Solar PV internship
Simulation and Modeling

Vardhan Consulting Engineers

Smart Task – 4

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Content

Preface

The following report contains all the information gathered by me in this Solar PV internship at VCE. This report describes all the types of renewable energy that was discussed in the internship. Later this report discussed about the elements which are used for the installation purpose and what are the ways to convert the solar energy into electrical energy . At the end, we had discussed about the cost for a solar PV module plant.

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Sources of Energy

Sources of energy can be classified into:

- Renewable Sources
- Non-renewable Sources

A renewable source is the natural resources that cause no impact to nature. Renewable sources of energy are available plentiful in nature and are sustainable. These resources of energy can be naturally replenished and are safe to the environment.

Examples of renewable sources of energy are: Solar energy, geothermal energy, Wind energy, biomass, Hydropower and tidal energy and many others.

Non-renewable sources of energy cause impact to nature and are a limited supply source. Non-renewable sources can be extracted from the earth, and will run out as time passes.

Examples of non-renewable sources of energy are: Natural gas, coal, petroleum, Nuclear energy and hydrocarbon gas liquids.

Among all of them , solar energy is the most cost effective and user friendly in nature . It is the energy from the sun that is harnessed using a range of technologies such as solar heating, solar architecture, photovoltaic's, and artificial photosynthesis. It is an essential source of renewable energy. The mechanism by which silicon solar panels harness the sun's energy and generate electricity is known as photovoltaic effect.

Solar energy refers to energy from the sun. The sun has produced energy for billions of years. It is the most important source of energy for life forms. It is a renewable source of energy unlike non-renewable sources such as fossil fuels. Solar energy technologies use the sun's energy to light homes, produce hot water, heat homes and electricity.

World's energy demand is growing fast because of population explosion and technological advancements. It is therefore important to go for reliable, cost effective and everlasting renewable energy source for energy demand arising in future. Solar energy, among other renewable sources of energy, is a promising and freely available energy source for managing long-term issues in an energy crisis. The solar industry is developing steadily all over the world because of the high demand for energy while major energy source, fossil fuel, is limited and other sources are expensive. It has become a tool to develop the economic status of developing countries and to sustain the lives of many underprivileged people as it is now cost effective after long aggressive research done to expedite its development.

The solar industry would definitely be the best option for future energy demand since it is superior in terms of availability, cost effectiveness, accessibility, capacity, and efficiency compared to other renewable energy sources. This paper, therefore, discusses the need of solar industry with its fundamental concepts, world's energy scenario, highlights of researches done to upgrade solar industry, its potential applications and barriers for the better solar industry in future in order to resolve the energy crisis.

The consumption of non-renewable sources like oil, gas, and coal is increasing at an alarming rate. The time has finally come to look after some other renewable sources of energy i.e. solar, wind and geothermal energy. Although many countries have started utilizing solar energy extensively but still have to go a long way to exploit this energy to fulfill their daily demands. Here are few facts on solar energy that can help you assess the potential of solar energy to meet global requirements

Solar Energy in India

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic's, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis.

It is an essential source of renewable energy, and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power, and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

The large magnitude of solar energy available makes it a highly appealing source of electricity.

When sunlight falls on the solar panels it gets absorbed by the PV cells and the silicon semiconductors in the cells convert the solar energy into electric energy through the PV effect. This electric energy is in the form of DC power which can directly charge the battery. The DC power in the battery is sent to an inverter which converts it into AC power. This AC power is now sent to the mains in the home which in turn can power all necessary applications.

Example of Solar project in India :

The **NP Kunta Ultra Mega Solar Park**, also known as **Ananthapuram - I Ultra Mega Solar Park**, is a solar park spread over a total area of 32 square kilometres (12 sq mi) in Nambulapulakunta mandal in the Ananthapur district of the Indian state of Andhra Pradesh.

