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Comparative Analysis of Solar PV Modules

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ABSTRACT: This paper gives design idea of optimized grid connected solar PV plant proposed at Bhopal. And a comparison has been made among results obtained after using three technologies available for modules poly crystalline silicon, mono crystalline silicon and a-siH thin film. Thus using actual data for both loads and irradiance is used for simulation of grid connected PV, done with the use of computer software package PVsyst 5.53. Analysis of results goes in favour of polycrystalline silicon technology.

I. INTRODUCTION

Contemporary technology is facing with difficulty of supply cleaner energy resources as an alternative to oil. These days' renewable energy sources are attaining increasing significance owing to its huge requirement and predicted collapse of fossil fuel. The main paybacks of renewable energy sources are: ecological settlement, energy potential and energy safety. Renewable energy will not run out forever. While other sources of energy are inadequate and are in short supply. Also it is required to have an energy source that is pollution free especially air pollution resulting from mass consumption of fossil fuels and to preserve the ecological cycle of the bio-systems on the earth.

Among all other renewable solar have its own benefits like potential of solar energy distributed in fairly equal manner and having potential to fulfil our all energy demand for subsequent thousands of year. Solar energy is the most readily available source of energy and it is free. Moreover, solar energy is the best among all the renewable energy sources since, it is non-polluting. Energy supplied by the sun in one hour is equal to the amount of energy required by the human in one year.

Although it is very costly to design or buy, it is still very cheap to maintain, also since the output of Solar photovoltaic cell is DC in nature and almost all our domestic load is alternating hence a very much important stage is required after the conversion of solar energy into electrical energy i.e. DC to AC conversion stage or inverter stage. Also the output power of PV arrays is always changing with weather conditions, i.e., solar irradiation and atmospheric temperature. Still the direct conversion of the energy from sun (solar energy) to electricity by photovoltaic cell has a number of advantages.

In the design of a solar power system (photovoltaic systems), there are certain things that need to be considered and one of them, which seems to be the most important is solar sizing (load calculation). This calculation outlines the sizing of a solar photovoltaic (PV) power system. PV systems are commonly used to supply power to small, remote installations (e.g. telecoms) where it is not practical or cost-efficient to run a transmission line or have alternative generation such as diesel generating sets. This calculation should be done whenever a solar PV power system is required so that the system is able to adequately cater for the necessary loads. The result can be used to determine the ratings of the system components (e.g. PV arrays, battery, inverter capacity etc.). Before performing the calculation, the following needs to be considered:

1. Loads required to be supported by the solar PV system.
2. Autonomy time or minimum tolerable downtime (i.e. if there is no sun, how long can the system be out of service).
3. GPS coordinates of the site (or measurements of the solar insolation at the site).
4. Output voltage (AC or DC).
5. Output power (wattage).

If the above is thoroughly considered before the calculation in the design of the PV system, an optimal output will be achieved. For optimal design and estimation of technical outputs of proposed PV project we are using computer program simulator PVsyst, designed by energy institute of Geneva, which contains all the subprograms for design, optimization and simulation of PV systems.

This paper presents a comparative analysis on PV cells performance for three different PV technologies for actual operating conditions. The result shows significant benefit of using Grid Connected PV at places where large space available at rooftop could be utilized, penetrating the existing network.

