

Available online at www.elixirpublishers.com (Elixir International Journal)

Electrical Engineering





Structuring, Costing and Maintaining a Solar PV System

Megha Khatri

Ansal University, Golf Course Road, Sector-55, Gurgaon and India.

ARTICLE INFO

Article history: Received: 5 August 2015; Received in revised form: 29 August 2015; Accepted: 3 September 2015;

Keywor ds

PV system, Distributed generation, Solar modules, Solar windows Costing PV.

ABSTRACT

This paper is the study on setting up a solar PV system plant and rooftop system in the northern hemisphere of India. It includes brief explanation on structure, calculations based on the approximated data collected from the 5MW plant and maintenance required to get the maximum efficiency of the plant. However many locations around the world have years of weather records that will provide average data which is sufficient for designing a PV systems and if no long term data exists for the chosen site, in that case the availability of sun light and the amount of sunshine can also be estimated with the help of available equipments.

© 2015 Elixir All rights reserved.

Introduction

Solar energy on the earth in direct or indirect form is the source of nearly all other energies i.e. Wind energy which uses air that is created by sunrays heating the surface of earth and the rotation of the earth, Hydropower depends on the evaporation of water by the sun, and its coming back to the Earth as rain to provide water in dams. Photovoltaic devices (solar cells) directly convert the incident solar radiation into electricity, which are noise free because of no moving parts, pollution free that makes them vigorous, reliable and long lasting. As per the study conducted by Einstein and Plank, light may be viewed as consisting of "packets" or particles of energy, called photons which can be used to produce electricity, the phenomenon is called Photoelectric effect [1]. The key characteristics such as the spectral content of the incident light, the angle at which the incident solar radiation strikes a photovoltaic module, the radiant energy and power density from the sun. This paper is divided into sections explaining study and approximate calculations for setting up a PV system.

The solar irradiance at the earth's surface depends on the parameters like atmospheric effects including absorption and scattering, the variations in the atmosphere such as water vapor, clouds, and pollution, latitude of the location that means the season of the year and the time of day. Atmospheric effects have several impacts on the solar radiation at the earth's surface. The important effects for photovoltaic applications are: reduction in the power due to absorption, scattering and reflection. Due to greater absorption or scattering of some wavelengths there can be change in the spectral contents of visible sunlight. Whereas the diffused/indirect components in the solar radiation are due to local variations in the atmosphere (such as water vapors, clouds and pollution) produces reflection [1-3].

The light that we see every day is only a fraction of the total energy emitted by the sun incident on the earth. The sunlight is a form of electromagnetic radiations and the visible light that we see is a small subset of the electromagnetic spectrum. The PV modules need photons of visible light in direct or indirect to convert it into electrical power.

Properties of Light and PV cells

Solar radiation can be useful either through solar photovoltaic route or solar thermal route. Solar radiations strike earth's surface at a particular time and place called Insolation. The total insolation striking the earth on a clear day is about $1000W/m^2$. However many other factors determine how much sunlight will be available at a given site.[2]

In PV system design it is essential to know the amount of sunlight available at a particular location at a particular time. The two common methods which characterize solar radiations are Solar Radiance (or radiation) and Solar Insolation. The solar radiance is an instantaneous power density in units of kW/m² whereas the solar insolation is total amount of solar energy received at a particular location during a specified time period unit kWh / (m² day). Whereas the solar radiations power incident on a PV module depends on the power contained in the sunlight and the angle between the module and the sun [3]. Normally optimum tilt angle is the latitude of the location, so in order the sun rays fall perpendicular to the module surface.

Properties of Light

Some important terms which we use working on the properties of light/ solar radiations on solar modules.

Air Mass

It is the path length which light takes through the atmosphere normalized to the shortest possible path length (that is, when the sun is directly overhead). The Air Mass is = 1/ Cos θ where θ is the angle from the vertical (zenith angle)). The standard spectrum outside the earth's atmosphere is called AM 0, because at no stage does the light pass through the atmosphere. Whereas when the sun is directly overhead, the Air Mass is 1 and at the angle $\theta = 48.2$ degree, the Air Mass is 1.5. For standard test conditions of Cells and Modules, the AM is considered 1.5.

Local Solar Time (LST)

It is defined as when the sun is highest in the sky i.e. twelve noon is called local solar time (LST). Local time (LT) usually varies from LST because of human adjustments such as time zones and daylight saving while we always consider local solar time for all the calculations related to modules [4],[5].

Tele: E-mail addresses: meghakhatri@ansaluniversity.edu.in

© 2015 Elixir All rights reserved

Solar Declination

Despite the fact that the Earth revolves around the sun, it is simpler to think of the sun revolving around a stationary Earth. **Peak Sun Hour**:

Peak Sun hour is an equivalent measure of total solar irradiation in a day given in 1 KWhr / m^2 .

Elevation Angle

The elevation angle / altitude angle is the angular height of the sun in the sky measured from the horizontal. It varies throughout the day.

Azimuth Angle

The azimuth angle is the compass direction from which the sunlight is coming. At solar noon, the sun is always directly south in the northern hemisphere and directly north in the southern hemisphere.

Properties of PV Cells

Absorption coefficient

The absorption coefficient determines how far into a material, light of a particular wavelength can penetrate before it is absorbed.

Module circuit Design

The voltage of a PV module is usually chosen to be compatible with a 12V battery. An individual silicon solar cell has approximate voltage of 0.6V under 25 °C and AM1.5 conditions. This gives an open-circuit voltage of about 21V under standard test conditions (STC), and an operating voltage at maximum power and operating temperature of about 17 or 18V. A typical module has 36 cells connected in series mostly.

Mismatch Effect

Mismatch losses are caused by the interconnection of solar cells or modules which do not have identical properties. When one solar cell is shaded while the remainder in the module are not, the power being generated by the "good" solar cells can be dissipated by the lower performance cell rather than powering the load. This in turn can lead to highly localized power dissipation and the resultant local heating may cause irreversible damage to the module.[6] Thus the output of the entire PV module under worst case conditions is determined by the solar cell with the lowest output. Large mismatches are most commonly caused by differences in either the short-circuit current or open-circuit voltage. With short-circuit current mismatch, severe power reduction can take place, if the poor cell produces less current than the maximum power current of the cells in good condition, the high power dissipation in the poor cell can cause irreparable damage to the module [7]. Whereas with open-circuit voltage mismatch the overall current from the PV module is unaffected. At the maximum power point temperature, the overall power is reduced because the poor cell is generating less power.

Hot Spot heating

If one shaded cell in a string reduces the current through the good cells, causing the good cells to produce higher voltages that can often reverse bias the bad cell. Bye pass diodes are used to reduce this effect.

Structure and operation of PV cell Structure of PV Cell modules

Silicon PV modules consist of a transparent top surface, an encapsulant, a rear layer and a frame around the outer edge as shown in the figure:1[4][9] .In most modules, the top surface is glass, the encapsulant is EVA (ethyl vinyl acetate) and the rear layer is known as Tedlar, which provides durability to PV modules.

The top surface have high transmission of light in the wavelength range of 350×10^{-9} m to 1200×10^{-9} m. The reflection

from the front surface must be low. An encapsulant is used to provide union between the solar cells. Followings are the characteristics of the rear surface of the PV module, that it should have low thermal resistance and that it must prevent the ingress of water or water vapors. A final structural component of the module is the edging or framing of the module.