The first phase of park was commissioned on 9 May 2016 with a capacity of 200 MW. An additional 50 MW capacity was commissioned on 29 July 2016. A further 750 MW was planned to have been commissioned by March 2018 in the second phase.

In August 2016, Tata Power Solar commissioned a 100 MW solar project at the park built over an area of 200 hectares (500 acres). This was the largest solar project commissioned using domestically manufactured solar cells and modules at the time.

In May 2018, Azure Power commissioned a 50 MW solar capacity at the park. In July 2018, Tata Power commissioned another 100 MW capacity, taking total commissioned capacity to 500 MW.

In July 2018, 750 MW were awarded for installation at ₹2.71/kW·h.

As of 30 April 2021, 978.5 MW capacity was commissioned with companywise break up of Sprng Agnitra (250 MW), Ayana Solar (228.5 MW), SB Energy Solar (250 MW) and NTPC (250 MW). Another 400 MW was installed by Tatas (100 MW), ACME (150 MW), Azure (50 MW) and FRV Ltd (100 MW) at adjacent Galiveedu Solar Park which is not part of NP Kunta Solar Park.

Kamuthi Solar Power Project is a photovoltaic power station spread over an area of 2,500 acres (10 km^2) in Kamuthi, Ramanathapuram district, 90 km from Madurai, in the state of Tamil Nadu, India. The project was commissioned by Adani Power.With a generating capacity of 648 MW_p at a single location, it is the world's 12th largest solar park based on capacity.

ABB commissioned five sub-stations to connect the solar park with the National Grid on 13 June 2016. The Kamuthi Solar Power Project was completed on 21 September 2016 with an investment of around ₹4,550 crore (equivalent to ₹53 billion or US$740 million in 2019). The solar plant consists of 2.5 million solar modules, 380,000 foundations, 27,000 metres of structures, 576 inverters, 154 transformers, and almost 6,000 km of cables.Construction of the structures needed to mount the solar panels required 30,000 tonnes of galvanised steel. Around 8,500 workers installed an average of 11 MW of capacity per day to complete the project within 8 months.

The entire solar park is connected to a 400 kV substation of the Tamil Nadu Transmission Corp. The solar panels are cleaned daily by a self-charged robotic system.

Solar Resource Assessment

Solar-resource assessment is the characterization of solar irradiance available for energy conversion for a region or specific location over a historical time period of interest. Solar-energy forecasting is required for the routine operation of an electrical grid with solar-power generation. Specifically, the information produced through solar-resource assessment and accurate solar-energy forecasting is important to each phase of a solar-power conversion project:

Feasibility phase: Identifying potential system locations and power-technology options based on historically available solar resources and economic, engineering, logistical, and other project constraints.

Design phase: Selecting the best power-conversion technology option and modeling plausible system configurations for producing the desired power output over the life of the system

Deployment phase: Applying due diligence in the construction, performance testing, and commissioning of the power system.

Operation phase: Integrating new power-generation systems into routine operation by an electrical utility, consistent with the needs of independent system operators (ISOs), regional transmission organizations (RTOs), and regulatory agencies (e.g., Federal Energy Regulatory Commission, or FERC).

Solar Power Plant

Solar power in India is a fast developing industry as part of the renewable energy in India. The country's solar installed capacity was 40.09 GW as of 31 March 2021.

The Indian government had an initial target of 20 GW capacity for 2022, which was achieved four years ahead of schedule. In 2015 the target was raised to 100 GW of solar capacity (including 40 GW from rooftop solar) by 2022, targeting an investment of US$100 billion. India has established nearly 42 solar parks to make land available to the promoters of solar plants. The Ministry of New and Renewable Energy had stated that a further 36.03 GW (as of January 31, 2021) of solar projects are under various stages of implementation and 23.87 GW are in the tendering process.

