SOLAR PV- SIMULATION AND DESIGNING

PROJECT REPORT

SUBMIT BY-
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ACKNOWLEDGEMENTS

The success and final outcome of this internship project required a lot of guidance and assistance from many people and I am extremely privileged to have got this all along the completion of my project. All that I have done is only due to such supervision and assistance and I would not forget to thank them.

I respect and thank Mr. Ashish Kumar, CEO Vardhan Consulting Engineers for providing me an opportunity to pursue the internship project and giving us all support and guidance, which made me complete the project duly. I am extremely thankful to him for providing such a nice support and guidance, although he had busy schedule managing the corporate affairs.

I owe my deep gratitude to our project guide Ms. Neha Kumari, HR Manager at Vardhan Consulting Engineers who took keen interest on our project work and guided us all along during the internship, till the completion of our internship.

I would not forget to remember my professors at National Institute of Technology, Patna for their encouragement and for their timely support and guidance.

I have gained skills and knowledge during the internship that will help me in the development of my career.

Sincerely,

MANISHA KUMARI

ABOUT VCE

VCE is a consulting company founded by group of engineers who have strong academic background with decades of management experience while working in companies all across the globe. VCE is providing solutions to the complex engineering, management and financial issues of clients.

VCE select students from various engineering and management colleges and provide them internship and training. Our internships and training are very unique in nature and its specially for the students of Core Engineering Sector (Electrical, Mechanical, Civil and Energy Engineering) and Finance Management for preparing them to corporate / industry ready. We provide them mentor from the industries.

I was provided with the opportunity to work as the Engineering Design and analyst Intern as Vardhan Consulting Engineers and was assigned to make a project report on the designing and simulation of a solar power plant. I have gained a lot of knowledge regarding the various aspects of PV simulation which would be beneficial to my career.

EXECUTIVE SUMMARY

This Project Report is about the Simulation and Calculation of AEP using PVSyst of Grid connected 100 kW Solar PV Project in Noida, U.P. We have analysed the various aspects related to the PV simulation and designing namely,

- Solar PV module
- controller
- inverter
- solar resource assessment
- losses

This report focuses on the Key takeaways as listed below

- In-depth knowledge of basics, working of solar PV power plant.
- Information about various components of a photovoltaic power plant such as photovoltaic modules, inverters, charge controllers, batteries, structures, and so on.
- Photovoltaic system types, design philosophy, principles, examples and calculations.
- Information and methodologies of solar resource assessment site survey tools, weather measurements, etc.

PV Systems: Comprehensive learning of industry-standard software.
Key issues, challenges, opportunities, and future scope in the domain of solar PV.This report concludes that how solar energy is the

techno-economic feasible option specially fora energy deficient country like India.

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1. INTRODUCTION

Solar renewable energy harvesting is the demand of the century because of the huge energy requirement of the world today. Solar power is inexhaustible. In an energy deficient country like India, where power generation is costly, solar energy is the best alternate means of power generation. India being a home to a huge population witnesses high Incident Solar radiations throughout the year. Planning has been made to produce at least 65 Gigawatts of high quality solar power by the year 2020.The following graph represents India’s year -on-year targets to reach ambitious 2022 solar goal:

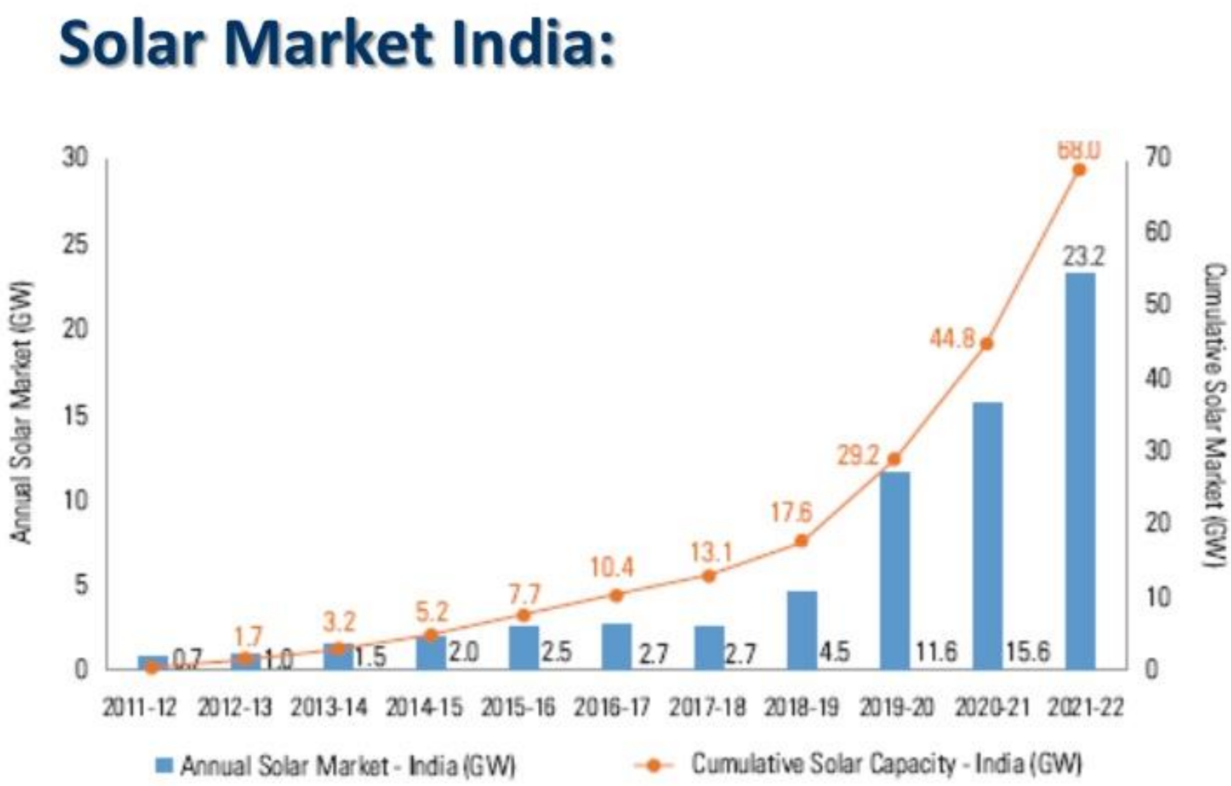

Figure1: India’s year on year solar Goals

The main obstacle for the wide usage of solar Photovoltaic systems is their efficiency which is very low (20-25% for single crystal 10-15% for polycrystalline and 3-5% for amorphous silicon solar cells) and high cost of manufacturing.

Solar Photovoltaic (PV) is a technology that converts sunlight (solar radiation) into direct current electricity by using semiconductors. When the sun hits the semiconductor within the PV cell, electrons are freed and form an electric current.

This basic working principle is known as photovoltaic effect Solar PV technology is generally employed on a panel (hence solar panels). PV cells are typically found connected to each other and mounted on a frame called a module.

Multiple modules can be wired together to form an array, which can be scaled up or down to produce the amount of power needed. Other than solar cells, solar PV power plant also consists of devices such as solar inverters, power optimizers, isolators, batteries, charge controllers, etc.

PVsyst is the most widely used solar simulation software for the energy yield estimation and for optimal design of solar power plants. PVsyst makes use of the extended knowledge of PV Technology Meteorological irradiation resources data and PV system components.

Thus PVsyst will help in understanding the PV system components and thus help in optimizing the system design. The subsequent sections of this report provide more detailed information regarding the comprehensive solar photovoltaic system program and analysis methods.

2. THE COMPONENTS OF SOLAR PHOTOVOLTAIC.

1. SOLAR PV MODULE-

Solar Module is the essential component of any solar PV system that converts sunlight directly into DC electricity.

Figure 2: solar PV module

2. CONTROLLER-

Solar Charge Controller It regulates voltage and current from solar arrays, charges the battery, prevents battery from overcharging and also performs controlled over discharges.

Figure 3: solar charge controller

3. INVERTER-

Inverter is a critical component of any solar PV system that converts DC power output of solar arrays into AC for AC appliances.

Figure 4: Inverter

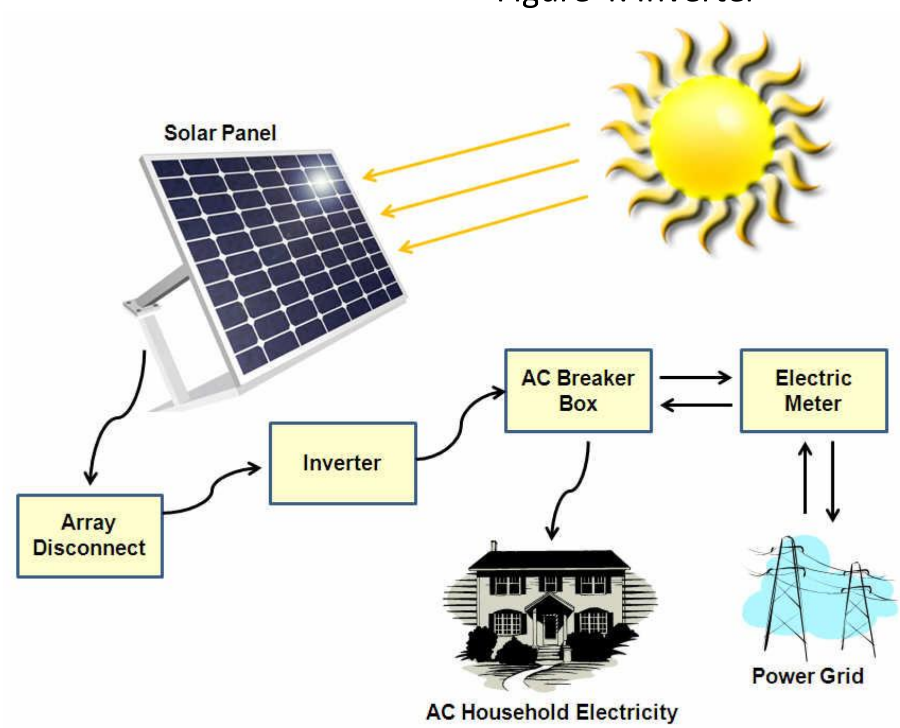

Figure :5 power transformation from Solar

3. SOLAR SYSTEM SIZING

1) DETERMINE POWER CONSUMPTION DEMANDS

The first step in designing a solar PV system is to find out the total power and energy consumption of all loads that need to be sup plied by the solar PV system as follows

1.1 CALCULATE TOTAL WATT-HOURS PER DAY FOR EACH APPLIANCE USED.

Add the Watt-hours needed for all appliances together to get the total Watt- hours per day which must be delivered to the appliances.

