Solar PV Internship Report On

Electrical Loss Analysis In Grid Connected Area

Project in Noida, Uttarpradesh

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Executive Summary

Global energy consumption has been increasing rapidly since industrial applications and technology have become developed. In order to meet the environmental requirements challenge in the 21st century, renewable energy sources must play a great role and no doubt Solar energy is the most demanding and secure renewable energy source of all the relevant renewable energy sources. It has a huge impact on reducing the use of conventional fuel and Photovoltaic (PV) plate is the representative of solar energy availability based on requirements.

Theoretically, a small fraction of the total solar energy can meet the entire country's power requirement. The vision to use Solar photovoltaic(PV) as a decentralised and sustainable source of energy in place of conventional energy from household requirements to industry requirements is shared by thousands of designers, architects and manufacturers world-wide. In principle PV can be integrated directly in products, such as devices, vehicles and buildings. India is most aggressively moving forward to achieving Universal household electrification by March 2019(Ministry of Power, 2017). Solar power has a key to play in this transition. Market trends suggest that this will involve a combination of Grid connected and decentralised energy systems, including standalone solar lightning products and home systems (SHSs). India is the third largest grid scale Solar Photovoltaic market in 2017.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 4-7 kWh per sq. m per day. Solar photovoltaic power can effectively be harnessed providing huge scalability in India.

Solar Photovoltaic power can effectively be used to provide huge scalability in India. Solar also provides the ability to generate power on a distributed basis. Off-grid power decentralised and low temperature application installation will be advantageous in rural areas and requirement of energy for lighting, power and heating and cooling in both rural and urban areas.

Most renewable energy capacity is installed in most developing countries and largely in China, the single largest developing country of renewable power and heat Over the last eight years. In 2016, renewable energy spread over the nation for developing and growing economics and some of those became important markets.

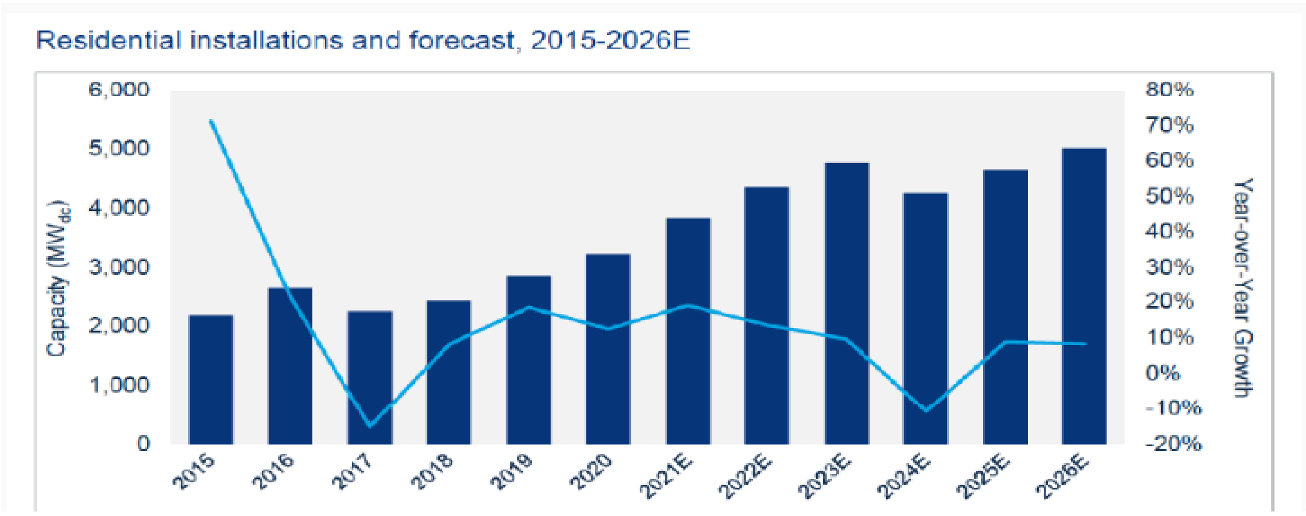


Fig. How day by day use of solar energy is increasing

More than 1 billion people are living without access to electricity. Renewable energy is mostly distributed for them, especially those in rural areas far from the centralized grid, and cost effectively.

The development of solar energy using PV panels requires more staff at the same time, which is the nation's benefit. The renewable energy sector employed 9.8 million people in 2016, an increase of 1.1% over 2015. By technology, solar PV and biofuels provided the largest numbers of jobs. Employment shifted further towards Asia, which accounted for 62% of all renewable energy jobs (not including large-scale hydropower), led by China.

There has been a visible impact of use solar energy in India. National Institute of Solar Energy has assessed the Country’s solar potential of about 748 GW assuming 3% of the waste land area to be covered by Solar PV modules. Solar energy has taken a central place in India's National Action Plan on Climate Change with National Solar Mission as one of the key Missions. National Solar Mission (NSM) was launched on 11th January, 2010. NSM is a major initiative of the Government of India with active participation from States to address India’s energy security challenges. It will also contribute towards the constitution of global efforts to meet the challenges of climate change. The mission's objective is to establish India as a global leader of solar energy as soon as possible. The Mission targets installing 100 GW grid-connected solar power plants by the year 2022. This is in line with India’s Intended Nationally Determined Contributions(INDCs) target to achieve about 40% cumulative electric power installed capacity from non-fossil fuel based energy resources and to reduce the emission intensity of its GDP by 33 to 35% from 2005 level by 2030.

To achieve the above target, the Indian government has started various schemes to make progress like Solar park, VGF Schemes, CPSU Scheme, Defence Scheme, Canal bank & Canal top Scheme, Bundling Scheme, Grid Connected Solar Rooftop Scheme etc.

Recently, India achieved 5th global position in solar power deployment by surpassing Italy. Solar power capacity has increased by more than 11 times in the last five years from 2.6 GW in March,2014 to 30 GW in July, 2019. Presently, solar tariff in India is very competitive and has achieved grid parity.

Why Solar?

A. World energy and environmental issue

World economic growth in the 20th century was strongly increased by technologies based on mass-consumption of fossil fuel. But on the other hand, drastic demand for electricity has led to global environmental issues including climate change. Although energy consumption and increasing Carbon emission is the main point. The mission of a low Carbon emissions society has been started internationally and these actions can be taken using sustainable sources of energy. According to World Energy Outlook by the International Energy Agency (IEA) energy consumption and Co2 emissions are increasing drastically in

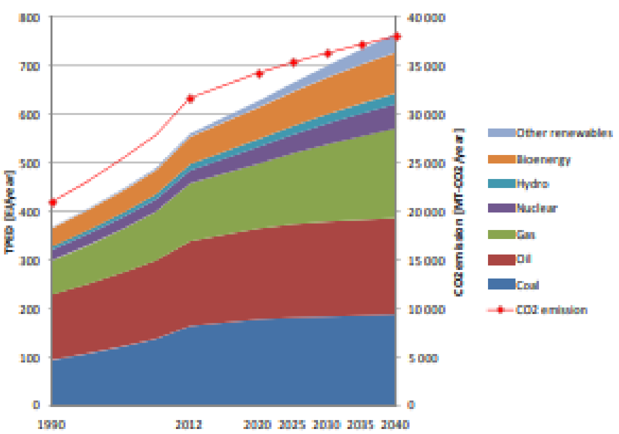


Fig. 1. Primary energy demand and CO_2 emission In the world (New Policies Scenario).

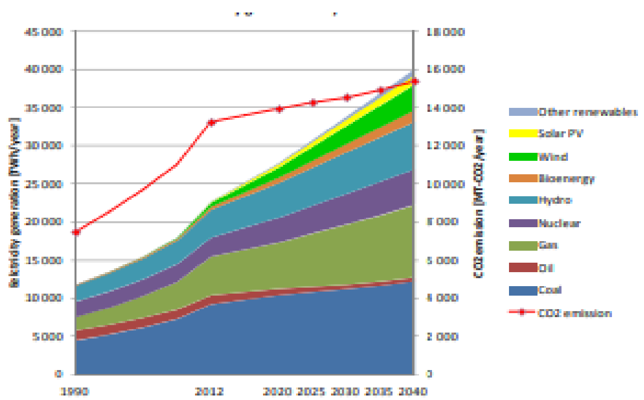


Fig. 2. Electricity generation and CO_2 emission by electricity generation (New Policies Scenario).

In fig.1 to 4.

According to that as mentioned before, increasing the energy consumption will increase the Co2 emissions in such areas.