Rooftop solar power accounts for 2.1 GW, of which 70% is industrial or commercial. In addition to its large-scale grid-connected solar photovoltaic (PV) initiative, India is developing off-grid solar power for local energy needs. Solar products have increasingly helped to meet rural needs; by the end of 2015 just fewer than one million solar lanterns were sold in the country, reducing the need for kerosene. That year, 118,700 solar home lighting systems were installed and 46,655 solar street lighting installations were provided under a national program; just over 1.4 million solar cookers were distributed in India.

The International Solar Alliance (ISA), proposed by India as a founder member, is headquartered in India. India has also put forward the concept of "One Sun One World One Grid" and "World Solar Bank" to harness abundant solar power on global scale.

Solar PV panels

The differences in materials and production cause differences in appearance between each type of solar panel:

Monocrystalline solar panels:

If you see a solar panel with black cells, it’s most likely a monocrystalline panel. These cells appear black because of how light interacts with the pure silicon crystal.

While the solar cells themselves are black, monocrystalline solar panels have a variety of colors for their back sheets and frames. The back sheet of the solar panel will most often be black, silver or white, while the metal frames are typically black or silver.

Polycrystalline solar panels:

Unlike monocrystalline solar cells, polycrystalline solar cells tend to have a bluish hue to them due to the light reflecting off the silicon fragments in the cell in a different way than it reflects off a pure monocrystalline silicon wafer.

Similar to monocrystalline, polycrystalline panels have different colors for back sheets and frames. Most often, the frames of polycrystalline panels are silver, and the back sheets are either silver or white.

Thin-film solar panels :

The biggest differentiating aesthetic factor when it comes to thin-film solar panels is how thin and low-profile the technology is. As their name suggests, thin-film panels are often slimmer than other panel ty[es. This is because the cells within the panels are roughly 350 times thinner than the crystalline wafers used in monocrystalline and polycrystalline solar panels.

It’s important to keep in mind that while the thin-film cells themselves may be much thinner than traditional solar cells, an entire thin-film panel may be similar in thickness to a monocrystalline or polycrystalline solar panel if it includes a thick frame. There are adhesive thin-film solar panels that lie asclose-as-possible to the surface of a roof, but there are more durable thin-film panels that have frames up to 50 millimeters thick.

As far as color goes, thin-film solar panels can come in both blue and black hues, depending on what they're made from.

Solar panel power and efficiency ratings:

Each type of solar panel varies in the amount of power it can produce.

Monocrystalline and polycrystalline solar panels :

Of all panel types, monocrystalline panels typically have the highest efficiencies and power capacity. Monocrystalline solar panels can reach efficiencies higher than 20 percent, while polycrystalline solar panels usually have efficiencies between 15 to 17 percent.

Monocrystalline solar panels tend to generate more power than other types of panels not only because of their efficiency but because they have come in higher wattage modules as well. Most monocrystalline solar panels come with more than 300 watts (W) of power capacity, some now even exceeding 400 W. Polycrystalline solar panels, on the other hand, tend to have lower wattages.

This doesn't mean that monocrystalline and polycrystalline solar panels aren't physically the same size – in fact, both types of solar panels tend to come with 60 silicon cells each, with 72 or 96 cell variants (usually for large-scale installations). But even with the same number of cells, monocrystalline panels are capable of producing more electricity.

Thin-film solar panels:

Thin-film solar panels tend to have lower efficiencies and power capacities than monocrystalline or polycrystalline varieties. Efficiencies will vary based on the specific material used in the cells, but they usually have efficiencies closer to 11 percent.

Inverters and Charge controllers

When the sun shines on your solar photovoltaic (PV) system, electrons within the solar cells start to move around, which produces direct current (DC) energy. Circuits within the cells collect that energy for you to use in your home.

This is where your solar inverter comes in. Most homes use alternating current (AC) energy, not DC, so the energy produced by your solar panels isn't useful on its own. When your solar panels collect sunlight and turn it into energy, it gets sent to the inverter, which takes the DC energy and turns it into AC energy. At that point, your solar electricity can power your appliances and electronics or, if you're producing more electricity than you need, it can feed back into the grid.