1.2 CALCULATE TOTAL WATT-HOURS PER DAY NEEDED FROM THE PV MODULES. Multiply the total appliances Watt-hours per day times 1.3 (the energy lost in the system) to get the total Watt-hours per day which must be provided by the panels.

2).SIZE THE PV MODULES

Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total peak watt produced needs. The peak watt (Wp) produced depends on size of the PV module and climate of site location. We have to consider panel generation factor which is different in each site location. For Thailand, the panel generation factor is 3.43.

To determine the sizing of PV modules, calculate as follows:

2.1 Calculate the total Watt-peak rating needed for PV module

2.2 Calculate the number of PV panels for the system Result of the calculation is the minimum number of PV panels. If more PV modules are installed, the system will perform better and battery life will be improved. If fewer PV modules are used, the system may not work at all during cloudy periods and battery life will be shortened.

3). INVERTER SIZING

An inverter is used in the system where AC power output is needed. The input rating of the inverter should never be lower than the total watt of appliances.

The inverter must have the same nominal voltage as your battery. For stand-alone systems, the inverter must be large enough to handle the total amount of Watts you will be using at one time.

The inverter size should be 25-30% bigger than total Watts of appliances. In case of appliance type is motor or compressor then inverter size should be minimum 3 times the capacity of those appliances and must be added to the inverter capacity to handle surge current during starting. For grid tie systems or grid connected systems, the input rating of the inverter should be same as PV array rating to allow for safe and efficient operation.

4).BATTERY SIZING

The battery type recommended for using in solar PV system is deep cycle battery. Deep cycle battery is specifically designed for to be discharged to low energy level and rapid recharged or cycle charged and discharged day after day for years. The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days. To find out the size of battery, calculate as follows:

4.2 Calculate total Watt-hours per day used by appliances.

4.2 Divide the total Watt-hours per day used by 0.85 for battery loss.

4.3 Divide the answer obtained in item 4.2 by 0.6 for depth Of discharge.

4.4 Divide the answer obtained in item 4.3 by the nominal battery voltage.

4.5 Multiply the answer obtained in item 4.4 with days of autonomy (the number of days that you need the system to operate when there is no power produced by PV panels) to get the required Ampere-hour capacity of deep-cycle battery.

Battery Capacity (Ah) = Total Watt-hours per day used by appliances x Days of autonomy (0.85 x 0.6 x nominal battery voltage)

5). SOLAR CHARGE CONTROLLER SIZING

The solar charge controller is typically rated against Amperage and Voltage capacities. Select the solar charge controller to match the voltage of PV array and batteries and then identify which type of solar charge controller is right for your application. Make sure that solar charge controller has enough capacity to handle the current from PV array.

For the series charge controller type, the sizing of controller depends on the total PV input current which is delivered to the controller and also depends on PV panel configuration (series or parallel configuration).

According to standard practice, the sizing of solar charge controller is to take the short circuit current (Isc) of the PV array, and multiply it by 1.3

Solar charge controller rating = Total short circuit current of PV array x 1.3

Remark: For MPPT charge controller sizing will be different.

3.SOLAR RESOURCE ASSESMENT-

The process of collecting data and analyse the condition that directly influence solar energy production rate and finally estimate the annual energy production in an efficient manner. It provide a mean to accurately determining the availability of solar radiation for developing cost effective solar energy.

There are two methods in which the assessment is done:

1.ground measurements- A variety of sensors are used such as pyranometers to measure solar irradiance at the location over a lengthy period
2.satellite derived data- This method involves studying obtained data from satellites, such as statistically aggregated solar data, to conduct the SRA. There are multiple commercial providers of solar radiation data, all of whom use satellite derived data fed into proprietary models to generate time series for multiple variables, with increasingly high degrees of uncertainty.

