Study of Performance of Solar Photovoltaic Installations

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Abstract— Renewable energy source are turning out to be most exceptionally well known and they are getting interest in most of the commonly utilization in power sector in recent decades. The energy generated using solar photovoltaic (PV) array system is an interesting example of a pollution free sustainable power source for robust applications with minimum amount of maintenance as compared to other sources. Because of the utilizing such PV solar panels as a suitable and sustainable power resource components of PV system array such as an inverter turn out to be broadly utilized for this reason and keeping in mind the final goal is to improve the desired amount of maximum power from PV solar plants. Recently distinctive strategies are utilized to accomplish the final output power as a result it has turned into an extremely extensive to use diverse technique to accomplish desired value of the maximum power from PV solar plants. The fundamental objective of this thesis is to present an approach such that the the usage of a photovoltaic system solar plants installed at integral university campus and to measure the output performance of this solar plant system in terms analysis of the system life cycle solar radiation data of thes PV solar plants will be used to gauge and observe the yearly energy yield using MATLAB programming. The performance ratio of this PV system is also calculated based on the measured output power and the radiation intensity.

Key words: Solar Photovoltaic, Solar Power System, Renewable Energy

I. INTRODUCTION

Solar photovoltaic system or Solar power system is one of renewable energy system which uses PV modules to convert sunlight into electricity. The electricity generated can be either stored or used directly, fed back into grid line or combined with one or more other electricity generators or more renewable energy source. Solar PV system is very reliable and clean source of electricity that can suit a wide range of applications such as residence, industry, agriculture, livestock, etc

II. LITERATURE REVIEW:

According to Akash Kumar Shukla, K. Sudhakar∗, Prashant Baredar System simulation is necessary to investigate the feasibility of Solar PV system at a given location. The study focuses on the use of Solargis PV Planner software as a tool to analyze the performance a 110 kWp solar photovoltaic rooftop plant and also compares the performances of different PV technologies based on simulated energy yield and performance ratio. Solargis proves to easy, fast, accurate and reliable software tool for the simulation of solar PV system [1].

According to G.Ravi Kumar, A.Hari Prasad, N.Satya Saketha, K.Saichandana The photovoltaic solar energy (PV) is the most direct way to convert solar radiation into electricity and is based on the photovoltaic effect. The maximum power point tracking of the PV output for all sunshine conditions is a key to keep the output power per unit cost low for successful PV applications. Grid-connected PV systems always have a connection to the public electricity grid via a suitable inverter because a PV module delivers only dc power. Solar photovoltaic modules can be developed in various combinations depending upon the requirements of the voltage and power output to be taken from the solar plant [3].

According to Jayanna Kanchikere, K. Kalyankumar Energy demand in India and especially in Karnataka state is continuously increasing, however the electric utilities failed to meet this load demand. Photovoltaic (PV) solar power plant is used for larger development of solar power generation. In a solar roof top system, the solar panels are installed on the roof of any residential, commercial, institution and industrial building. The solar roof top system may come up with storage facility using battery or grid connected. In grid connected roof top solar PV system, available roof top area on the buildings is used for setting up solar power plant and the DC power generated from solar photovoltaic panel is converted to AC power using solar grid inverter and is fed to grid during day time and in night when solar power is not sufficient, loads are served by drawing power from grid [4].

K. Agbossou, M. Kolhe, J. Hamelin, and T. K. Bose proposed an AC-linked hybrid wind/photovoltaic (PV)/fuel cell alternative energy system for stand-alone applications. Wind and PV are the primary power sources of the system, and a fuel cell electrolyser combination is used as a backup and a long-term storage institute is using utility power and also diesel generator to backup for power outing. Financial analysis has been performed with present system cost based on life cycle cost of energy. Standard financial procedures have been used and the sensitivity parameters studied, mainly focusing on various factors, solar insolation variability at the site, the financial interest rates and operational and maintenance cost.

According to Majid Jamil, Sheeraz Kirmani, Mohammad Rizwan With the rapid depletion of fossil fuel reserves, it is feared that the world will soon run out of its energy resources. This is a matter of concern for developing countries whose economy heavily leans on its use of energy. Under the circumstances it is highly desirable that renewable energy resources should be utilized with maximum conversion efficiency to cope with the ever increasing energy demand. Furthermore, the global economic and political conditions that tend to make countries more dependent on their own energy resources have caused growing interest in the development and use of renewable energy based technologies. In terms of its environmental advantages, renewable energy sources generate electricity with insignificant contribution of carbon dioxide (CO2) or other greenhouse gases (GHG) to the atmosphere and they produce no pollutant discharge on water or soil and hence power generation from renewable becomes very important. Major types of renewable energy sources include solar, wind, hydro and biomass, all of which have huge potential to meet future energy challenges. Solar photovoltaic technology in one of the first among several renewable energy technologies that have been adopted worldwide for meeting the basic needs of electricity particularly in remote areas [8].