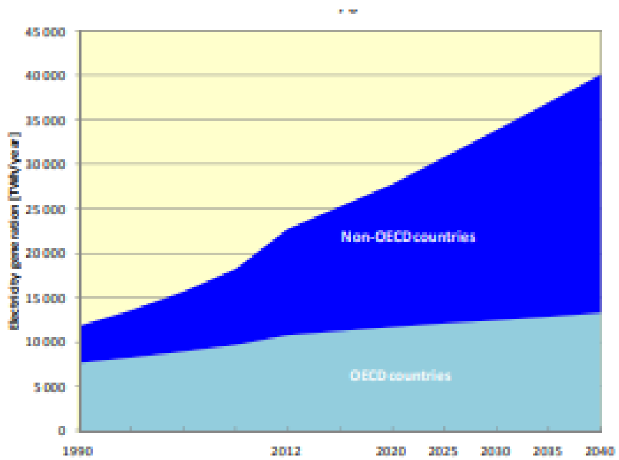


Fig.3. Electricity generation in OECD and Non-OECD Countries (New Policies Scenario).

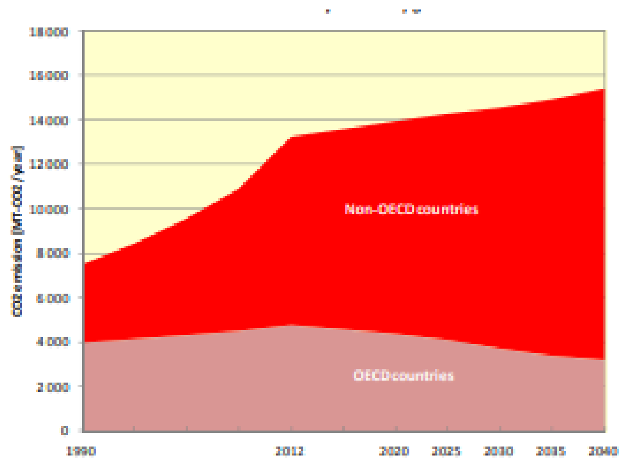


Fig.4. CO_2 Emission by electricity generation in OECD and Non-OECD countries (New Policies Scenario).

B. PV power in Dessert – As PV is the most essential energy producing so it has a huge impact in nations. To produce large power by using solar energy it is beneficial to have vast land with huge solar irradiation falling land. The dessert is the place where can this may possible greatly.

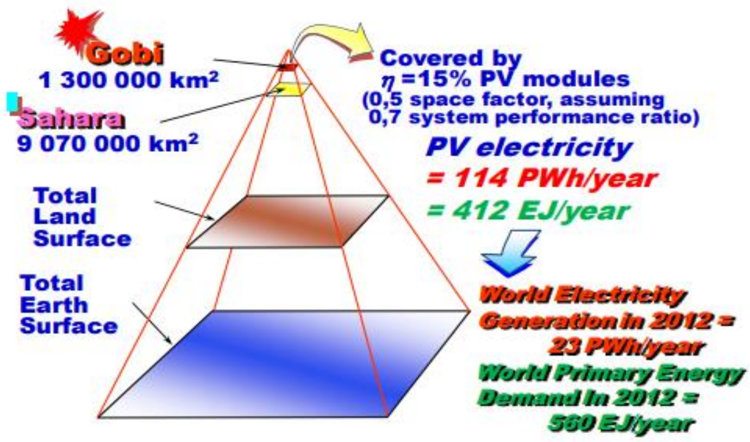


Fig.5. Solar Pyramid

Contents

Topic	Page No.
1. Introduction	1
1.a. Solar PV System	1
1.b. Machines Used in the project	1
2. Solar Power Process Flow	3
Generating Process	3
3. Solar PV Sizing	5
3.1. Sizing Of the Solar Array	5
3.2. Sizing of the Battery Bank	6
3.3. Sizing of the Voltage Controller	6
3.4. Sizing of the Inverter	7
3.5. Sizing of the System Wiring	7
4. Losses In Solar Power Plant	7
4.1. Solar Panels	8
4.2. Battery	8
4.3. Inverter	8
4.4. Wires	9
4.5. Environmental Losses	9
4.6. Module Mismatch Loss	10
4.7. Direct Current Cable Loss	10
4.8. Module Quality Loss	11
4.9. Transmission Loss	11
4.10. Soiling Loss	11
4.11. Irradiance Loss	11
4.12. Array Incidence Loss	12
4.13. Array Loss	12
4.14. Age of the System	12
5. PVsyst Simulation Report	
Project and results summary	14
General Parameter, PV array characteristics, system losses	15
Near shading definition – Iso-shadings diagram	17
Main results	18
Loss Diagram	19
Special graphs	20
Conclusion	21
References	22

1. Introduction

1.a. Solar PV System

Solar PV system is a most promising renewable energy source and energy is provided by the sunlight where photovoltaic is the representative technology for utilising solar energy. Sun ray offers an ideal energy source, unlimited in supply, inexpensive which does not produce air and water pollution. The amount of sunlight reaching the earth's surface is more than the plant's energy requirements in one year, so that this excess amount of sun rays is easy to use just by converting it into usable form. The amount of solar energy we can use varies according to the time of day and the season of the year.

Solar Energy is increasingly popular day by day as it is converted and used as an alternative source of fossil fuels. Many technologies have been applied to produce solar electricity directly from this source for use in homes and businesses globally.

Solar PV System can be of two types On-grid or Grid connected and Off-grid or Standalone system. In On-grid connected PV, system doesn't require any battery to store the solar energy which is expensive. This system send excess power to the utility grid when you are overproducing and so that system allows you to save more savings because it offers net metering, requires a low cost of equipment and installation. Off-grid system allows you to store the solar power in battery and use this power when power grid goes down. Main disadvantage of off-grid is that it takes 3-4times more cost than the grid connected system with suitable battery.

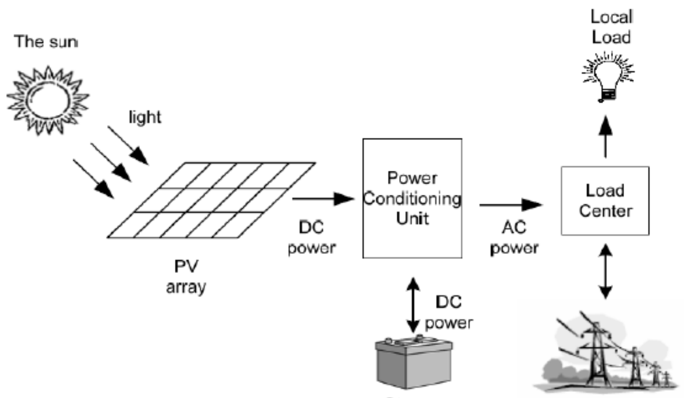


Fig.6. Solar power flow with grid connected system

1.b. Machines used in the project -

Fig.7. Solar PV Module

1.b.1. Photovoltaic Cells and Solar Panel - Solar panel is a semiconductor material made up of Silicon. PV is used for conversion of solar energy into electrical energy. In daytime when sunlight strikes the PV plate a certain amount of light gets absorbed by the PV plate which is the cause of electricity to flow.

Fig.8. Solar Battery

1.b.2. Battery - Battery is used for storing energy when solar radiation is not available in cloudy days, night time, high energy demand and also for sending to grids. Battery converts chemical energy into electrical energy. It's used for household, robotics, industrial applications etc.

Fig.9. Inverter

1.b.3. Inverters – Inverter is one of the most important equipment for whole process as it is convert the DC current into AC current which is then fed into the grid for use.

Fig.10. Energy Meter

1.b.4. Energy meter – The Solar power system are connected to the utility grid via customer's main service and meter. When system overproducing the Solar power than is needed at the site, sends back the excess Power to the grid through the meter. And reversing the meter from it's usual direction.

1.b.5. Solar Charge Controller – Solar Charge controller regulates the voltage and/or ampere of the load that is delivered and maintain the battery from any excess delivery power to it so that it couldn't get overcharged in day time when sun radiation directly falling into the PV panel.

Fig.11. Solar Charge Controller

2. Solar Power Process Flow

In a Solar photovoltaic (PV) power plant Solar PV is used to convert solar energy into electrical energy. Solar PV panels contain a semiconductor material which directly transforms sunlight into electrical energy which is then fed into the grid for domestic and industrial use.