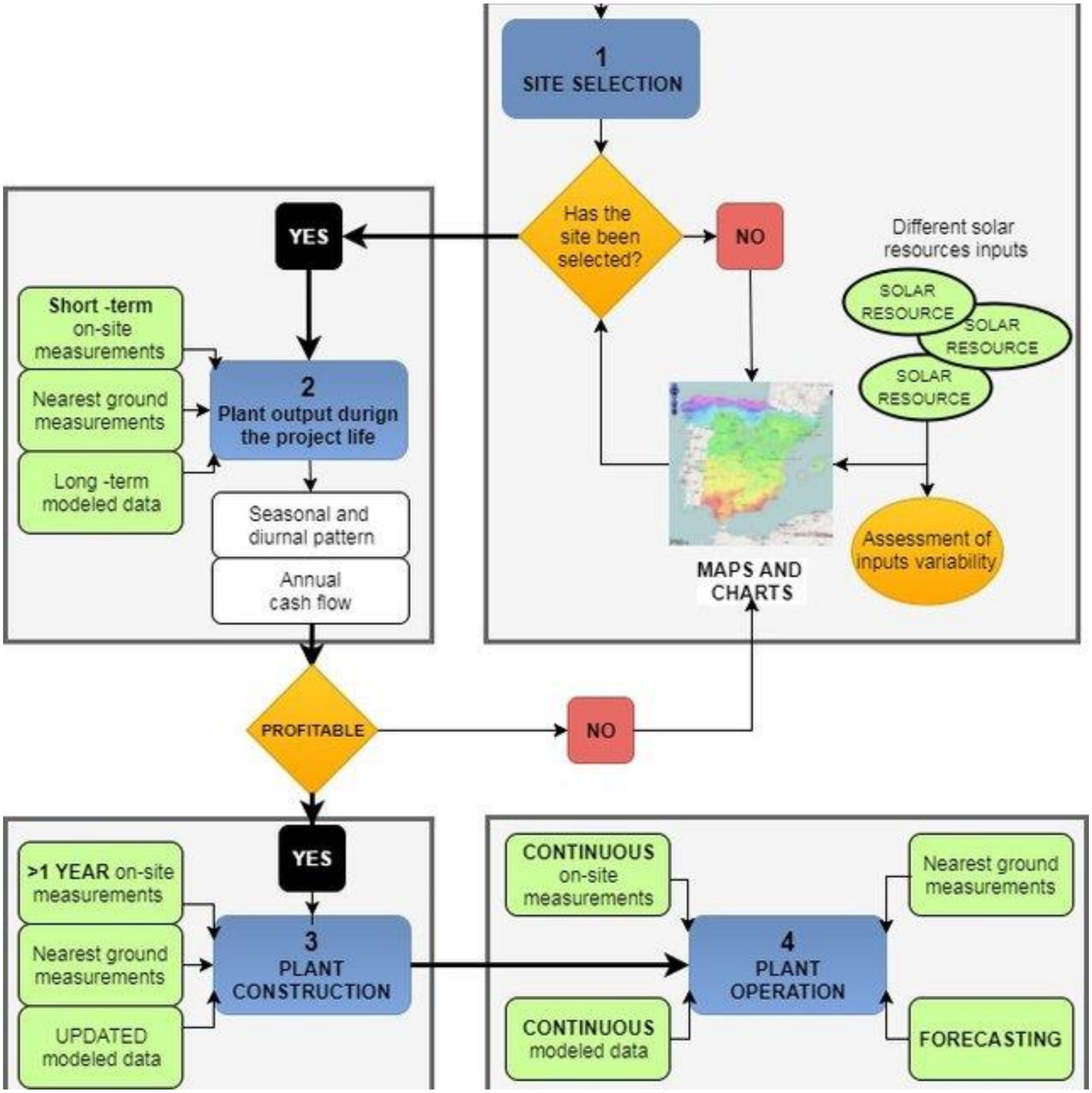

Figure :6 Flow-Chart Of solar Resource Assessment

4.LOSSES IN SOLAR POWER PLANT

Losses that occur in solar PV plant include:

- PV loss due to irradiance level
- PV loss due to temperature
- Module quality loss
- Mismatch loss
- Ohmic wiring loss
- Various inverter losses

