100 MWp (DC) ground mounted solar power project under Government of Nagaland Renewable Energy Policy, 2018. The proposed solar project shall be connected at Dept of Power 66/33 KV Tizit substation, Mokokchung considering the initial feasibility and availability of nearest substation of Dept of Power, which is around 12-15 KM (by road) distance from the project site. We propose for grid connectivity at Dept of Power Tizit substation, Mokokchung. The purpose of the project is generation of electricity by harnessing solar energy through internationally and nationally accepted and proven Crystalline Silicon Photovoltaic (PV) – Polycrystalline / Mono crystalline technology using Power Conditioners / Inverter, along with other sub-systems/ components.

The 100 MWp DC Solar Power Project is proposed on approximately 400-450 Acres of Land at Takun, Tizit; Dist:- Mon, State - Nagaland.

Nagaland has endow with average solar irradiation of 3 to 4 KWh/m^2/day & approximately 210 - 230 clear sunny days are the important climatic criterion that adds to successful power generation from a plant based on PV crystalline technology.

The solar PV power project shall use proven crystalline silicon (c-Si) photovoltaic (PV) cell module, solar inverters and balance of plant (BOP) sub-systems / components for generating electricity from solar radiation. Due to advancement in technology and reduced size of modules, the total land requirement for 100 MWp DC solar power project would be even less and our company has identified the required 400-450 acres of land for this project. The power generated from the project shall be fed to Nagaland State Electricity Distribution Company Limited substation at 66/33 kV level at Tizit. The power generated from the solar project shall be sold to Electricity board and excess units can be sold to third party at mutually agreed rate under open access mechanism.

The electricity hence generated will add to the total renewable energy power generation base of Nagaland and India, thereby reducing the overall greenhouse gases (GHG) reduction. The GHG emission reduction shall provide Carbon Credits i.e. certified Emission Reduction (CERs) to the project and will form a revenue stream depending upon market conditions. The Clean Development Mechanism (CDM) program of United Nations Framework Convention on Climate Change (UNFCCC) allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tone of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol, on European Emission Allowances Auction (EUA), Global 4 Environmental Exchange, popularly known as EEX (European Energy Exchange). **The Nagaland government can match their Renewable Power obligation (RPO) with this 100 MWp green energy plant.**

The energy generated shall be metered at the injection point of the substation. The evacuation arrangement shall be executed and completed within the stipulated time period and after the receipt of Grid Connectivity from Nagaland Electricity Board or with the assistance of NREDA or Dept of Power,

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Govt of Nagaland. The proposed capacity shall be commissioned within 18 months from the date of PPA signing and Grid allocation.

100% of the power generated from the plant need to be procured by Nagaland Power Distribution Company (Offtaker). All the power produced from the project to be procured by Off-taker on first priority basis. The project is selected to install Polycrystalline/ Mono crystalline modules which comply with IEC 61215:2005 for quality and IEC 61730:2007 safety standards.

The Power Project would generate direct and indirect employment opportunities; create of civic facilities for establishment of ancillary industries.

Benefit to Government:

a. Employment generation for local youth
b. Availability of power at low tariff
c. Minimal escalation in tariff for entire project lifecycle leading to significant cost reduction
d. RPO benefits
e. Increase Renewable portfolio of state; green credits
f. Enhanced investment attractiveness of the state
g. Utilization of land; which is unused
h. Availability of power acts as catalyst for flourishing of local industries

SALIENT FEATURES OF THE PROJECT:

Sr. no.	Particulars	Details
1	Project Site	Takun, Tizit
2	District Name	Mon
3	Name of the State	Nagaland
4	Location	As per attached file
5	Irradiation details Considered	YES
6	Type of System	Fixed ground mounted MMS
7	Type of PV modules Considered	Poly crystalline / Monocrystalline
8	Proposed Capacity	100 MWp
9	Capacity of each Module proposed	Mono 500 - 560 Wp
10	Inverters Capacity	String Inverter 1 /2.5 MVA x 50 nos. or more as per designing
11	Nearest Substation	Dep. of Power; 66/33 KVA Tizit, Mokokchung Transmission Division
12	Injection point	66 KVA
12	Land area	Apprx 400-450 acres
11	Projected Energy Production per year	1249 MWh Unit; Apprx 1.20 MWh/kWp/Year
12	CUF	12%

Chapter -1
INTRODUCTION

1.1 GLOBAL ENERGY SCENARIO

- Power is a vital input for economic development and sustenance of modern economy. Power is also important for eradication of poverty. However, providing adequate and clean power to face the ever-growing environmental degradation has been a great challenge of the current century. Basically the objective of sustainable development is also the same.
- The inevitable increase in the use of fossil to be in step with the economic growth has associated side effects of threat to energy security of the country and environmental degradation, through climate change. World population is expected to double by the middle of the 21st century (Global Energy, 1998) and economic development needs to continue. It is expected that this will result in a 3-5 fold increase in world economic output by year 2050 and a 10-15 fold increase by year 2100. Some studies predict that despite rapid economic development adequate energy services may not be available to one and all. A 1.5 to 3 fold increase in primary energy requirements by 2050 and a 2 to 5 fold increase by 2100 is expected.
- As early as 1896, the Swedish scientist Svante Arrheniushad predicted that human activities would interface with the way the sun's interaction with the earth, resulting in global warming and climate change. The prediction is becoming more or less true mostly due to the indiscriminate use of fossil fuel. The following issues are considered to be of global significance.
  - Ozone layer depletion
  - Land degradation
  - Air and water pollution
  - Sea level rise
  - Loss of bio-diversity
- A very important aspect of the global environment degradation is that it affects all on a global scale irrespective of country, race or region.
- Fossil fuel combustion is a major contributor to harmful emission which aggravates the ozone layer depletion. Sulphur oxides, nitrogen oxides, carbon monoxide, and suspended particulate matter are the main pollutants. Acid deposition from fuel combustion is causing significant damage to natural system, crops etc., affecting entire eco-systems and crossing national boundaries. In many regions, acidification has diminished the productivity of forests, fisheries and farm lands. Carbon dioxide (CO2) produced by fossil fuel combustion, is the biggest source of the anthropogenic greenhouse gas emissions that are changing the global climate system.
- To achieve a stable atmospheric CO2 concentration at any level would required that CO2 emissions be cut by more than half from current levels, maybe within the next few decades. However, if the present trend is allowed to continue, current CO2

emissions will lead to more than a doubling of atmospheric concentration before 2070.

1.1.1 Sustainable Development

- The World Commission on Environment and Development (the Brundtland Commission) defines sustainable development as "development that meets their own needs". While the development needs are recognized, it emphasizes that it must be based on the efficient and environmentally responsible use of all of society's scarce resources- natural, human and economic.

Figure 1: Multiple Objective of Sustainability

- The multiple Objectives of Sustainability is indicated in Figure 1 as shown.

1.1.2 Oil Depletion

- It is generally accepted that the world runs on oil. As the oil is termed as 'fossil fuel', the consensus is that it was formed in the past which means that the depletion has started the day the first barrel was consumed.
- The raging debate between the economists and natural scientists withstanding, the economist maintaining that the reserves are constantly being renewed as they are extracted as Minerals are inexhaustible and will never be depleted and the natural scientists maintaining that an oilfield contains what it contains, because it was filled in the geological past. But the general pragmatic thinking is that the reserve will not last long. As per Mr. Colin J. Campbell, the watershed for oil comes around 2010, followed five years later by the peak of oil and natural gas combined.
- The base case scenario projected by him (please refer Figure 2 below) points to 2010 but could come sooner, as per him, if economic recovery should drive up the demand for oil.

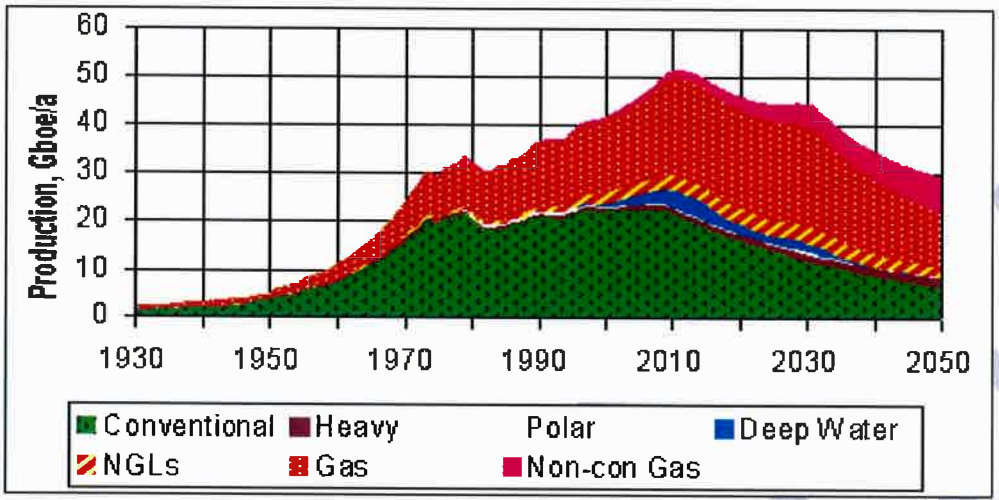


Figure 2: All Hydrocarbons Base Case Scenario 2002

- Oil, which provides about 40% of global energy needs and about 90% of transport fuel, is set to start to decline within about ten years. Mr. Campbell warns that world will have to learn to use less of oil.
- World demand drives the rate of depletion. The scenarios projected earlier assumes that demand will be on average about flat, giving a plateau of production until the five swing countries of the Persian Gulf are no longer able to offset the decline of the rest of the world. As per Cambell, this time should be expected to be reached around 2010 when the demand is placed on these swing countries to produce over 20 Mb/d (millon barrels a day) or about 36% of world demand. The world production would then have to commence its long term decline (World Hubbert Peak) he predict.

1.1.3 Role Of Renewable Energy

- Renewable energy sources have the potential to provide energy services with zero or almost zero emissions of both air pollutants and green house gases. It is estimated that renewable energy sources supply 18% of total world energy demand. New renewable energy sources (other than traditional biomass) contributed to 16.7% of the world's energy consumption in 2010 as shown in figure 3.
- It is worth mentioning here that each gigawatt-hour of electricity generated by solar photovoltaic, rather than burning coal, prevents up to 820 tons of CO_2 emission.

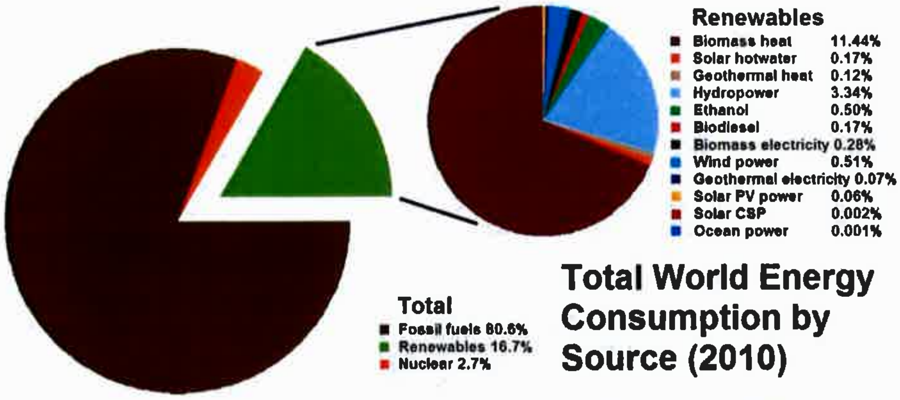


Figure 3: Renewable Energy share of global final energy consumption 2010

1.2 INDIAN ENERGY SCENARIO

India is endowed with vast solar energy potential. About 5,000 trillion kWh per year energy is incident over India's land area with most parts receiving 3-7 kWh per sq. m per day. Hence both technology routes for conversion of solar radiation into heat and electricity, namely, solar thermal and solar photovoltaic's, can effectively be harnessed providing huge scalability for solar in India. Solar also provides the ability to generate power on a distributed basis and enables rapid capacity addition with short lead times. Off-grid decentralized and low-temperature applications will be advantageous from a rural electrification perspective and meeting other energy needs for power and heating and cooling in both rural and urban areas. From an energy security perspective, solar is the most secure of all sources, since it is abundantly available. Theoretically, a small fraction of the total incident solar energy (if captured effectively) can meet the entire country's power requirements. It is also clear that given the large proportion of poor and energy un-served population in the country, every effort needs to be made to exploit the relatively abundant sources of energy available to the country. While, today, domestic coal based power generation is the cheapest electricity source, future scenarios suggest that this could well change.

The Electricity Act 2003 is intended to consolidate the laws relating to the generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to the development of electricity industry promoting competition therein, protecting interest of consumers and supply of electricity to all areas. Under paragraph 3 (1) of part 2- 'National Electricity Policy and Plan' of the electricity Act 2003, it is provided that, "the central Government shall from time to time, prepare the national electricity policy of tariff policy, in consultation with the state Governments and the Authority for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or materials, hydro and renewable sources of Energy ".

Under paragraph 6.4 " Non-conventional sources of energy generation including co-generation, of the tariff policy, it is provided that", "Pursuant to provisions of section 86(i) (e) of the Act , the Appropriate Commission shall fix a minimum percentage for purchase of energy from such sources taking into account availability of such resource in the region and its impact on retails tariffs. Such percentage for purchase of energy should be made applicable for the tariff to be determined by the SERCs latest by April 1,2006.

1.3. POWER SCENARIO NAGALAND

- Nagaland is the avg. sun radiating power generating state in India with installed electricity generation capacity of hydro based (As on 31st July 2019). Nagaland constitutes very minimum SHP of the total installed electricity generation capacity in India which is mainly from Hydro & Inter State. The state of Nagaland has a PGCIL of the Northern eastern grid of India which now comes under North, East, grid of India.
- Nagaland state operates mainly hydro power plants in the state. In addition to the state government owned power generation plants, there are privately owned power generation plants that transmit power through Nagaland State Electricity Transmission Company which looks after Trans-mission of Electricity in the state.
- **Electricity shortage**
- Nagaland experienced increasing capacity addition in the last few years. In the year 2016, to meet the expanding energy requirement in the state, additions to generating capacity were made both in the private as well as the state sector, expected to leading in reducing deficits. However, the state of Nagaland has been experiencing energy deficits since 2015-16. This is still less than many other states but if the scenario remains same for years ahead, the deficit will further grow.

- Despite the additional installed capacity, the peak demand deficit in the state has increased from 17% in 2015-16 to 22% in 2016-17. Between 2015-16 and 2016-17, peak electricity demand grew at a compound annual growth rate (CAGR) of 5%, while peak demand met at the CAGR of 4% over the period of 8 years.

- Overall, the electricity scenario is not good in the state and needs further investment to increase power generation. Based on the current status of fossil fuel supply to the power plants, it is difficult to rely on a single source of energy in the years ahead. Renewable energy should be the future of energy sector in Nagaland and also in the entire country. Aligned with the **R**enewable **P**urchase **O**bligations under the Electricity Act and India's National Action Plan of Climate Change, capacity addition to the renewable energy sector is taking place in the state. The state of Nagaland has considerable Hydro, Biomass, Waste to Energy, wind and solar energy harnessing potential. The State and central government subsidies and the recently introduced accelerated depreciation benefits to the solar power producers is also helping RE project developers to invest in this sector. The collective encouragement to the RE sector can help to resolve electricity supply position in the state of Nagaland.

1.4 RENEWABLE ENERGY IN INDIA

- India has a huge potential for renewable energy, and it has one of the largest programs in the world for deploying renewable energy products and systems.
- Indeed, it is the only country in the world to have an exclusive Ministry for renewable energy development, the Ministry of New and Renewable Energy (MNRE). Since its formation, the Ministry has launched one of the world's largest and most ambitious programs on renewable energy. Based on various promotional efforts put in place by MNRE, significant progress is being made in power generation from renewable energy sources.
- Renewable energy technologies based on the inexhaustible resources of sunlight, wind, water and biomass are considered to offer sustainable energy alternatives to a world beset by serious environmental problems and volatile fossil fuel politics. An increasing share of global energy needs is expected to be met by renewable in the years ahead.
- India is abundantly endowed with renewable energy resources viz. solar energy, wind energy, biomass and small hydro, widely distributed across the country, and can be utilized through commercially viable technologies to generate power.
- Around 35,000 MW (around 15% of total installed capacity in the country capacity of renewable energy projects has been installed in the country.
- The environment has become the main driving force behind efforts in use of renewable energy projects and energy efficiency & conservation. Evidence is accumulating that the burning of fossil fuels contributes to global warming and climate change.
- The demand for power supply has been increasing considerably year after year due to more & more industrialization, development of various industries etc. and the need to bring irrigation facilities to the farms in the dry zones, increase dependency on power in domestic sector, to meet minimum needs programs of electrifying the villages etc.
- The need for harnessing renewable sources of energy has, therefore gained, increased importance not only to meet the growing demand for energy but also for the fact that sources like coal, oil, petroleum product and other hydrocarbons aree fast getting depleted in the world and particularly in Indian.
- India is a tropical country and has abundant solar insolation throughout the country for most part of the year. Since the seasonal variation is marginal solar energy can be harnessed economically throughout the year.
- Taking the above factors into consideration, Government of india had formulated a policy frame work for enhancing the share of renewable energy in the energy mix of the country known as National Action Plan on Climate Change.