When Sun rays fall into the PV plane which is a semiconductor material, photons (particles of solar energy) strike the surface of the PV cells. Two plates of semiconductor, one negatively charged & one positively charged. This semiconductor exhibit a property known as the photoelectric effect, which causes them to absorb the photons and release negatively charged particles, namely electrons from the PV plate that form the basis of electricity. These electrons are loosening from the electric field across the junction between two plates causing electricity to flow. Thus, generating direct current (DC). In physics, this effect is known as the photo-effect. Not all the photons striking the surface of the solar PV will not absorbed by it to hit the electrons but some amount of photons is going back to the sun.

Thus the generated Direct current (DC) can be converted into an alternating current (AC) through a special tool called inverter.

Solar PV electric plants don't require bright sunlight in order to operate, which means it can be operated on cloudy days too to generate electricity. But the amount of flow of electricity will be lesser than the days with bright sunlight, the greater the intensity of sunlight the bigger the flow of electricity.

Generating process

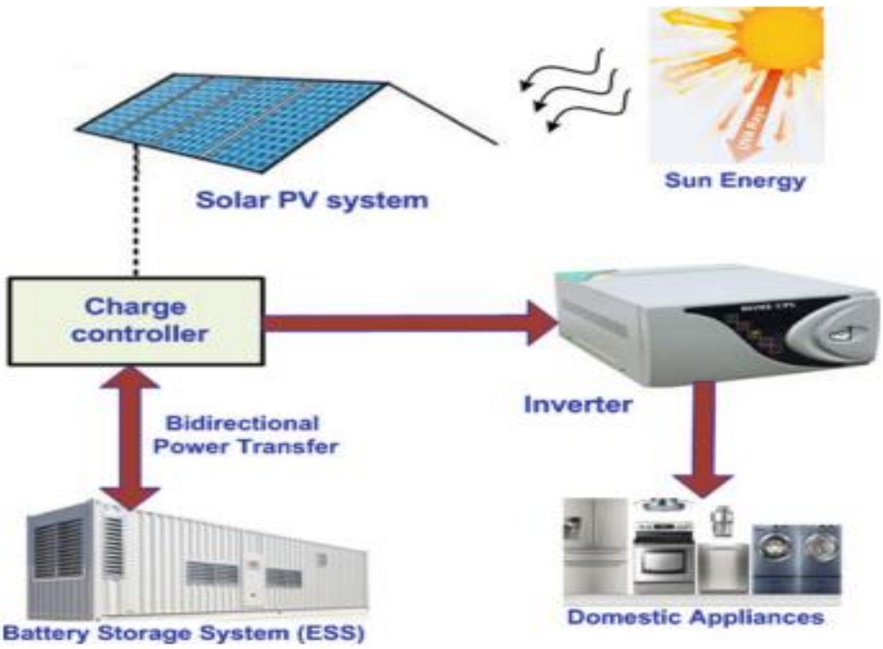


Fig.12. Schematic diagram of Solar PV with standalone system

A typical schematic diagram of solar PV power plant showing the arrangement of how the solar radiation directly converting in AC electricity. Photovoltaic planes are representative of this system which is comprised of individual cells known as Solar cell. Each solar cell generates a large amount of electricity. When connect many solar cells together they generate high amount electricity. Within each solar cell a thin semiconductor material made from two dissimilar charged layers of Silicon, forming an electric field. When Sunray strikes the solar panels it energize the cell and causes electrons to loose from atoms within semiconductor wafer. Those loose electrons are set into motion by the electric field surrounding the wafer, and this motion creates an electric current.

Now solar panels working efficiently to transform sunlight into electricity. The energy generated through thus process is DC. To convert it into AC electrical a gadget Inverter is required, which powers the most homes.

Once the energy is converted from DC to AC electricity, it runs through electrical panels and powers all the home appliances. It is exactly same electric power what you receive from your utility grid company distributed by the utility grid.

In standalone system will often utilise a battery or series of batteries to store collected energy delivered by a charge controller, Inverter or both – then making the resulting energy ready for withdrawal on demand when system operators requires it.

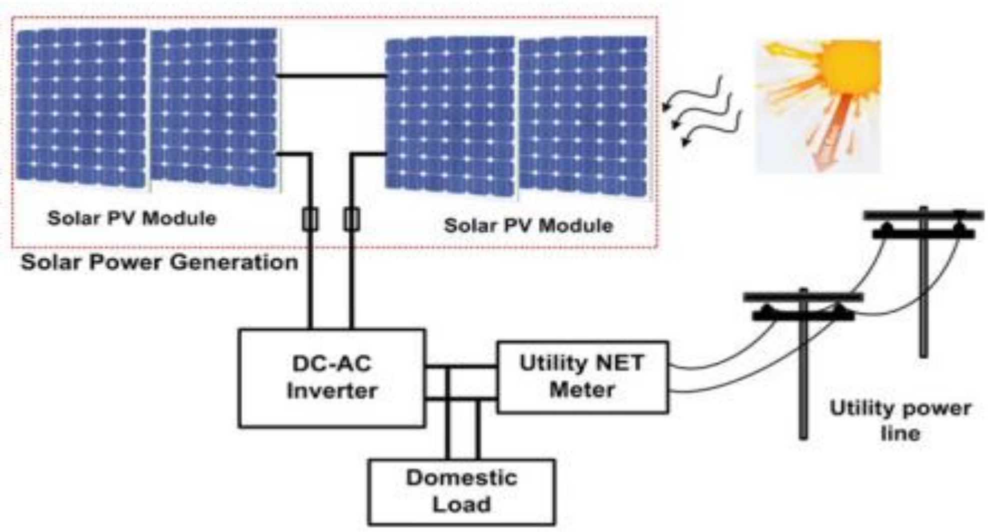


Fig.13. Schematic diagram of On-Grid connected system

But in Grid connected system On cloudy days, overnight, when energy production is excess by your solar panels or when there is No-one in your home, A bidirectional interface is made between the PV system AC output terminals and the grid utility network through a meter. This enables PV system to supply power to the local loads or feed to the supply, when PV power is greater than load demand power and your surplus energy they may collect. That's why a meter is required to measure which can be rotate in both directions - to and from your home. In that case your utility grid company will give you credit for the delivered surplus energy from your home. This is called Net metering.

3. Solar PV Sizing

System sizing

System sizing is the process of evaluating the adequate voltage and current ratings for each component of the photovoltaic system to meet the electric demand at the facility and at the same time calculating the total price of the entire system from the design phase to the fully functional system including, shipment, and labour.

3.1. Sizing of the Solar Array

Before sizing the array, the total daily energy in Watt-hours (E), the average sun hour per day T_{min}, and the DC-voltage of the system (VDC) must be determined. Once these factors are made available we move to the sizing process. To avoid under sizing, losses must be considered by dividing the total power demand in Wh.day-1 by the product of efficiencies of all components in the system to get the required energy E_r.

To avoid under sizing we begin by dividing the total average energy demand per day by the efficiencies of the system components to obtain the daily energy requirement from the solar array:

$$E_r = \frac{Daily\ average\ enegy\ consumption}{Product\ of\ component's\ efficiency} \quad (1) \quad = \frac{E}{\eta_{Overall}}$$

To obtain the peak power, the previous result is divided by the average sun hours per day for the geographical location T_{min} .

$$P_P = \frac{Daily\ energy\ requirement}{Minimum\ peak\ sum - hours\ per\ day} \quad (2)$$

$$= \frac{E_r}{T_{min}}$$

The total current needed can be calculated by dividing the peak power by the DC- voltage of the system.

$$I_{DC} = \frac{Peak\ power}{System\ DC\ voltage} = \frac{P_p}{V_{DC}} \quad (3)$$

Modules must be connected in series and parallel according to the need to meet the desired voltage and current. First, the number of parallel modules which equals the whole modules current divided by the rated current of one module I_r.

$$N_p = \frac{Whole\ module\ current}{Rated\ current\ of\ one\ module} = \frac{I_{DC}}{I_r} \quad (4)$$

Second, the number of series modules which equals the DC voltage of the system divided by the rated voltage of each module V_r .

$$N_S = \frac{System\ DC\ voltage}{Module\ rated\ voltage} = \frac{V_{DC}}{V_r} \quad (5)$$

Finally, the total number of modules Nm equals the series modules multiplied by the parallel ones:

$$N_m = N_s * N_p \quad (6)$$

3.2. Sizing of the Battery Bank

The amount of rough energy storage required is equal to the multiplication of the total power demand and the number of autonomy days $E_{rough} = E \times D$.