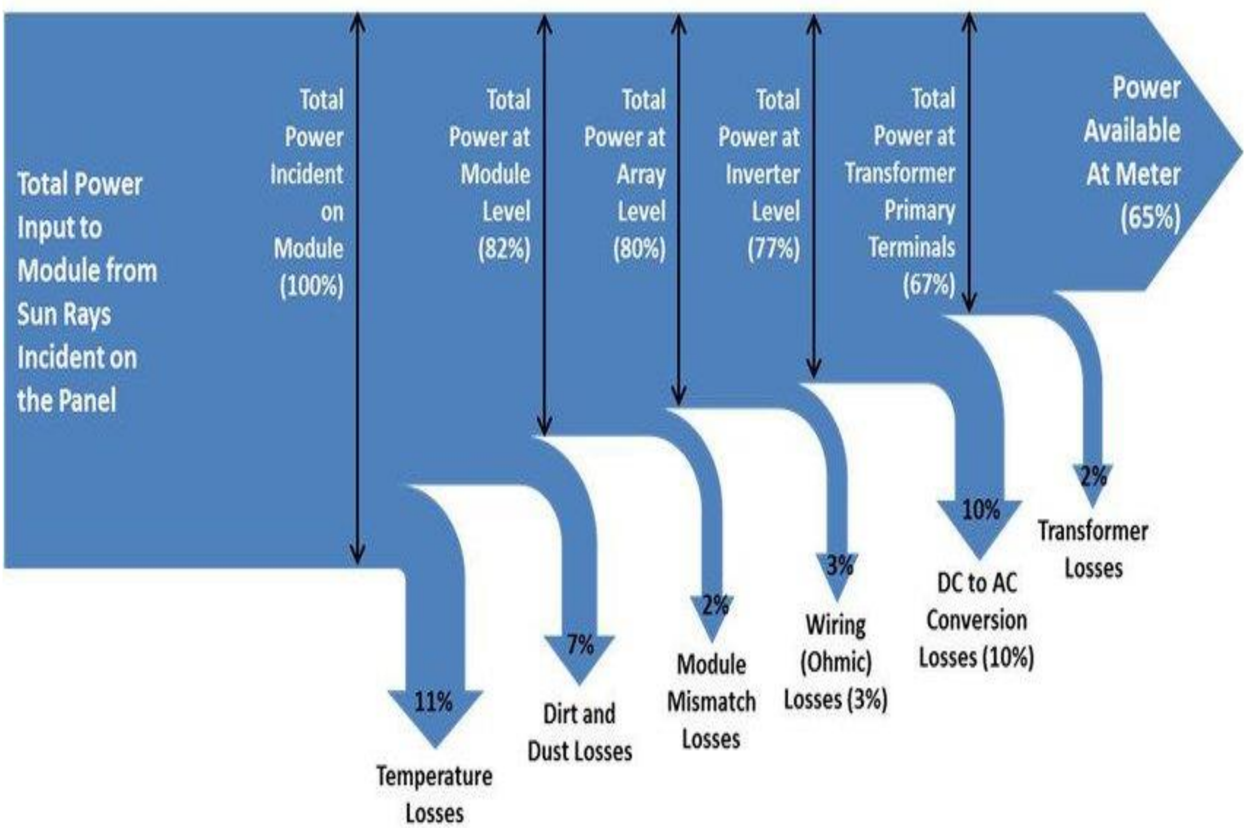

Figure :7 flow chart of power losses in solar pv plant

5 ANNUAL LOSSES ASSESSMENT-(CASE STUDY)

we are provided with three projects out of which we have to select any one of them then we must go through the case problem assessment of the project and start analysing the project using PV Syst software.

The project is to analyse losses in Grid connected Solar PV project in NOIDA, U.P.

We are assumed to be a Techvardhan Power Pvt. Ltd client and we get a contract of setting up 100 KW rooftop solar PV plant based on above project. So we have to design and simulate the project using Solar PV Syst Software and prepare a detailed solar resource assessment and solar losses report.We used PV Syst Software version 6.8.6 for solving the current solar pv problem.

The detailed report of the project are described below:

As the Noida is near Delhi so we select database station as MeteoNorm 7.2 station, which is database station in Delhi.

1. Installation Setup:	
• Site:	Noida, U.P.
• Meteo:	MeteoNorm 7.2 station
• Field Type:	Fixed Tilted Plane
• Plane tilt:	29 degree
• Azimuth:	0 degree
• Planned power:	100 Kw

Table :1 installation setup

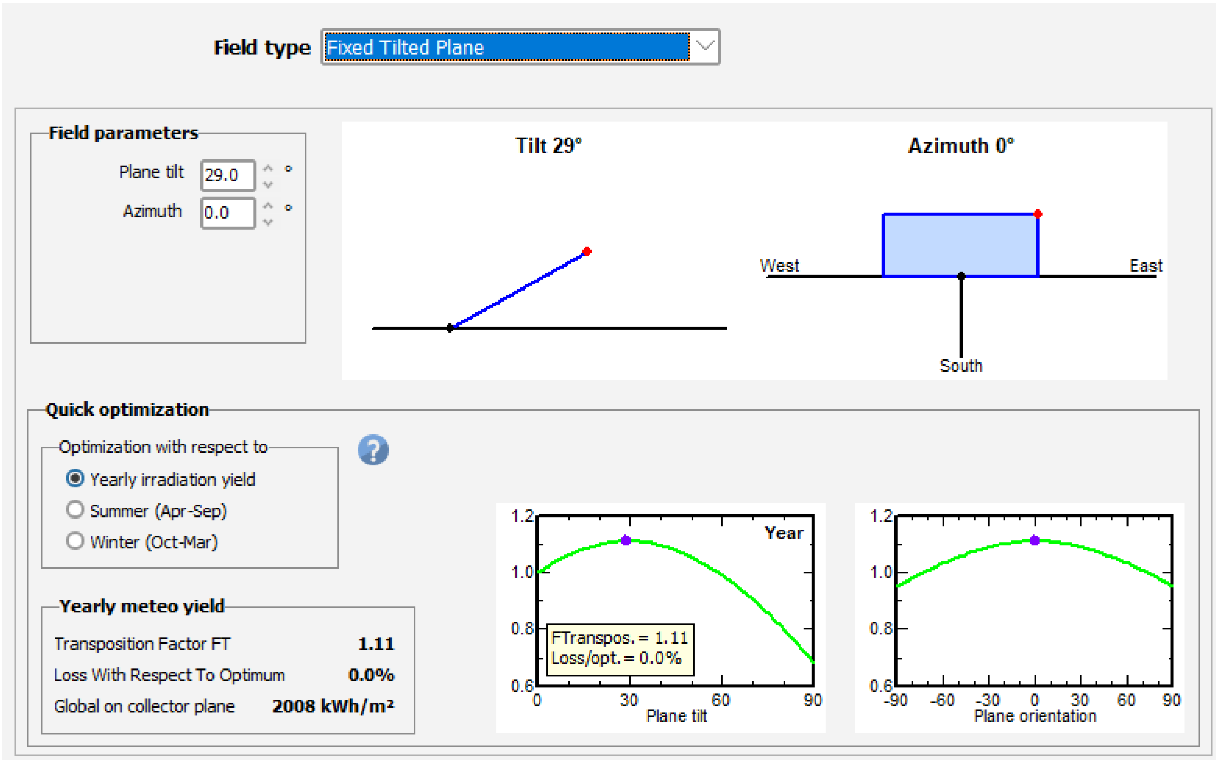

Figure :8 installation setup (PV syst)

1. PV module selection:

• Manufacturer	: Generic
• Size	: Poly 60wp 3cells
• Voltage	: 14 volts
• Module needed	: 1660