Chapter – 2
OBJECTIVES OF THE PROJECT

2.1 OBJECTIVE

- In the light of the growing importance of renewable energy, especially solar photovoltaic energy and in the context of climate change and energy security, M/S. Tvaksas Renewable Pvt Ltd. PUNE desires to diversity its portfolio by developing power stations based on renewable energy and solar photovoltaic electricity for a long term basis.
- **To contribute to nation mission from a part of Prime Minister's Solar Mission 500 GW by 2030**.
- Ministry of New and Renewable Energy (MNRE), GOI has issued guidelines for generation based incentive for grid interactive solar power generation projects vide notification no. POWER -81/2017/13 dated 28.08.2017.
- The solar PV power plant shall consist of a solar PV array of 100 MWp. The generated DC power will fed into power conditioning units with capacity of 1000 KW = 1 MW to convert DC power to AC power at 3ph, 690 V, 50Hz.
- The output of PCU are connected through proper isolation and circuit breaking arrangement to transformers with a total capacity of 20% more i.e. 1250 KVA to step up the 690 V, 3Ph AC supply to 33 kV, 3 ph AC supply and further 66 KV.
- Synchronization arrangements effected through electronics provided in the PCU ensure adequate synchronization of the two sources of power supply namely, the grid power and the solar power.

Local employment for security, OEM, service and construction works – skilled Min. 20 nos. & unskilled 40 -50 no of labors with project insurances in regards with safety, security and health management. Green, Clean energy to maintain clean environment statics' w.r.t. power demand and supply in future of 25years without any carbon emission.

The Power Project would generate direct and indirect employment opportunities; create of civic facilities for establishment of ancillary industries.

Benefit to Government:

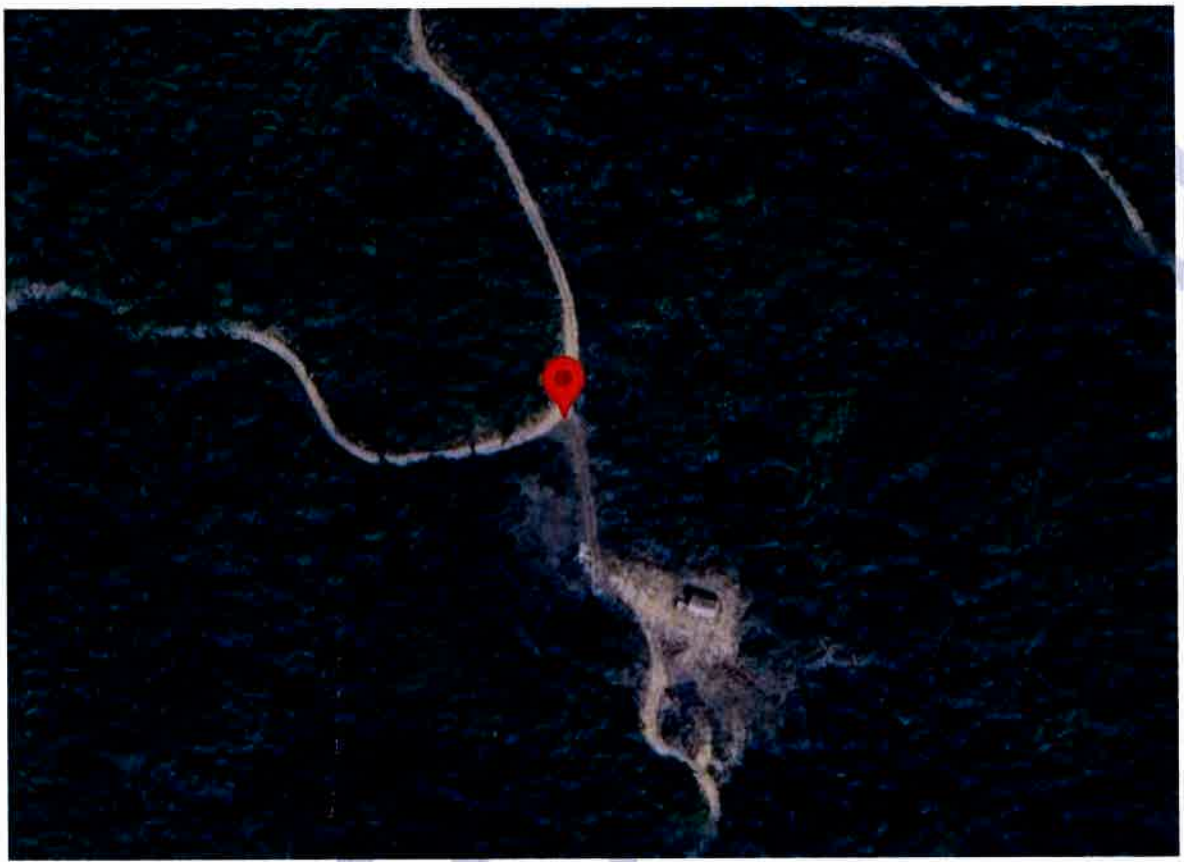
a. Employment generation for local youth
b. Availability of power at low tariff
c. Minimal escalation in tariff for entire project lifecycle leading to significant cost reduction
d. RPO benefits
e. Increase Renewable portfolio of state; green credits
f. Enhanced investment attractiveness of the state
g. Utilization of land; which is unused
h. Availability of power acts as catalyst for flourishing of local industries

Chapter – 3
PROJECT LOCATION & SITE DETAILS & SITE TOPOGRAPHY

3.1 LOCATION & DETAILS & TOPOGRAPHY

- M/S. Tvaksas Renewable Pvt Ltd is proposing to install a 100 MWp dc grid connected solar photovoltaic Grid interactive Solar PV power project at Tizit; Dist:- Mon, State - Nagaland.
- Expected energy generation for sale will be approximately Avg. 1249 MWh / year with the approximate performance ratio of 78.1%.
- The solar PV power will be generated at 690 Volt AC, will be step Up to 33KV level and connected to 66/33 KV or 132/66 KV grid at internal switch yard substation within fenced plant.
- Availability Of Land : apprx 400-450 Acre available
- Nearest Railway Station : Bhojo railway station18.5 KM; Longpatia railway station19.7 KM; Safrai railway station19.7 KM; Sapekhati railway station 24.3 KM; Baruanagar railway station30.7 KM from the site
- Nearest Airport: Jorhat Airport
- Availability Of Water : Nearby Storage natural resource / Borewell
- Power Evacuation: At 66/33 KV with solar pooling SS of capacity 132/66/33kV SS Power Plant at Tizit Substation, Mokokchung
- Solar Radiation: Latitude 26°53'59.8"N and 94°57'52.1"E Longitude Was chosen.
  Averaged Direct Normal Radiation = 908.8 kWh/m2/year
  Elevation: 236 m
- Location: The site is adjacent to Assam-Nagaland Boarder Bridge road at 08-10 km, Easy approach.
- Surface Strata: Soft Mining strata Murum about 2 Mtr Depth, below that hard murum up to 1.5 to 2 m depth and below those boulders for about 1.5 to 2 m height.

The land is evenly spread with top soil, mix of rocky pieces of land patch in between with no hindrance for solar power generation. Soil consists of approximately Black (5%), Red (5%), Alluvial (8%), Sandy (12%) & Sandy loams (30%). It is relatively mountain hilly land with natural slope. The selected land is free from any shadow, which interns can predicts more generation. Near the land currently no agricultural activities are undertaken.



The Project site is situated right next to Assam – Nagaland Boarder bridge road, which is a key arterial road connecting the towns of Tela 3.6 KM , Yanpan 4.3 KM , Neitong 5.3 KM , Longting 5.3 KM , Sangsa 7.0 KM , Ngangting 8.1 KM , Lapa 8.3 KM , Nokzang 8.8 KM , Zakho 10.2 KM , Nokyan 11.2 KM , Tingalibam 11.7 KM , Jaboka 12.2 KM , Longlem 13.0 KM , Zangkham 13.3 KM in the four geographical directions.

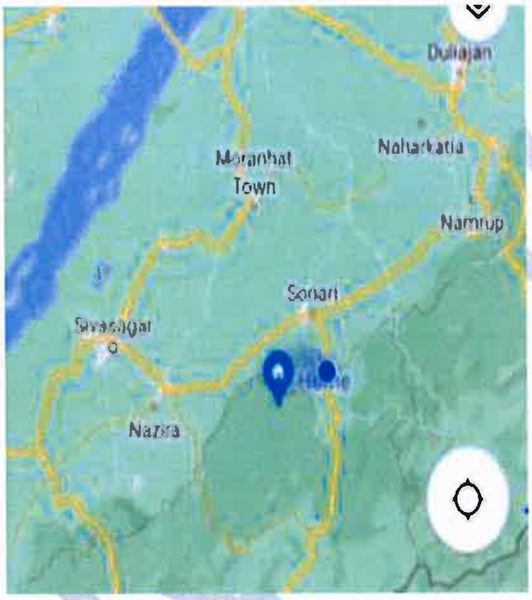
Similar type of concept can be implemented at selected land where the solar modules can be installed at shadow free area facing towards the south – East directions.

Grid Connectivity:

The proposed project would be connected at Dept of Power 66/33 KV Tizit Substation, Mokokchung which is at a distance of ~ 12-15 KM (by road) from the project site.

The grid connectivity work including development of evacuation facility should be governed as per prevailing Dept of Power commercial circulars/regulations and their standards and specifications and would also comply with prevailing State Regulations, CEA Standards, Government of NREDA Solar Policy and Methodology for RE Policy etc.

Interconnecting Substation: Tizit Substation



Interconnection point of the project will be with Tizit Substation at 66/33 or 132/66 KV voltage level. This substation and transformer needs to be installed or upgraded immediate after signing of power purchase agreement.

Water Availability:

Sufficient quantity of water i.e. around 70 – 120 M^3/day is available at site for cleaning the solar panels. Water availability can be varied during the summer around 40 – 70 M^3/day. Availability of water can be increase through local water supply/wells.

Weather Quality:

Air doesn't have much of visible particulate matter. So, power loss due to dust on solar modules would be minimal.

Country	India
City	Nagaland
Longitude	95.077133
Latitude	26.886189
Attitude/Elevation	Nonem (0ft) / 236 (m)
Annual high temperature	30.21°C (86.38°F)

Annual low temperature	19.87°C (67.77°F)
Average annual precip.	338.62mm (13.33in)
Warmest month	August (33.54°C / 92.37°F)
Coldest Month	January (12.5°C / 54.5°F)
Wettest Month	July (755.22mm / 29.73in)
Driest Month	December (30.83mm / 1.21in)
Number of days with rainfall (≥ 1.0 mm)	222.27 days (60.9%)
Days with no rain	142.73 days (39.1%)
Humidity	74.85%

The proposed project is environment friendly and as such has no impact on quality of air.

3.2.2 Civil Works

Topographical Survey

- Of the proposed site at 5 m interval by plain table or any other suitable standard method of survey. The formation level of the proposed power plant will be fixed with reference to high flood level of the clear demarcation showing boundary pillars, location of control room, array yard, sewerage system and approaches and general Ranges out fall etc. will be prepared.

Soil Test

- To ascertain soil parameter of the proposed site for construction of control room, HT lines & array yard, sub soil investigation will be carried out through certified soil consultant.
  - ➢ The scope of sub soil investigation covers: execution of complete soil exploration including boring, drilling, collection of undisturbed soil sample where possible, otherwise disturbed soil samples, conducting laboratory test of samples to find out the various parameters mainly related to load bearing capacity, ground water level, settlement, and sub soil condition and submission of detail reports along with recommendation regarding suitable type of foundation for each bore hole along with recommendation for soil improvement where necessary.
  - ➢ Detailed Soil Test report after PPA signing.

Planning and Designing

- The firm will develop general layout drawing of Array yard, internal road & dRinage (ensuring no water logging in the power plant compound) along with sanitary plumbing layout of the power plant. It will also include landscaping & beautification of the entire area of the PV power plant which will be done by Client.
- The plan will be innovative taking into consideration the following:
  - Land utilization is in such a way that maximum power tracking is done with appropriate array layout.
  - Control Room design taking in to consideration if possible passive architecture.
  - LED/CFL Solar lighting system arrangement as required.
- The design shall be developed considering optimal usage of space, material and labour without compromising the effect of shadow, cooling, ventilation, accessibility, losses during electrical interconnections etc.
- Indentified another land parcel of 400 acres in Niuland district under Dimapur if require installing in different location for feasibility of power evacuation, generation, forecast and scheduling.

Construction Works

- The substation area shall be designed based on topological survey report and soil testing report, relevant BIS code, national building code of india. It is estimated that the area required for the pulling substation would be approximately 4000 sqm.

Fencing and Gate:

- Appropriate GI sheet and gate along security post shall be designed and constructed keeping in view the safety and security of the power plant as a whole.

Approach Road and Path ways

- These shall be designed and constructed based on general layout as per the IRC standard.

Sign Board

- The signboard will contain the brief of the power plant. The signboard will be made of steel/power coated aluminum letters with proper illumination arrangement. The design & size of the signboard shall be considered to fit the matter

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Chapter no. 04
SOLAR RESOURCE ASSESSMENT AND SOLAR POWER GENERATION

4.1 Solar Resource Assessment

India falls in the northern hemisphere of Earth, quite near to equator. This provides us an edge over many other countries to harness the vast potential of sun as a resource and clean fuel for power generation and many other uses. For a sustainable and clean future, which every country is aiming today can be fulfilled to quite an extent by using solar energy.

India being a tropical country is blessed with good sunshine over most parts. India is in the sunny belt of the world having nearly 300 clear sunny days in a year. The country receives solar energy equivalent to more than 5,000 trillion kWh per year. On an average India receives 300 days of clear sunshine, with 5-7 kWh per square meter per day of average incident solar radiation, with the sunshine hours ranging between 2300 and 3200 per year.

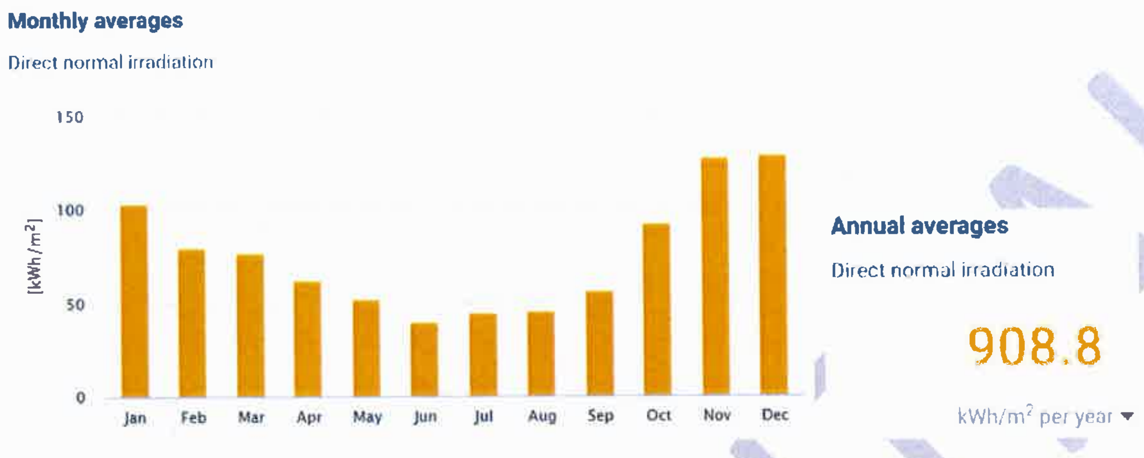
Solar radiation data has been taken from National Aeronautics and Space Administration's (NASA) Surface meteorology, Meteonorm and PV SYST Software simulation process for project site.

Monthly average insolation incident on a horizontal surface data in KWh/m2/day of the project site is an important parameter which plays a major role in energy generation from a solar PV plant.