For safety, the result obtained is divided by the maximum allowable level of discharge (MDOD):

$$E_{Safe} = \frac{Energy\ storage\ required}{Maximum\ depth\ of\ discharge} = \frac{E_{rough}}{MDOD} \quad (7)$$

At this moment, we need to make a decision regarding the rated voltage of each battery V_b to be used in the battery bank. The capacity of the battery bank needed in ampere-hours can be evaluated by dividing the safe energy storage required by the DC voltage of one of the batteries selected:

$$C = \frac{E_{Safe}}{V_b} \quad (8)$$

According to the number obtained for the capacity of the battery bank, another decision has to be made regarding the capacity C_b of each of the batteries of that bank. The battery bank is composed of batteries The total number of batteries is obtained by dividing the capacity C of the battery bank in ampere-hours by the capacity of one of the battery C_b selected in ampere-hours:

$$N_{batteries} = \frac{C}{C_b} \quad (9)$$

The connection of the battery bank can be then easily figured out. The number of batteries in series equals the DC voltage of the system divided by the voltage rating of one of the batteries selected:

$$N_s = \frac{V_{DC}}{V_b} \quad (10)$$

Then number of parallel paths N_p is obtained by dividing the total number of batteries by the number of batteries connected in series:

$$N_p = \frac{N_{batteries}}{N_s} \quad (11)$$

Once the sizing of the battery bank is made available, we proceed to the next system component.

3.3. Sizing of the Voltage Controller

According to its function it controls the flow of current. A good voltage regulator must be able to withstand the maximum current produced by the array as well as the maximum load current. Sizing of the voltage regulator can be obtained by multiplying the short circuit current of the modules connected in parallel by a safety factor F_{Safe} . The result gives the rated current of the voltage regulator I.

$$I = I_{SC} * N_P * F_{Safe} \quad (12)$$

The factor of safety is employed to make sure that the regulator handles maximum current produced by the array that could exceed the tabulated value. And to handle a load current more than that planned due to addition of equipment, for instance. In other words, this safety factor allows the system to expand slightly. The number of controller equals the Array short current Amps divided by the Amps for each controller:

$$N_{Controller} = \frac{I}{Amps\ each\ controller} \quad (13)$$

3.4. Sizing of the Inverter

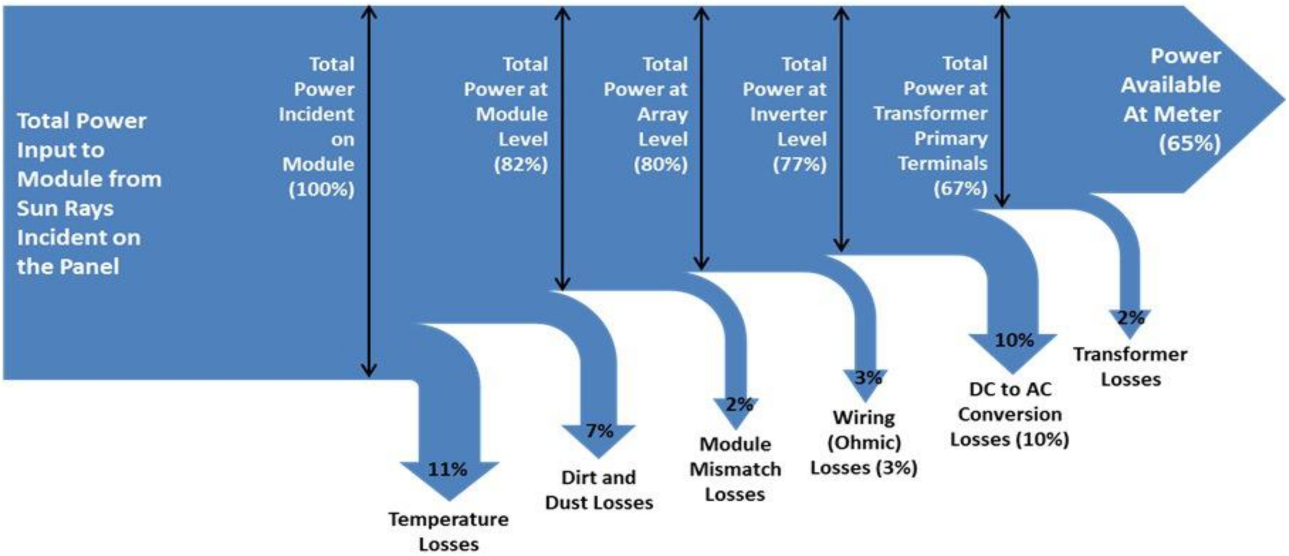
When sizing the inverter, the actual power drawn from the appliances that will run at the same time must be determined as a first step.

3.5. Sizing of the System Wiring

Selecting the correct size and type of wire will enhance the performance and reliability of a photovoltaic system. The National Electrical Code is NEC.

4. Losses in Solar Power Plant

As no system is fully efficient. That is, it can convert a certain amount of input energy into output energy of usable form and the remaining energy is lost from the system, that is exactly the losses of the system. There are various types of reasons for which losses occur. The power loss can vary between 10% to 70% depending on different reasons which effect the PV system performance. About 25% of the produced energy by the PV system is lost due to some system losses as shown in the above figure.



4.1. Solar Panels (Conversion loss)

The basic function of a Solar panel is to convert Solar energy into DC electrical energy. Not all the sunlight falling into the PV panels is absorbed by the electrons but some amount of energy is reflected back to the sun or dissipated by the earth.

In noon times or when sunlight directly falls into the PV panels of 1m^2 receives around 1000 watts of solar power. But only 18% of solar energy is absorbed by the electrons and the remaining 82% is either reflected back or dissipated on earth. This 82% is defined as conversion loss of solar energy and 18% means 180 watts (efficiency of solar panels) of 1000 watts converted into usable form.

4.2. Battery (Conversion loss)

When the converted energy from sunlight is not used for running the appliances, Solar battery is used to store the energy in the form of chemical energy. Later on this stored energy can be used to run appliances on cloudy or rainy days.

Basically this battery converts the chemical energy into DC electrical energy. If the efficiency of the battery is 85% then it will convert 85% of energy and the remaining 15% will be the conversion loss.

4.3. Inverter (Conversion loss)

After conversion the DC electrical energy is passing through an Inverter.

Basic function of an inverter is to transform the DC electrical energy into AC electrical energy. If efficiency of the inverter is 95% then 95% will be converted into output. Means it will convert those 180 watts of DC electrical energy into 95% of 180 or 171 watts of AC electrical energy. Remaining 9 watts are lost as conversion loss into the system.

4.4. Wires (Transfer loss)

The output energy we get from the system is used to run the appliances, needs a medium to travel from one place to another and that medium is called Wire. Commonly, copper wires are used in solar power stations.
Loss depends on the heating rate of the wire. If distance from generating station to receiving end is more then more wire will require results heating loss will be more. If wire losses are 1% then 1% of 180 will be lost.

4.5. Environmental loss

4.5.1. Shading - One of the most important factors affecting the performance of the PV panels is shading. Factors that may cause shading are neighbouring buildings, shrubs and energy transmission towers etc. Generally, buildings are built very close together especially in the city centres and this cause shading on PV modules especially installed on the rooftops. Sometimes due to the wrong designing of PV system array, self-shadowing is also possible. Because of the fact that these cases will reduce the performance of the panel, it should be given the right decisions in the design phase. The location where the PV system is installed must be selected carefully. Another factor that can widely cause the losses is trees especially in rooftop applications as depicted in. So, the surrounding trees should be well analysed when the PV system is designed. If a PV system is planned to install close to the trees, leaf-shedding trees should be preferred. Therefore, it can be facilitated from the incoming solar radiation onto the panel at lower angles especially in the winter seasons.

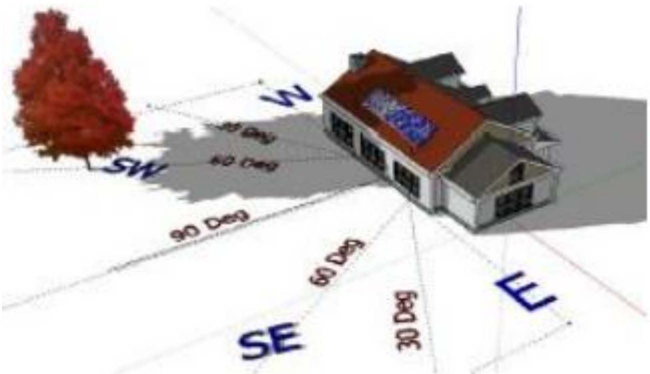


Fig.14. . A solar panel exposed to shading

4.5.2. Dust Losses - These losses are caused by pollution of PV module surface due to any reason or decreasing the incoming solar radiation due to snow accumulation on the module surface. The research results made for losses caused by dusting show that, especially in areas where there is little rainfall, these losses reach 15% in extraordinary cases. Figure 3 shows a solar panel which is contaminated due to dust [8]. To improve system efficiency, the module needs to be cleaned regularly. But in the big solar power plant, especially in areas with water shortage, this process is very costly.