The operation of a solar cell is based on the generation of light-generated carriers that implies generation of current, large voltage across the solar cell and dissipation of power in the load. Efficiency of a Solar Cell plays a very important role in the operation of PV cell, which is defined as the ratio of energy output from the solar cell to input energy from the sun determined as the fraction of incident power which is converted to electricity [8]. This is the commonly used parameter to compare the performance of one solar cell to another where terrestrial solar cells are measured under AM1.5 conditions at a cell temperature of 25°C and Irradiance 1000 Watt /Sq mt. For example if a one Sq. mt. cell produces 150 Watt peak at STC condition then the efficiency of the cell is 15%. One method to increase the efficiency of a solar cell is to split the spectrum and use a solar cell that is optimized to each section of the spectrum known as tandem cells. For the solar collectors or cells which are flat, global horizontal irradiance (GHI) is important. For solar collectors or cells which are concentrating, direct normal irradiance (DNI) is important. The module data which is provided on the back side of each module is shown below at Standard Test Condition (STC) and at Nominal Operating Cell Temperature (NOCT)

Module Data				
Electrical Data @ STC	REC 240PE			
Nominal Power - Pmpp (Wp)	240			
Watt Class sorting (watt)	0/+5			
Nominal Power Voltage- Vmpp (V)	29.9			
Nominal Power Current- Impp (A)	8.04			
Open Circuit Voltage- Voc (V)	37			
Short Circuit Current- Isc (A)	8.60			
Module Efficiency (%)	14.50			
Electrical Data @ NOCT	REC 240PE			
Nominal Power - Pmpp (Wp)	176			
Nominal Power Voltage- Vmpp (V)	27.30			
Nominal Power Current- Impp (A)	6.45			
Open Circuit Voltage- Voc (V)	34.10			
Short Circuit Current- Isc (A)	6.96			
Normally operating Cell Temp (deg C)	47.9			
Temperature related Data	REC 240PE			
Temp Coefficient of Pmpp	-0.43 % / deg C			
Temp Coefficient of Voc	-0.33 % / deg C			
Temp Coefficient of Isc	0.074 % / deg C			
Operating Temp range	-40 to + 80 Deg C			
Warranty	10 yr product warranty			
Performance Warranty	25 yr linear warranty			

Selection of Components for Solar PV System

Following are the basic key components with their parameters required to setup a PV system [2],[3]