II. SOLAR PHOTOVOLTAIC ENERGY

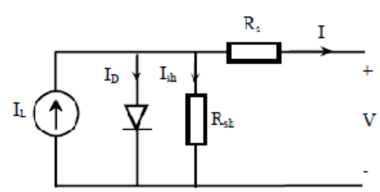
Solar photovoltaic system is used as the source of energy. Photovoltaic systems perform in surprising and useful way, They convert sun light into electricity. In clas-sical mechanical sense photovoltaic's have no moving parts to wear out, contain no fluids or gases (except for hybrid systems) that can leak out. Solar system Can operate at moderate temperatures also they are pollution free for producing electricity (although waste products from their manufacture and toxic gases in the event of catastrophic failure and disposal may be a concern). Solar system require little maintenance if properly manufactured and installed can be made from silicon, the second most abundant element in the earth's crust. They have a relatively high conversion efficiency giving the highest overall conversion efficiency from sun-light to electricity yet measured also have wide power-handling capabilities, from micro- watts to megawatts. The sun is an regular star. It has been burning for more than 4-billion years, and it will burn at least that long into the future before erupting into a giant red star, engulfing the earth in the process. The sun is responsible for nearly all of the energy available on earth. The exceptions are attributable to moon tides, radioactive material, and the earth's residual internal heat. Everything else is a converted form of the sun's energy: Hydropower is made possible by evaporation-transpiration due to solar radiant heat; the winds are caused by the sun's uneven heating of the earth's atmosphere; fossil fuels are remnants of organic life previously nourished by the sun; and photovoltaic electricity is produced directly from sun light by converting the energy in sunlight into free charged particles within certain kinds of materials.

Solar energy is the most demanding source of energy as it is freely available every-where at the same time. Now a day's Many researches and related work is going on to increase the efficiency of the solar photovoltaic array and various effort are being made to reduce its high installation cost of solar arrays, so that it can be sustainable and reliable for all kinds of application ranging from the small domestic purposes to the very large generation of hundreds of megawatts. The hybrid system which may be the combination of solar energy, hydrogen energy and wind energy can be modelled to utilize the full potential of the renewable energy sources.

III. INPUT DATA

A. PV cell modelling

PV cell modeling can be one diode or two diode model. Following equivalent circuit is the one diode model, composed by an ideal current source, a diode in parallel accounting for solar behavior in absence of solar radiation, series and parallel resistance show intrinsic resistance of the cell [9][16].



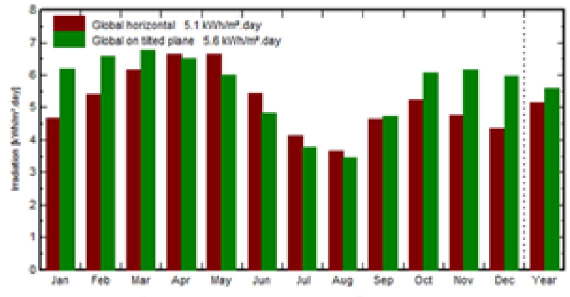
$$I_A = N_p [I_L - I_O \{\exp [q/AkT_c (V_A / N_s) + (I_AR_s/ N_p)]\} - 1] – (N_p/R_p) [(V_A / N_s)+ (I_AR_s/ N_p)]$$

Here I_A is PV array output current, I_L is solar cell photocurrent, I_O is solar cell reverse saturation current, V_A is PV array output voltage, q is charge of electron, A is P-N junction ideality factor (between 1 to 5), k is boltzman constant, T_c is absolute operating temperature of cell, N_s is number of cells in series, N_p is number of cells in parallel, R_s is series resistance of cell, R_p is parallel resistance of cell.