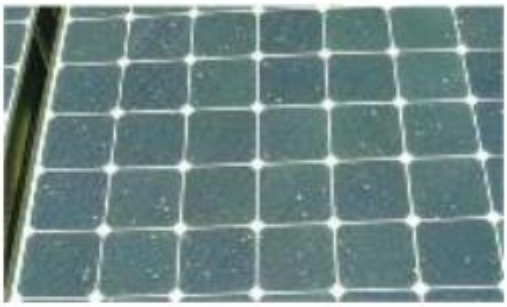


Fig. 15. Dirt accumulated on solar panel

4.5.3. Reflection Losses

While the PV module absorbs some of the solar radiation, a certain amount of solar radiation is reflected back from the module surface. This is called the reflection losses due to the back-reflected radiation. To reduce reflection, the module surfaces are coated with an anti-reflecting film.

4.5.4. Thermal Losses

Solar panels are tested under standard test conditions corresponding 25 °C, 1000 W/m2 solar radiation and AM 1.5 (air mass). The efficiency of the panel is calculated according to the standard test conditions. Producing electricity starts with receiving solar radiation on the PV module surface. While some of the incident solar radiation is transformed into electrical energy, a portion of solar radiation is converted into heat energy. PV performance is decreasing with increasing temperatures that occur in the panel. PV panels can't convert the entire solar energy into electrical energy. The conversion rate of PV panels is about in the range of 5- 25%. Therefore, more energy that the solar modules can't convert it to the electrical energy causes heating of the modules and so thermal losses.

4.6. Module Mismatch Loss

The "Mismatch loss" is mainly due to the fact that in a string of modules (or cells), the lowest current drives the current of the whole string.

Now when installing real modules in the field, the characteristics of each module are never rigorously identical. The parameters (I_{sc} ,V_{CO} , P_{mpp}) usually present statistical distributions, which may be rather Gaussian, or with a square shape for P_{mpp}, if they result from a sorting at the output of the manufacturing process.

4.7. Direct Current Cable Losses

Normally the cable losses for a well-designed installation should be less than 2% and this proportion shouldn't rise over time. The cause of some of the losses occurring in the cables is corrosion and overheating. In a PV system installation, solar cables are used to connect PV modules and inverters. The cable power losses can be expressed as follows depending on time. Here is r_{DC} resistance of the cable, V_{DC} voltage between cable ends, P_{loss} is DC power loss.

$$P_{loss}(t) = 2.I_{DC\_Cable}^{2} r_{DC} \quad (1)$$

$$P_{loss}(t) = 2.\left(\frac{P_{DC\_Cable}(t)}{V_{DC}}\right)^{2} r_{DC} \quad (2)$$

Energy losses due to resistive loads are proportional to the increase of wiring resistance. Electricity generation in PV systems needs to minimize system losses because it is expensive. A significant portion of the system losses occurs in the electrical parts. These losses occur largely in cables and inverters. PV system characteristics are obtained under the standard test conditions (STC). But PV system output is always variable and rarely works in the STC. Therefore, solar cables carry the different amount of electrical current. So, the calculated cross sections of solar cables under STC may be unsuitable. The cable voltage drop occurring due to the cross-section leads to energy loss and also reduces the efficiency. Because of aforementioned reasons, the crosssection of the cable must be calculated carefully to minimize losses that may occur in PV systems.

4.8. The Module quality loss

The Module quality loss is a parameter that should express your own confidence in the real module's performance, with respect to the manufacturer's specifications.
It is at your disposal: you can put it at any value (for example for keeping some reserve on the production warranty, etc.).

By default, PVsyst initializes the "Module Quality Loss" according to the PV module manufacturer's tolerance specification.
PVsyst will choose a quarter of the difference between these values. For example, with -3...+3%, it will be 1.5%, and with positive sorting 0...+3%, it will be -0.75% (i.e. a negative loss value, representing a gain).

4.9. The transmission loss

The transmission loss is a general phenomenon, due to the reflexion and transmission of the sun's ray at each material interface (air-glass, glass-EVA, EVA-cell), as well as some absorption in the glass. This arises for any incidence ray. For normal incidence, the reflexion is of the order of 5%, and is included in the measured STC performance. The IAM only concerns the angular dependency of this effect, i.e. it is normalized to the transmission at perpendicular incidence (0° incidence angle).

4.10. Soiling loss

Accumulation of dirt and its effect on the system performance is an uncertainty which strongly depends on the environment of the system, raining conditions, etc. The soiling losses are strongly dependent on the rainfalls of course. Therefore in report PVsyst allows the definition of soiling loss factors in monthly values. During the simulation, the soiling loss is accounted for as an irradiance loss.

4.11. Irradiance loss

Irradiance loss In PVsyst, the evaluation of the "Losses" of a PV array (as for the definition of the normalized performance ratio), takes as starting point the energy which would be produced if the system worked always at STC conditions (1000 W/m^2, 25°C, AM1.5).
The loss due to operating temperature (instead of 25°C STC) is well-known and referenced by everybody. It is strange that nobody tells anything about the loss due to the irradiance level, which is of the same kind. Please have a look on the graphs of the behavior of a crystalline PV module (in the PV module dialog, choose "Graphs" / "Efficiency vs Irradiance"), you will see that the efficiency decreases for lower irradiances: this leads to the "Irradiance loss" (with respect to 1000 W/m^2). Therefore this Irradiance loss is a consequence of the intrinsic behavior of the PV modules, described by the "one-diode" model.

In the one-diode model, the efficiency at low levels depends on two parameters:

- The R_{Shunt} exponential behaviour: when the irradiance diminishes the R_{Shunt} increases exponentially (and therefore the corresponding loss diminishes). The lower R_{Shunt} at STC, the more losses to be retrieved by this process, and therefore the higher "low irradiance" efficiency.
- The R_{Series} resistance goes with the square of the current, therefore increasing with power. If the R_{Series} is high (bad), the losses are higher at STC (or reciprocally the efficiency will be enhanced at low irradiance levels).

Therefore "bad" modules (low R_{Shunt} ,high R_{Series}) have the best performances under low irradiance conditions (with respect to STC specification).

This may be easily understood by an opposite point of view: when you start from performances at low irradiance of a given module (say, 200 W/m2), the efficiency at higher irradiances is penalized by these losses, resulting in bad STC conditions. But in reality you buy the STC value...

This explains (along with the temperature coefficient) why amorphous modules show a better productivity [kWh/kWp] than crystalline ones in middle Europe climates.

4.12. Array incidence loss (IAM)

The incidence effect (the designated term is IAM, for "Incidence Angle Modifier") corresponds to the decrease of the irradiance really reaching the PV cells's surface, with respect to irradiance under normal incidence. This decrease is mainly due to reflexions on the glass cover, which increases with the incidence angle.

4.13. Array losses

Array losses can be defined as all events which penalize the available array output energy with respect to the PV-module nominal power as quoted by the manufacturer for STC conditions.

4.14. Age of the system

In general, the output of the solar panels reduces to 80% of their rated power in the 25th year.