Masa-Bote and Caamaño-Martín developed a methodology to estimate BIPV electricity production under shadow. The developed methodology was validated by means of one-year experimental data obtained from two similar PV systems. The study included several weather conditions: clear, partially overcast and fully overcast sky9.

Mei et al. estimated the thermal parameters which describe the performance of ventilated photovoltaic facades integrated into buildings. The method allowed the heat transfer coefficients to be obtained from data measured on an operational ventilated photovoltaic facade. The performance of PV systems is realized by comparison with a corresponding reference system. The simulations require input of the horizontal solar radiation and the ambient temperature data, both on a monthly basis, which have been obtained from PVGIS (0000) [10].

According to Mevin Chandel, G.D. Agrawal, Sanjay Mathur, Anuj Mathur The potential and the cost-effectiveness of a solar photovoltaic power plant for meeting the energy demand of garment zone at Jaipur (India) is analyzed. Also, the energy demand of garment zone for year 2011has been estimated (2.21 MW) and the design of the solar PV power plant of 2.5 MW capacity has been proposed, which requires about 13.14 acres of land area. Looking at the scarcity and cost of the land near the city, an off-site proposal for the power plant has also been considered and compared with the on-site option. For the onsite solar PV power plant internal rate of return (IRR) is 11.88%, NPV @ 10% discount rate is 119.52 million INR, simple payback period is 7.73 years and discounted payback period @10% is 15.53 years, while for the off-site power plant IRR is 15.10%, NPV is 249.78 million INR, simple payback period is 6.29 years and discounted payback period is 10.14 years. Levelized cost of energy is Rs. 14.94 and Rs. 11.40 per kW h for on-site and off-site solar PV plants respectively @ 10% discount rate, which is quite attractive [11].

According to Piyush Charan, Mohammad Maroof Siddiqui, Nupur Mittal, Zohaib, Hasan Khan Energy scavenging (also known as energy harvesting or ambient power) is a major challenge for scientists to overcome in small, wireless autonomous electronic devices like those used in wearable electronics and wireless sensor networks. As of today, solar energy is the cleanest vitality source available in abundance. This fact has interested the researchers, industries and consumers to develop technology that can harvest solar energy and can possibly convert to useful electrical energy. The enhancing research in photovoltaic (PV) application has demonstrated that photovoltaic renewable vitality is considered as a standout amongst the most encouraging source to support the increasing demand in electrical utilization [12].

III. Methodology

Solar power systems provide a continuous, reliable power solution that's easily deployed, cost-effective and requires little maintenance. Solar Power Systems are complete, fully integrated solar power supplies designed for site loads requiring 12, 24 or 48 volts DC. Each solar power system provides safe and reliable power generation without the need and expense of installing utility power. The sealed, maintenance free batteries are designed for deep cycle operation and extended life in solar applications. The aluminum array support structures and battery enclosures are strong yet lightweight and corrosion resistant for harsh marine or severe weather locations. Solar power system is the one which can be conveniently installed and transported. It also has the perfect characteristics of self-control, self-protection, needing no attention, compact structure, elegant outline and convenience for using etc.

A. The Basic Components of a Solar Power System

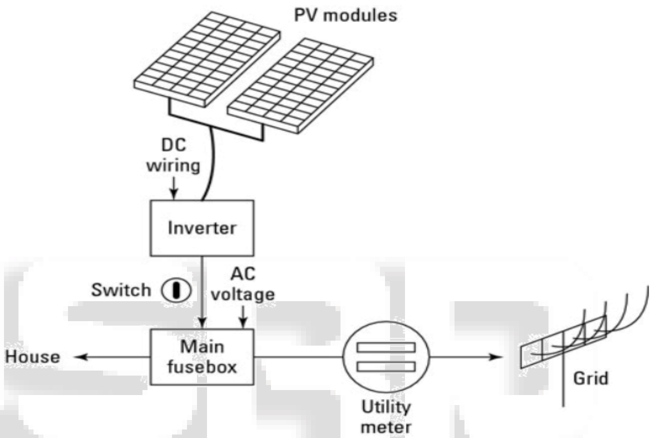


Fig.-The solar PV-generated power is connected to home's grid at main fuse box

Solar intertie photovoltaic (PV) systems are not particularly complex. First there are panels, which collect the sunlight and turn it into electricity. The DC signals are fed into an inverter, which converts the DC into grid-compatible AC power. Various switch boxes are included for safety reasons, and the whole thing is connected via wires and conduit. In PV system terminology, everything besides the PV modules themselves is called "balance of system" or BOS.