All inverters have the same basic task: convert DC solar energy into useful AC energy for your home. However, there are three different solar inverter technologies that you can choose for your solar panel system, and each of them works slightly differently.

String inverters: a standard centralized inverter

Most small-scale solar energy systems use a string inverter, also known as a "central" inverter. In a solar PV system with a string inverter, each panel is wired together into a "string", and multiple strings (normally up to three) can be connected to your central inverter. When your panels produce energy, it all gets sent to a single inverter, which is usually located on the side of your home, in a garage, or in your basement. The inverter will convert all of the electricity from your solar panels into AC electricity for use on your property.

Pros: String inverters are the lowest-cost inverter option, and are a very durable inverter technology. They are also the easiest to maintain, because they are in an easy-to-access location.

Cons: A drop in the performance of an individual solar panel (i.e., from shading) can impact the output of all of the panels on an individual string. While multiple strings can accommodate multiple roof planes on the same inverter, string inverters may not be right for more complex system designs or roofs with regular shading.

Best for: Properties with “uncomplicated” roofs that get consistent sun throughout the day, and homeowners looking for lower-cost solar PV systems.

Power optimizers: a panel-located option to pair with a string inverter

Power optimizers can be thought of as a compromise between string inverters and micro inverters. Like micro inverters, power optimizers are located on the roof next to (or integrated with) individual solar panels. However, systems with power optimizers still send energy to a centralized inverter.

Power optimizers don’t convert the DC electricity into AC electricity at the site of the solar panel. Rather, they “condition” the DC electricity by fixing the voltage of the electricity, at which point the electricity is sent down to the string inverter. A system that pairs power optimizers with a string inverter is more efficient than one that uses a string inverter alone in shading scenarios.

Pros: Like micro inverters, power optimizers can improve the efficiency of your solar panel system if you have a complicated roof or frequent shading; however, optimizers tend to cost less than micro inverters. They optimize the output of each individual panel to mitigate the impact any one shaded panel can have, and also provide the benefit of monitoring the performance of individual panels.

Cons: A system that pairs power optimizers with a string inverter will cost more than a system with a standard string inverter option. As with microinverters, solar PV systems that include power optimizers can be more difficult to maintain.

Best for: Homeowners with a slightly less than ideal roof for solar who are willing to pay more to increase the performance of their solar panel system, but who don’t want to invest in micro inverters.

Micro inverters: high-performance at a higher cost

If a string inverter can be considered a “central” inverter, micro inverters are “distributed” inverters. Solar PV systems with micro inverters have a small inverter installed at the site of each individual solar panel. Rather than sending energy from every panel down to a single inverter, micro inverter systems convert the DC solar energy to AC energy right on the roof.

Pros: Having micro inverters at every solar panel provides performance benefits, especially for systems with a more complicated design or that experience shading. Micro inverters optimize the output of every panel at the panel to mitigate the impact of shading, and to allow for panel-level monitoring of your system.

Cons: Micro inverters cost significantly more than a string inverter, and can be more difficult to maintain or repair in the event of a problem because they are located on the roof.

Best for: Systems with solar panels that face multiple directions, homeowners who want to maximize solar production in a small space, and properties that have “complicated” roofs with gables, chimneys, or other objects that can cause shade.

Software Used

PVsyst is designed to be used by architects, engineers, and researchers. It is also a very useful educative tool. It includes a detailed contextual Help menu that explains the procedures and models that are used, and offers a user-friendly approach with a guide to develop a project. PVsyst is able to import meteo data, as well as personal data from many different sources.

With the help of this software , we can calculate the losses done by the solar PV panels.

Conclusion

The report helps me to gain different kind of knowledge regarding modeling and simulation of Solar PV system. Beside that we also came to know about different kinds of losses which is used to occur in the panels. This report summarizes the process of designing and simulation of a solar system in a cost effective way.

Thank You for this opportunity.