PVsyst - Simulation report

Grid-Connected System

Project: VCE Project

Variant: Noida, UP Sheds

on Roof-top

System power: 100 kWp

Noida, UP - India

Project summary

Geographical Site

India

Situation

Latitude	28.54 °N
Longitude	77.39 °E
Altitude	199 m
Time zone	UTC+5.3

Project settings

0.20

Meteo data

Noida, UP

System summary

Grid-Connected System

Simulation for year no 10

Sheds on ground

PV Field Orientation

Fixed plane
Tilt/Azimuth 24 / 0 °

Near Shadings

Linear shadings

User's needs

Unlimited load (grid)

System information

PV Array

Nb. of modules	324 units
Pnom total	100 kWp

Inverters

Nb. of units	1 Unit
Pnom total	100 kWac
Pnom ratio	1.004

Results summary

Produced Energy	157.2 MWh/year	Specific production	1565 kWh/kWp/year	Perf. Ratio PR	78.32 %

General parameters

Grid-Connected System

Sheds on ground

PV Field Orientation

Orientation		**Sheds configuration**		**Models used**	
Fixed plane		Nb. of sheds	16 units	Transposition	Perez
Tilt/Azimuth	24 / 0 °	**Sizes**		Diffuse	Perez, Meteonorm
		Sheds spacing	5.00 m	Circumsolar	separate
		Collector width	3.14 m		
		Ground Cov. Ratio (GCR)	62.8 %		
		Shading limit angle			
			31.0 °		

Horizon | **Near Shadings** | **User's needs**

PV Array Characteristics

PV module		**Inverter**	
Manufacturer	Generic	Manufacturer	Generic
Model	SPR-E19-310-COM	Model	SG110-CX
(Original PVsyst database)		(Original PVsyst database)	
Unit Nom. Power	310 Wp	Unit Nom. Power	100 kWac
Number of PV modules	324 units	Number of inverters	1 unit
Nominal (STC)	100 kWp	Total power	100 kWac
Modules	27 Strings x 12 In series	Operating voltage	200-1000 V
At operating cond. (50°C)		Max. power (=>45°C)	110 kWac
Pmpp	91.1 kWp	Pnom ratio (DC:AC)	1.00
U mpp	583 V		
I mpp	156 A		
Total PV power		**Total inverter power**	
Nominal (STC)	100 kWp	Total power	100 kWac
Total	324 modules	Nb. of inverters	1 Unit
Module area	528 m²	Pnom ratio	1.00
Cell area	477 m²		

Array Loss

Array Soiling Losses		**Thermal Loss factor**		**DC wiring losses**	
	2.0 %				62 mΩ
		Uc (const)	29.0 W/m²K	Global array res.	
Module Quality Loss		**Module mismatch losses**		**Strings Mismatch loss**	
	1.0 %	Loss Fraction	2.0 % at MPP		

Module average degradation

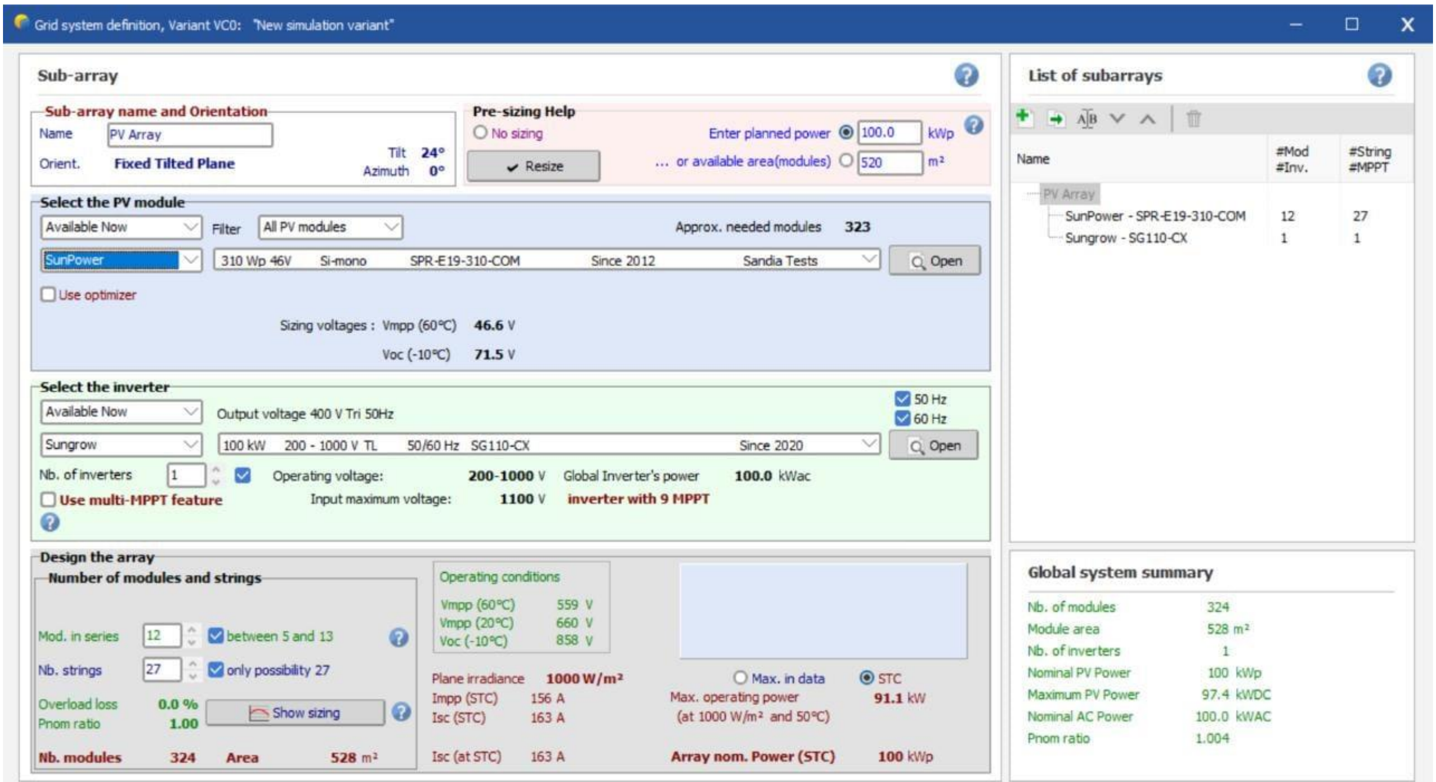
	10
Loss factor	0.4 %/year
Mismatch due to degradation	
Imp RMS dispersion	0.4 %/year
Vmp RMS dispersion	0.4 %/year

Array losses

IAM loss factor

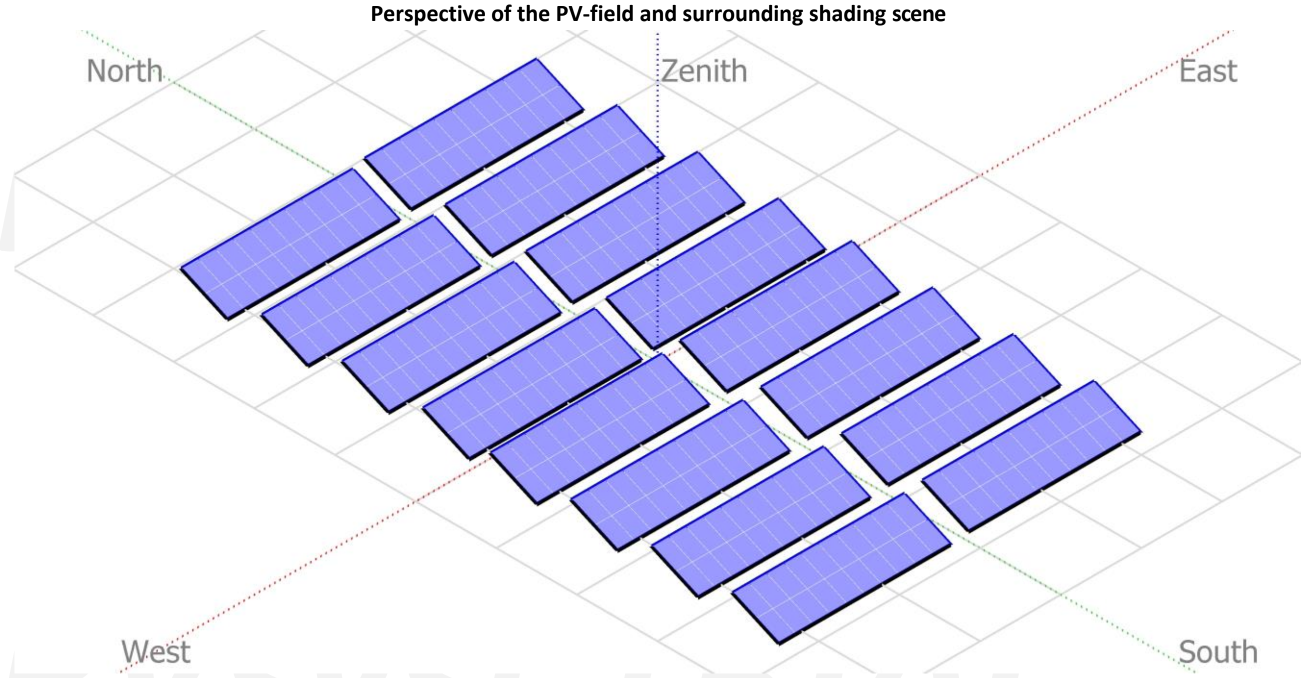
Incidence effect (IAM): User defined profile