1. Land & Infrastructure 2. Silicon Solar Modules - Location and A valiability of land. -Crystalline Silicon Modules. - Hardness of the soil. -Forst Crystalline Silicon Modules. - Hardness of the soil. -Thin Film PV Modules. - Availability of portable water.	ing are the basic key components with their paramete	
 Location and Availability of land. Land topolog. Distance from Substation. Resistivity of land. Availability of portable water. Hardness of the soil. Shafa Model Parameters Stolar Model Parameters Stolar Model Parameters Stolar Model Parameters Stolar Model Parameters Amorphous Silicon. Modules. Tracking Product Warranty. Product Scalable. Product Warranty. Product	1. Land & Infrastructure	2. Silicon Solar Modules
 Hand topology. Jostance from Substation. Poly Crystalline Silicon Modules. Poly Crystalline Silicon Modules. Poly Crystalline Silicon Modules. Poly Crystalline Silicon Modules. This Film PV Modules. Anamoting Structure Assessment of radiation at the location. Solar Module Parameters Anomiting Structure Cost. Flora & Jana. Assessment of radiation at the location. Solar Module Parameters Cost. Flora & Jana. Assessment of radiation at the location. Solar Module Parameters Cost. Flora the location. Solar Module Parameters Cost. Flora the location. Solar Module Parameters Cost. Flora the location. Solar Module Parameters Anometring Structure Singe Axis Tracking. Tracking + Tracking. Poly Creation Structures. Waranty on Structures. Waranty on Structures. Waranty on Structures. Size of cable (4 mm & 6 mm). Size of cable. Cost. Cost. Supper Cables. Cost cables. Cost cables. Corran tensors (Hall effect sensor / Resistive Sensor). Different types of Connectors. Different type of conductors. Supper Cable. Cost cable. Cost cable. Corran tensors (Interfers) The parameters of a Control panels. Handia static at right. Pover consumption in itela static at right. Pover consumption itela	•Location and Availability of land.	•Crystalline PV M odules.
-Distance from Substation. Poly Crystalline Silicon Modules. -Natiobility of Portable water. -Thin Film PV Modules. -Natability of Portable water. -Thin Film PV Modules. -Shafing. -Thin Film PV Modules. -Shafing. -Thin Film PV Modules. -Shafing. -Thin Film PV Modules. -Stating. -Thin Film PV Modules. -Stating. -Thin Film PV Modules. -Assessment of radiation at the location.	•Land topology.	Mono Crystalline Silicon Modules.
•Resistivity of land. •Thin Film PV Modules. •Availability of portable water. •Amorphous Silicon Modules. •Hardness of the sol. •Shading. •Flora & fauna. •Assessment of radiation at the location. •Assessment of radiation at the location. •Shading. •Cost. •Fired TII •Cificiency. •Single Axis Tracking. •Availability. •Tracking technology. *Product Warranty. •Distance between the rows. •System Vilage. •Design strangh. •Pore Circuit Voltage. •Aditional gain due to tracker. •Max Power point Voltage. •Aditional gain due to tracker. •Weight. •Guarnate against additional gain. •Specification of Cables, viz. FRLS, UV resistant etc. •Various Components of a SCB. •Virging of DC cables. •Different types of Connectors. •Different types of Connectors. •DC Switch / Circuit breaker. •Different types of Connectors. •Det hold ischarge (DOD). •Award New point Contage. •Nato Copper Cable. •Dort cables. •Det hold ischarge (DOD). •Free Blocks. •Comper table. •Different type of Conductors. •Det hold ischarge (DOD) of battery. </th <th>•Distance from Substation.</th> <th>Poly Crystalline Silicon Modules.</th>	•Distance from Substation.	Poly Crystalline Silicon Modules.
-Availability of portable water. Amorphous Slicon Modules. -Shading. Tandem Junction Modules. -Shading. Tandem Junction Modules. -Shading.	•Resistivity of land.	•Thin Film PV Modules.
Hardness of the soil. Tandem Junction M odules. Shading Flora & finana. Assessment of radiation at the location. Hardness of the soil. Stolar Module Parameters 4. Mounting Structure FCost. Fixed Till Efficiency. Single Axis Tracking. Product Warranty. Tracking technology. Product Warranty. Distance between the rows. System Voltage. Ower required for tracking operation. Max Power point Voltage. Additional gain due to tracker. Waranty opint Voltage. Additional gain due to tracker. Weight. Guarantee against additional gain. Performance Ratio 6. String Combiner Boxes *Size of cable (4 mm & 6 mm). *Size of cable (4 mm & 6 mm). *Specification of Cables. *Oren cables. +Driferent types of Connectors. -Using of DC cables. *Different types of Connectors. -Using of DC cables. *Different types of Connectors. -DC Copper Cable. *DL Loss Calculation. -DC cable. *Different type of onductors. -DC cable. *Different type of onductors. -DC cable. The other parameters related to inverters are	•Availability of portable water.	Amorphous Silicon Modules.
Sharing	•Hardness of the soil	Tandem Junction Modules
- Flora & Janna. - Assessment of radiation at the location. - Solar Module Parameters - Cost. - Efficiency. - Availability. - Product Warnary. - Open Circuit Voltage. - Open Circuit Voltage. - Max Power point Voltage. - Max Power point Voltage. - Warnary on Structures. - Weight. - Portraut Voltage. - Size of cable (Amm & 6 mm). - Specification of Cables. - Avoid looping. - Parallel and Series connections. - Uying of DC cables. - DC Loss Calculation. - DL Loss Calculation. - DL Loss Calculation. - The orher parameters related to inverters are: Sing of Max. Power point Temperature - Higher onput AC voltage. - Deck cable. - DL Loss Calculation. - DL Loss Calculation. - Turverters* - Range of Max. Power point Temperature - Higher onput AC voltage.	•Shading	
-Assessment of radiation at the location. 3.8 Joar Module Parameters 4. Mounting Structure Cost. +Efficiency. -Availability. Product Warranty. Power output Warranty. Open Circuit Warranty. Open Circuit Warranty. Open Circuit Warranty. Open Circuit Warranty. Max Power point Voltage. Max Power point Current. Warranty on Structures. +Weight. +Performance Ratio. SDC Cabling and Connectors Size of cable (4 mm & 6 mm). +Specification of Cables, viz. FRLS, UV resistant etc. -Wring of DC cables. -Parallel and Series connections. -Uying of DC cables. -Dict cable. -Dict cable. -Theorematters related to inverters are: Sitability of Nate AC power. -Max Power point Temperature +Higher output AC voltage. -Range of Max Power point Temperature +Higher output AC voltage. -Buttry pack Battery charger. -Different type of onductors. -Size of the cable and cable loss. <td< th=""><th>•Flora & fauna</th><th></th></td<>	•Flora & fauna	
3. Solar Module Parameters 4. Mounting Structure 4. Solar Module Parameters 4. Mounting Structure Cost. Efficiency. 4. Solar Module Parameters 4. Mounting Structure Product Warranty. -Daal Axis Tracking. +Product Warranty. -Daal Axis Tracking. +Power output Warranty. -Dasign strength. •Open Circuit Voltage. -Dosign strength. •Open Circuit Voltage. -Dosign strength. •Max Power point Current. •Waranty on Structures. •Weight. -Performance Ratio. 5. DC Cabling and Connectors 6. String Combiner Boxes •Size of cable (4 mm & 6 mm). -Specification of Cables. •Parallel and Series connections. -Parallel and Series connectors. •Different types of Connectors. -DC Copper Cable. •DC Cotage. -DC Copper Cable. The other parameters related to inverters are: The parameters of additional gower requirement +Power consumption during operation. -Max Efficiency and the ampere-hour (Ath) capacity of battery. •Mak D voltage. -Desting the parameters of concern regarding the batteries are as follows: •Sitability of Rated AC power. -Destore the Three winding transformers are as fo	•Assessment of radiation at the location	
3. Sound rotation and inducts *. Nonining Structure Cost. Firther Tile +Efficiency. *. Single Axis Tracking. + Availability. *. Dual Axis Tracking. + Product Warranty. *. Distance between the rows. + System Voltage. *. Down required for tracking operation. + Availability. *. Distance between the rows. + Power optint Valtage. *. Additional gain due to tracker. + Max Power point Voltage. *. Additional gain due to tracker. + Max Power point Carent. *. Guarantee against additional gain. + Performance Ratio. *. String Combiner Boxes - Size of cable (4 mm & 6 mm). *. Specification of Cables. + Avoid looping. +. Terminal Blocks / Connectors. + Different types of Connectors. DC Cox Cables. + Different types of Connectors. DC Cox Cable. - Dic Loss Calculation. DC Switch / Craubter agree. - Higher output AC voltage. *. Number of days of autonomy.** + Higher output AC voltage. *. Nover rese. + Higher output AC voltage. *. Over or simption during operation. - Power consumption during operation. 	2 Solor Modulo Peremotors	1 Mounting Structure
 Löst. Efficiercy. Availability. Product Warranty. Product Warranty. Product Warranty. Power output Warranty. System Voltage. Open Circuit Voltage. Max Power point Current. Waight. Performance Ratio. SDE Cabling and Connectors SDE Cabling and Connectors. Specification of Cables. Parallel and Series connections. Hyring of DC cables. Parallel and Series connections. Hyring of DC cables. Different types of Connectors. Different type of conductors. Size of cable (and x. Power, point Temperature Higher output AC voltage. Parallel and Stries connections. Different type of conductors. Size of cable and cable loss. Requirement of SCADA control panels. Pattry and State art night. Power consumption during operation. Power consumption during o	S. Solar Woulde Farameters	
 *Single Axs Tracking *Single Axs Tracking technology. *Det Cash Sing And Connectors. *Det Cash Caluation. *Single Axs Parking *Single Axs Tracking technology. *Single Axs Park Tracking technologie antruling. *Single Axs Park	•Cost.	
 Availability. Product Warranty. Product Warranty.	•Efficiency.	•Single Axis Tracking.
•Product Warranty. •Iracking technology. •Power output Warranty. •Distance between the rows. •System Voltage. •Dower point Voltage. •Max Power point Voltage. •Additional gain due to tracker. •Max Power point Voltage. •Additional gain due to tracker. •Weight. •Guarante against additional gain. •Performance Ratio. 6.String Combiner Boxes *Size of cable (4 mm & 6 mm). •Specification of Cables, viz. FRLS, UV resistant etc. •Wring of DC cables. •Different types of Connectors. •Different type of conductors. •Destrome between the rows. •Max Power point Tomperature •Hoke A power. •Max Power point Point power consumption in ideal state at night. •Destrome between the rows. •Destrome between the rows. •Surge Protection Devices (SPD). •Aroid looping •Terminal Blocks / Connectors. •Different type of Conductors. •De Copper Cable. •Different type of conductors. •Depth of discharge (DOD) of battery. •Max Dev ropint advalue loss. •Max Power ropint Perfect type of outper point Perfect type of quality cores. •Different type of conductors. •Destrome between the rows. •Site of the cable and cable loss. •Max Elfriderecy	•Availability.	•Dual Axis Tracking.
+Power output Warranty. +Distance between the rows. System Voltage. +Dosign strength. -Open Circuit Voltage. +Additional gain due to tracker. -Wax Power point Current. +Warranty on Structures. +Weight. +Guarantee against additional gain. +Performance Ratio. -String Combiner Boxes -Size of cable (4 mm & 6 mm). -String Combiner Boxes +Size of cable (4 mm & 6 mm). -Various Components of a SCB. +Specification of Cables, viz. FRLS, UV resistant etc. -Various Components of a SCB. +Various Components of a SCB. -Current sensors. (Hall effect sensor / Resistive Sensor). +Uring of DC cables. -DC Copper Cable. >DC Loss Calculation. -DC Copper Cable. 7.Juwerters* 8.Batteries The other parameters related to inverters are: The parameters of concern regarding the batteries are as follows: *Utability of Ratel AC power. -Voltage and the ampere-hour (Ah) capacity of battery. +Name of days of autonomy.** -Number of days of autonomy.** +Inferion type of conductors. -String monitor in dating operation. -Power consumption in ideal state at night. -Power onsumption in ideal state at night. +Powere consumption in duels state at night.	•Product Warranty.	•Tracking technology.
 -System Voltage. -Open Circuit Voltage. -Max Power point Voltage. -Performance Ratio. -De Cables. -Avoid looping. -Parallel and Series connections. -Lying of DC cables. -Different types of Connectors. -Different type of conductors. -Different type of Interparation. -Different type of Interfacing. -Data acquisition and transfer through own network. -Data acquisition and transfer through own network. -Data acquisition and transfer through own network. -Data acquisition and Costing -Corrent Hough Pu (Chroersemmetable logic controllew) -Data capaistion and transfer through own network. -Data capaistion and transfer through own network. -Data capaistion and transfer through own network. -Da	•Power output Warranty.	•Distance between the rows.
Open Circuit Voltage.•Power required for tracking operation.•Max Power point Vurrent.•Variants again due to tracker.•Weight.•Guarantee against additional gain.•Performance Ratio.•Guarantee against additional gain. 5.DC Cabling and Connectors6.String Combiner Boxes •Size of cable (4 mm & 6 mm).•Various Components of a SCB.•Specification of Cables, viz., FRLS, UV resistant etc.•Various Components of a SCB.•Wring of DC cables.•Various Components of a SCB.•Parallel and Series connections.•Uarrent sensors. (Hall effect sensor / Resistive Sensor).•Lying of DC cables.•DC Copper Cable.•DC Loss Calculation.•DC Copper Cable.•DC tox Calculation.•DC Copper Cable.•DC tox Calculation.•DC Copper Cable.•DC tox Calculation.•Depth of discharge (DOD) of battery.•Max DC voltage.•Number of days of autonomy.**•Higher output AC voltage.•Depth of discharge (DOD) of battery.•Number of days of autonomy.**•Number of days of autonomy.**•Different type of conductors.•Size of the cable and cable loss.•Requirement of SCADA control panels.•Usage of good quality cores.•Data acquisition and transfer through own network.•Oranter Station•Different type of Interfacing.•Pyranometer or Pyrheliometer.•Different type of Interfacing.•Pyranometer or Pyrheliometer.•Data acquisition and transfer through own network.•Pyreof Cell.•Data acquisition and transfer through own network.•Pyreof Cell.•Diat mansf	•System Voltage.	•Design strength.
•Max Power point Current. •Additional gain due to tracker. •Weight. •Warranty on Structures. •Weight. •Guarantee against additional gain. •Performance Ratio. •Stre of cable (4 mm & 6 mm). •Specification of Cables, viz., FRLS, UV resistant etc. •Narious Components of a SCB. •Specification of Cables, viz., FRLS, UV resistant etc. •String of DC cables. •Parallel and Series connections. •Uarious Components of a SCB. •Lying of DC cables. •Different types of Connectors. •Different type of conductors. •Different type of conductors. •Size of the cable and cable loss. •Perforent sensors. •Higher output AC voltage. •Naraber of cables. •Infield starting power requirement •Power consumption during operation. •Power consumption in ideal state a night. •Power onsumption during operation. •Power consumption during operation. 10.Transformers •Different type of conductors. •Stage of the cable and cable loss. •Accuracy class of CT/PT. •Cable route marking. •Cable route marking. •Cable route marking. •Cable route marking. •Different type of florend site. •Data transformers. •Pyranometer or Pyrheliometer.	•Open Circuit Voltage.	•Power required for tracking operation.
+Max Power point Current. •Warranty on Structures. •Weight. •Warranty on Structures. •Performance Ratio. •Guarantee against additional gain. •Size of cable (4 mm & 6 mm). •Specification of Cables, viz. FRLS, UV resistant etc. •Wiring of DC cables, viz. FRLS, UV resistant etc. •Various Components of a SCB. •Yaroul looping. •Various Components of a SCB. •Parallel and Series connections. •Uirig of DC cables, •Different types of Connectors. •DC Cosp Calculation. •DL coss Calculation. •DC Copper Cable. •DC totage. •DC Copper Cable. *Max DC voltage. •Deth of discharge (DOD) of battery. •Mang of Max. Power point Temperature •Higher output AC voltage. •Higher output AC voltage. •Deth of discharge (DOD) of battery. •Number of days of autonomy.** •Number of days of autonomy.** •Different type of conductors. •Size of the cable and cable loss. •Battery pack/ Battery chargr. •Low on load loss: •Accuracy class of CT/FT. •Low on load loss: •Cable sleeve fixing. •Pyranometer or Pyrheliometer. •Different type of Interfacing. •Pyranometer or Pyrheliometer. •Different type of Interfacin	•Max Power point Voltage.	•Additional gain due to tracker.
