Simulation Model of Grid Connected Rooftop Solar Power Plant

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Abstract- *Solar rooftop PV system is an attractive alternate electricity source for households. The potential of solar PV at a given site can be evaluated through software simulation tools. This study is done to assess the feasibility of grid-connected rooftop solar photovoltaic system for a household building in holy city Ujjain, India. The study focuses on the use of various simulation software, PV*SOL, PVGIS, Solar GIS and SISIFO to analyze the performance of a grid-connected rooftop solar photovoltaic system. The study assesses the energy generation, performance ratio and solar fraction for performance prediction of this solar power plant. PV*SOL demonstrates to be easy, fast, and reliable software tool for the simulation of a solar PV system.*

Keywords- Solar Photovoltaic PV*SOL SOLARGIS PVGIS SISIFO Energy Grid

I. INTRODUCTION

Solar energy is the primary source of energy that affects physical formations in the space and atmosphere system. The solar energy that falls on the earth every year is about 160 times higher than the fossil fuel reserves that have been determined up to now on Earth. Moreover, energy production from fossil, nuclear, and hydroelectric plants produced in a year is 15,000 times less than solar energy. Just as the energy can come into existence like chemical, potential, kinetic in the natural sciences, it may take place in nature in different forms such as the sun and the wind. However, electrical energy is generally obtained by conversion from different energy forms, and the energy sources that make up the first step of this process are mostly fossil fuels. Fossil fuels account for about 80% of the world's total energy production. The burning of fossil fuels releases harmful gasses such as CO2, SO2, CO, NO2, and NO3. The release of these gasses triggers irregular climate changes. For all these reasons, the demand for environmentally friendly, renewable energy systems has increased over the last decade. In our modern world, there is a parallelism between the level of development and the economic situation of society and energy production/consumption. Energy costs create an undeniable impact on the economic well-being of a country. Across the world, population and, energy consumption in parallel are dramatically ascending after the industrial revolution. At any cost, the world has transition immediately to green energy, of which renewable energy sources (RESs) are preferred. The two main resources for very large scale renewable energy (RE) harvesting are the wind and solar resources. The wind resource may show variability and be limited, but the harvesting of solar resources is easier and more common than the wind. Therefore, solar energy is a suitable technology for both small and large scale applications. It is clean energy according to the principle of sustainability. In particular, solar energy is the fastest- growing energy technology in the world. Solar energy includes the two main way as photovoltaic (PV) and concentrating solar power (CSP). PV is unquestionably more applicable than CSP. Therefore, generating energy with solar PV is the most trending application in terms of using RESs across the world. Recently, in developing countries across the world, decisions are being debated and a transitioning to the dependence from fossil fuels to RES. Among renewable energy, especially the PV systems play a vital role in this transition for PV applications. In the literature, in terms of solar energy is examined, it was observed that studies on the rooftop solar photovoltaic applications especially in faculty buildings are not very extensive.

In electricity generation, India is presently the sixth-largest country and accounts for approximately 4% of the world's total annual electricity generation. India is ranked sixth in annual electricity consumption. Fossil fuel based electricity generation systems are responsible global warming and therefore affecting the environment. Therefore, it is necessary to generate electricity by some renewable sources which are environment friendly in nature. According to data released by the Ministry of New and Renewable Energy (MNRE), total solar energy installations in India have reached 4.1GW. A total of 358MW of grid-connected solar energy capacity has been installed in the first four months of this financial year 2015/16, with a target to deploy 1.4GW by the end of the fiscal year. In the off-grid solar PV installations, a total of 234MW has been installed. Solar power technology remains the fourth-largest in terms of installed capacity among all renewable energy technologies in India.

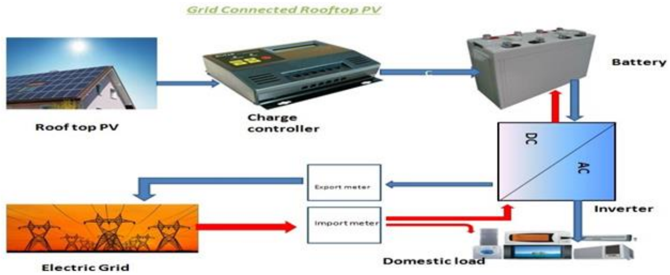

Fig.1. Investment options in off grid and on grid connected rooftop

II. PERFORMANCE PARAMETERS

1. Array yield

Array yield is equal to the time for which the solar photovoltaic plant has to operate with nominal solar power Po to generate array energy EA (Direct Current). Its units are kWh/d∗kWp. YA = Ea /PO where, Array energy output per day EA = Idc∗Vdc∗t (kWh), Idc = DC current (A) Vdc = DC voltage

(V) P0 = Nominal Power at STC.