0°	50°	60°	65°	70°	75°	82°	88°	90°
1.000	1.000	0.990	0.970	0.940	0.890	0.770	0.620	0.000

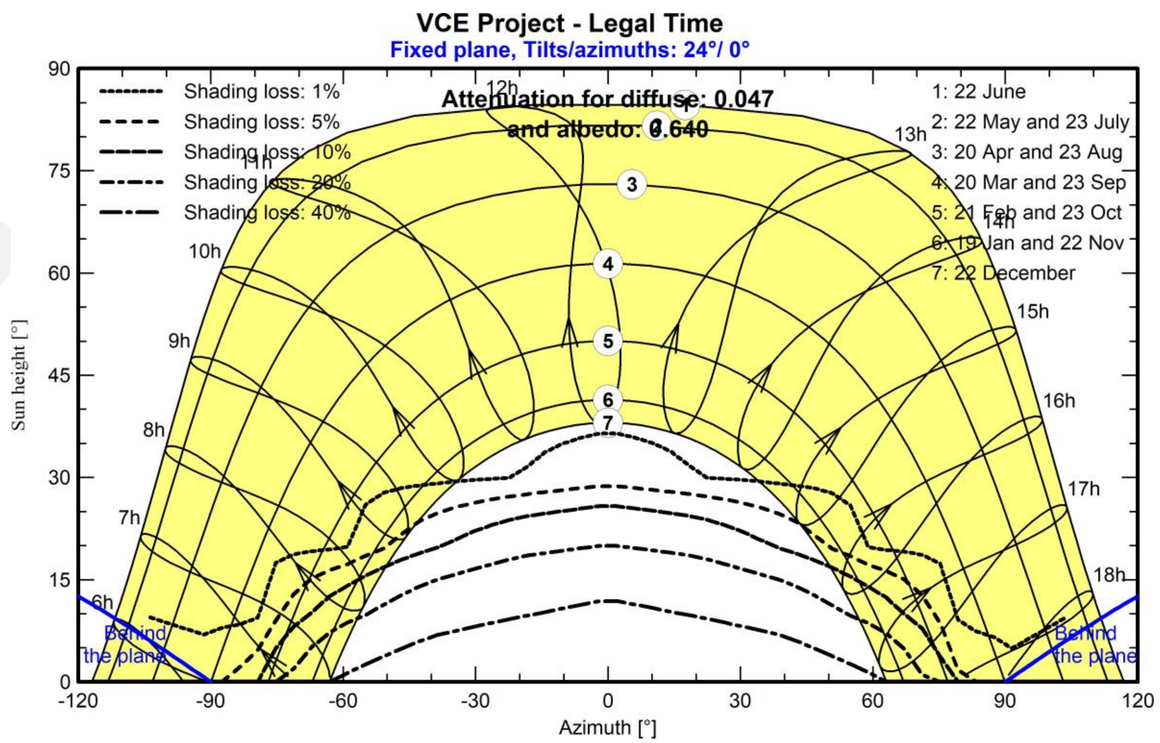


Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

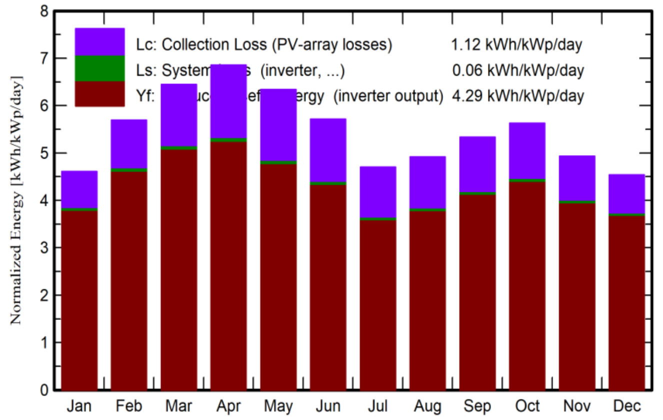


Main results

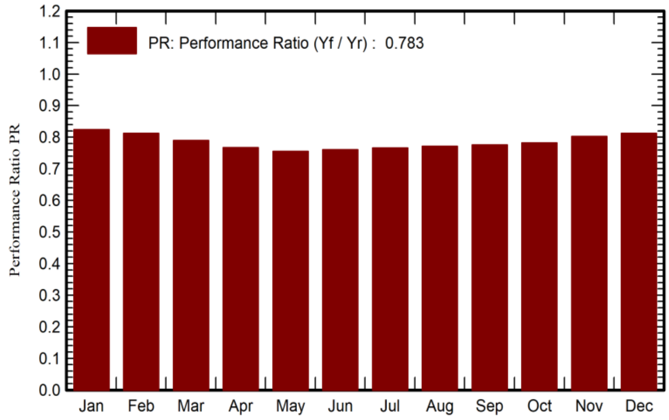
System Production

Produced Energy	157.2 MWh/year	Specific production	1565 kWh/kWp/year
		Performance Ratio PR	78.32 %

Normalized productions (per installed kWp)



Performance Ratio PR



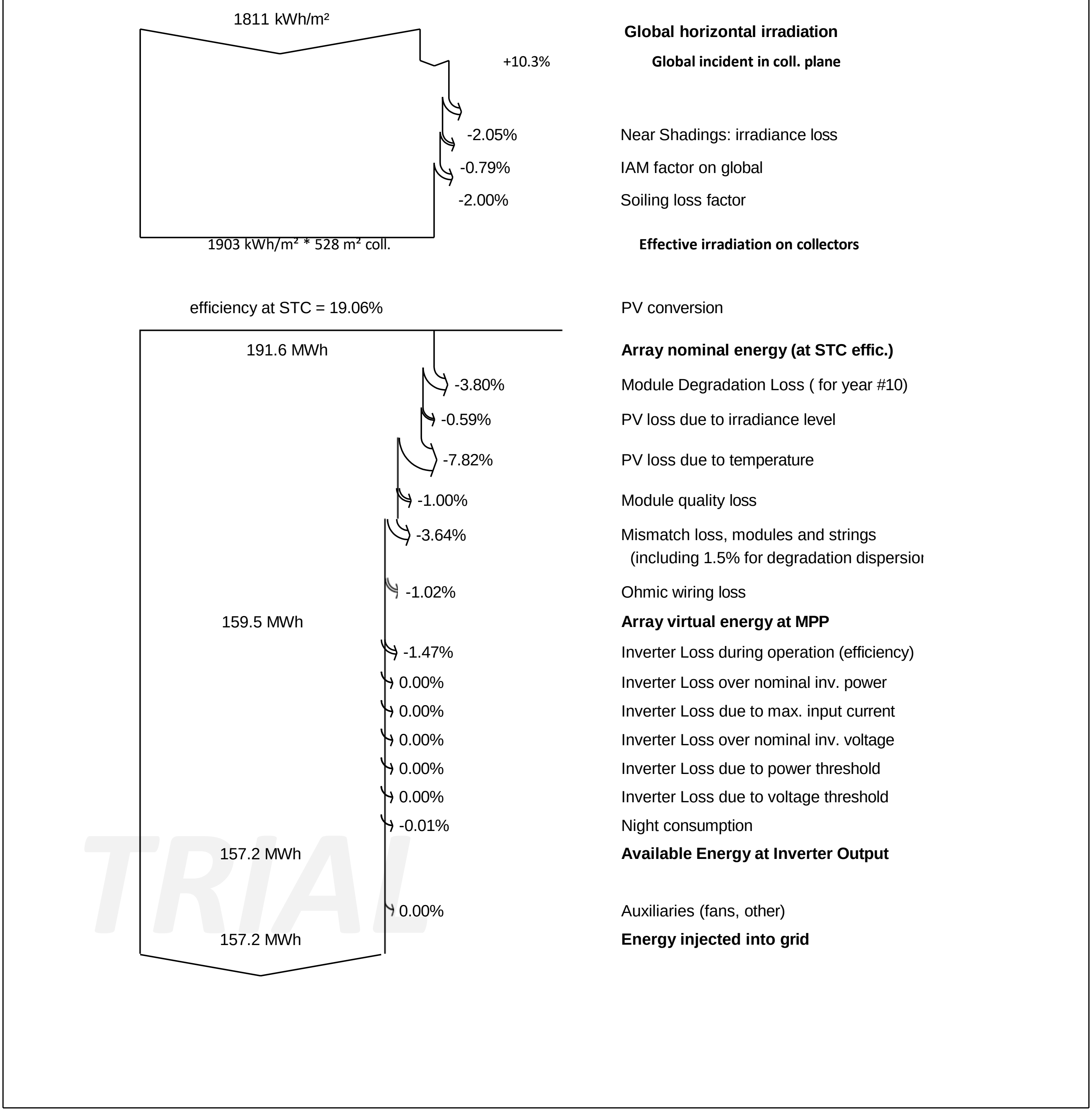
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	106.7	46.0	13.19	142.9	135.6	12.01	11.83	0.825
February	126.5	46.9	17.46	159.5	153.0	13.20	13.01	0.812
March	174.7	64.1	23.63	199.8	191.8	16.07	15.85	0.790
April	198.3	77.8	29.68	205.7	197.1	16.07	15.84	0.767
May	203.7	98.7	33.51	196.5	187.4	15.13	14.90	0.755
June	182.6	103.1	33.12	171.5	162.8	13.30	13.09	0.760
July	153.8	101.2	31.48	145.8	137.6	11.40	11.21	0.766
August	154.1	97.2	30.53	152.6	144.4	12.00	11.81	0.771
September	148.7	77.6	29.18	160.1	152.4	12.65	12.46	0.775
October	147.0	66.9	26.41	174.6	167.3	13.93	13.72	0.782
November	112.9	51.4	20.08	148.0	140.7	12.10	11.93	0.802
December	102.1	45.8	14.83	140.8	132.5	11.66	11.49	0.812
Year	1811.1	876.7	25.29	1997.8	1902.5	159.51	157.16	0.783