•Weight. •Guarance against additional gain. •Performance Ratio. •Guarance against additional gain. •Performance Ratio. 6.String Combiner Boxes •Size of cable (4 mm & 6 mm). •Specification of Cables, viz. FRLS, UV resistant etc. •Wring of DC cables. •Surge Protection Devices (SPD). •Parallel and Series connections. •Urent sensors. (Hall effect sensor / Resistive Sensor). •Different types of Connectors. •DC Copper Cable. •Different types of Connectors. •Depth of discharge (DOD) of battery. •Max DC voltage. •Number of days of autonomy.** •Higher output AC voltage. •Number of days of autonomy.** •Namer of scharge (DAC) battery. •Number of days of autonomy.** •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Deration losses. •Different type of formage. •Low on load loss: •Accuracy class of CT/PT. •Low on load loss: •Cable sleeve fixing. •Weat Praneters for the Three winding transformers. •Cable route marking. •Quarance against additional gain. •Different type of functioning parameters. •Dow no load loss: •Cable sleeve fixing. •Pyranometer or Pyrheliome	•Max Power point Current.	•Warranty on Structures.
•Performance Ratio. 6.String Combiner Boxes •Size of cable (4 mm & 6 mm). •Specification of Cables, viz. FRLS, UV resistant etc. •Wring of DC cables. •Various Components of a SCB. •Specification of Cables, viz. FRLS, UV resistant etc. •Various Components of a SCB. •Various Components of a SCB. •Surge Protection Devices (SPD). •Fuse Blocks. •Different types of Connectors. •DC Loss Calculation. •DC Capter. 7.Inverters* 8.Batteries The other parameters related to inverters are: •Det hord fischarge (DOD) of battery. •Wark Over point Temperature •Voltage. •Higher output AC voltage. •Det wer consumption in ideal stat at night. •Power consumption in during operation. •Variansformers •Different type of Conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CTPT. •Low operation losses. •Cable route marking. •Wage of Bood at max efficiency. •Cable route marking. •Wage of Thermorpile. •Different type of Interfacing. •Pyranometer or Pyrheliometer. •Different type of Interfacing. •Pyranometer or Pyrheliometer.	•Weight.	•Guarantee against additional gain.
5. DC Cabling and Connectors 6.String Combiner Boxes *Size of cable (4 mm & 6 mm). *Specification of Cables, viz, FRLS, UV resistant etc. •Various Components of a SCB. *Wring of DC cables. •Various Components of a SCB. •Terminal Blocks / Connectors. •Lying of DC cables. •Uartown stress connections. •Uartown stress connections. +Lying of DC cables. •Different types of Connectors. •DC Copper Cable. •Different types of Connectors. •DC Copper Cable. •DC Copper Cable. •Different types of Naxe Power point Temperature •Higher output AC voltage. The parameters of concern regarding the batteries are as follows: •Number of days of autonomy.** •Number of days of autonomy.** •Number of days of autonomy.** •Higher output AC voltag. The parameters for the Three winding transformers are as follows: •Different type of conductors. •Different type of conductors. •Different type of full cables. •Low no load loss: •Accuracy class of CT/PT. •Low no load loss: •Cable sleeve fixing. •Different type of Therdacing. •Data transfer through own network. •Type of Thermopile. •Data at angeter through words with work. •Type of Thermopile. •Dat transformers. •Type of Thermo	•Performance Ratio	
• Size of cable (4 mm & 6 mm). • Various Components of a SCB. • Specification of Cables, viz. FRLS, UV resistant etc. • Various Components of a SCB. • Wiring of DC cables. • Surge Protection Devices (SPD). • Parallel and Series connections. • Uirfuent sensors. (Hall effect sensor / Resistive Sensor). • Lying of DC cables. • DC Coss Calculation. • DT Loss Calculation. • DC Cospec Cable. • Dat cases of Max Power point Temperature • Higher output AC voltage. • Higher output AC voltage. • Namber of days of autonomy.** • Higher output AC voltage. • Number of days of autonomy.** • Different type of conductors. • User of scalbe. • Size of the cable and cable loss. • User of scalbos. • Battery pack/ Battery charger. • Low no load loss: • Cable sleeve fixing. • User of scalbos. • Data transfer through vendor site. • Pyranometer or Pyrheliometer. • Data ransfer through vendor site. • Pyre of Cell. • Data mase of Correng parketers. • Pyre of Cell. • Data mase of Correng. • Pyre of Cell. • Corter of through Puredors ite. • Pyre of Cell. • Paralle and costing • Type of Cell. • Typ	5 DC Cabling and Connectors	6 String Combiner Boxes
 Size of cable (4 mm & 6 mm). Specification of Cables, viz. FRLS, UV resistant etc. Wiring of DC cables. Avoid looping Parallel and Series connections. Lying of DC cables. Different types of Connectors. DC Loss Calculation. The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Highed starting power requirement Power consumption in ideal state at night. Power consumption during operation. Different type of conductors. Size of the cable and cable loss. Size of the cable and cable loss. Size of the cable and cable loss. Statery pack/ Battery charger. Accuracy class of CT/PT. Cable sleeve fixing. Different type of Interfacing. Cable sleeve fixing. ILMonitoring System Different type of Interfacing. Different type of Interfacing. Acauras equisition and transfer through vendor site. Data transfer through vendor site. Data transfer through vendor site. Data ransfer through vendor site. Data transfer through vendor site. Data ransfer through vendor site. Data ransfer through vendor site. Data transfer through vendor site. Data transfer through vendor site. Data ransfer through vendor site. Data ransfer through vendor site. Data ransfer through vendor site. Data transfer through vendor site. Data ransfer through vendor site. Data transfer through vendor site. Data transfer through vendor site. Data ransfer through vendor site. Data transfer through vendor site. Data transfer through vendor site. Data transfer	5. De custing and connectors	olo tring compiler boxes
 Superification of Cables, viz. FRLS, UV resistant etc. Wiring of DC cables. Parallel and Series connections. Lying of DC cables. Piffernt types of Connectors. Differnt types of Connectors. Differnt types of Connectors. DC Loss Calculation. The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Higher output AC voltage.<td>\mathcal{L}</td><td>Verieur Commensate of a SCD</td>	\mathcal{L}	Verieur Commensate of a SCD
 Inferent type of Conductors. Inferent type of Interfacing. Inferent type of Interfacing. Inferent type of Interfacing. Cable sleeve fixing. Inferent type of Interfacing. Interfacing. Interfac	•Size of cable (4 mm & 6 mm).	• various Components of a SCB.
 Avoid looping. Avoid looping. Avoid looping. Parallel and Series connections. Lying of DC cables. Different type of Connectors. Higher output AC voltage. Andraft data an ight. Power consumption in ideal state at night. Power consumption in ideal state at night. Power consumption during operation. JHVAC cable gad Control Panels Different type of Conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery carger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Different type of Interfacing. Data transfer through vendor site. Data transfer through vendor site. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing Control through PG (Pargersmmable logic controller) Control through PG (Pargersmable logic control	•Specification of Cables, VIZ. FRLS, UV resistant etc.	• Terminal blocks / Connectors.
 *Avoid looping *Parallel and Series connections. Lying of DC cables. *Different types of Connectors. *DC Loss Calculation. 7.Inverters* 8.Batteries The other parameters related to inverters are: Suitability of Rated AC power. *Max DC voltage. *Infield starting power requirement *Power Consumption in ideal state at night. *Power Consumption during operation. 9.HVAC cabling and Control Panels. *Battery pack/ Battery charger. *Accuracy class of CT/PT. *Cable sleeve fixing. *Cable conternation and transfer through von network. *Monitoring parameters. *Catried Horawch PI COPparammable logic controllers) *Use Bolocks. *Cortrot Horawch PI COPparammable logic controllers) 	•Wiring of DC cables.	• Surge Protection Devices (SPD).
•Parallel and Series connections. •Current sensors. (Hall effect sensor / Resistrive Sensor). •Lying of DC cables. •DC Switch / Circuit breaker. •DT Loss Calculation. •DC Copper Cable. •DC Loss Calculation. •DC Copper Cable. •DT enterters* 8.Batteries The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Depth of discharge (DOD) of battery •Nams and costing •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** •Number of days of autonomy.** •Number of days of autonomy.** •Number of days of autonomy.** •Different type of conductors. •Number of days of autonomy.** •Number of days of autonomy.** •Number of days of autonomy.** •Different type of conductors. •Number of days of autonomy.** •Number of bays of autonomy.** •Number of days of autonomy.** •Different type of conductors. •Nax Efficiency at low loads. •Size of the cable and cable loss. •Nax Efficiency at low loads. •Cable route marking. •Cable connectivity. •Cable sleeve fixing. •Cable Connectivity. •Cable sleeve fixing. •Pyranometer or Pyrheliometer. <tr< th=""><th>•Avoid looping.</th><th>•Fuse Blocks.</th></tr<>	•Avoid looping.	•Fuse Blocks.
 I-Lying of DC cables. Different types of Connectors. DC Loss Calculation. 7.Inverters* 8.Batteries 7.Inverters* 8.Batteries The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Max DC voltage. •Infield starting power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power consumption in ideal state at night. •Power consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCAD A control panels. •Battery pack/ Battery charger. •Cable sleve fixing. •Cable sleve fixing. •Cable sleve fixing. •Different type of Interfacing. •Data acquisition and transfer through own network. •Monitoring parameters. •String monitoring. •Alarms and Costing •Control through PL CPargrammable logic controllers) •Control through PL CPargrammable logic controllers) •Control through PL CPargrammable logic controllers) •Control through PL CPargrammable logic controllers •Different type of Contoring •Control through PL CPargrammable logic controllers •Control through PL CPargrammable logic controllers 	•Parallel and Series connections.	•Current sensors. (Hall effect sensor / Resistive Sensor).
Different type of Connectors. •DC Copper Cable. •DC Loss Calculation. •DC Copper Cable. •DC Loss Calculation. •DE Copper Cable. 7.Inverters* 8.Batteries The other parameters related to inverters are: The parameters of concern regarding the batteries are as follows: Suitability of Rated AC power. •Depth of discharge (DOD) of battery. •Max DC voltage. •Depth of discharge (DOD) of battery. •Namber of Max. Power point Temperature •Different type of conductors. •Power Consumption in ideal state at night. •Power consumption during operation. 9HVAC cabling and Control Panels 10.Transformers •Different type of conductors. The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Battery pack/ Battery charger. •Low no load loss: •Cable coute marking. •Gable connectivity. •Cable sleeve fixing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Pyranometer or Pyrheliometer. •Data acquisition and transfer through own network. •Type of Thermopile. •Data acquisition and transfer through own network. •Type of Cell. •Monitoring anameters.<	•Lying of DC cables.	•DC Switch / Circuit breaker.
•DC Loss Calculation. 7.Inverters* 8.Batteries 7.Inverters* 8.Batteries The other parameters related to inverters are: Suitability of Rated AC power. 8.Batteries •Max DC voltage. The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Max DC voltage. •Depth of discharge (DOD) of battery •Infield starting power requirement •Voltage and the ampere-hour (Ah) capacity of battery. •Power consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels 10.Transformers •Different type of conductors. The parameters for the Three winding transformers are as follows: •Size of the cable and cable loss. •Max Efficiency at low loads. •Battery pack/ Battery charger. •Low operation losses. •Cable route marking. •Cable Connectivity. •Cable sleeve fixing. •Paraometer or Pyrheliometer. Different type of Interfacing. •Paraometers of Pyrheliometer. •Data ransfer through vendor site. •Pyranometer or Pyrheliometer. •Data caquisition and transfer through own network. •Pyreaof Cell. •Monitoring parameters. •Wind vanes. •Monitoring parameters. •Wind v	•Different types of Connectors.	•DC Copper Cable.
7.Inverters* 8.Batteries The other parameters related to inverters are: The parameters of concern regarding the batteries are as follows: Suitability of Rated AC power. •Max DC voltage. •Max DC voltage. •Depth of discharge (DOD) of battery •Name of Max. Power point Temperature •Voltage and the ampere-hour (Ah) capacity of battery. •Infield starting power requirement •Power consumption during operation. •Power consumption during operation. •Number of days of autonomy.** 9.HVAC cabling and Control Panels 10.Transformers •Different type of conductors. •Max Efficiency at low loads. •Requirement of SCADA control panels. •Usage of good quality cores. •Accuracy class of CT/PT. •Low no load loss: •Cable sleeve fixing. •Weather Station Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Pyranometer or Pyrheliometer. •Data acquisition and transfer through own network. •Wind vanes. •Maring parameters. •Wind vanes. •Atarms and Costing •Wind vanes. •Courted through PL CProgrammable logic controllers •Wind vanes.	~ *	**
The other parameters related to inverters are: The parameters of concern regarding the batteries are as follows: Suitability of Rated AC power. •Max DC voltage. •Max DC voltage. •Depth of discharge (DOD) of battery. •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 10.Transformers PIXAC cabling and Control Panels 10.Transformers •Different type of conductors. The parameters for the Three winding transformers are as follows: •Size of the cable and cable loss. •Max Efficiency at low loads. •Requirement of SCADA control panels. •Uow peration losses. •Accuracy class of CT/PT. •Low no load loss: •Cable sleeve fixing. •% age load at max efficiency. •Cable sleeve fixing. •Wather Station Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Pyranometer or Pyrheliometer. •Data acquisition and transfer through own network. •Type of Thermopile. •Monitoring parameters. •Wind vanes. •Atarms and Costing •Mind vanes. •Atarms and C	•DC Loss Calculation.	
The other parameters related to inverters are: The parameters of concern regarding the batteries are as follows: Suitability of Rated AC power. •Max DC voltage. •Max DC voltage. •Depth of discharge (DOD) of battery •Nax DC voltage. •Note parameters of autonomy.** •Infield starting power point Temperature •Number of days of autonomy.** •Infield starting power requirement •Number of days of autonomy.** •Power consumption in ideal state at night. •Number of days of autonomy.** •Power consumption during operation. DIfferent type of conductors. •Size of the cable and cable loss. The parameters for the Three winding transformers are as follows: •Battery pack/ Battery charger. •Low no load loss: •Accuracy class of CT/PT. •Low no load loss: •Cable sleeve fixing. •W. 11.Monitoring System 12.Weather Station Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Pyranometer or Pyrheliometer. •Data ransfer through vendor site. •Type of Cell. •Marms and Costing •Pyranometer sensors. •Atarms and Costing •Hunidity Sensors	•DC Loss Calculation. 7.Inverters*	8.Batteries