B. Weather data

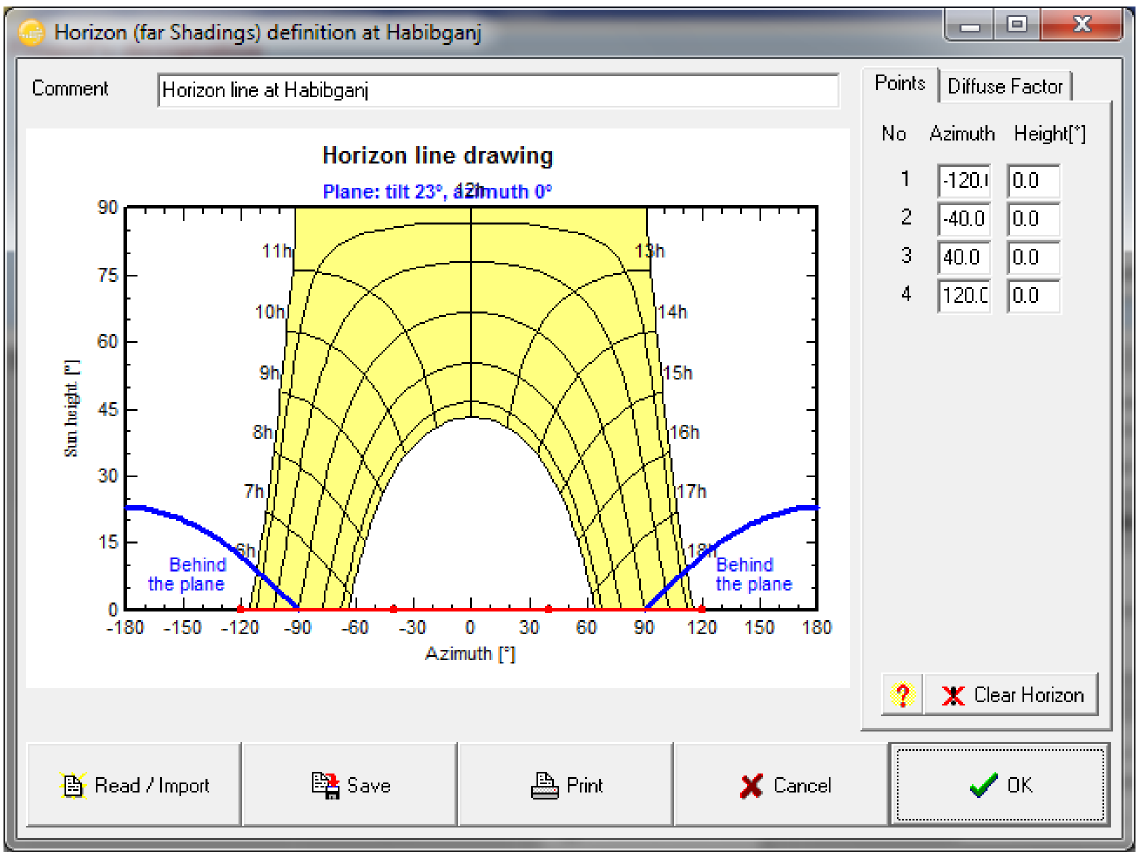
For predicting the output of PV energy system the basic input set is the meteorological data. The amount of power generated by PV array is proportional to intensity of solar radiation, but is also affected by environmental factors like ambient temperature, irradiance, spectral effects, angle of incidence and to a certain extent also on the wind velocity. A $100W_p$ solar module would produce $100W_p$ at $1000w/m^2$, air mass 1.5, normal incidence and temperature 25^0C [10][2]. But this ideal standard test condition (STC) is difficult to achieve. In a tropical country like India, radiation and temperature data both vary seasonally.

Fig. 1 shows irradiance at Bhopal located in central India. This chosen geographical site has longitude 77.75^0E and latitude 22.617^0N, altitude 319m. Meteorological data from this site is taken from NASA site.



Monthly averaged insolation and diffused radiation incident on a horizontal surface in kWh/m^2/day and monthly averaged air temperature in ^{0}C at 10m above the surface of earth is taken from site http://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?+s01#s01

Hourly synthetic data is synthesized from the program meteonorm'97. Wind velocity data in m/s is also taken from NASA site. The value of Albedo effect for urban sites is 0.14 to 0.22, we have taken average of 0.2.



IV. METHODOLOGY

For analysis and comparison, estimation of technical outputs of proposed PV project we are using computer program simulator PVsyst, designed by energy institute of Geneva, which contains all the subprograms for design, optimization and simulation of PV systems, grid connected, isolated and pumping applications. The program includes a separate database for about 7200 models of PV modules and 2000 models of inverters [1].

PVsyst is a computer software package for study, sizing, simulation and data analysis of complete PV systems. It is a tool that allows to analyze precisely different configurations and its outcome can be estimated in order to identify best technical and economical solutions and closely compare the performance of different technological alternatives for any explicit PV project.