2. Final Yield (YF)

It is the ratio of net energy output of the solar photovoltaic system to the rated power of the installed solar photovoltaic system. Final yield provides the number of hours required by the solar photovoltaic system to operate at rated power to the yield the net energy. It is the normalized value of system energy output with respect to system size. Final yield estimates the solar photovoltaic system performance in terms of solar radiation resource.

3. Reference Yield (YR)

It is the ratio of total in-plane solar insolation to the reference irradiance of solar photovoltaic system. Reference radiation is considered as 1000W/m2 at STC. Reference yield normalizes the available solar radiation with reference radiation. It measures the solar energy input for required output. It generally depends on site geographical condition, weather conditions and orientation of solar photovoltaic array. Reference Yield for the solar photovoltaic plant is the actual energy plant would have been generated under STC 1000W/m2, 250C,1.5 Air mass and no wind.

4. Performance Ratio (PR)

Performance ratio is a dimensionless quantity and is defined as the ratio of final yield to the reference yield. Performance Ratio gives details about the day impact of overall system losses on the rated output. The losses include solar photovoltaic array losses, tilt angle losses, loss due to dust, loss due to shade, loss due to variation in module temperature. Performance ratio has effect on system down time and failure of components. It is used to analyze the performance of solar photovoltaic system annually and decrease in performance ratio is an indicator of the degradation of the system performance. Performance ratio will indicate how close the solar photovoltaic plant is able to approach the ideal performance in real time conditions.

5. Capacity Utilization Factor (CUF)

Capacity Utilization Factor (CUF) is defined as the ratio of actual energy output of the solar photovoltaic system to the energy output system would generate if it works at rated power for 24 Hrs/day/month/year. It is a dimensionless quantity and used to evaluate the performance of solar PV units. CUF = Energy measured (kWh)/(365 ∗ 24 ∗ installed capacity of the plant). To evaluate the various losses involved in solar photovoltaic system it is necessary to calculate array yield, capture losses and system losses. Capture losses includes thermal loss which depends on solar module temperature and other losses which depends on losses due to dust accumulation, variable irradiation etc. System losses include DC and AC cabling losses.

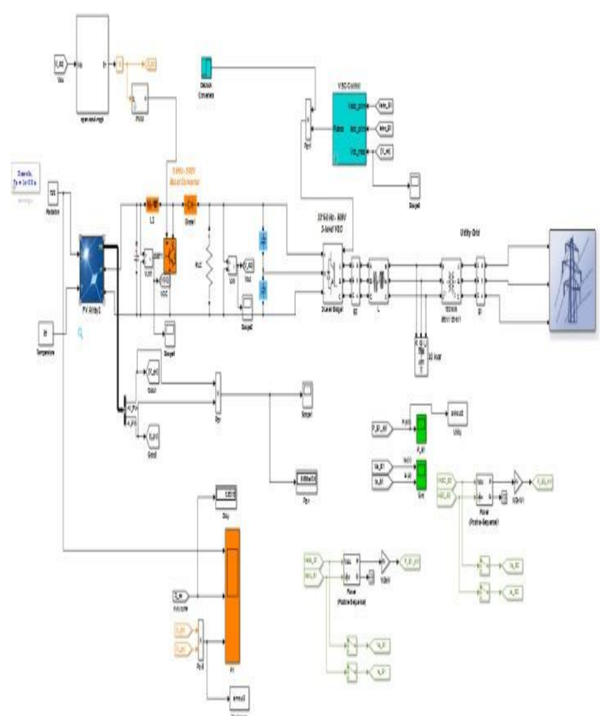

Fig.2. Simulation model of Grid connected Rooftop solar power plant

6. Energy output or energy fed to utility grid

The energy generated by the solar photovoltaic system is the measure of energy across the inverter output terminals for every minute. It is defined as the total daily monitored value of AC power output and the monthly AC energy generated.