Suitability of Rated AC power. •Depth of discharge (DOD) of battery •Max DC voltage. •Depth of discharge (DOD) of battery •Nax DC voltage. •Nemperature •Higher output AC voltage. •Number of days of autonomy.** •Infield starting power requirement •Power consumption in ideal state at night. •Power consumption during operation. 10.Transformers 9.HVAC cabling and Control Panels 10.Transformers •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Usage of good quality cores. •Battery pack/ Battery charger. •Low operation losses. •Accuracy class of CT/PT. •Low on load loss: •Cable sleeve fixing. •% age load at max efficiency. •Cable sleeve fixing. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 11.Monitoring System 12.Weather Station Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data acquisition and transfer through own network. •Pyre of Thermopile. •Data acquisition and transfer through own network. •Wind vanes. •Atrans and Costing •Wind vanes. •Atarms and Costing •Wi	•DC Loss Calculation. 7.Inverters*	8.Batteries
 •Max DC voltage. •Nax DC voltage. •Nange of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement Power Consumption in ideal state at night. •Power consumption during operation. 9.HYAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CT/PT. •Cable route marking. •Cable sleeve fixing. 11.Monitoring System 12.Weather Station •Different type of Interfacing. •Data transfer through vendor site. •Data acquisition and transfer through own network. •Marms and Costing •Control through PI (CProgrammable logic controller) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are:	8.Batteries The parameters of concern regarding the batteries are as follows:
 •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CT/PT. •Cable route marking. •Cable sleeve fixing. •Different type of Interfacing. •Different type of Interfacing. •Different type of Interfacing. •Data transfer through vendor site. •Data acquisition and transfer through own network. •Monitoring parameters. •String monitoring. •Alarms and Costing 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power.	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery
 Higher output AC voltage. Infield starting power requirement Power Consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. 11.Monitoring System Different type of Interfacing. Alarms and Costing Control through PL (CProgrammable logic controllers) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage.	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery.
 Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels IO.Transformers Pifferent type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable sleeve fixing. II.Monitoring System Different type of Interfacing. Different type of Interfacing. Data transfer through vendor site. Data transfer through vendor site. Adarms and Costing Alarms and Costing Control through EC (Programmable logic controllers) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature	8.Batteries Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.**
•Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CT/PT. •Cable sleeve fixing. •Cable sleeve fixing. •Different type of Interfacing. •Data transfer through vendor site. •Data acquisition and transfer through own network. •Monitoring parameters. •String monitoring. •Alarms and Costing	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature Higher output AC voltage.	8.Batteries Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.**
•Power consumption in total state at mgn. •Power consumption during operation. •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CT/PT. •Cable route marking. •Cable sleeve fixing. •Cable sleeve fixing. •Cable sleeve fixing. •Cable sleeve fixing. •Cable connectivity. •Evacuation Transformer. •Cost per MW 11.Monitoring System Different type of Interfacing. •Data acquisition and transfer through own network. •Monitoring parameters. •String monitoring. •Alarms and Costing •Control through PL C(Programmable logic controllers)	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement	8.Batteries Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.**
P.HVAC cabling and Control Panels 10.Transformers • Different type of conductors. • The parameters for the Three winding transformers are as follows: • Size of the cable and cable loss. • Max Efficiency at low loads. • Requirement of SCADA control panels. • Usage of good quality cores. • Battery pack/ Battery charger. • Low operation losses. • Accuracy class of CT/PT. • Low operation losses. • Cable route marking. • Max Efficiency. • Cable sleeve fixing. • Cable Connectivity. • Cable sleeve fixing. • Cable Connectivity. • Low operation Transformer. • Cost per MW 11.Monitoring System 12.Weather Station Different type of Interfacing. • Pyranometer or Pyrheliometer. • Data acquisition and transfer through own network. • Type of Thermopile. • Data acquisition and transfer through own network. • Type of Cell. • Monitoring parameters. • Wind vanes. • String monitoring. • Wind vanes. • Alarms and Costing • Humidity Sensors	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night	8.Batteries Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.**
•Different type of conductors. •Different type of conductors. •Size of the cable and cable loss. •Max Efficiency at low loads. •Requirement of SCADA control panels. •Usage of good quality cores. •Battery pack/ Battery charger. •Low operation losses. •Accuracy class of CT/PT. •Low no load loss: •Cable route marking. •% age load at max efficiency. •Cable sleeve fixing. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 11.Monitoring System 12.Weather Station Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Type of Cell. •Monitoring parameters. •Type of Cell. •String monitoring. •Wind vanes. •Alarms and Costing •Oir controllers)	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation	8.Batteries Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.**
 •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CT/PT. •Cable route marking. •Cable sleeve fixing. •Cable sleeve fixing. •Cable sleeve fixing. •Cable sleeve fixing. •Cable connectivity. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 11.Monitoring System Different type of Interfacing. •Data transfer through vendor site. •Data acquisition and transfer through own network. •Monitoring parameters. •String monitoring. •Alarms and Costing •Control through PI C(Programmable logic controllers) •Different type of Interfacing. •Control through PI C(Programmable logic controllers) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9 HVAC cabling and Control Parels	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.**
 Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Cable sleeve fixing. Cable sleeve fixing. Cable sleeve fixing. Interfacing. Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Max Efficiency at low loads. Usage of good quality cores. Low no load loss: Cable Connectivity. Evacuation Transformer. Cost per MW 11.Monitoring System 12.Weather Station Pyranometer or Pyrheliometer. Type of Thermopile. Type of Cell. Wind vanes. Wind vanes. Wind vanes. Humidity Sensors 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels Different two of conductors	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows:
 Kequirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Cable connectivity. Evacuation Transformer. Cost per MW 11.Monitoring System Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing Control through PL C(Programmable logic controllers) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. Sing of the apple and opple loss.	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency of the Update
 Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Cable sleeve fixing. Cable sleeve fixing. Cable connectivity. Evacuation Transformer. Cost per MW 11.Monitoring System Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing Control through PI C(Programmable logic controllers) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. Size of the cable and cable loss. Power consumption to the part of SCA Detarchemeter	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Using of near direction
 Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Cable sleeve fixing. Cable sleeve fixing. Cable Connectivity. Evacuation Transformer. Cost per MW 11.Monitoring System Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing Control through PI C(Programmable logic controllers) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Power consumption shore the control panels.	8.Batteries B.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores.
 Cable route marking. Cable sleeve fixing. Cable sleeve fixing. Cable sleeve fixing. Cable Connectivity. Evacuation Transformer. Cost per MW 11.Monitoring System Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing Control through PI C(Programmable logic controllers) Alarms and Costing Control through PI C(Programmable logic controllers) 	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger.	8.Batteries B.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low operation losses.
•Cable sleeve fixing. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 11.Monitoring System 12.Weather Station Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Type of Thermopile. •Data acquisition and transfer through own network. •Type of Cell. •Monitoring parameters. •Wind vanes. •Alarms and Costing •Wind vanes. •Control through PI C(Programmable logic controllers) •Humidity Sensors	DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT.	8.Batteries Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low no load loss:
•Evacuation Transformer. •Cost per MW 11.Monitoring System12.Weather Station Different type of Interfacing. •Data transfer through vendor site. •Data acquisition and transfer through own network. •Monitoring parameters. •String monitoring. •Alarms and Costing •Control through PI C(Programmable logic controllers)•Evacuation Transformer. •Cost per MW•Humidity Sensors•Wind vanes. •Humidity Sensors	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CT/PT. •Cable route marking.	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low no load loss: •% age load at max efficiency.
•Cost per MW 11.Monitoring System 12.Weather Station Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Type of Thermopile. •Data acquisition and transfer through own network. •Type of Cell. •Monitoring parameters. •Wind vanes. •Alarms and Costing •Wind vanes. •Control through PI C(Programmable logic controllers) •Humidity Sensors	•DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. •Max DC voltage. •Range of Max. Power point Temperature •Higher output AC voltage. •Infield starting power requirement •Power Consumption in ideal state at night. •Power consumption during operation. 9.HVAC cabling and Control Panels •Different type of conductors. •Size of the cable and cable loss. •Requirement of SCADA control panels. •Battery pack/ Battery charger. •Accuracy class of CT/PT. •Cable route marking. •Cable sleeve fixing.	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low no load loss: •% age load at max efficiency. •Cable Connectivity.
11.Monitoring System12.Weather StationDifferent type of Interfacing. •Data transfer through vendor site. •Data acquisition and transfer through own network. •Monitoring parameters. •String monitoring. •Alarms and Costing •Control through PI C(Programmable logic controllers)•Pyranometer or Pyrheliometer. •Type of Thermopile. •Type of Cell. •Wind vanes. •Humidity Sensors	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** IO.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer.
Different type of Interfacing. •Pyranometer or Pyrheliometer. •Data transfer through vendor site. •Type of Thermopile. •Data acquisition and transfer through own network. •Type of Cell. •Monitoring parameters. •Wind vanes. •Alarms and Costing •Wind vanes. •Control through PI C(Programmable logic controllers) •Humidity Sensors	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** IO.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low operation losses. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW
 Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing Control through PL C(Programmable logic controllers) Type of Thermopile. Type of Cell. Wind vanes. Humidity Sensors 	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low operation losses. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 12.Weather Station
 Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing Control through PL C(Programmable logic controllers) Type of Cell. Type of Cell. Wind vanes. Humidity Sensors 	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** 10.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low operation losses. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 12.Weather Station •Pyranometer or Pyrheliometer.
•Monitoring parameters. •String monitoring. •Alarms and Costing •Control through PL C(Programmable logic controllers)	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Different type of Interfacing. Data transfer through vendor site. 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** IO.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. Usage of good quality cores. •Low operation losses. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 12.Weather Station •Pyranometer or Pyrheliometer. •Type of Thermopile.
•String monitoring. •Alarms and Costing •Control through PL C(Programmable logic controllers)	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** IO.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. Usage of good quality cores. •Low operation losses. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 12.Weather Station •Pyranometer or Pyrheliometer. •Type of Thermopile. •Type of Cell.
•Alarms and Costing •Control through PL C(Programmable logic controllers)	DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. II.Monitoring System Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** IO.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. Usage of good quality cores. •Low operation losses. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 12.Weather Station •Pyranometer or Pyrheliometer. •Type of Cell. •Temperature sensors.
•Control through PI C(Programmable logic controllers)	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** IO.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 12.Weather Station •Pyranometer or Pyrheliometer. •Type of Cell. •Temperature sensors.
	 DC Loss Calculation. 7.Inverters* The other parameters related to inverters are: Suitability of Rated AC power. Max DC voltage. Range of Max. Power point Temperature Higher output AC voltage. Infield starting power requirement Power Consumption in ideal state at night. Power consumption during operation. 9.HVAC cabling and Control Panels Different type of conductors. Size of the cable and cable loss. Requirement of SCADA control panels. Battery pack/ Battery charger. Accuracy class of CT/PT. Cable route marking. Cable sleeve fixing. Different type of Interfacing. Data transfer through vendor site. Data acquisition and transfer through own network. Monitoring parameters. String monitoring. Alarms and Costing 	8.Batteries The parameters of concern regarding the batteries are as follows: •Depth of discharge (DOD) of battery •Voltage and the ampere-hour (Ah) capacity of battery. •Number of days of autonomy.** IO.Transformers The parameters for the Three winding transformers are as follows: •Max Efficiency at low loads. •Usage of good quality cores. •Low no load loss: •% age load at max efficiency. •Cable Connectivity. •Evacuation Transformer. •Cost per MW 12.Weather Station •Pyranometer or Pyrheliometer. •Type of Cell. •Temperature sensors. •Wind vanes. •Humidity Sensors