Monthly Average Direct Normal Radiation (KWh/m2/day) data at project site:

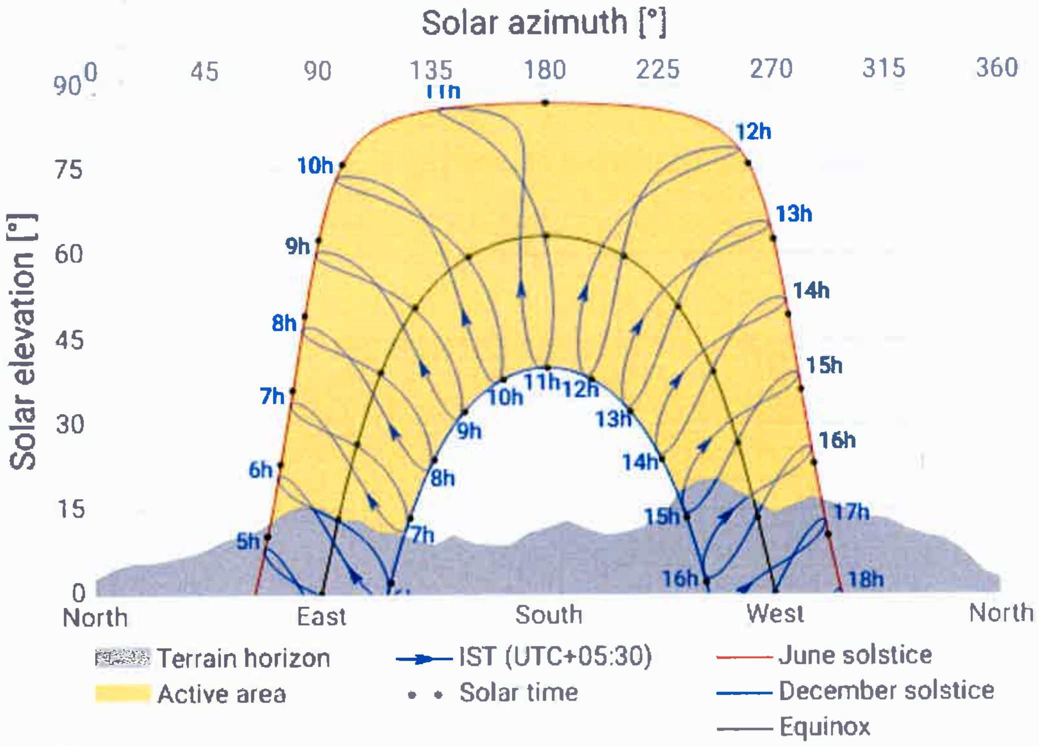
Map data Per year

Direct normal irradiation	DNI	879.8	kWh/m²
Global horizontal irradiation	GHI	1407.8	kWh/m²
Diffuse horizontal irradiation	DIF	813.3	kWh/m²
Global tilted irradiation at optimum angle	GTI opta	1524.1	kWh/m²
Optimum tilt of PV modules	OPTA	28 / 180	°
Air temperature	TEMP	23.0	°C
Terrain elevation	ELE	488	m

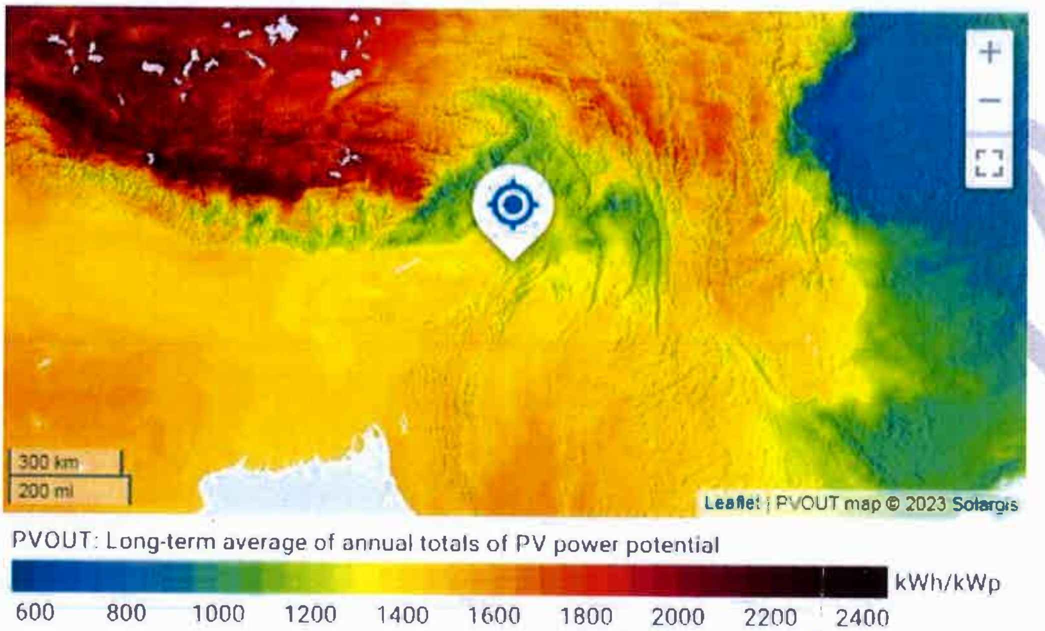


Meteorology:

Horizon and sunpath



PVOUT map



The horizon line in Solar Path Diagram of project site explains the azimuth angle at the various key time periods of the year. The study was carried with actual geographical coordinates of the proposed site and the results clearly depict the movement of the Sun all the year around. Horizon line diagrams are a convenient way of representing annual changes in the path of the Sun through the sky within a single 2D diagram. Their most immediate use is that the solar azimuth and altitude can be read off directly for any time of the day and day of the year.

They also provide a unique summary of solar position that the designer can refer to when considering shading requirements and design options. Also, this data is more helpful while designing solar power plants with single & double axis tracking. Although such structure are not advisable in India because financial benefits in such projects are less when compared with monetary expenses. While, if we consider the angle of inclination, this is taken as optimum angle of the project site. The current study also uses the same for energy generation calculation. The module mounting structure has a fix tilt arrangement at optimum angle for harnessing optimum yield.

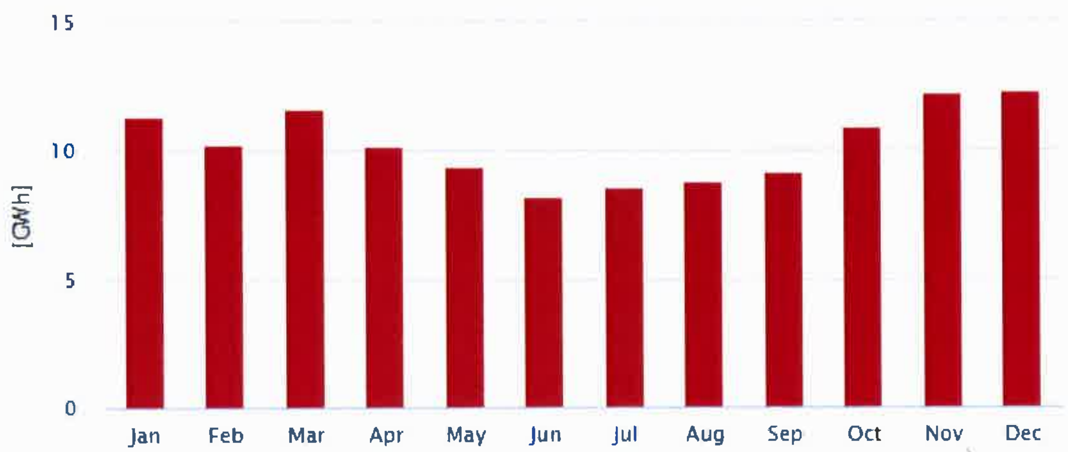
Average hourly profiles

Direct normal irradiation [Wh/m^2]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6						12						
6 - 7			22	45	85	71	64	37	68	66		
7 - 8	143	157	148	143	139	105	87	98	174	327	444	302
8 - 9	389	312	245	214	188	139	121	138	227	401	567	536
9 - 10	479	394	321	269	217	165	154	172	258	437	628	617
10 - 11	519	431	357	290	224	174	179	192	256	420	624	634
11 - 12	498	421	348	283	205	163	184	189	230	371	581	607
12 - 13	453	376	315	248	169	131	165	175	196	320	521	539
13 - 14	394	314	267	208	145	115	147	153	170	290	444	463
14 - 15	318	255	241	170	121	92	124	127	141	245	365	384
15 - 16	135	197	167	128	100	74	104	102	107	96	81	82
16 - 17			58	78	76	62	86	82	48			
17 - 18						15	20					
18 - 19												
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	3328	2856	2488	2076	1668	1318	1435	1464	1874	2973	4254	4165

Monthly averages

Total photovoltaic power output



PV system configuration

Pv system: **Ground-mounted large scale**

Azimuth of PV panels: **Default** (180°)

Tilt of PV panels: **28°**

Installed capacity: **100000 kWp**

Change PV system

Annual averages

Total photovoltaic power output and Global tilted irradiation

122.699	1515.9
GWh per year	kWh/m² per year

Average hourly profiles

Total photovoltaic power output [MWh]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6			0	1	2	2	1	1	0	0		
6 - 7	0	1	3	7	8	8	7	6	6	6	1	0
7 - 8	12	14	17	17	18	15	13	14	18	24	28	19
8 - 9	34	32	32	30	28	24	21	23	29	38	46	42
9 - 10	49	47	45	41	37	33	30	32	39	49	59	57
10 - 11	59	56	54	47	41	37	36	38	44	53	64	64
11 - 12	60	58	56	49	42	38	39	40	44	51	63	64
12 - 13	55	54	53	45	37	34	36	39	40	46	57	58
13 - 14	46	45	45	39	32	30	33	34	34	40	46	47
14 - 15	34	34	37	31	26	23	26	27	26	30	33	34
15 - 16	15	22	23	20	18	16	18	18	16	12	9	9
16 - 17	2	4	9	10	10	9	11	10	6	2	1	1
17 - 18		0	1	2	2	3	4	2	0			
18 - 19					0	0	0					
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	366	366	374	339	302	273	276	284	304	351	406	396

Average Temperature:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Oct	Dec	Year
Record high °C (°F)	33.0 (91.4)	36.0 (96.8)	41.0 (105.8)	41.0 (105.8)	42.0 (107.6)	42.0 (107.6)	40.0 (104.0)	40.0 (104.0)	39.0 (102.2)	37.0 (98.6)	34.0 (93.2)	30.0 (86.0)	42.0 (107.6)
Average high °C (°F)	24.7 (76.46)	27.44 (81.39)	30.53 (86.95)	31.98 (89.56)	33.23 (91.81)	33.51 (92.32)	32.44 (90.39)	33.54 (92.37)	32.27 (90.09)	30.82 (87.48)	27.35 (81.28)	24.66 (76.39)	30.21 (86.38)
Daily mean °C (°F)	19.74 (67.53)	22.54 (72.57)	25.77 (78.39)	27.72 (81.9)	29.48 (85.06)	30.49 (86.88)	29.73 (85.51)	30.56 (87.01)	29.1 (84.38)	26.82 (80.28)	22.91 (73.24)	20.23 (68.41)	26.26 (79.27)
Average low °C (°F)	12.5 (54.5)	14.98 (58.96)	17.62 (63.72)	20.54 (68.97)	22.68 (72.82)	25.04 (77.07)	25.3 (77.54)	25.46 (77.83)	24.08 (75.34)	20.65 (69.17)	15.97 (60.75)	13.63 (56.53)	19.87 (67.77)
Record low °C (°F)	6.0 (42.8)	10.0 (50.0)	12.0 (53.6)	16.0 (60.8)	16.0 (60.8)	19.0 (66.2)	20.0 (68.0)	23.0 (73.4)	18.0 (64.4)	15.0 (59.0)	12.0 (53.6)	7.0 (44.6)	6.0 (42.8)
Average precipitation mm (inches)	58.5 (2.30)	101.74 (4.01)	166.91 (6.57)	318.26 (12.53)	448.16 (17.64)	670.72 (26.41)	755.22 (29.73)	671.69 (26.45)	544.65 (21.44)	247.22 (9.73)	40.5 (1.59)	30.83 (1.21)	330.02 (13.33)
Average precipitation days (≥ 1.0 mm)	7.0	8.82	15.91	22.91	26.09	27.82	29.36	28.18	26.18	18.82	6.82	4.36	18.52
Average relative humidity (%)	66.33	63.16	60.65	68.09	74.53	80.57	84.47	82.37	84.07	81.97	78.85	73.11	74.85
Mean monthly sunshine hours	10.39	11.01	11.16	11.07	10.99	12.57	12.0	10.42	10.26	10.47	10.56	10.49	10.95

PVSYST simulation covers the detailed-feasibility of solar radiation resource assessment and other climatic factors affecting the solar PV power plant working along with simulation parameters, collector plate orientation, PV Array Characteristics, PV Array loss factors , System loss factors etc.

PV Syst Report:

Version 7.4.0

PVsyst - Simulation report

Grid-Connected System

Project: 100MW Solar Power Plant_Nagaland

Variant: New simulation variant
No 3D scene defined, no shadings
System power: 100.0 MWp
Oting - India

Project: 100MW Solar Power Plant_Nagaland

Variant: New simulation variant

PVsyst V7.4.0
VC0, Simulation date:
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with v7.4.0

Project summary

Geographical Site
Oting
India

Situation

Latitude	26.90 °N
Longitude	94.96 °E
Altitude	128 m
Time zone	UTC+5.5

Project settings
Albedo 0.20

Meteo data
Oting
Meteonorm 8.1 (1991-2000), Sat=100% - Synthetic

System summary

Grid-Connected System

No 3D scene defined, no shadings

PV Field Orientation
Fixed plane
Tilt/Azimuth 25 / 0 °

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

System information

PV Array		Inverters	
Nb. of modules	181840 units	Nb. of units	612 units
Pnom total	100.0 MWp	Pnom total	76.50 MWac
		Pnom ratio	1.307

Results summary

Produced Energy	124914403 kWh/year	Specific production	1249 kWh/kWp/year	Perf. Ratio PR	79.99 %

Table of contents

Project and results summary ... 2
General parameters, PV Array Characteristics, System losses ... 3
Main results ... 4
Loss diagram ... 5
Predef. graphs ... 6
P50 - P90 evaluation ... 7

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Project: 100MW Solar Power Plant_Nagaland

Variant: New simulation variant

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VC0, Simulation date:
04/08/23 18:57
with v7.4.0

General parameters

Grid-Connected System

No 3D scene defined, no shadings

PV Field Orientation

Orientation
Fixed plane
Tilt/Azimuth 25 / 0 °

Sheds configuration
No 3D scene defined

Models used
Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon
Free Horizon

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	Axitec Energy
Model	AXIpremium XXL HC AC-550MH/144VAU
(Original PVsyst database)	
Unit Nom. Power	550 Wp
Number of PV modules	181840 units
Nominal (STC)	100.0 MWp
Modules	9092 Strings x 20 In series
At operating cond. (50°C)	
Pmpp	91.39 MWp
U mpp	754 V
I mpp	121207 A

Inverter

Manufacturer	Sungrow
Model	SG125CX-P2
(Original PVsyst database)	
Unit Nom. Power	125 kWac
Number of inverters	612 units
Total power	76500 kWac
Operating voltage	180-1000 V
Pnom ratio (DC:AC)	1.31
Power sharing within this inverter	

Total PV power

Nominal (STC)	100012 kWp
Total	181840 modules
Module area	469945 m²
Cell area	433675 m²

Total inverter power

Total power	76500 kWac
Number of inverters	612 units
Pnom ratio	1.31

Array losses

Array Soiling Losses
Loss Fraction 3.0 %

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 0.10 mΩ
Loss Fraction 1.5 % at STC

Serie Diode Loss
Voltage drop 0.7 V
Loss Fraction 0.1 % at STC

LID - Light Induced Degradation
Loss Fraction 2.0 %

Module Quality Loss
Loss Fraction -0.2 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.2 %

IAM loss factor
Incidence effect (IAM): Fresnel smooth glass, n = 1.526

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.998	0.981	0.948	0.862	0.776	0.636	0.403	0.000

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TVAKSAS RENEWABLE PVT. LTD.