Table :2 module data

2. Inverter Selection :

• Manufacturer:	Generic
• Output Voltage:	230 volts
• No. of inverter:	3

• Nominal AC Power:	90 KW
• Frequency:	50/60 Hz

Table:3 inverter data

3. Array Design:

• Module in series:	16
• No. of strings:	22
• No. of modules:	352

Table :4 array design

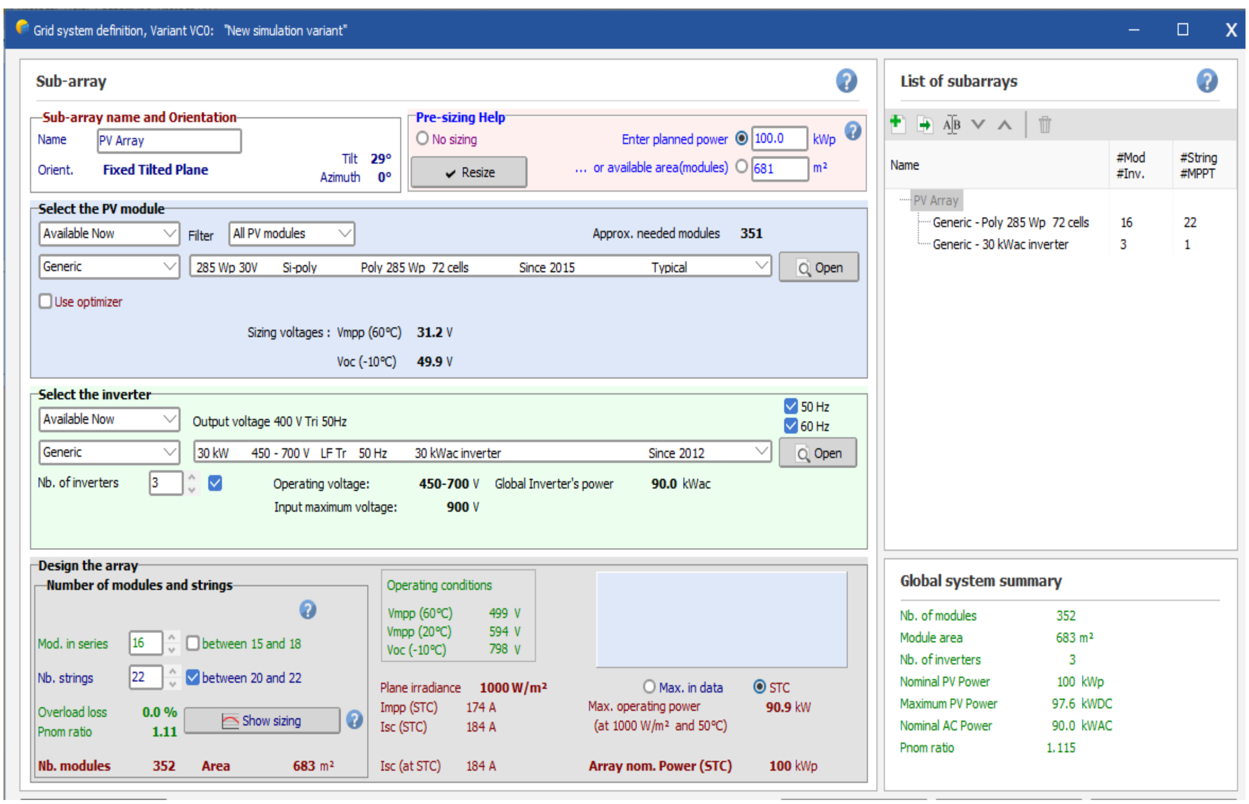

Figure :9 PV module ,Inverter& array selection

As our project is to analyse losses in Grid connected solar PV plant of 100 KW power located in Noida, U.P. Above we simulate our problem using solar PV Syst Software and now we discussed the main result and elaborate losses in detail.

1) Main Result:

• System production:	157 MWh/year
• Performance Ratio:	0.784
• Normalized Production :	4.30 KWh/KWp/day
• Array Losses:	0.87 KWh/KWp/day
• System Losses :	0.32 KWh/KW
• Specific production :	1568 KWh/KWp/yr

Table 5: main result

Results overview

System kind	**No 3D scene defined, no shadings**	
System Production	**157**	MWh/yr
Specific production	**1568**	kWh/kWp/yr
Performance Ratio	**0.784**	
Normalized production	**4.30**	kWh/kWp/day
Array losses	**0.87**	kWh/kWp/day
System losses	**0.32**	kWh/kWp/day

Figure :10 result overview

PV Array Characteristics

PV module		Inverter	
Manufacturer	Generic	Manufacturer	Generic
Model	Poly 285 Wp 72 cells	Model	30 kWac inverter
(Original PVsyst database)		(Original PVsyst database)	
Unit Nom. Power	285 Wp	Unit Nom. Power	30.0 kWac
Number of PV modules	352 units	Number of inverters	3 units
Nominal (STC)	100 kWp	Total power	90.0 kWac
Modules	22 Strings x 16 In series	Operating voltage	450-700 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.11
Pmpp	90.9 kWp		
U mpp	523 V		
I mpp	174 A		

Total PV power		Total inverter power	
Nominal (STC)	100 kWp	Total power	90 kWac
Total	352 modules	Nb. of inverters	3 units
Module area	683 m²	Pnom ratio	1.11
Cell area	616 m²		