* Two types of inverters are generally used named as String Inverters and Central Inverters are used depending upon the scale of the plant. For MW plant the string and central inverters both are used while for small scale plants central inverters are more efficient.

* *The battery capacity for a given load can be determined as Watt Hr Storage= (Daily watt hr consumption X Days of Autonomy)/ (Inverter Efficiency * Depth of discharge) Battery Capacity (in Ah) = Watt Hr Storage / Battery voltage/ Battery efficiency No of Batteries= Total Amp hr / Amp hr per battery.

	Cost Of Solar Pv Project Without Land Cost						
Sr. No	Particulars	Nos	per unit cost	Cost per MW (Rs in lakhs)	Total cost (Rs in lakhs)		
	Cos	t of lan	d & boundary v	vall etc			
1	Cost of land (in Acres)	4	0	0			
2	Convey ancing charges	15%		0			
3	Boundary wall (mt)	600	0	0			
4	Site development	1	0	0			
	Sub Total			0	0		
	·	Plar	t & Machinery	1			
5	Modules	1000	45	45000	45000		
6	Inverters	1	9000	9000	9000		
7	Module mounting structures	0.3	80000	24000	24000		
8	Cables & connectors	1	8000	8000	8000		
9	SJB	12	0	0	0		
10	Lightning arresters	1	4000	4000	4000		
11	Transformer & HT panels	1	0	0	0		
12	Evacuation line	5	0	0	0		
			Civil Construc	tion			
13	Inverter & control Room (Sqft)	1750	0	0			
14	Trenches	1	0	0			
15	Internal roads	1	0	0			
	Sub Total			0	0		
16	SCADA	1	0	0	0		
17	M etering panels	1	0	0	0		
18	Misc approvals etc	1	0	0	0		
				0	90000		
	Cost of Project without land cost				90000		