Project: 100MW Solar Power Plant_Nagaland

Variant: New simulation variant

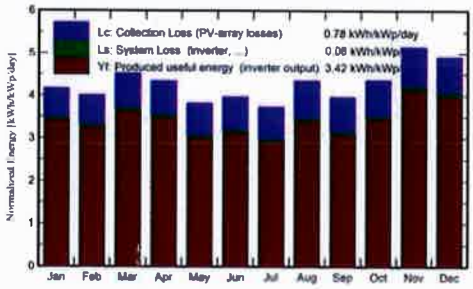
PVsyst V7.4.0
VC0, Simulation date:
04/08/23 18:57
with v7.4.0

Main results

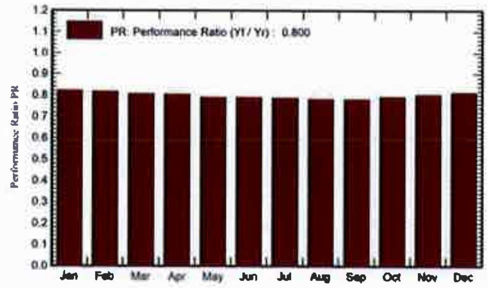
System Production

Produced Energy	124914403 kWh/year	Specific production	1249 kWh/kWp/year
		Perf. Ratio PR	79.99 %

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	100.0	47.49	16.96	129.3	122.6	10878250	10624861	0.822
February	95.7	56.99	19.07	112.1	106.0	9393384	9174438	0.818
March	128.9	78.05	21.81	140.2	132.3	11584952	11322651	0.807
April	131.4	85.13	23.31	130.3	122.4	10732087	10487168	0.805
May	126.6	79.71	26.23	118.5	110.8	9599114	9377139	0.791
June	129.0	82.67	27.50	119.3	111.9	9654807	9430800	0.791
July	125.1	81.90	28.42	115.8	108.3	9341139	9125153	0.788
August	137.5	79.55	28.67	134.9	126.8	10809603	10560838	0.783
September	114.0	62.13	27.50	119.1	112.0	9521407	9297954	0.781
October	117.3	62.20	25.92	135.2	127.9	10977325	10727692	0.793
November	116.0	42.29	21.40	154.4	146.3	12690899	12406837	0.803
December	107.7	36.54	18.12	152.2	144.3	12666652	12378873	0.813
Year	1428.9	794.63	23.77	1561.3	1471.6	127849820	124914403	0.800

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		

PVsyst V7.4.0
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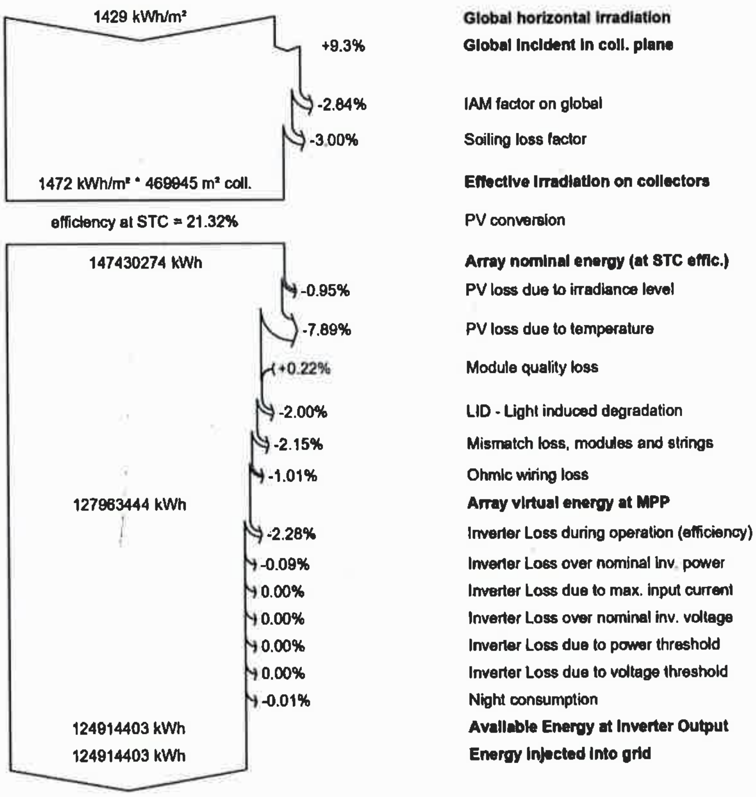
with v7.4.0

Project: 100MW Solar Power Plant_Nagaland

Variant: New simulation variant

Loss diagram



PVsyst V7.4.0
VC0, Simulation date:
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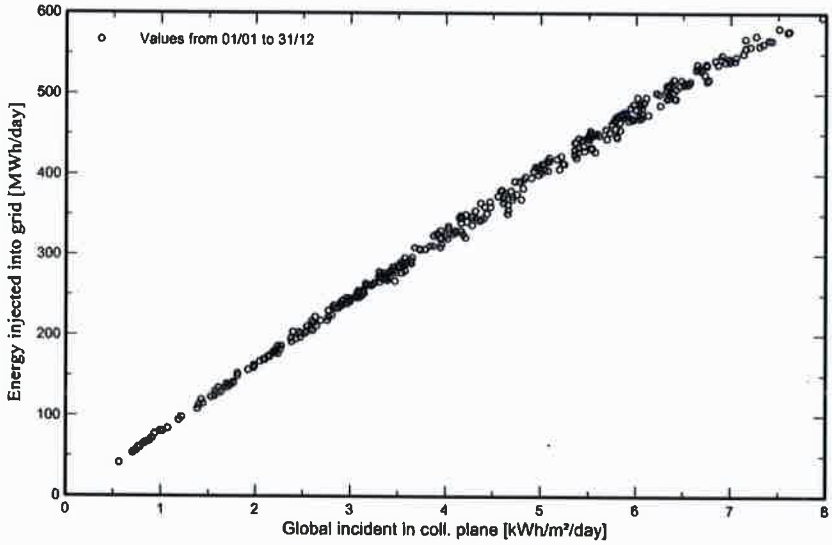
with v7.4.0

Project: 100MW Solar Power Plant_Nagaland

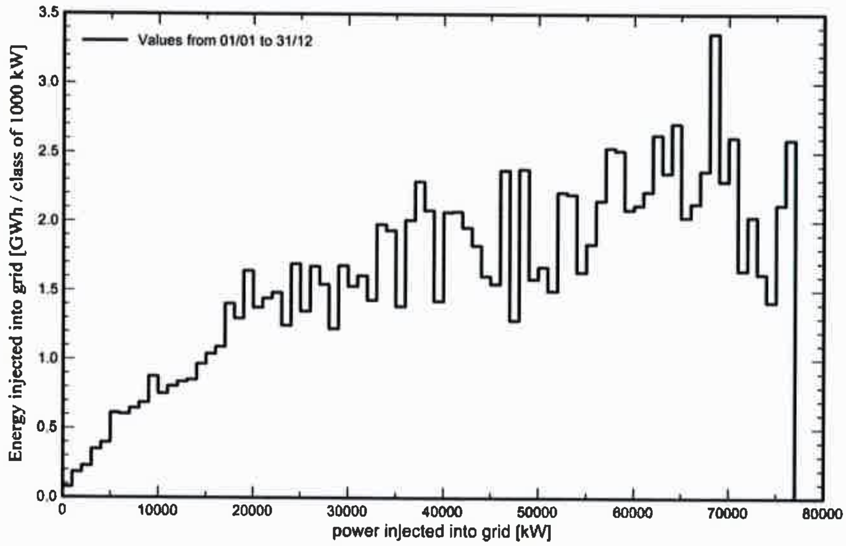
Variant: New simulation variant

Predef. graphs

Daily Input/Output diagram



System Output Power Distribution



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Project: 100MW Solar Power Plant_Nagaland

Variant: New simulation variant

PVsyst V7.4.0
VC0, Simulation date:
04/08/23 18:57
with v7.4.0

P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.1 (1991-2000), Sat=100%	
Kind	Specific year	
Year	Synthetic	
Year-to-year variability(Variance)		5.0 %
Specified Deviation		
Year deviation from average		0.0 %

Global variability (meteo + system)

Variability (Quadratic sum)	5.3 %

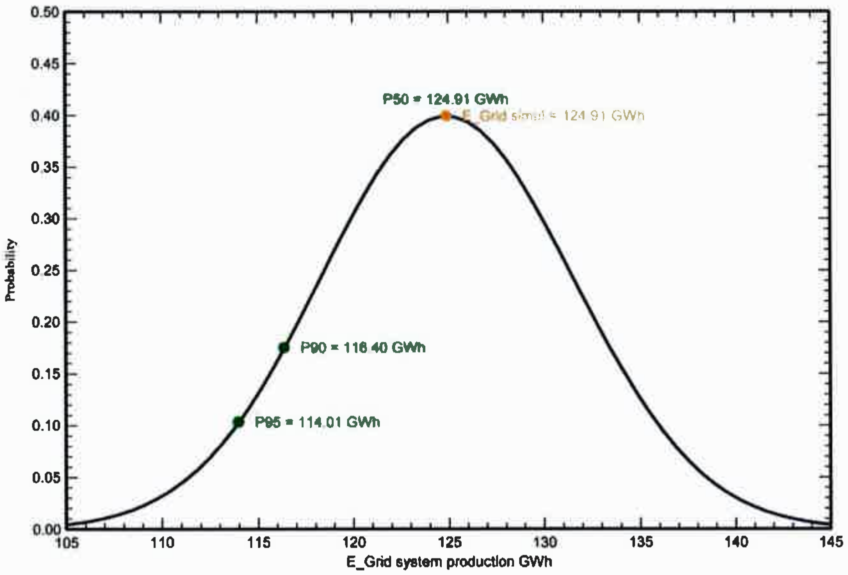
Simulation and parameters uncertainties

PV module modelling/parameters	1.0 %
Inverter efficiency uncertainty	0.5 %
Soiling and mismatch uncertainties	1.0 %
Degradation uncertainty	1.0 %

Annual production probability

Variability	6.64 GWh
P50	124.91 GWh
P90	116.40 GWh
P95	114.01 GWh

Probability distribution



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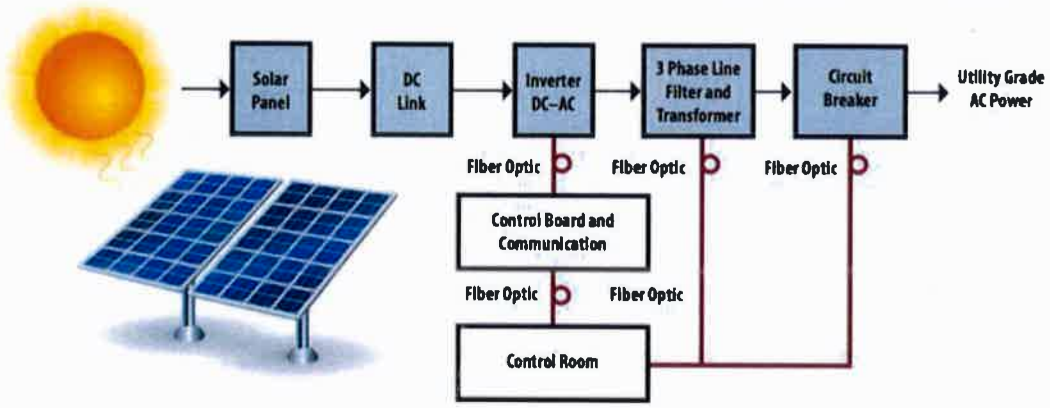
Chapter no. 05
GRID CONNECTED, GROUND MOUNTED SOLAR POWER PROJECT

5.1 Executive Summary



The Solar Photovoltaic power generator is the total arrangement of modules in series and parallel connections. Individual solar cells are connected together in a module (in series connection), which are hermetically sealed to survive in rugged weather conditions and ensures optimum performance during its long life.

In order to achieve a higher system voltage, modules are installed in a row arrangement, called a string. A higher system voltage has the advantage of lesser installation work, higher efficiency of the entire plant and usage of smaller cross section cables. Numbers of strings are connected in parallel in the Array Junction Boxes (AJB). These junction boxes not only act as a junction point but also can monitor string output (Optional) which will be fed to the central monitoring and analysis system. Outputs from many such junction boxes are connected in parallel in the Main Combiner Box (MCB). This Main Combiner Box output is fed to the central inverters to convert solar generated DC power in to conventional 3 phase AC power.

Central inverters / sting Inverter operate on MPPT (Maximum Power Point Tracking) mode to ensure maximum output from the solar generators at different ambient conditions. Central inverters use higher system voltages to reach very high plant efficiency. Furthermore, installations can be expanded with additions of more modules without problems.

For a typical 100 MWp (DC) solar power project, around 180000-182000 nos. of modules can be used each having 550 Wp/400 Wp capacity. Arrangement of modules and strings in series and parallel combination is given in PVSyst simulation data. Total module area would be around 469945 m2.

The DC generated power can be fed to inverter which in terns converts DC- AC power and then electricity fed to the grid through step-up transformer and switchgear assembly. The system is design with protection relays, safety devices, energy meters, control panel and power conditioning unit.

POWER GENERATION

The PV crystalline silicon technologies have been a proven technology nationally and globally for the past 20+ years in solar market. Various aspects of these technologies have been practically analyzed like generation, requirement of O&M, probability of operational failure etc. Out of the various factors considered before finalizing this technology for current project, practical functionality of the technology was one of the major ones. As a part of calculation, CUF for the plant has been considered as 12%. Accordingly estimated yearly generation from 100 MWp solar power project would be around 124MUs/year.

The project will be developed with Photovoltaic Modules of Poly /Mono Crystalline technology. Technology has a good market presence and has successfully shown expected performance globally.

Technical Requirements for Grid-connected Solar PV Power Plants

The following are some of the technical measures to ensure quality of equipment used in grid connected solar photovoltaic power projects:

(i) SPV Modules

The SPV modules used in the grid solar power projects will qualify to the latest edition of any of the following IEC PV module qualification test or equivalent BIS standards.

• Crystalline Silicon Solar Cell Modules IEC 61215

• Thin Film Modules IEC 61646

• Concentrator PV modules IEC 621081

• In addition, SPV modules will qualify to IEC 61730 for safety qualification testing at 1000V DC or higher. The modules to be used in a highly corrosive atmosphere throughout their lifetime must qualify to IEC 61701.

(ii) Power Conditioners/ Inverters:

The Power Conditioners/ Inverters of the SPV power plants will conform to the latest edition of IEC/ equivalent Standards as specified below:

• Efficiency Measurements - IEC 61683

• Environmental Testing - IEC 60068 -2/IEC 62093

• EM Compatibility (EMC) - IEC 61000-6-2, IEC 61000-6-4 & other relevant parts of IEC 61000 Electrical safety IEC 62103/ IEC 62109-1

- Anti-Islanding Protection - IEEE 1547/IEC 62116/UL 1741 or equivalent BIS Standards

(iii) Other Sub-systems/ Components:

Other subsystems/components used in the SPV power plants (Cables, Connectors, Junction Boxes, Surge Protection Devices, etc.) shall also conform to the relevant international/ national Standards for Electrical Safety besides that for Quality required for ensuring Expected Service Life and Weather Resistance.

The Cables of 600- 1800 Volts DC for outdoor installations shall comply with the BS EN 50618:2014 / 2pfg 1169/08.2007 for service life expectancy of 25 years.

(iv) Authorized Test Centers:

The PV modules / Power Conditioners deployed in the power plants will be valid test certificates for their qualification as per above specified IEC/ BIS Standards by one of NABL Accredited Test Centers in India.

(v) Warranty:

PV modules used in grid solar power plants must be warranted for output wattage, which shall not be less than 90% at the end of 10 years and 80% at the end of 25 years.

(vi) Identification and Traceability:

Each PV module used in any solar power project will use a RF identification tag. The following Information will be mentioned in the RFID used on each module (This can be inside or outside the laminate, but must be able to withstand harsh environmental conditions.)

• Name of the manufacturer of PV Module

• Name of the Manufacturer of Solar cells

• Month and year of the manufacture (separately for solar cells and module)

• Country of origin (separately for solar cells and module)

• I-V curve for the module at Standard Test Condition (1000 W/m2 , AM 1.5, 250C)

• Wattage, Im, Vm and FF for the module

• Unique Serial No and Model No of the module

• Date and year of obtaining IEC PV module qualification certificate

• Name of the test lab issuing IEC certificate

• Other relevant information on traceability of solar cells and module as per ISO 9000

(vii) Performance Monitoring:

Proposed Grid solar PV power projects shall install necessary equipment to continuously measure solar radiation, ambient temperature, wind speed and other weather parameters and simultaneously measure the generation of DC power as well as AC power generated from the plant.

Chapter no. 06
PROJECT ESTIMATATION & FINANCIAL ANALYSIS

6.1 PROJECT COSTING

- The costing details for the project includes the cost of the following elements
  - ➢ Civil, Electrical & mechanical Work
    - ✓ Solar PV Power Plant
    - ✓ Power Evacuation System
    - ✓ Transmission line – (will be done by Client)
    - ✓ Switch gear items at substation
  - ➢ Miscellaneous
  - ➢ Taxes
  - ➢ Contingencies
  - ➢ Profit
  - ➢ Interest during construction
- The detailed costing has been shown.

6.2 FINANCIAL ANALYSIS ASSUMPTIONS

- The project under study envisages installation of 100 MWp Grid Interactive Solar Photovoltaic power plant at Tizit .
- The debt equity ratio considered is 30:70 for the funding of the projects.
- The loans required from the banks/a financial institution is expected to be repaid within a period of 12-15 years. Term loan is proposed to be repaid in 180 equal monthly installments, considering 1st year as moratorium period.
- Interest rate for term loan is considered as 9-10% per annum.
- The viability of the project is based on the generation of the energy, which has been obtained from RET screen installation PV Syst software - Clean Energy Project Analysis Software results which on backend consider past twenty years of average solar radiation data available at NASA website for the project site location.
- The power so generated would be transmitted through the grid. Naturally, all the shortcomings associated with this grid would be applicable to the project under consideration.
- The total life of the project is considered as 25 years.