Array losses

Thermal Loss factor

Module temperature according to irradiance

Uc (const) 20.0 W/m²K

Uv (wind) 0.0 W/m²K/m/s

DC wiring losses

Global array res. 50 mΩ

Loss Fraction 1.5 % at STC

Module Quality Loss

Loss Fraction -0.8 %

Module mismatch losses

Loss Fraction 2.0 % at MPP

Strings Mismatch loss

Loss Fraction 0.1 %

IAM loss factor

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

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

Figure:11 PV array characteristics and array losses

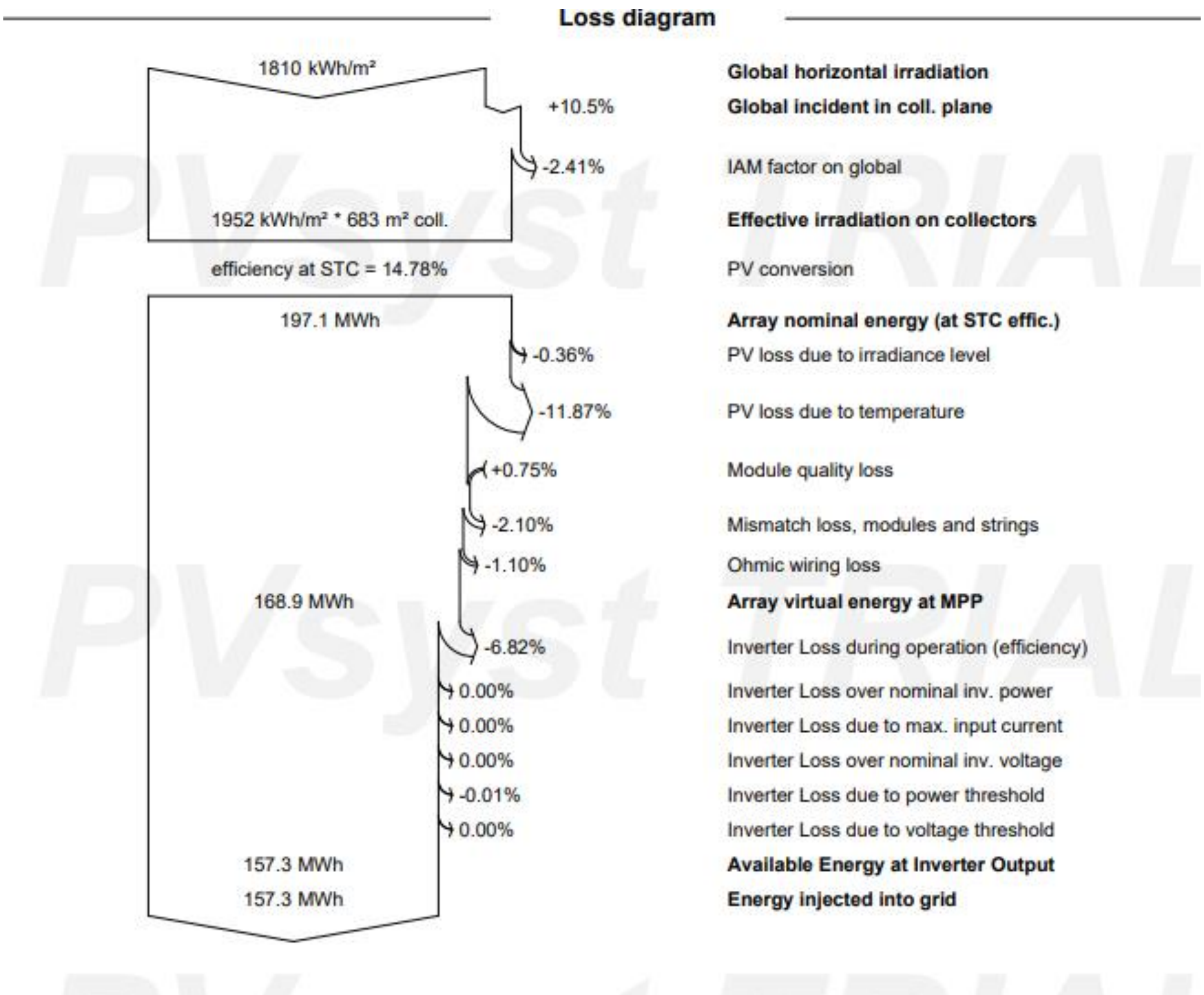

Figure :12 shows the detailed power loss diagram which we want to conclude in this report