	Cost	Of Solar Pv	Project With L	and Cost	
					Total cost
Sr.No	Particulars	Nos	per unit cost	Cost per MW (Rs in lakhs)	(Rs in lakhs)
	(Cost of land	& boundary wa	ll etc	
1	Cost of land (in Acres)	4	400000	1600000	
2	Convey ancing charges	15%		240000	
3	Boundary wall (mt)	600	2000	1200000	
4	Site development	1	500000	500000	
	Sub Total			3540000	3540000
		Plant	& Machinery	•	•
5	Modules	10,000,00	38	38000000	38000000
6	Inverters	2	2500000	5000000	5000000
7	Module mounting structures	55	80000	4400000	4400000
8	Cables & connectors	1	2800000	2800000	2800000
9	SJB	12	80000	960000	960000
10	Lightning arresters	10	50000	500000	500000
11	Transformer & HT panels	1	6000000	6000000	6000000
12	Evacuation line	5	1200000	6000000	6000000
	Civil Construction			63660000	
13	Inverter & control Room (Sqft)	1750	1600	2800000	
14	Trenches	1	300000	300000	
15	Internal roads	1	500000	500000	
	Sub Total			3600000	3600000
16	SCADA	1	2000000	2000000	2000000
17	M etering panels	1	200000	200000	200000
18	Misc approvals etc	1	2000000	2000000	2000000
				4200000	
				7500000	75000000
	Cost of Project without land cost				71460000

Basic Calculations Based On Approximated Data

For the calculation of azimuth angle and elevation angle of solar modules following calculations are required [9]. **Calculating Azimuth Angle for solar modules**



Where

 ϕ_s is the solar azimuth angle

 α_s is the solar elevation angle, $\sigma_{s=}90^\circ - \theta_s$.

- *h* is the hour angle, in the local solar time.
- δ is the current declination of the sun.

 φ is the local latitude.

Calculating Angle of Elevation for solar modules



Figure 3 $\sin \alpha_s = \cos h \cos \delta \cos \varphi + \sin \delta \sin \varphi$ Where

 $\alpha_{s \text{ is the solar elevation angle}}, \sigma_{s=}90^{\circ} - \theta_{s}$.

h is the hour angle, in the local solar time.

 δ is the current declination of the sun.

 φ is the local latitude.

Declination Angle

$$\delta = -23.44^{\circ} * \cos\left[\frac{360^{\circ}}{365}(N+10)\right]$$

Calculating Inter Row spacing distance

$$D' = \frac{1}{\tan \alpha}$$

 $D = D' * \cos(180 - \emptyset)$

 $\sin \alpha_s = \cos h \cos \delta \cos \varphi + \sin \delta \sin \varphi$ Where

 α_{s} is the solar elevation angle, $\sigma_{s}=90^{\circ}-\theta_{s}$.

h is the hour angle, in the local solar time.

 δ is the current declination of the sun.

 φ is the local latitude.

Thus the solar modules are installed in rows which causes shadow falling on the modules installed behind. We cannot have shadow free module spacing throughout the period of sun shine. Decide on solar window, which is the time during which you do not want any shadow on the modules caused due to modules installed on the front side.

The "backtracking" feature in a tracking system is to avoid morning and afternoon shading of PV modules by neighbouring tracker rows when several trackers are installed side-by-side. Shading losses are more that the loss due to different angle of incidence of solar rays on the module [9]. Thus the required angle for the tracker is reduced to avoid, any shadow on the module.

Solar window is decided, based on the space available for installation of solar panels.