FINANCIAL ANALYSIS

The financial analysis for the project has been carried out on the basis of present economic scenario, various provision of the State polices, Regulations of Central Electricity Regulatory Commission and Maharashtra Electricity Regulatory Commission, Equipments and Component Supply Cost including land cost, Project Management Challenges, Operation & Maintenance expenses, Debt-equity ratio, Interest on term loan, Interest on working capital, Electricity and REC component.

A power generated from proposed solar power project shall be sold to third party or under REC mechanism.

The Commercial viability for 100.0 MWp DC rated installed capacity Solar project has been worked out as tabulated below:

Capital Cost Parameters:

Sr. No.	Parameters for 100 MWp DC (installed capacity)	Amount in Rs.(Cr)
1	PV Modules cost	283.00
2	Power conditioning units and other accessories	125.00
3	Land and site development cost	8.00
4	Mounting structure and foundation /plinth cost	32.00
5	Evacuation arrangement cost	40.00
6	Transportation & admin expence	7.00
7	Miscellaneous expense	5.00
	Total Capital Cost	**500.00**

Commercial Parameters details:

Sr. No	Parameter	Unit	
1	Project Owner	Company	M/s. Tvaksas Renewable Pvt Ltd
2	Name of the Customer of Power	Company	Govt. of Nagaland – NREDA / DISCOM
3	Term loan from financial institutions	Company	NBFC / Bank / FDI
4	Expected Plant Commissioning Date	Months	18 months from PPA signing*
5	Size of the project	MWp	100.0 DC
6	Total Capital Cost for 100.0 MWp DC Solar PV project including cost of infrastructure	Rs. Crore	569**
7	Equity of the project (30%)	Rs. Crore	170.70
8	Debt of the project (70%)	Rs. Crore	398.30
9	Estimated generation/year	Million Units	~ 125.02

TVAKSAS RENEWABLE PVT. LTD. *

10	Capacity utilization Factor	%	12.0
11	Operation & Maintenance for 100 MWp/year	Rs. lakhs	300
12	Operation & Maintenance annual escalation	%	4
13	Free Operation & Maintenance	Year	01
14	Proposed Tariff realization - sale to EB; DISCOM (base tariff)	Rs / Unit	4.6
15	Tariff escalation assumed	Rs / Unit	NA
16	Interest rate	P.A%	9%
17	Loan Term	Year	15
18	Moratorium	Quarters	4
19	REC benefit if applicable from the state	Rs / Unit	1.00***
20	CFA / VGF	Rs. /MW	As per state Govt norms
21	I.R.R (weighted average) Return on Equity considering minimum tariff of Rs. 4.60/kWh	25 Years	~ 12-13%

*This would be subjected to transfer of land from owner and bay extension, approval for bay extension from Off-taker, availability of right of way of transmission line from plant to interconnecting substation within 3 months from signing of Power Purchase Agreement.

**GST included at actual i.e. 13.8%

***Renewable Energy Certificate can be applicable to IPP if States allows

Conclusion from Financial Analysis:

- Project site is technically feasible by considering average monthly solar insolation, average temperature and relative humidity factor at project site.
- Considering proposed power purchase tenure for 25 years at Rs. 4.6/kWh, the project will be financially viable.

Chapter – 07
PROJECT DESCRIPTION

"Design, Supply, Fabrication, Civil, Mechanical, Electrical, Erection, Testing, Operation and Commissioning and Services" – On Ground, On Grid Fixed structure basis solar Power Plant

Inclusive of works scope as below –

Stage I _ (Sr. no. 1 to 7)

1) To do land survey, PTTS , Contour mapping survey – detailed mapping of proposed land parcel
2) SBC testing with geographical assessment in all respect for further executions
3) To design the power plant of 100 MWp capacity w.r.t. networks, EPC layouts, drawings and proposed assessments
4) To submit **third party stability certification** for Mechanical, Electrical and Civil aspects for each parameters of EPC plant supply, drawings as well as material certification as per MNRE standards
5) To clear drawings as per designed parameters of solar EPC
6) To do leveling , refilling platform as per necessary requirements of solar EPC
7) To do land scoping, platform setting for solar power plant

Stage II _ (Sr. no. 8 to 10)

8) GI chain mesh link based boundary fencing with retaining stone based wall at bottom level with leveling
9) GI, barbered wire based protected fencing for entire designed power plant as per drawings with proper entrance gates, doors etc. With security concerns
10) To do WBM civil constructive based internal pathways road – interconnecting solar structure rows, columns – as per designed power plant access and internal approaches w.r.t. safety and security

Stage III _ (Sr. no. 11)

11) **Supply** – as per MNRE check lists of standards , terms and conditions approved by PPA

- Solar Panels -100.00 MWP
- Inverters – Central Solar/ string Inverter On grid DC-AC inverter with MPPT / PWM basis charging - as per third party validation reports
- Solar super structure – MS, hot dipped GI with hardware, anchors, nut bolts, connectors – South facing

- Electrical supply like- JCB, ACDB, DCDB, Lugs, MC4 Connectors, Y Connectors, DC/ AC Cables (All Kinds), Needful Cable Trenches, Cable Tie, Cable Arrestors, Channels, MCB's , Protected Devices, Inverters , Battery Bank
- Earthing – panel, structure, DP yard, control room, LA – at actual as per design / standards of EB
- Lighting arrestors – set as per designing
- Weather monitoring station with pyrometers
- Switch yard – internal – transformer, VCB, CT / PT with DP, Isolator designed
- Civil supply- Soil, Murum, Sand, Bricks, Cement, Rocks, Chips, Water, Aggregate
- Control room RCC, Slab / GI corrugated sheets , air Ventilated, water leakage proof, painted, and furnished with trenches
- Security cabins
- Water storage syntax tanks, pump
- Fire alarm system

Stage IV _ (Sr. no. 12 to 19)

12) Civil auguring / drilling, RCC foundations, grouting, Muffing , conducing
13) ETC – erection, installation, assembly, mechanical , electrical terminations / connections as per design
14) 33kV External line construction from existing dead end to power plant location max. 300 meters SCOH DOG
15) 33kV External feeder with CR panel, VCB, isolator, **ABT metering 0.2 S class**, Gantry, bus bar & earthling-1 no.
16) Testing
17) Operation, Execution, Erection, Installation
18) CEIG approval
19) Commissioning of power plant w.r.t. external line and bay & SPV power plant bay

Stage IV _ (Sr. no. 20 to 27)

20) Services for 1 years
21) Safety, Security
22) Transport, Freights, Insurances of labours and material till the commissioning for our scope of works
23) Warrantee / Guarantee certification directly in the name of Investor / customer name as per standards of MNRE & SECI norms
24) Service warrantee – 1 years from COD of projects
25) Labour, Skilled, unskilled – Projects, Man power admin, lodging, boarding, medical, transport etc.
26) Tools, Tackles, hydra, cranes, JCB's, excavator, boring machines, auguring, pile machines, drills, site vehicles, trailers, tractors, rollers etc.- all kind of machineries and equipment with fitness certification, insured and accessories
27) Construction water, power , admin

28) Project supervision – Engineering , Certification
    - To provide safety, security, labour admin at actual till the project to be handover to service / OEM dept.

7.1 POWER GENERATION SCHEME

7.1.1 Electrical System Types:

- Being intermittent, the electricity produced by solar PV array needs to be properly controlled, stored and distributed. The two major possibilities currently prevalent are (i) Stand-alone system and (ii) Grid connected system.
- It may be noted that many devices are needed between the array and the load to provide electrical power.
- A typical stand- alone photovoltaic system is composed of an array converting sunlight into electricity. Electrical current flows into a bank of batteries through a charge controller (regulator) that protected the batteries from overcharge or over discharge. By using a DC-DC converter required levels of DC voltage can be obtained if the loads to be connected are of DC types and if the loads are of AC type a DC-AC inverter may be needed.
- A schematic diagram of a stand-alone PV system is shown in Figure 9:

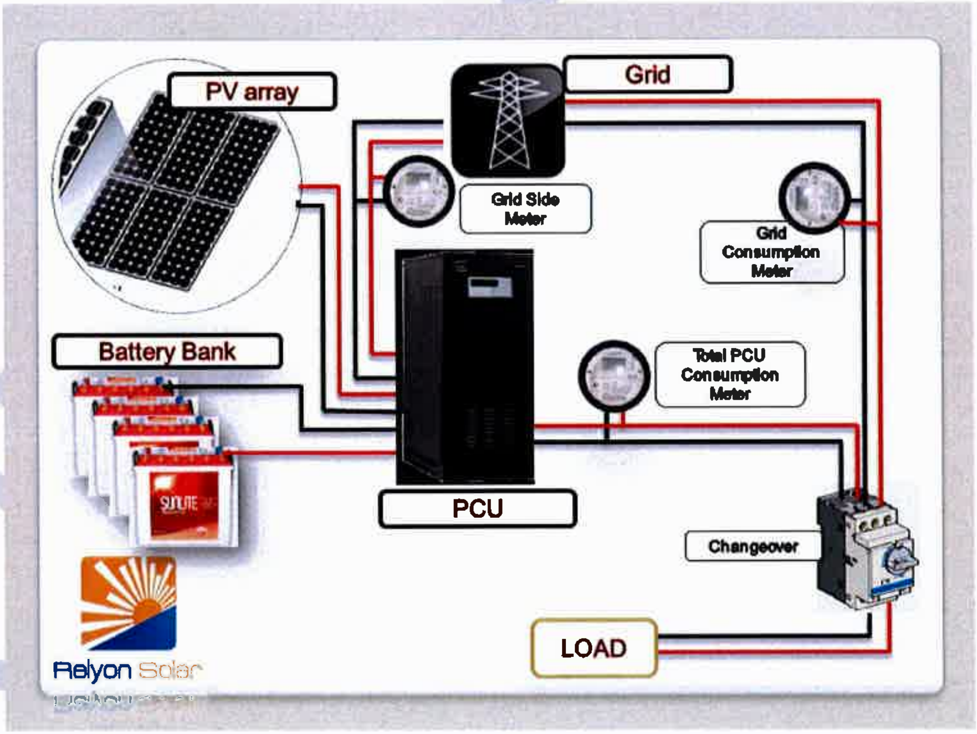


Figure 9: Schematic Diagram of stand – alone PV system

- The project is of the grid connected system type. The system operates only when the utility is available. The system consists mainly of the following:

- Solar PV array- Which produces DC electricity when solar rays incident on it.
- Power Conditioning Units(PCU) – which convert DC electricity into AC (Alternating Current) electricity and facilitates synchronization with the grid power.
- Transformers- Which transform the AC output of the Power Conditioning Units to the level required at the grid.

7.1.2 Operating Principle Of Grid Connect Solar PV System

- The system automatically 'wakes-up' in the morning and feeds-in power to the grid, provided the grid power is within the window (Voltage and frequency limit) synchronization.
- The maximum Power Point Tracking (MPPT) circuit within the PCU extracts the Maximum available power from the solar array and feeds it to the grid. If the grid voltage and/or frequency goes out of the window, the PCU is immediately isolated from the grid.
- The PCU will reconnect after a pre-determined time when the grid is back within the window. When the feed-in power is below a predetermined level or when the solar insolation is below a selected value for a pre-determined level or when the solar insolation is below a selected value for a pre-determined period of time PCU is isolated from the grid and is operated in sleep mode. This minimizes the stand by losses.

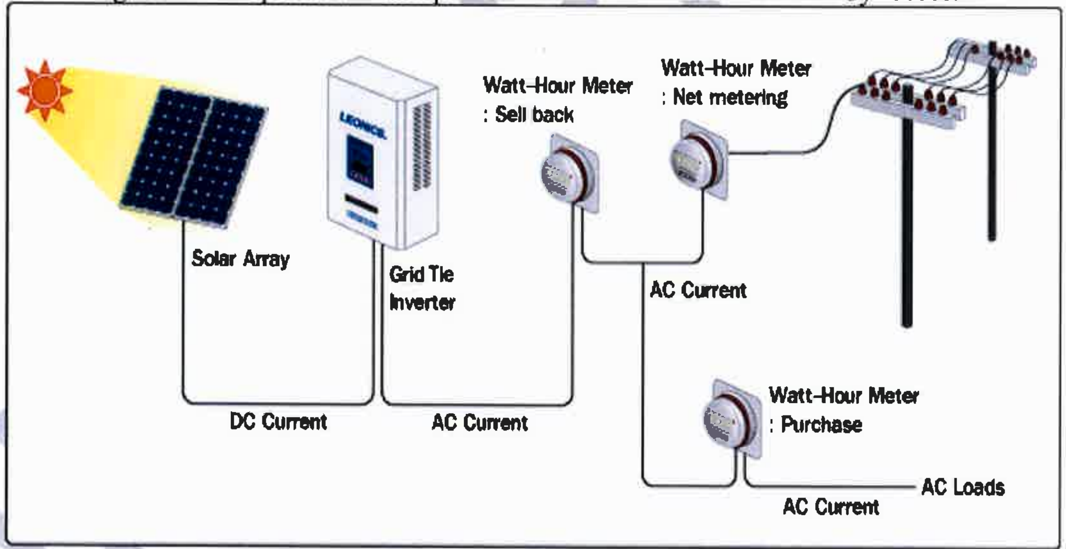


Figure 10:- Schematic Diagram of Grid Connected Solar PV system

7.2 TYPICAL SYSTEM COMPONENTS OF GRID CONNECT SPV SYSTEM

7.2.1 Solar PV modules/Array

- As the solar cells have limited linear dimensions, a number of cells are to be interconnected to provide required voltage and current. These are encapsulation using a material such as Ethylene Vinyl Acetate (EVA) between a transparent window and moisture-proof backing to insulate and protect them.

- As the PV cells are less efficient at higher temperatures, modules mechanically designed as not to retain the 'solar heat' and mounted so permit natural cooling. The Figure 11 Below depicts the structure commercial module.

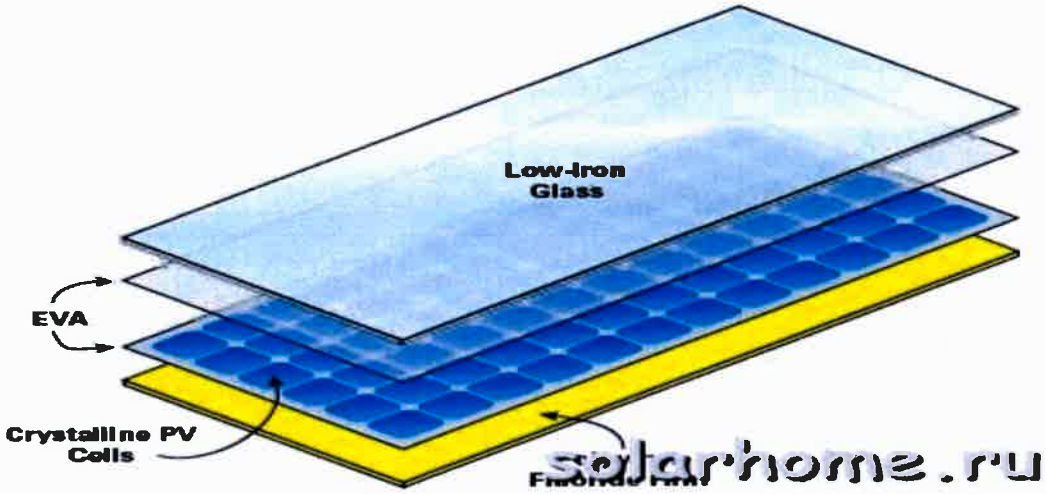


Figure11- Structure of a Commercial Module

- The electrical performance of a module is more or less identical to a solar cell. It is shown in the figure 12 below:

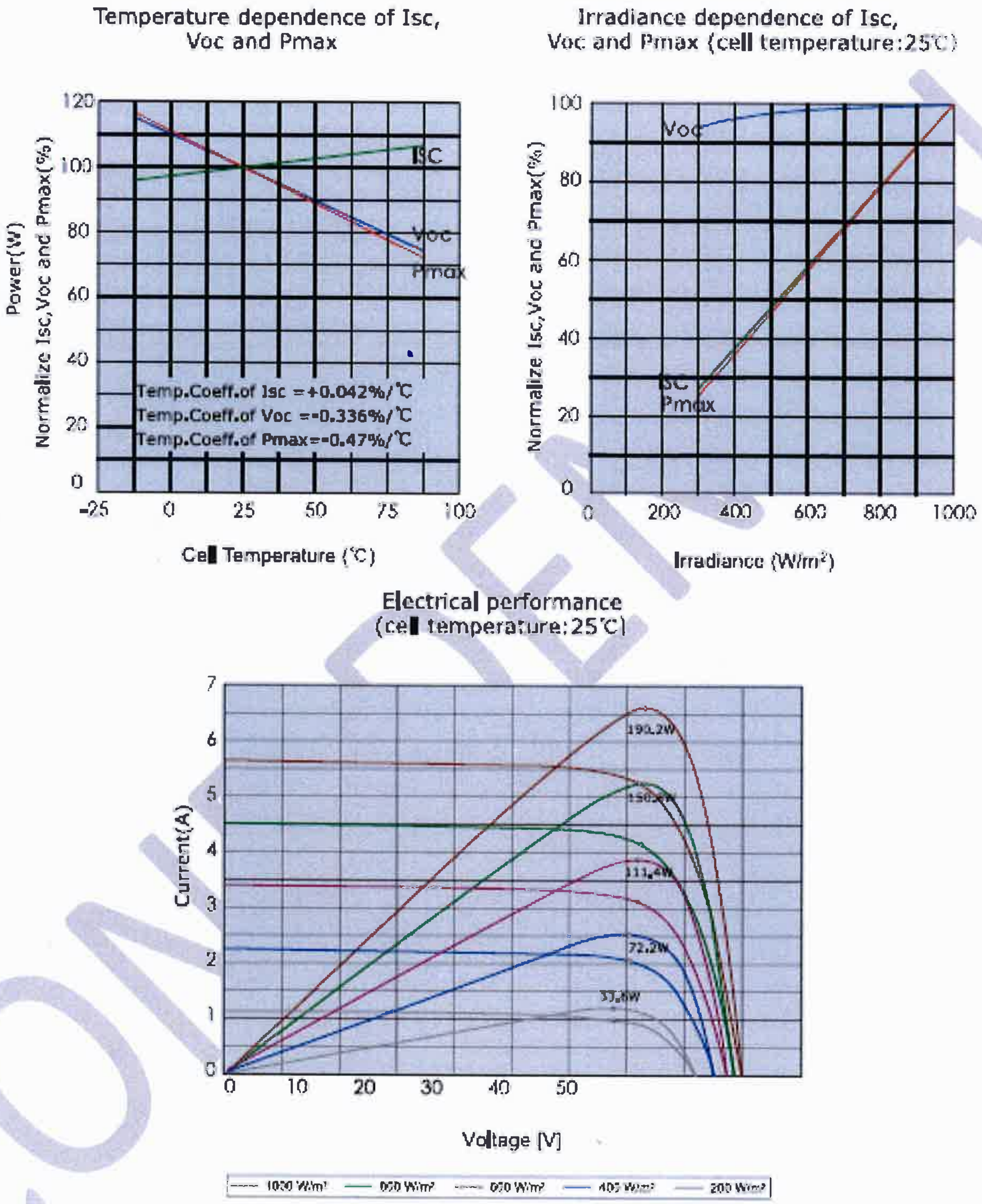


Figure 12: Characteristic Curve

- The following parameters need to be considered while selecting a module for use:
  - Open-Circuit Voltage – Voc
  - Short- Circuit Current- Isc
  - Voltage Corresponding to MPP – Vmp
  - Current Corresponding to MPP- Imp
  - Maximum power- Pm
- Generally, the aforementioned values are compared to a solar irradiation of 1000W/m2 with a spectrum of AM 1.5 and solar cell temperature of 25°C
- Another very important feature connected with solar PV module performance is the Normal operating cell temperature (NOCT).
- NOCT is that value of cell temperature which is reached when the incident solar radiation is 800 W/m2, ambient temperature is 20°C and wind velocity is 1 meter/second.

7.2.2 Solar PV Array

- Depending on the load power requirements, modules are interconnected in series or parallel to constitute a PV array. The Figure 13 below is a representation of cell to module and module to array.

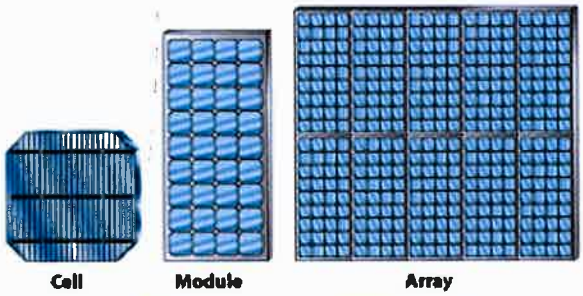


Figure 13: Cell to Module & Module to Array

- Figure 12 showing I-V curve of PV panel.
- Diodes are used in two ways in a photovoltaic array. Brief details are given below:

Blocking Diodes:

- These are places in series with a module to prevent current flowing backwards through to modules.

By-Pass Diodes:

- When a cell gets shaded from the sun, an open-circuit can exist in which there is no current flow. By-pass (or shunt) Diodes are used to shunt-current, so that the other cells and modules continue to produce power in the PV array.

7.2.3 Balance of System (BOS)

Power Conditioning Units/ Inverters

- The power conditioning units used in grid connected SPV system consist of an inverter and other electronics for MPPT, synchronization and remote monitoring.
- The inverter is the most complicated part of the PV system. It has to act as the interface between the PV array and the Grid. As the PV array output varies with the solar radiation the inverter has to cope with the same.
- The main functions carried out by the PCU are as follows:
  - Change the incoming DC received from PV modules into AC with suitable power quality. The inverter produces sinusoidal AC wave forms with low harmonic distortion.
  - The inverter also has to act as protective devices of the system. It needs to trip out if the voltage, current or frequency goes outside acceptable ranges.
- Pulse width modulation is used to generate a wave from as near as possible to a sine wave. High speed switching device are used to generate pulses of the devices mainly used for inverter circuitry.
- Inverter efficiencies are now reaching about 98% at STC and full load , mainly by deploying new switching topologies.

Other BOS Items

- Solar PV module mounting structures, interconnection system and protection system which are used to integrate the solar PV modules into the structural and electrical system are known as other BOS items.
- The SPV array (constituting solar PV modules of selected rating connected in series to build up the required voltage and in parallel to build up the required current) of the designed DC power produces DC electricity when solar insolation is incident on it. The DC power thus produced is taken through various junction boxes and isolators and connected to the PCU.
- The PCU houses the inverter circuitry which converts DC power supply into AC power supply, the synchronization circuitry which actualizes the tie-up of solar PV source to the grid source and the remote monitoring and control circuitry. A number of PCUs are connected in parallel to build up the required AC power, and combiners permit AC output power at 3ph, 390 V, 50Hz to be fed into transformers.
- Depending on the grid voltage level to which the solar PV power is being synchronized, different levels of step-up transformers need to be deployed. In the project under Consideration, as the grid voltage is at 33 kV level, there will be one step-up transformer from 415V to 33KV.
- The protection and metering circuits play a very significant role. Appropriate current transformers and potential transformer are used to tap required feedback signals to initiate action on metering and protection.

7.3 SOLAR PV MODULE TYPES

- Over the past three decades SPV technology has shown impressive growth towards technological and economic maturity. The major SPV technologies based on material used are (I) Crystalline Technology (II) Thin Film Technology.

7.3.1 Crystalline Technology

- Crystalline silicon (mono & multi) cell technology continues to dominate and forms about 90% of market share. It is the current industry leader and almost all applications use crystalline silicon based PV technology. It is ideally suited for locations with space constRints due to high efficiency than thin-films.

Overview of the Technology

- Crystalline silicon (c-Si) was chosen as the first choice for solar cells, since this material formed the foundation for all advances in semiconductor technology. The technology led to development of stable solar cell with up to 16 % efficiency. Two types of crystalline silicon cells are used in the industry. The first is mono crystalline Si, produced by growing high-purity, single crystal Si rods and slicing them into thin wafers. The second is multicrystalline Si, made by sawing a cast block of silicon first into bars and then wafers. Major trend in PV industry is toward multi crystalline technology. In both mono and multi crystalline Si, a semiconductor junction is formed by diffusing phosphorus (an n-type dopant) into the top surface of an already boron doped (p-type) Si wafer. Screen-printed contacts ae formed on the top and bottom of the cell, with the top contact pattern specially designed to allow maximum light to enter the Si material and minimize electrical losses in the cell.
- Each c-Si cell generates typically about 0.5V. Usually 36 cells are soldered together in series to generate voltage levels that can charge a standard 12V battery. The cells are hermetically sealed with glass on the front side and plastic materials at the back to produce highly reliable, weather resistant c-Si modules with performance guarantees in excess of years. Typical c-Si cell is shown in figure 14

Figure 14: Crystalline silicon solar cell

Advantages:

- Highest efficiency level (14.5 % to 16%)
- Commercially most viable among PV technologies.
- Sustained dominance in PV industry for over 25 years.
- Higher current/lower voltage features enable easier system design

- Project implementation can be done in stages starting with module assembly and backward integration to wafer fabrication stage or the other way from Wafer to cell to module.
- Performance guarantee for c-Si modules is generally in excess of 25 years.

Disadvantages:

- In c-Si technology consumption of material (silicon) is far more than what is actual needed for converting light into electricity.
- High dependence on polysilicon availability and pricing.
- Melting point of silicon being high (1415°C) power consumption is high in polysilicon production and wafer fab process.

7.3.2 Thin Film Technology

Overview of the technology

- The high cost of crystalline silicon wafers (they make up 40-50% of the cost of a finished module) has led the industry to look at cheaper materials to make solar cells. The selected materials are all strong light absorbers and only need about 1 micron thick, so materials cost are significantly reduced. Amorphous silicon thin film solar cell is the earliest device development in this area. Types of thin film cells that followed are cadmium telluride (CdTe) and Cadmium indium Gallium Diselenide (CIGS) solar cells. New development in the include 'Micromorph' cells (a combination of amorphous and microcrystalline silicon materials) that has yielded higher efficiencies and has better stability features.
- The semiconductor junctions are formed in a different way, either as a pin device structure in amorphous silicon, or as a hetero-junction. A transparent conducting oxide layer (such as tin oxide) forms the front electrical contact of the cell, and a metal layer forms the rear contact. Thin film technologies are all complex. They have taken at least twenty years, supported in some case by Major Corporation, to get from the stages of promising research to the first manufacturing plant producing early product. Typical thin film silicon solar cell is shown in fig 15.

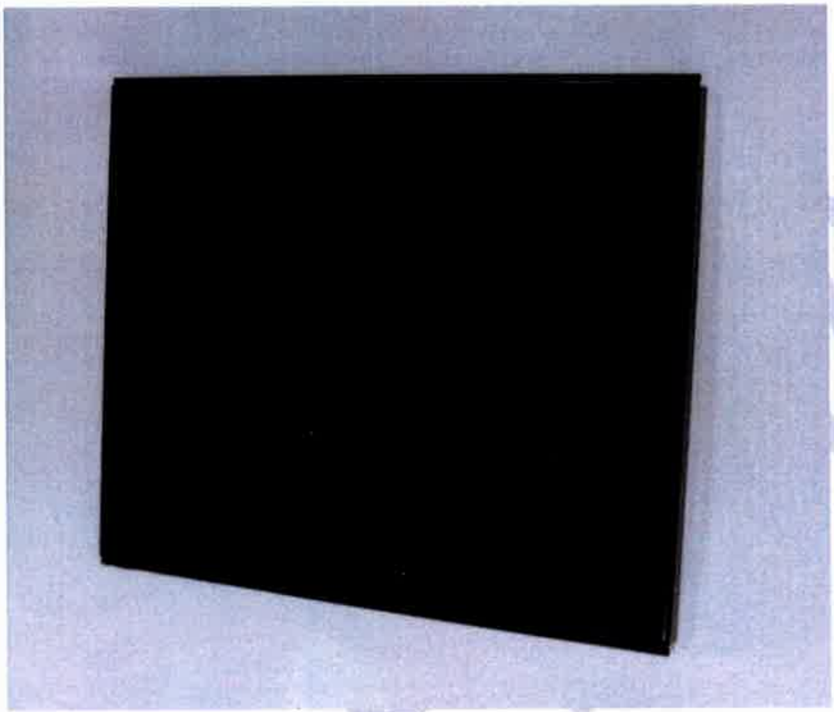


Figure 15: Thin film silicon solar cell

Advantages

- Significant lower material cost per Wp.
- Faster manufacturing processes with less number of steps.
- Comparatively lower energy consumption processes.
- Higher energy performance (Thin film modules generate more electricity per unit of installed capacity than crystalline silicon modules)
- Lightweight and flexible substrate.

Disadvantages

- Suffers from less than adequate conversion efficiency.
- Poor long term stability
- High capital costs.
- Scalability and control of uniformity over large area designs.
- Lower environmental compatibility in respected of CdTe and CIGS technologies.

7.4 CLEAN DEVELOPMENT MECHANISM (CDM) BENEFITS

- Internationally, global warming and carbon emission are being priority issues. The Kyoto Protocol laid down a worldwide target for a reduction in the global emission of green house gases of 9% by 2017-18 compared to the actual level in 1990.

- Carbon dioxide represents the majority of the greenhouse gas emissions protocol has now been ratified by 180 courtiers.

This also shall create a revenue stream for renewable energy based power generating units through trading of carbon credits, green certificates etc. benefits trough CDM are considered in financial analysis of the project.

Chapter – 08
PLANT AND EQUIPMENT DESIGN CRITERIA

8.1 SOLAR PHOTOVOLTAIC (SPV) MODULES

- PV modules to be supplied are having minimum declared output of 330-350-360 Wp or more. Number of modules to be supplied are 3,200 / per MW to get output of 1.10 MWp. Stabilized output of the solar PV array for the power plant should not be less than 1 MW under standard test condition after one year of operation. Modules for power plant shall be made of crystalline silicon. The SPV modules must be tested and certified by an independent international testing laboratory.
- The module frames shall be made of corrosion resistant material, which shall be electrolytically compatible with the structural material used for mounting the modules.
- The modules shall be provided with a junction box with provision of MC-4 connector and with arrangement for provision of by-pass diode. The box should have hinged, weatherproof lid with captive screws and cable gland entry points.

8.2 MODULE MOUNTING STRUCTURE

- The structure shall be designed to allow easy replacement of any module. The structure shall be designed for simple mechanical and electrical installation. It shall support SPV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly.
- The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panel; at the same time it will withstand severe cyclonic storm with wind speed up to maximum 200 Km per hour. Nut and bolts and supporting structures including module mounting structures shall have to be adequately protected with atmosphere and weather prevailing in the area.
- The legs of the structure with appropriate strength will be fixed in the foundation columns as per design based on site soil condition. The minimum clearance between lower edge of the PV and ground shall be 500mm. While making foundations design due consideration will be given to weight of module assembly, maximum wind speed of 200 km per hour. Seismic factors for the site will be considered while making the design of the foundation. The design of array structure shall be based on soil test report of the site.

8.2.1 Manual Tilting Arrangement

- The mounting structure shall have adequate provision to alter the tilt of the panel at $5^{0,}$ 20^0, and 30^0 for seasonal tracking

8.2.2 Soil Test

- To ascertain soil parameter of the proposed site for construction of room, HT line & array yard, the sub soil investigation through certification consultant shall be carried out.
- The scope of sub soil investigation covers the following: execution of complete soil exploration including boring, drilling, collection of undisturbed soil sample where possible, otherwise disturbed soil sample, conducting laboratory for samples to find out the various parameters mainly related to load bearing capacity, ground water level, settlement, and sub soil condition and submission of detail report with recommendation for soil improvement where necessary.

8.3 BALANCE OF SYSTEMS

8.3.1 Junction Box

- The junction boxes shall be dust, vermin, and water- proof. The terminals connected to copper bus- bar arrangement of proper sizes to be provided, the junction boxes will have suitable cable entry point fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Suitable marking to be done at the cable termination points for identification.
- The junction boxes shall have suitable arrangement for the following
  - ➢ Combine groups of modules into independent charging sub-arrays
  - ➢ Provide arrangement for disconnection for each of the groups.
  - ➢ Provide a test point for each sub-group for quick fault location
  - ➢ To provide group array isolation
  - ➢ The current carrying ratings of the junction boxes shall be suitable with adequate safety factor to inter connect the solar PV array.

8.3.2 Power Conditioning Unit (PCU) with Synchronisation Circuitry

- PCU should be having efficiency levels of 98% and above. Each inverter shall be with capacity of 11KW and 93 Nos of string inverters will be connected together to make 1023 KW. The output power factor of the PCU should be of suitable range to supply. The PCU shall have internal protection arrangement against any sustained fault in feeder line and lighting in feeder circuit. The PCU are single phase static solid state type power conditioning unit with self adjusting on three phase. Both AC & DC lines shall have suitable fuses. The PCU shall have provision for input and output isolation.
- PCU shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start until fault is rectified.
- PCU front panel shall be provided with display to monitor the following :
  - ➢ DC power input

  - DC input voltage
  - DC current
  - AC power output
  - AC voltage (all 3 phase and line)
  - AC current (all 3 phase and line)
  - Power factor
- Provision should be available in the PCU for remote monitoring of all the parameters mentioned under paragraph above and other important data.