Project design part, performing detailed simulation in hourly values, including an easy to use expert system, which helps user to define PV-field and to select the correct components. Tools perform the database meteo and component management. It also provides a extensive option of general solar tools (solar geometry, meteo on tilted planes etc.). PVsyst also gives assess in to meteorological sources available on internet [15][4].

Spacing of PV array is also very important after the PV panels are selected and installed at a certain angle. It is required that longest shadow of front line in winter should not obstruct the rear line between 9am to 3pm [14].

V. COMPARISON OF PV TECHNOLOGIES

For proposing a 100kW PV system at Bhopal, we made analysis using PVsyst software tool for three different PV module types chosen, flat PV panels are chosen. After giving required input details, we chose SMA inverter model sunny central 100, 450-820V, 50Hz, 100 kWac. A high quality inverter is characterized to include higher energy efficiency; large operating temperature ranges to make sure the inverter performs well in summer and winter without power derating [5]. Compared with multiple inverters a single central inverter is less complex, economic, more efficient, avoids problems due to mismatch and also central inverter is better when working at higher voltages, so that no further amplification is needed like multi inverter. Mismatch is intrinsic in PV modules due to cell dissimilarity but can also be formed by exterior reasons that may affect output of a PV array such as shading. For a judiciously positioned PV array, mismatch is usually considered to lead to 1-3% reduction in dc power [13]. Default loss management can be improved, specially the "module quality loss" which is determined from PV module's tolerance and the mismatch on Pmpp which is dependent on the module technology.

Here PV modules chosen are BP Solar Si poly model 4165N, SunTech Solar Si mono XTP 165-34, and NexPower a.Si:H NH100AT 5A. Following table shows the results with them.

Table1. Simulation results.

System summery	Poly Si	Mono Si	Thin film
No. of modules	608	612	960
Module area(m^2)	765	784	1512
No. of inverters	01	01	01
Nominal PV power(kW_p)	100	101	101
Max PV power(kWdc)	93.8	96.9	104
Array loss%at STC	15.3	16.8	9.1
System losses%T STC	13.6	13.8	15.1
Mismatch loss(%at mpp)	2.1	2	1
No. of modules in series	19	18	16
No. of parallel strings	32	34	60
Performance ratio%	69.7	70	75.8
Produced energy(MWh/year)	142.6	144	156
Array efficiency	10.54	10.42	5.91
System efficiency	9.14	9.02	5.05

VI. RESULTS AND DISCUSSION

We wanted to know how much electricity could be obtained and how much will be maximum power produced by PV system connected to network, proposed to be build on building roof. Space has area something over 2000m^2 and it has no objects that could cause shadows. We want to propose installation of PV panels, and for choice of panels we made a comparative study of outcomes taking different types of manufacturing technologies. Specifications of panels and inverter are chosen from those available in library of PVsyst.

Table 1 shows that using thin film PV will give highest performance ratio (PR) and highest produced energy per year. In comparing PV generation technologies conversion efficiency is the most important parameter to be determined, Array efficiency and system efficiency of poly and mono crystalline are comparable, whereas that of thin film is much lower. Poly Si requires minimum number of modules and minimum area. So it is suggested to go for poly crystalline technology.

VII. CONCLUSION

Photovoltaic energy sources with their complete related limitations are found to be one of the most hopeful solutions for the energy demand of the forthcoming years. Latest initiatives by Indian government for promotion of installments and proposals of solar PV power and favorable climatic conditions of central India at Bhopal provide a substantial reason for proposing installation of solar PV systems. In many places the solar modules are often operated inefficiently due to lack of proper pre-sizing analysis and estimation. This paper presents a simulation result on the PV system using prediction tool PVsyst for grid connected system by assessing three different PV technologies polycrystalline, monocrystalline and amorphous silicon. Decision is made in favour of polycrystalline technology of PV modules.

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