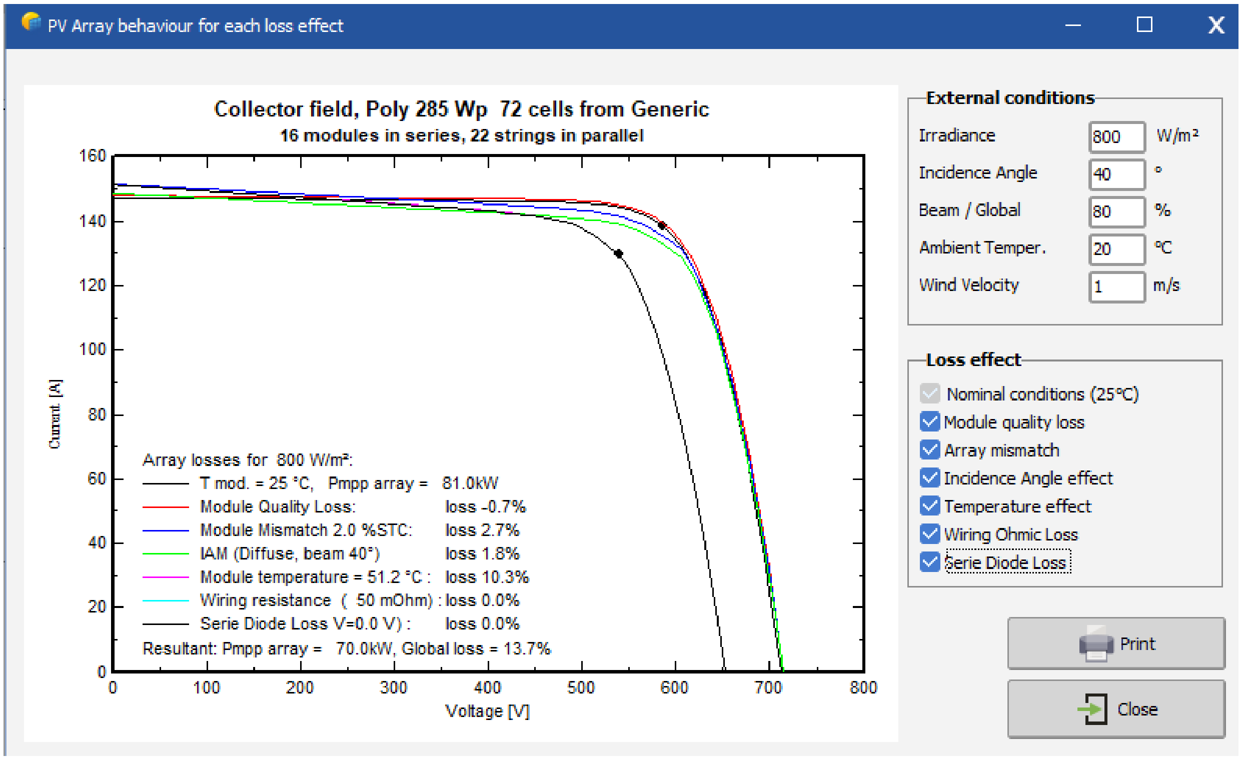

Figure :13 detailed graph of losses

The detailed study of above-mentioned losses in power loss diagram are studied below with the value obtained in each case. In module 4 we have to prepare a detailed report of losses for our client.

1. MODULE QUALITY LOSS: The Module quality loss is a parameter that should express your own confidence to the real module's performance, with respect to the manufacturer's specifications. In our project this loss is 2.50%.

2. PV LOSS DUE TO IRRADIANCE LEVEL: The efficiency decreases for lower irradiances: this leads to the "Irradiance loss. Therefore, this Irradiance loss is a consequence of the intrinsic behaviour of the PV modules, described by the "one-diode" model. In our project these losses are 0.19%.

3. PV LOSS DUE TO TEMPERATURE: These losses arise because the temperature is not always at STP i.e. 250C, so losses arises due to this called temperature losses. Most losses on pv array are due to this loss. In our project this loss comprises of 14.60%.

4. MISMATCH LOSS, MODULES AND STRINGS: Mismatch losses are due to the interchanging of solar PV panels in series and parallel. The modules do not have same properties from each other. In our project these losses are around 1.10%.

5. INVERTER LOSSES:

- **Global inverter losses**: Sum of all inverter losses. In our project it was 4.58% approx.
- **Inverter losses during operation**: The inefficiency loss computed according to the efficiency curve. It is around 3.3% in our project.
- **Inverter loss due to power threshold**: loss when the power of the array is not sufficient for starting the inverter. It is negligible around 0.01%.
- **Inverter loss due to voltage threshold**: It arises due to low voltage at Maximum Power Point (MPP). These losses are also negligible.

6.CONCLUSIONS

It had a great pleasure for me to get a chance to work in Vardhan Consulting Engineers. At the end of my training tenure, I wish to summarize the benefits acquired over the period of training. This training certainly helped me in bridging the gap between theory and practical. It provides me opportunity to learn under different environment. It's also helped me in analyse my gaps and Benchmarks.

This internship comprises of various Technical divisions, where I had the opportunity to work with the Solar PV system which is a growing sector in these days.

I gained quite a lot of things from this training and they are quoted below:

• I understood the scope and job responsibilities of the various departments of an engineering organization

. • I got a chance to get the knowledge about basic components and understanding the terms related to solar PV plant.

• During the training period I learnt working on PV Syst Photovoltaic software to set up 100 KW solar PV rooftop plant. I also covered some new topics which were not an academic subject like solar resource assessment, losses in electricity generated from solar.

• Photo voltaic plant, complete use of PV Syst Software.

• I also came to know the importance of responsibility & authorities allotted for different task & successful accomplishment of the same as early as possible.

Thus, I confidently conclude that this training was the most beneficial and enlightening experience, which is bound to help me in my future. I will forever be grateful to VCE for this internship experience.

To be a part of this online internship conducted by Vardhman Consulting Engineers (VCE) under the guidance of Mr. Ashish Kumar I learned a lot of new things and commercially applicability.