8.4 WATER FOR CLEANING

- Adequate size pipe line should be supplied, erected and commissioned for supply of water for cleaning the solar PV modules on a periodic base. In a place like Kolkata this may be necessitated once in a fortnight since heavy dust is prevalent in this area. The pipe network also shall include appropriate arrangement for easy sprinklings of water on to the panels.

8.5 LT POWER INTERFACING PANEL

- The panel shall have adequate inputs to take in from individual PCUs and adequate output to transformer.
- The panel shall be floor mounted type. All the measuring instruments such as voltmeter, ammeter, frequency meter, electronic energy meter (for measuring the deliverable unit (kWh) for sale), selector switches, and mimic front panel will be present.

8.6 COMPUTER AIDED DATA ACQUISITION SYSTEM

- Computer aided Data Acquisition Unit shall have features for simultaneous monitoring and recording of various parameters of different transducers to read the different various parameters of different sub-systems, power supply of the power plant at the DC side and AC side.
- The unit shall be a separate & individual system comprising of different transducers to read the different variable parameters, A/D converter, Multiplexer, De-multiplexer, interfacing and other electrical parameters are to be supplied alongwith the data logger unit.
- The data acquisition system shall perform the following operations, which include the measurement and continuous recording of :
  - Ambient air temperature near array field
  - Control room temperature
  - Module back surface temperature
  - Wind speed at the level of array plane
  - Solar radiation incidental to array plane
  - Inverter output
  - System frequency
  - DC bus output
  - Energy delivered to the GRID in kWh (Export)

- Energy Taken from GRID in kWh (import)

- All data shall be recorded chronologically date wise. The data file should be MS excel compatible. The data logger shall have internal reliable battery backup to record all sort of data simultaneously round the clock. All data shall be stored in a common work sheet chronologically.
- Representation of monitored data in graphics mode or in tabulation form should be available. Provision should be available for remote monitoring through GRS system.

8.7 LIGHTING & OVER VOLTAGE PROTECTION

8.7.1 Lighting Protection for Array yard

- The SPV power plant should be provided with lighting and over protection. The main aim of over voltage protection is to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system component.
- The source of over voltage can be lighting or other atmospheric distance. The lighting conductor shall be made as per applicable Indian standard in order to protect the entire array yard from lighting stroke.
- Necessary concrete foundation for holding the lighting conductor in position will be made after giving due consideration to maximum wind speed and maintenance requirement at site in future.
- Each lighting conductor shall be fitted with individual earth pit as per required standards including accessories and providing masonry enclosure with cast iron cover plate having locking arrangement, watering pipe using charcoal or coke and salt as per required provisions of IS.

8.7.2 LIGHTNING PROTECTION FOR CONTROL ROOM BUILDING

The control room Building is to be protected from lightning strike with lightning conductor as per requirements of IS standards.

8.8 EARTHING SYSTEM

8.8.1 LT Side

- The earthing for array and LT power system shall be as required as per provisions of IS. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of resistance. Each array structure of the SPV yard shall be grounded properly.
- The array structures are to be connected to earth pits as per IS standards. The earthing for the power plant equipment shall be made as per provisions of IS. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.

- The complete earthing system shall be mechanically and electrically connected to provide independent return to earth. All three phase equipment shall have two distinct earth connections.
- An Earth Bus shall be provided inside the control room. For each earth pit necessary Test point shall have to be provided.
- In compliance to rule 33 and 61 of Indian Electricity rules, 1956 (as amended up to date), all non-current carrying parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.
- The 33 KV side equipments and parts shall be earthed as required as per provisions of IS.
- The 66/33 KV side equipments and parts shall be earthed as required as per provisions of IS.

8.9 ENERGY METER

- An Energy Meter shall be provided as approved to measure the delivered quantum of energy to the GRID for sale. Meter must be provided with necessary data cables.

8.10 PROTECTIVE RELAYS

- The SPV system and associated power evacuation system should be protected as per Indian Standards. Over Current Relays, Reverse Power protection and Earth fault Relays are the minimum requirements.

8.11 POWER EVACUATION ARRANGMENT

8.11.1 690 Volts / 33 KV Transformers

- Adequate capacity Transformers shall be provided to step up the voltage to 3 Ph, 690 Volts, 50 Hz output of the PCUs to 33 KV level and further 66 KV to 33 or 132 KV to 66 KV to be taken to Tizit substation.
- Transformers shall be of Standard make and will have relevant international certifications. Transformers shall have relevant monitoring protection devices as per the relevant Indian Standards. The transformer manufacturer shall provide Test certificates for tests carried out on the transformer per relevant IS standards.

8.11.2 Circuit Breakers and Other isolators and protective and Metering Arrangement

- Appropriate Circuit breakers and isolators shall be provided as per the Indian Standards and IE rules.
- The system shall be designed with appropriate CTs & PTs to have all protection arrangements like reverse power, over current, Earth etc. In addition CTs and PTs shall also be provided for metering elsewhere specified.
- Power transformer should be minimum full load & no load losses.

CABLE TRACE

- The inter connection AC cabling upto switchyard will be underground while from switchyard to Tizit substation shall be using overhead conductor.

Chapter 9
POWER EVACUATION SYSTEM & GRID INTERACTION

9.1 SUITABILITY OF SPV POWER PLANT UNIT TO OPERATE IN PARALLEL WITH GRID

- It is important that the SPV power plant is designed to operate satisfactorily in parallel with the grid under extremely high voltage and frequency fluctuation conditions, so as to export the maximum possible units to grid.
- It is also extremely important to safeguard the system during major disturbances, like tripping/pulling-out of big generating stations and sudden overloading during falling of portion of the grid loads on the power plant unit in island mode, under fault/feeder tripping conditions.

9.2 PROPOSED SYSTEM

- The SPV based power project envisages a power export of 100 MWp during normal operating conditions. The grid connections will be at 66/33kV or 132/66 KV level.
- The exportable power from the plant shall be evacuated by stepping-up the power from 690 V to 33kV through 2500 or 10000 KVA step up transformer x nos. of transformers
- Proposed 33kV & 66 KV switchyard in the SPV plant premises will have single bay arrangement with power transformer of 33kV level with control and protection equipment (circuit breaker, CTs, PTs, isolators etc.)
- CTs, PTs, isolators, lightning arrestors, and TVM for Dept of Power measurement will be arranged. Switchyard arrangement and other requirements will be in line with Dept of Power DISCOM specifications.
- Protection, metering & control panels for the switchyard and grid feeder will be accommodated in the plant's control room.
- Tariff main metering shall be accommodated in outdoor kiosk on plant land. Tri vector meter that will be provided in the plant's control building or as per Dept of Power's requirement and will have main & checking arrangement, and these shall be agreed upon with the Dept of Power. The tariff meters shall register import as well as export parameters.
- Transmission line between the SPV plant switch yard and the Tizit sub-station shall be of double circuit conductor, and shall be taken through transmission tower suitable for double circuit conductors and is being laid by client.

9.3 TRANSFORMER

- Transformer of rating 2500 to 10000 KVA that will be used to step-up the generated exportable power at 690 V into 33kV and further 66 KV, shall be housed in the switchyard, inside SPV plant premises.

- The transformer conforming to applicable standards will be complete with the fitting and accessories like conservator, MOG, breather, Buchholz relay terminal contacts for alarm and trip, pressure relief devices, thermometer pockets, Oil WTI, valves, earthing terminal, cooling accessories, bi-directional flanged with locking and bolting device for mounting on Rils, air release device inspection cover, off load tap changer (OLTC), marshalling box, etc.

9.4 CIRCUIT BREAKERS

- Circuit breakers of suitable type shall be provided in SPV plant switchyard as well as at Tizit substation. Sub-station for the plant feeder. The circuit breaker and accessories will be in general conforming to IEC standards.
- The circuit breaker will be totally restrike free under all duty conditions and will be capable of breaking magnetizing current of transformer and capacitive current of unloaded overhead lines without causing over voltages of abnormal magnitudes.
- The circuit breakers will be suitable for use in the switchgear under the operating conditions.
- Closing coil will be suitable for operation at all values of voltages between 70% and 110% of the rated voltage. Shunt trip will operate correctly under operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

9.5 PROTECTION METERING, & CONTROL CUBICLES

- The transformer will have the following minimum protections, in addition to the in-built protections (Buchholz relay, oil & winding temperature relays, magnetized oil level gauge), to isolate the equipment during fault conditions:
  - Over current & earth fault relays on HV & LV sides
  - Differential relay
  - Restricted earth fault protection at HV side
  - Over voltage relay
  - Reverse power relays
- The feeders linking the plant substation and the EB substation will be protected with distance protection, directional as well as non-directional over current & earth fault relays. Rate of change of frequency protection and vector surge protective relay will also be provided to isolate the generating system during grid disturbances/over loading conditions.
- Meters for monitoring the electrical parameters, mimics, transducers, and annunciator for fault signals, control switches shall be provided in the control panels. Electrical Interlocking between breakers/isolators/earth switches for safe operation of the system shall also be ensured.
- All the protection, metering and control cubicles shall be housed in the SPV plant's control room.
- The plant feeder at Tizit sub-station shall be provided with directional over current and earth fault relays, backed-up by non-directional elements. Trivector meter (TVM) may also be provided in the substation for this feeder, so as to give backup for main metering, which shall be arranged in the SPV plant premises.

9.6 LIGHTNING ARRESTORS

- Lightning arrestors of adequate capacity will be provided for transformer/switchyard equipment protection and on terminating ends of the transmission lines.
- The lightning arrestor will be heavy duty station class type, discharge class I, conforming to IEC specification.
- Arrestors will be complete with Insulating base, self contained discharge counters and suitable milli-ammeters.

9.7 ISOLATORS AND INSULATORS

- Isolators complete with earth switch (wherever necessary), galvanized steel base provided with holes, solid core type post insulators with adequate creep age distance, blades made up of non-rusting material, operating mechanism (gang operated, manual/motor charging mechanism).
- They will be center post rotating horizontal double break type and consist of 3 poles.
- Solid core type post insulators of adequate creep age distances (suitable for very high pollution category) will be provided for insulation and support in switchyard at plant/Pune substation side.

9.8 INSTRUMENT TRANSFORMERS

- The instrument transformers and accessories will conform to applicable standards.
- Instruments transformers will be mounted on 33 kV 66 KV class, sealed bushing suitable for outdoor service and upright mounting on steel. Instrument transformers will be hermetically sealed units with-in-built provision to dissipate any excessive pressure build up.
- Current transformers will be of ring type with suitable construction for bringing out secondary terminals.

9.9 STRUCTURES

- The structures will be made up of hot-dip galvanized/pre galvanized steel and design to withstand forces during normal conditions (viz. wind loads & dead loads, switchyard components) and abnormal conditions (viz. short circuit, earthquake etc.).

9.10 SAFETY EARTHING SYSTEM

- A safety earthing system consisting of buried GI flat conductor earthing will be provided for the switchyard. The earthing system will be formed to grid resistance to below 1 ohm. In the switchyard area, the touch potential and step potential will be limited to the safe values.
- The buried earthing grid will be connected to earthing electrode underground. Neutral point of transformer, non-current carrying equipment, lightning arrestors, fence etc., will be earthed rigidly. The factors will be considered for earthing system design:
  - Magnitude of fault current
  - Duration of fault
  - Soil resistivity

- Resistivity of surface material
- Material of earth conductor
- Earth mat grid geometry

9.11 LIGHTNING PROTECTION SYSTEM

- Switchyard equipment will be shielded against direct lightning protection providing spikes/shield wires.
- The spikes/wires shall be formed to shield all substation equipment will be of shield of 30Deg/45Deg.

9.12 SAFETY REGULATIONS

- Statutory regulations on safety measures shall be strictly followed. Safety appliances, viz. fire extinguishers, sand buckets, earth rods, gloves, rubber mats, danger sign boards, safety regulation charts, etc. shall be procured and installed as per safety norms.
- Oil collection pits and soak pits for the transformers shall also be constructed. All cables in switchyard shall be neatly laid/ dressed and shall be barricaded inside trenches along the length with fire proof bricks.

9.12.1 Fire fighting System

- Suitable provisions shall be made for installing a fire fighting system at the SPV Power Plant premises.

9.13 AC AND DC AUXILIARY SUPPLY

- Supplies of single and three phases for illumination, transformer tap changer drives, and breaker/disconnect switch motors, space heaters in cubicles and marshalling kiosks shall be arranged from reliable AC supply source.
- 110V DC auxiliary supply required for closing and tripping of circuit breakers, emergency lighting in switchyard will be supplied by DC system.

9.14 GRID INTERCONNECTION TO Dept of Power DISCOM 66/33KV FEEDER

- A T junction arrangement will be made on 66/33 kV incoming feeder at Tizit substation to the SPV expansion power station inside the Solar Park compound wall on the South-West side and the 33kV feeder will be extended to the power plant site.
- A distance of about 12 km is estimated. Necessary switchgear will be provided for power evacuation to this feeder at the Solar Power Plant Site.

9.15 POWER REQUIREMENT FOR CONSTRUCTION

- Provision need to be made for supply of 500 kVA of power at 3 phase, 415V, 50Hz for construction purpose.

Chapter no. 10
RELEVANT STANDARDS

10.1 RELEVANT STANDARDS

- In 1981 technical committee TC82 was established. It is the most important international body regarding photovoltaic standardization.
- The main tasks of TC82 are to prepare international standards for systems of photovoltaic conversion of solar energy into electrical energy and for all the elements in the entire photovoltaic energy system.
- TC82 has several working groups – each group is responsible for specific standardization related topic (glossary, non concentrating modules, BOS, PV energy storage systems and concentrator modules).
- List of organizations for Standardization are as follows:
  - International Organization for Standardization (ISO)
  - Institute of Electrical and Electronic Engineers (IEEE)
  - International Electrotechnical Commission (IEC)
  - Deutsches Institute for Normung (DIN)
  - European Committee for Electrotechnical Standardization (CENELEC)
  - American Society for Testing and Materials (ASTM)
  - Underwriter Labotatories Inc. (UL standards)

10.1.1 Standards referring to solar cells and modules:

- Standards from this category regulate solar cells (modules) characteristic measurement, solar cells (modules) tests and other standards referring to solar cells (modules) production and testing – production procedure, mechanic or electric photovoltaic module testing, I-V module characteristics measurement etc

  IEC 60891, Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices

  IEC 60904-1, Photovoltaic devices. Part 1: Measurement of photovoltaic current-voltage characteristics

  IEC 60904-2, Photovoltaic devices. Part 2: Requirements for reference solar cells

  IEC 60904-2/A1, Photovoltaic devices. Part 2: Requirements for reference solar cells, Amendment

  IEC 60904-3, Photovoltaic devices. Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data

  IEC 60904-5, Photovoltaic devices. Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method

  IEC 60904-6, Photovoltaic devices. Part 6: Requirements for reference solar modules

  IEC 60904-6/A1, Photovoltaic devices. Part 6: Requirements for reference solar modules, Amendment 1

  IEC 60904-7, Photovoltaic devices. Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device

IEC 60904-8, Photovoltaic devices. Part 8: Measurement of spectral response of a photovoltaic (PV) device
IEC 60904-10, Photovoltaic devices. Part 10: Methods of linearity measurement
IEC 61277, Terrestrial photovoltaic (PV) power generating systems- General and guide
IEC/PAS 62011, Specifications for the use of renewable energies in rural decentralised electrification
IEC 61215, crystalline silicon terrestrial photovoltaic (PV) modules- Design qualification and type approval
IEC 61345, UV test for photovoltaic (PV) modules
IEC 61646, Thin-film terrestrial photovoltaic (PV) modules- Design qualification and type approval
IEC 61701, Salt mist corrosion testing of photovoltaic (PV) modules
IEC 61721, Susceptibility of a photovoltaic (PV) module to accidental impact damage (resistance to impact test)
JRC-ISPRA 503, Qualification Test Procedures Crystalline Silicon photovoltaic modules
IEC 61829, crystalline silicon photovoltaic (PV) array – On-site measurement of I-V characteristics
IEEE 929, recommended practice for utility interface of residential PV systems
IEEE 1262, recommended practice for qualification of PV modules
IEEE 1513, recommended practice for qualification of concentrator photovoltaic modules