Normally for solar window, the period during 8am to 4 pm is considered in locations near to equator and the period during 9am to 3pm is considered in locations away from equator on the day of 21st December of the year, if the location is in northern hemisphere. This date is chosen, since on this day, the sun is in the southern hemisphere and is far away from the location in the northern hemisphere. This day will cause longest shadow of any object situated in the northern hemisphere.[10]

Calculation of inter row spacing of different solar windows shown at latitude: 41.21 deg

shown at hardadet 1121 acg				
Solar Window	7AM to 5PM	8AM to 4PM	9AM to 3PM	
Length of the Module (mts.)	1.66	1.66	1.66	
Tilt (angle in degree)	41	41	41	
Tilt angle in Radian Height	0.72	0.72	0.72	
(h)				
Longest shadow assessment				
Solar Inclination(α)	0.7	5	13.8	
Solar Azimuth(ϕ_s)	57.8	52.7	41.7	
Distance(D)	89.13	12.45	4.43	
Distance between array (D)	47.47	7.54	3.31	
Ratio of distance to height	43.57	6.92	3.04	

Comparison	of angles from	solar path	diagram	and formula

Solar Window	7AM to	8AM to	9AM to
	5PM	4PM	5PM
Declination Angle		-23.44	
Hour Angle	45	60	75
Sine of angle of elevation	0.3974	0.228	0.0309
Angle of elevation	23.416	13.176	1.775
Cosine of Azimuth angle	-	-0.5778	-0.4625
	0.70717		
Azimuth angle	135	125.3	117.54
Height of module	0.75	0.75	0.75
Length of long shadow	1.73	3.2	24.2
Distance between rows	1.22	1.85	11.18
Elevation based on sun path	23.6	13.4	1.9
chart			
Azimuth based on sun path	134.8	125.6	117.5
chart			

In case of modules being installed in the southern hemisphere, 21nd June is normally taken, since the longest shadow will be caused on this day.

Once the solar window is decided, one can find out the azimuth angle as well as elevation of sun on that day and time. All the calculations presented above, assumes that the site is located in the northern hemisphere. The same calculations can be done for locations in southern hemisphere, by taking the same data for 21st June.

Degradation of Solar Cells

Light Induced Degradation

C-Si solar cells fabricated on Czochralski (CZ) wafers exhibit light-induced degradation (LID) of the cell performance. This effect is generally ascribed to boron-oxygen (B-O) defects in the wafer and is accompanied by a reduction in the minority-carrier lifetime in the bulk of the wafer [11]. There is an initial rapid decay of all cell parameters (within a few minutes), followed by a slower degradation. In general, all cell parameters experience a reduction. Under 1-sun at 25°C, it takes about 72 hours for complete light-induced degradation.

Potentially Induced Degradation

The cause of PID is mainly due to high voltage stress, high humidity as well as high temperature. The degradation depends on the polarity and the extent of potential between cell and ground which is determined by the actual configuration of the PV system. Lower quality silicon or comparably high concentration of crystal defects seems to increase the tendency of PID [12]. There are different parameters having a large impact on PID but the Anti Reflection Coating deposition was seen to have a crucial role in not only influencing but actually preventing PID on cell level. It also shows that by using suitable combination of Refractive Index and thickness of ARC, PID can be completely prevented on cell level. Negative earthing can also reduce the voltage stress, thereby reducing the PID effect.

Transparent Oxide Coating (TCO) Corrosion

Even after a small period of operation, it is being observed that degradation occurs in the TCO layer in certain thin film modules[13]. The study showed that a-Si and CdTe thin film solar cells are mostly affected.TCO corrosion occurs on the edge of the PV module as a result of the reaction of moisture with sodium that is contained in the glass cover. As a result, the TCO becomes milky and the conductivity reduces and subsequently efficiency[14]. This is prevented by negative grounding the PV array using grounding kit, which the positively charged sodium ions are repelled from TCO. This prevents corrosion. Penetration of moisture is prevented through improved sealing of the module edge.

Maintenance of Solar System

Maintaining the solar system require the following check [16]

•Crimping of Cables on DC side of converters.

•Check for any shading due to any object or dust on the modules by visual inspection.

•Checking the module for hotspots with infrared camera.

•Laying of Cables: Check visually and by Meggar for any faults before setting in position for use.

•Faults in Jointing Kits.

•Faults in modules of SCADA.

•Checking of string voltage and string current regularly. •Current checking with respect to current irradiance level.

•Checking input DC power and output AC power of Inverter.

•Changing of Silica Gel in the breather of Transformer.

•Cleaning of Inverters & Fan filters.

•Fixing of RF ID tag.

•Check for inverter data using inverter software.

•Check for battery charger & battery bank condition.

•Working out maintenance schedule and follow the same & keep all records.

Conclusion

This paper briefly addresses the technical and economic aspects of setting up a photo voltaic solar plant at commercial and rooftop levels. Northern hemisphere is chosen for the approximate calculation at latitude of 41.21 degrees. This study can help to reduce the everyday struggle for electricity at peak load durations and can also meet the storage capacity of national grids. The stored electricity can be consumed in case of blackout in summer and during other difficult situations. The degradation and maintenance of PV modules are very important aspects discussed above plays very important role in the overall efficiency of the solar system.

Acknowledgment

I would like to extend my sincere gratitude to Mr. Panangadan Bhasker, Kanoria Chemicals Pvt. Ltd., for providing a platform and encouraging me to structure this paper. It was his guidance and support, which results in successful completion of this study.

References

[1] A. Hunt and P. Watkiss, "Climate change impacts and adaptation in cities: a review of the literature, Climate Change 2011, 104(1), pp. 13–49.

[2] J. D. Kim, D. H. Han, and J. G. Na, "The Solar City Daegu 2050 project: visions for a sustainable city," Bulletin Science Technology Society, vol. 26, no. 2, pp. 96-104.

[3] Simon Joss, "Eco-cities and Sustainable Urbanism" International encyclopedia of the social and behavioral sciences (Second Edition), 2015, pp. 829-837.

[4] S. Joss, D. Tomozeiu, R. Cowley, "Eco cities: a global survey. London, UK: University of Westminster, 2011.

[5] P. Droege, "The renewable city: A comprehensive guide to an urban revolution," West Sussex, UK, John Wiley and Sons Ltd, 2007.

[6] C. Chu, A. Bruner and J. Byrne, "DESEU Energy Efficiency Revenue Bonds Series 2011: Project Savings Analysis," Center for Energy and Env. Policy, 2015.

[7]H. Kabir, W. Endlicher, J. Jagermeyr, "Calculation of bright roof-tops for solar PV applications in Dhaka Megacity, Bangladesh," Renew. Energy, vol. 35,Iss. 8, pp. 1760- 64, 2010.
[8] S. Marcel, H. Thomas and D. Ewan, "Potential of solar electricity generation in the European Union member states and candidate countries," Sol. Energy, vol. 81, no.10, pp. 1295-1305, 2007.

[9] C. Honsberg and S. Bowden "Concepts of PV systems internet: http://www.pveducation.org/, 2013.

[10] J. Hofierka and J. Kanuk, "Assessment of photovoltaic potential in urban areas using open-source solar radiation tools: Renew Energy, Elsevier Science, vol. 34, no. 10, pp. 2206-14, 2009.

[11] N. Hadjsaid, J. F. Canard and F. Dumas, "Dispersed generation impact on distribution networks," IEEE Computer Applications in Power, vol. 12, no. 2, pp. 22–28, 1999.

[12] H. L.Willis and W. G. Scott, Distributed Power Generation Planning and Evaluation. New York: Marcel Dekker, 2000.

[13] C. D. Feinstein, R. Orans and S.W. Chapel, "The distributed utility: A new electric utility planning and pricing paradigm," Annual Review Energy Environment, 1997.

[14] N. Ramchander, Tulasi Ram Das and T. S. Surendra, "Long term evaluation of silicon PV technologies," International proceedings on Low Carbon Earth Summit (LCES 2011), Dalian, China, 2011.

[15] M. Tayyib, J. O. Odden, Y. H. Rao and Surendra, "Initial light-induced degradation study of multi-crystalline modules made from silicon material processed through different manufacturing routes" IEEE 38th Photovoltaic Specialists Conference (PVSC), 2012, pp. 2395-2399, Austin, Texas, 2012.

[16] D. watts, M.F. Valdes, D. Jara and A. Watson, "Potential residential PV development in Chile: The effect of Net Metering and Net Billing schemes for grid-connected PV system," vol. 41, 2015, pp.1037-1051.