System Components: Basic components of grid-connected PV systems with and without batteries are:

- Solar photovoltaic modules
- Array mounting racks
- Grounding equipment
- Combiner box
- Surge protection (often part of the combiner box)
- Inverter
- Meters – system meter and kilowatt-hour meter
- Disconnects:-
  - Array DC disconnect
  - Inverter DC disconnect
  - Inverter AC disconnect
  - Exterior AC disconnect
- If the system includes batteries, it will also require:
  - Battery bank with cabling and housing structure
  - Charge controller

- Battery disconnect

B. Solar Photovoltaic Modules or Solar Panels or Solar Electric Panels or Pv Modules

PV (photovoltaic) panels are the most common type of panel, especially for residential installations. They are made from three layers:

1) The N-Layer – silicon that is mixed with phosphorus
2) The P/N Junction – pure silicon
3) The P-Layer – silicon that is mixed with boron

C. The Panels or Solar photovoltaic modules

When sunlight strikes the N-Layer, it knocks electrons loose. These electrons pass through the P/N junction (which is a one-way junction) into the P-Layer. This creates an electrical field that then drives the electrons that have been "knocked off" from the silicon, creating an electric current. Solar panels provide electricity from sunlight. They are typically made of silicon crystal slices called cells, glass, a polymer backing, and aluminum framing. Solar panels also have voltage ratings.

IV. Results and Discussion

This demonstrates the performance based analysis of solar array based electric generation system in terms of generation efficient in a monthly basis for different months in a year. Results are generated using programming on MATLAB by considering various data records related to power generation and losses specification of solar cell installed in a building. The data that is used is given below:

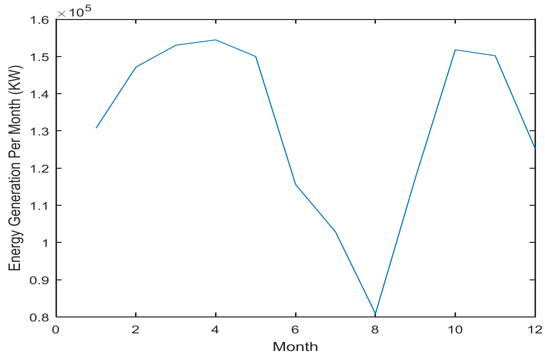
Observed Data for 100 KW solar power plant

Months	Total Derating Factor	Energy Yield (kWh)	Monthly Specific Yield (kWh/kW)	Monthly Performance Ratio	Plant Load Factor/ CUF based on AC nominal Capacity	Generation loss due to temperature	Total
January	0.77	142540	148.9	0.86	0.176	0.085	138955
February	0.72	141094	144.6	0.83	0.219	0.096	152524.66
March	0.77	172338	155.4	0.81	0.206	0.125	163737.19
April	0.79	138717	135.6	0.68	0.215	0.14	143366.33
May	0.76	132299	151.0	0.68	0.202	0.157	156394.3
June	0.69	122510	107.8	0.69	0.161	0.129	103875.16
July	0.7	101997	98.68	0.82	0.138	0.109	91834.203
August	0.81	93220	96.89	0.84	0.109	0.103	83735.861
September	0.83	121378	97.43	0.8	0.163	0.125	114847.14
October	0.79	148630	125.2	0.72	0.204	0.103	128402.98
November	0.73	153334	140.7	0.82	0.209	0.094	140980.67
December	0.85	136526	138.1	0.73	0.168	0.088	130510.44
Annual	0.77	142540	148.9	0.86	0.176	0.085	138955.28