Legends

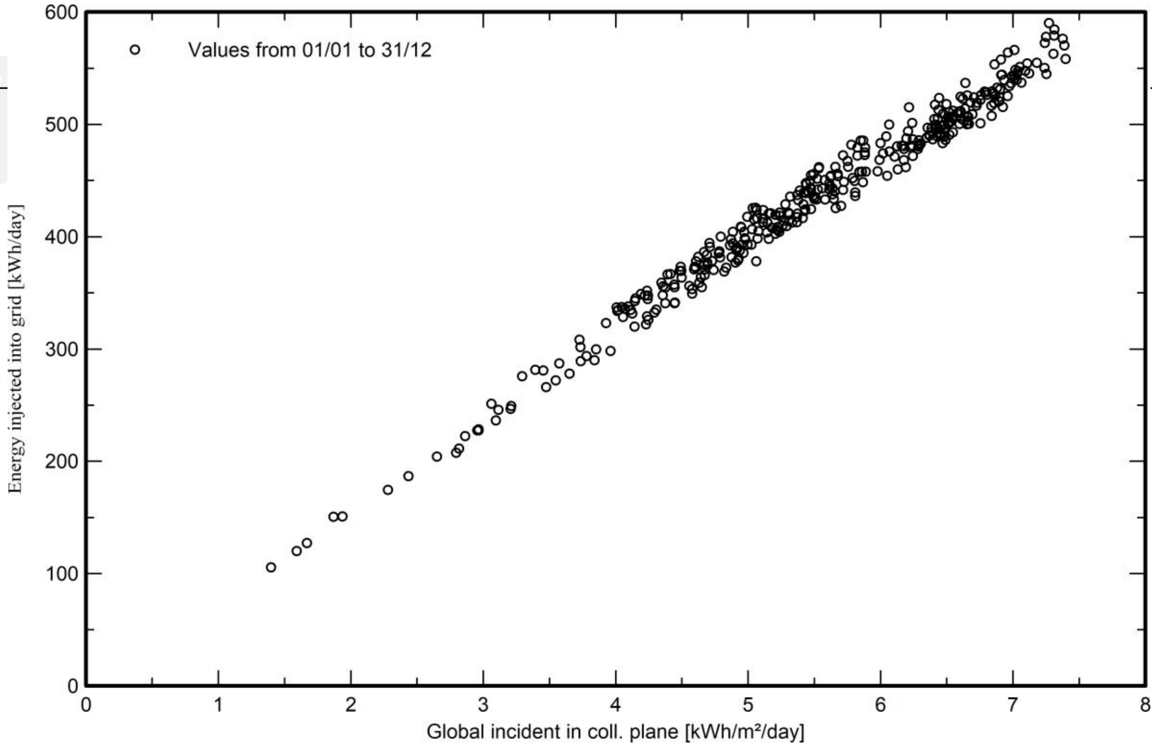
GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Loss diagram

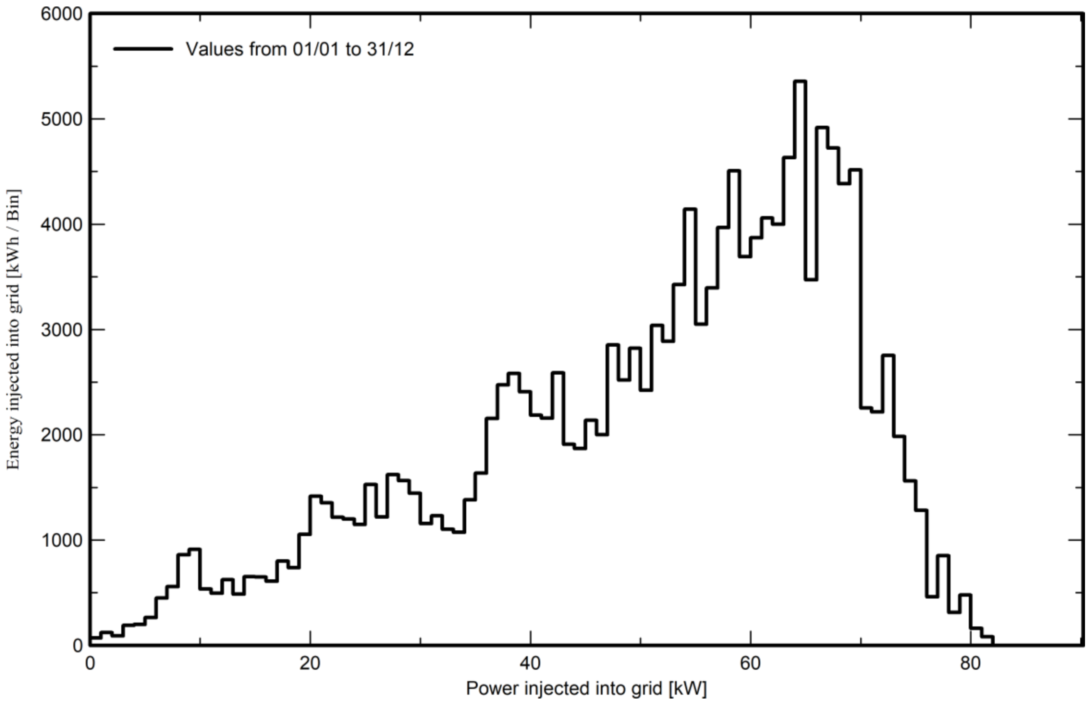


Special graphs

Daily Input/Output diagram



System Output Power Distribution



Conclusion

Overall this internship is a really good program and recommended to my fellow friends. It helps to develop and enhanced my skills, abilities, and knowledge. VCE is the good place to do the internships for future development. Its provide numerous benefits and advantage to the practical trainees.

In this study, the losses occurring in the cables used in PV systems are investigated. Before going into the simulation and application studies, some information is given about the losses encountered in PV systems. Then PV system simulation is performed with PVsyst software.

The geographical location of Noida, UP makes it a relatively sun-rich region with an annual solar irradiance of 100kwh. There is a great tendency for the use of Roof-top photovoltaic stations distributed in remote areas due to the known benefits of this source of energy. This subject needs to be defined for people living in these areas. In this paper, the author introduces the procedures employed in building and selecting the equipment's of a stand-alone photovoltaic system based on the Watt-Hour demand. As a case study, a residence in Noida, UP with medium energy consumption is selected. The factors that affect the design and sizing of every piece of equipment used in the system have also been presented. Over- and under-sizing have also been avoided to ensure adequate, reliable, and economical system design.

One of the most important points to be considered before the installation of PV systems is the cost accounts. The use of cables with a larger cross section than is required will cause lower resistance and voltage drop but this selection increases system installation cost unnecessarily. In this case, it should be determined the most appropriate cable crosssections considering both system security and unnecessary cost increases.

So, at point of job market this internship is profitable and the way of get success. My coordinator helped me a lot to working on this with overnice behaviour. Also the CEO of VCE Mr. Ashish S. Kumar helped a lot to handle some of my weakness and provided guidance to me whenever I am in need. I think the 2 month duration for the internship program will be make as a core subject . It will help us to identify our strengths, abilities, weakness and more.

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