10.1.2 Standard for Photovoltaic System:

- In this category various standards regulating modes of Photovoltaic System functioning supervision or standards advising planning and implementation of such systems can be found. The category includes safety regulations, which have to be considered upon photovoltaic systems implementation
  IEC 60364-7-712, Electrical installations of buildings- Part 7-712: Requirements for special installations or locations – Solar Photovoltaic (PV) power supply Systems.
  IEC 61194, Characteristics parameters of stand-alone Photovoltaic (PV) Systems
  IEC 61702, rating of direct coupled Photovoltaic (PV) pumping System
  IEC 61724, Photovoltaic systems performing monitoring – Guidelines for measurement, data exchange and analysis
  IEC 61727, Photovoltaic (PV) systems – Characteristics of the utility interface
  IEC 61683, Photovoltaic systems – Power conditioners – Procedure for measuring efficiency
  IEC/TR2 61836, Solar Photovoltaic energy systems – Terms and symbols
  IEC 62124, Photovoltaic Stand-Alone systems – Design Qualification and Type Approval
  IEEE 928, recommended criteria for terrestrial PV power systems
  IEEE 1373, recommended practice for field test methods and procedures for grid-connected PV systems
  IEEE 1374, Guide for terrestrial PV power system safety

10.1.3 Standards for Other parts / components of Photovoltaic systems:

- The standard within this category refer to batteries, over-voltage protection components and other system components not included in the categories mentioned above.
  IEC 61173, Overvoltage protection for Photovoltaic (PV) power generating systems – Guide
  IEC 61683, Photovoltaic systems- Power conditions – Procedure for measuring efficiency
  IEC 61427, Secondary cells and batteries for solar photovoltaic energy systems – General requirements and methods of test
  IEEE 937, recommended practice for installation and maintenance of lead-acid batteries for PV systems
  IEEE 1144, Sizing of industrial nickel-cadmium batteries for PV systems
  IEEE 1145, recommended practice for installation and maintenance of nickel-cadmium batteries for PV systems
  IEEE 1361, recommended practice for determining performance characteristics and suitability of batteries in PV systems

10.1.4 ASTM Standards:

ASTM E 927, Standard Specification for solar Simulation for Terrestrial Photovoltaic Testing
ASTM E 948, Standard Test Method for Electrical Performance of Photovoltaic cell using Reference Cells under Simulated Sunlight
ASTM E 973M, Standard Test Method for Determination of the Spectral Mismatch Parameter between a Photovoltaic Device and a Photovoltaic Reference Cell
ASTM E 1021, Test Method for Measuring Spectral Response of Photovoltaic Cells
ASTM E 1036, Standard Test Method for Electrical Performance of Nonconcentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells
ASTM E 1036M, Standard Test Method for Electrical Performance of Nonconcentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells
ASTM E 1038, Standard Test Method for Determining Resistance of Photovoltaic Modules to Hail by Impact with Propelled Ice Balls
ASTM E 1040, Standard Specification for Physical Characteristics of Nonconcentrator Terrestrial Photovoltaic Reference Cells
ASTM E 1125, Standard Test Method for Calibration of primary Non- concentrator Terrestrial Photovoltaic Reference Cells Using a Tabular Spectrum
ASTM E 1143, Standard Test Method for Determining the Linearity of a Photovoltaic Device Parameter with respect to a test Parameter
ASTM E 1171, Standard Test Method for Photovoltaic Modules in Cyclic Temperature and Humidity Environments
ASTM E 1328, Standard Terminology Relating to Photovoltaic Solar Energy Conversion
ASTM E 1362, Standard Test Method for Calibration of Non- concentrator Photovoltaic Secondary Reference Cells
ASTM E 1462, Standard Test Method for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules
ASTM E 1596, Test Methods for Solar Radiation Weathering of Photovoltaic Modules

ASTM E 1597, Standard Test Method for Saltwater Pressure Immersion and Temperature Testing of Photovoltaic Modules for Marine Environments
ASTM E 1799, Standard Practice for Visual Inspections of Photovoltaic Modules
ASTM E 1802, Standard Test Method for Wet Insulation Integrity of Photovoltaic Modules
ASTM 1830, Standard Test Method for Determining Mechanical Integrity of Photovoltaic Modules
ASTM E 2047, Standard Test Method for Wet Insulation Integrity of Photovoltaic Arrays
ASTM E 2236, Standard Test Method for Measurement of Electrical Performance and Spectral Response of Nonconcentrator Multijunction Photovoltaic Cells and Modules
ASTM G 173, Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37^0 Tilted Surface

10.1.5 UL Standards:

UL 1703, Standard for Flat-Plate Photovoltaic Modules and Panels
UL 1741, Standard for Invertors, Convertors and Controllers for Use in Independent Power Systems

10.2 PHOTOVOLTAIC MODULE TESTING:

- TUV Rheinland – The work of TUV is animated by the conviction that social and industrial development cannot be achieved without technical progress. Proceeding from 125 years of tradition and experience, our market activities are concentrated especially in the five fields of Industrial Services, Mobility and Transport, Product Safety and Quality, Education and Consulting, and New Business Development.
- Photovoltaic Testing Laboratory – PTL – Photovoltaic Testing Laboratory at Arizona State University was established in 1991. The main tasks are: develop a hands-on tRining laboratory for graduate and undergraduate students, provide state-of-the-art laboratory equipment with which faculty, staff, and students could perform research; establish the capability to perform qualification testing per all relevant national and international standards, including Underwriters Laboratories (UL) 1703; provide PV module qualification testing services to the PV industry; provide related applied research to the PV industry etc.
- JRC ISPRA – Located in Ispra (Italy), the Institute for Environment and Sustainability (IES) is one of the institutes that constitute the joint Research Centre of the European Commission. In line with the JRC mission, the aim of IES is to provide scientific and technical support to European Union strategies for the protection of the environment contributing to a sustainable development.

10.3 PHOTOVOLTAIC PRODUCTS QUALITY ASSURANCE:

- PV GAP – PV GAP is a not-for-profit organisation, registered in Switzerland, which certifies the quality of PV systems and Components. PV GAP also promotes the development and utilization of internationally accepted standards that promote the new integration of quality into all aspects of PV energy delivery.
- NREL Photovoltaic Research – Measurements & Characterization

Chapter 11
POWER GENERATION SCHEME AND SIMULATION RESULTS

11.1 SOLAR RADIATION

- The solar Radiation available at the project site is around 1249 kWh/kWp/year.
- The following are the details of the considerations in the design:
  - Location: Tizit

11.2 ESTIMATED ENERGY GENERATION

- Our system design considering Multicrystalline modules concludes output of 1 MWp Solar PV power plant at proposed location a yield approx 12.30 Lakhs units/year for utilization & sale to Govt Of Nagaland.
- The generation of the energy has been estimated by RET screen International Clean Energy Project Analysis Software results which on back end considering twenty two years of average solar radiation data available at NASA website for the site location.
- Simulation results as per PV Syst report attached herewith.

Chapter no 12
OPERATION AND MAINTENANCE REQUIREMENTS

12.1 OVERVIEW

- This section of the report outlines the operation and maintenance philosophy to be adopted for the proposed grid connected SPV power plant. These broad outlines, given here, will provide useful guidelines for the basic and detailed engineering of the plant , so that all the requirements of the operation and maintenance of the plant are met and provided for in the engineering stage itself.
- The production of power plant from SPV plant is generally a static affair with no moving parts except in case of tracking is involved. The SPV array produces the electricity by deploying SPV modules which are warranted for 25 years. Once properly selected and installed these require no major maintenance. The DC power produced by the array is converted into AC power by battery of PCUs which need some attention because of electronics involved.
- The AC output at 690 V level is stepped up 33 kV by a set of transformers. These transformers and associated switch gear need proper preventive maintenance. The most important aspect of the system which needs proper monitoring is the synchronizations which ensure the availability of the power to the grid.

12.2 SYSTEM DESIGN PHILOSOPHY

- The main O & M objective is the high availability and reliability of the plant. In order to achieve the main objective, the following principles would be adopted.
    - Building up adequate capacity to ensure generation of power as per design estimates. This is done by applying liberal de-rating factors for the array and recognizing the efficiency parameters of PCUs, transformers, transmission lines, etc.
    - Providing redundancy to ensure at least 50% availability in case of major break downs of transformers.
    - Use of equipments and systems with proven design and performance that have a high availability track record under similar service conditions.
    - Selection of the equipment and adoption of a plant layout to ensure ease of maintenance.
    - Strict compliance with the approved and proven quality assurance norms and procedures during the different phases of the project.
- The basic detailed engineering of the plant will aim at achieving high standards of operational performance especially with respect to the following key parameters:
    - Optimum availability of modules during the day time

- ➢ Ensuring model layout to prevent shading
- ➢ High DC system voltage and low current handling requirements.
- ➢ Selection of PCU with high track record.
- ➢ Selection of transformers with low maintenance requirements.

- The plant instrumentation and control system should be designed to ensure the availability and reliability of the plant to assist the operators in the safe & efficient operation of the plant. It should also provide for the analysis historical data and help in the plant maintenance people to take up the plant equipment on preventive maintenance.

12.3 OPERATION REQUIREMENTS

- The operation of the plant starts with the commissioning. In broad terms, commissioning can be defines as setting up of the plant to work safely and on program.
- It is necessary to ensure that all equipment is completely erected before operations begin. Although this may be considered difficult, the other extreme operating a plant with inefficient instrumentation, controls, and alarms volume dangerous.
- Although some compromise can be made with regard to plant completion. Commissioning procedure should never compromise personnel and the system safety.
- A proper checklist procedure must be drawn up, which would include the sections of the plant and shall take into account the contractual responsibility the technological relationship between the sections, pre-commissioning, cleaning requirements, etc.
- The checklists procedure helps in the following:

  - ➢ To ensure that the necessary checks are carried out on each item in the plant before it is put into commercial service.
  - ➢ To ensure that energy is supplied to grid when it is safe to do so.
  - ➢ To facilitate the recording of the progress on the various commissioning activities.
  - ➢ To provide a basis for the plant history.
- The operation of the power plant unit interconnected to the grid is essential and must be properly coordinated, within the plant as well as with the Operating sub-station to which the plant feeds power.
- Operation in parallel with the grid eventually makes the SPV power plant a part of the DEPT OF POWER's utility system and hence the power plant must have some of the same responsibilities of DEPT OF POWER.
- With this, the DEPT OF POWER's local dispatch center will need to monitor the incoming power from the SPV power plant on a continuous basis.
- .An important feature of the modern power generating plant is the automatic safety lock-out devices.
- While sufficient thought goes into it at the design stage, it remains the responsibility of the operating staff to ensure that the safety devices are set correctly and kept in operation.
- While safety of the plant and personnel is the foremost importance in the operation, the efficient operation of the plant cannot be ignored.
- While operating, it is important to check the essential parameters of the plant and equipment to ensure that the plant performance is at the optimum level.

- Any variations in the operating parameters or any deviations from normal performance of the equipment or plant shall have to be analyzed immediately to diagnose the problem and to take remedial measures to bring back the plant and equipment to its original parameters.
- The plant operator should follow the guidelines given below:
  - Frequent checking and calibrations of instrument;
  - Developing a habit of cross checking instrument indications with each other to determine whether the instrument is faulty or there is an abnormal operating condition;
  - And developing habit of analyzing indicated data to determine accurately what could be wrong.

12.3.1 Evacuation of power generated by the SPV power plant

- It is important to recognize that:
  - Generating voltage of 690 V has to be stepped up to 33kV and further 66 KV at the high voltage side of the transformer to match the grid voltage at the point of interconnection.
  - The power plant has to operate in parallel with the grid system which is a vast power carrier. The power plant has to protect its equipment against possible faults or other disturbances from the grid.

12.4 MAINTENANCE REQUIREMENTS

- The main objectives of the plant maintenance are to keep plant running reliably and efficiently as long as possible.
- RELIABILITY is impaired when a plant undergoes forced and unforeseen outages. This aspect Assumes greater significance for a SPV power plant exporting power to the DEPT OF POWER grid under contractual commitments.
- It is imperative that any planned maintenance is undertaken with closer coordination with maintenance.
- There are two components in maintenance cost: one is the direct cost of maintenance, (i.e. the material and labor), and the other is the cost of production loss.
- There are two categories of maintenance work:
  - One is the irksome breakdown maintenance which is expensive. Much as it is desirable to avoid or minimize this, it's existence must be accepted.
  - Secondly, it is the preventive maintenance with proper planning and execution of plant and equipment overhauls. This maintenance activity should be clearly planned with regard to the availability of material and labour.
- It is also essential to develop proper inspection procedures with non-destructive testing methods.
- Such inspections by tRined personnel reveal defects not necessarily detected by mere visual inspection.
- The following help in reducing the breakdown maintenance and also help in planning for preventive maintenance:

- ➢ Careful logging of operation data/historical information from the data /historical information from the data Monitoring Systems , and periodically processing it to determine abnormal or slowly deteriorating conditions.
- ➢ Walk down checks of plant.
- ➢ Regulate routine maintenance work such as keeping equipment clean, cleaning SPV modules and delicate ingredients of transformers and circuit breakers. Cleanliness of isolators also to be ensured.
- ➢ Close coordination with the manufacturers to effect improvements in plant layouts and design, use of better material, introduction of such facilities as cathodic protection, use of better protective paints, etc.

- It is extremely important that proper records are maintained not merely for the maintenance work done but also of the material used and actual man hours spent, etc.
- Solar sort of a card system shall have to be introduced to keep records that are most useful in future planning of outages and providing for effective control .

12.4.1 Annual Operation and Maintenance Contract with Supply of Spares

- A list of recommended spare parts for storage for maintenance shall be recommended by supplier.
- Another important requirement of a good maintenance program is to ensure that spares are ordered in time and good stocks of the frequently required spares are maintained.

12.5 PREVENTIVE MAINTENANCE (SPECIFIC GUIDELINES)

- The Company will provide a comprehensive O & M program for the project.
- The O & M team will operate the solar facility in accordance with an Operations and Maintenance Agreement (the "O & M Agreement") which shall provide for, at a minimum, the following services:
  - ➢ Performing routine and non-routine maintenance on solar facility during and after the EPC warranty period ;
  - ➢ Operating the solar facility:
    - o Providing all materials and services necessary for solar facility maintenance;
    - o Monitoring the operations of the project via the computer monitoring system;
    - o Performing all duties to the standard mandated by the PPA;
    - o Complying with all regulatory obligations;
    - o Developing operating and safety plans;
    - o Maintenance all Project information and facility data, including providing reports to the company.
- Solar photovoltaic systems are highly reliable and minimal maintenance.
- Several maintenance activities need to be completed at regular intervals during the lifetime of the system.

Chapter 13
ORGANIZATIONAL ARRANGEMENTS

13.1 STAFF

- Depending on the O & M requirements the firm will make necessary arrangements for proper implementation of O & M.
- This will be through direct presence of the firm's staff or through their technology partners.
- Typically, the power plant will be under the charge of an engineer with the support of adequate staff for security and O & M.
- Exact orientation structure and number of staff will depend on the site conditions which will be assessed during the implementation of the project.

13.2 TRINING

- During the commissioning of the plant, training will be imparted to the Engineer, Supervisor and Operators.
- This operational training shall cover the following:
  - The nature, purpose and limitations of all plant and equipment.
  - The detailed operating instructions on each section and equipment of the plant
  - Normal startup and shut down program for the plant.
  - The emergency procedures and all related HSE issues according standards
- The basis for the training shall be the plant's O & M manual.

Chapter 14
PROJECT IMPLEMENTATION & SCHEDULE

14.1 PROJECT IMPLEMENTATION STRATEGY

- The most essential aspect regarding the implementation of this SPV power project is to ensure the project completion within the schedule, spanning for eleven months from the commencement date.
- A good planning and monitoring methodology is essential to complete the project on time. It is expected that the project execution will commence within 15-18 months after PPA signing.

14.1.1 Essential Functions Of the Project

- The overall project activities for the SPV power plant divided into sub packages as given below. The split of supplies is as follows:
    - ➢ Site preparation, leveling etc. Construction of control room, fencing, peripheral lighting, water supply system, dRinage system, approached roads etc. supply, erection, installation and commissioning of lighting arrestors.
    - ➢ Supply, erection, installation of SPV modules on structures. Supply, erection, installation and testing of PCUs. Interconnection of equipments and commissioning of the power plant (deliver 3 Ph, 690 V AC supply and combining outputs of 100 nos. of PCUs.). Completion of earthing system before commissioning. Supply, installation and commissioning of data monitoring system.
    - ➢ Supply, erection, installation, interconnection and commissioning of power evacuation system consisting of isolators, circuit breakers, transformers and transmission line along with commissioning of metering and protection system.
    - ➢ Actualize grid fed-in by synchronizing SPV power supply with 66/33 kV conventional grid at Tizit.
    - ➢ Acceptance test of metering system and energy sale.

14.2 PROJECT EXECUTION

- The execution will be planned, monitored and controlled through project management techniques employing MS-Project (PERT-CPM CHARTS).
- A provisional time line of the project shall be given at the time of power purchase agreement.