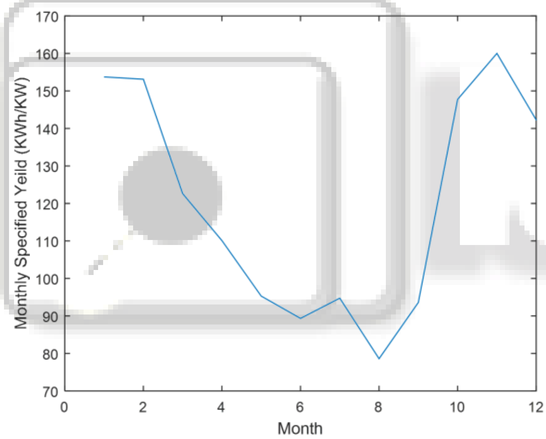
Month	Days	Average Daily solar radiation (GHI) (kWh/m2/day)	Day time average temperature (deg C)	Cell Temperature (deg C)	Temperature Derating Factor	Average Shadow Loss	Derating Factor for shadow loss	Derating Factors for Other Losses
January	31	5.3	24.1	46.3	0.98	0.11	1	0.86
February	28	6	25.9	51.22	0.83	0.12	0.99	0.79
March	31	6.2	30.1	48.28	0.97	0.05	1	0.94
April	30	6.8	32.6	62.7	0.87	0.04	0.94	0.82
May	31	6.3	33	62.02	0.89	0	1	0.8
June	30	4.4	30.8	61.84	0.96	0.01	0.96	0.84
July	31	4.6	25	51.73	0.84	0.01	0.93	0.86
August	31	4	23.8	52.44	0.86	0.03	0.94	0.8
September	30	5.1	30.7	48.13	0.87	0.05	0.98	0.96
October	31	5.1	24.8	48.24	0.94	0.04	0.91	0.84
November	30	6.4	21.3	50.7	0.96	0.25	0.95	0.83
December	31	6.2	18.9	44.03	0.84	0.21	0.91	0.79
Annual	365	5.3	24.1	46.3	0.98	0.11	1	0.86

Using above data given in the table 1 various performance indices for demonstrating the plant performance is performed in monthly basis.

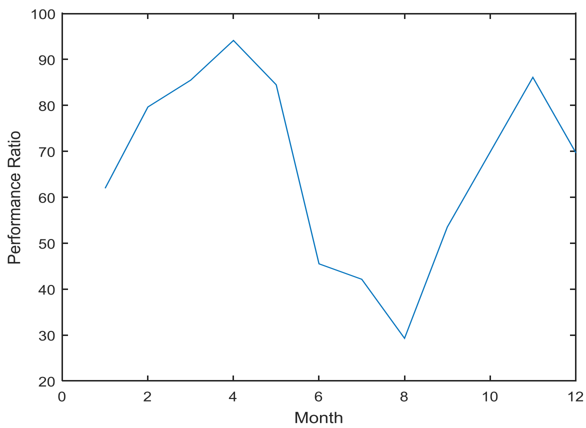
a) Energy generation in a month=panel rating x efficiency of cell x days x hour
b) Specified Yield in a moth=KWh/KW=Actual Energy Yield / Nominal Solar Power
c) Performance Ratio={Measured output in KW/installed plant capacity}x{measured radiation intensity/1000}
d) CUF (capacity utilization factor)=Energy measured(KWh)x365 x 100kw x 24



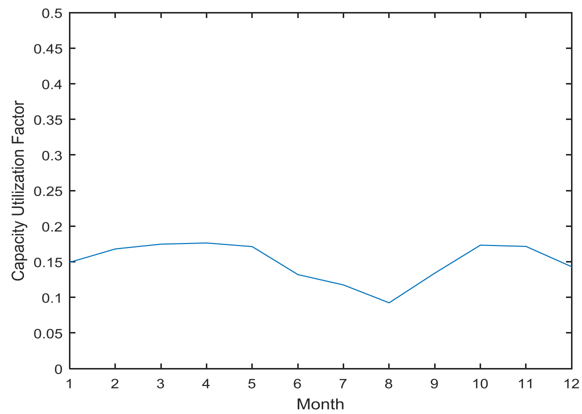
Energy generation at different months



Monthly Specified Yield at different month



Performance ratio at different month



Capacity utilization factor at different month

V. Future Scope of Installing Grid Interactive SPV Plant

1) To promote the grid connected SPV rooftop and small SPV power generating plants among the residential, community, institutional, industrial and commercial establishments.
2) To mitigate the dependence on fossil fuel based electricity generation and encourage environment friendly Solar electricity generation.
3) To create enabling environment for investment in solar energy sector by private sector, state government and the individuals and to create enabling environment for supply of solar power from rooftop and small plants to the grid.
4) To encourage innovation in addressing market needs and promoting sustainable businesses models and ensures employment opportunities.
5) To provide support to channel partners and potential beneficiaries, within the framework of boundary conditions and in a flexible demand driven mode and to create a paradigm shift needed for commoditization of grid connected SPV rooftop applications.
6) To support consultancy services, seminars, symposia, capacity building, awareness campaigns, human resource development, etc. and to encourage replacement of diesel, wherever possible.

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