III. ROOFTOP SOLAR POWER DESCRIPTION

A brief description of each of the components is presented below:

PV Modules – The PV modules are the devices that actually convert solar energy to electricity. PV modules are made from PV cells, which are most commonly manufactured using silicon; other materials used include cadmium telluride (CdTe), copper indium gallium selenide/sulfide (CIGS). Generally, silicon-based solar cells provide higher efficiency (15% - 20%) but are relatively costly to manufacture, whereas thin film cells are cheaper but less efficient (5% - 10%). Since different types of PV modules have different characteristics (in terms of efficiency, cost, performance in low irradiation levels, degradation rate), no single type is preferable for all projects. Good quality PV modules generally have a useful life of 25 to 30 years. It is important to assess the quality of PV modules for use in projects.

Inverter –The inverter converts the DC power produced by the PV modules into AC power. The AC power is then either injected into the grid or consumed on-site. For grid-connected rooftop solar applications, inverters come in standard sizes ranging from a few hundred watts to hundreds of kilowatts, depending on system size. These inverters are usually string inverters, which have smaller capacities (typically < 90 kW), as opposed to central inverters, which have larger capacities (typically > 300 kW) and are generally used in MW-scale solar PV projects. There are many different types of inverters in the market; selection of an inverter for a project depends on a number of factors, including application, size, cost, function, usage, etc. Inverters also perform energy monitoring functions. From the technology perspective, inverters have matured to a large degree and opportunities of cost reduction through technology innovation are not expected in the market. Top-of-the-line inverters offer efficiencies in the range of 97% - 99%.

Module Mounting Structure– The mounting structure, or racking system, is the support structure that holds the PV panels. PV modules are generally mounted on support structures in order to more efficiently capture solar insolation, increase generation, and have a stable structural support. Mounting structures can be either fixed or tracking. Fixed tilt mounting systems are simpler, low-maintenance and cheaper than tracking systems. Due to these reasons, fixed tilt mounting structures are the norm in India. Mounting structure designs are highly specific to the site, and over time have seen improvement in durability and reduction in costs. Cost reduction is mostly achieved through designs that use less material (mostly steel or aluminium). Mounting structures for rooftop solar PV installations also require compliance with regulations or guidelines associated with the structural aspects of the roof, such as load-bearing capacity, wind loading, etc. 4. Balance of System – Balance of system (BoS) consist of cables, switchboards, junction boxes, meters, etc. Electricity meters record the amount of electricity consumed and/or produced (in kWh and kVAh) by a customer within a premises. In addition to the metering of the net energy consumption/production of a grid-connected rooftop solar PV system, most regulations in India on metering also stipulate the location of a n energy meter for measuring the generation of the PV array.

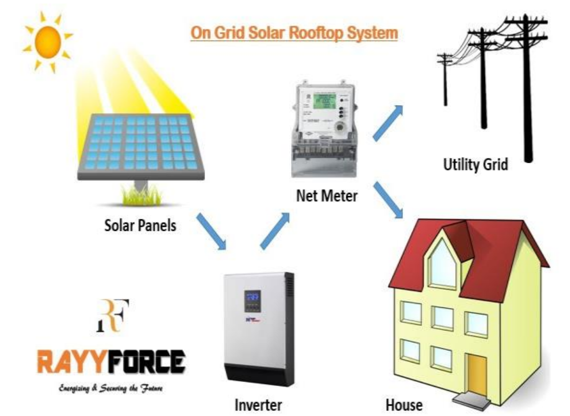

Fig.3. Off-Grid Solar Power Plant

IV. CONCLUSION

In this paper, the installation of solar panels on roof tops is being proposed to reduce the energy consumption from the non-renewable sources. Solar power has the flexibility that it can be used anywhere and everywhere. The work is to be carried out in a college building with an aim to cater to the electricity demand through the solar power. It was concluded that the initial set up of solar power generation is costly but it is a viable solution for sustainable operation of the building.

It can be a great method to not only reduces electricity bills, but also the generated power can be routed to places whichn have a shortage of electricity.

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