Analysis of Solar Power Potential with Variations in Panel parameters

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Abstract: Energy extracted from solar is one of the major renewable energies currently in use, wherein energy is extracted directly from the sun radiation using photovoltaic modules, but due to intermittent nature of solar availability and other different off-weather conditions, there are many challenges to provide reliable power through SPV systems. The SPV systems are basically either Grid connected or off grid. This report discusses about a complete off grid solar SPV system for different day to day applications suitable for remote locations. The report includes discussing about various aspects of reusable energy, mainly energy extracted from solar and about possible implementation of such a system in any household to rectify the electrical energy deficiency of the planet (in under developed and developing nations of the world) in special context to North Eastern Region. Chapter-I reflects information about Renewable power scenario worldwide especially in North-Eastern region of India, Energy consumption and production in India from various renewable sources, Energy demand and energy supply in India, Solar PV energy conversion process, also about the government initiatives in this field of energy specially in the renewable sector to nullify the energy demand and supply gap and electrification of the country.

A case study was done to estimate solar radiation potentials for last three years (2020, 2021 and 2022) of five random districts from Northern, Eastern, Western, Southern and North-Eastern regions of India. Chapter II shows another case study was conducted where consumer energy demand has been estimated for three different household. From the study, battery rating, solar panel, charge controller rating, inverter rating, cable size determination were carried conducted for designing of SPV system for complete off-grid application.

Keywords: Performance Ratio; Slope angle

1. RENEWABLE POWER SCENARIO

In Global scenario, the CO2 emission from fossil fuels and average industry use fuels is nearly flat, rises only 0.2% in 2020. In the previous years it was found to be 2.2%, showing a great improvement in improving Global warming [2]. This improvement is due to many factors which are associated with each other. Despite declinations of the coal prices in previous, the global price for oil and natural gases increases in exponential way make a big challenge for uplifting the use of renewable energy sources and conversions, especially in transport sector like cars, truck, buses etc [1].

The use of renewable energy is mainly in the form of electricity in India. As per the record from National Power Portal as of March, 2020 the installed electricity capacity stands at 370784.12 MW. The renewable sources contribute a total of 123339.26 MW which is around 33.26% of the total energy capacity of India. Also, the RES capacity stands at 87669.19 MW. The total installed capacity in electrical energy in the north-eastern region of India estimates at about 4690.34 MW. The hydro contributes at around 1727 MW, Small Hydro Power contributes around 286.34 MW [2].

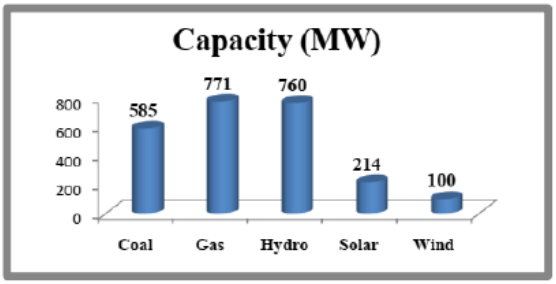

Figure 1: Installed electricity (renewable) capacity in North-Eastern region of India [2]

2. SOLAR PHOTOVOLTAIC ENERGY CONVERSION PROCESS

The conversion from energy from sun to electricity is based on photovoltaic effect. The light energy is

converted to other form of energy that is electrical energy. High configured Solar cells with semiconductor materials are used for this energy conversion phenomenon. Here an artificial electric field is created by help of p-n junction which is constant in nature [3].

A standard PV cell is a thin semiconductor sandwich, with two layers of highly purified silicon. Photovoltaic arrays are nothing more than huge matrices of interconnected semiconductor sandwiches [11]. Usable PV systems comprised all sorts of equipment that protects the user from electrical shock, stores the electricity in battery banks, and converts the direct current (DC) into alternating current (AC), which is what people use in their houses [12].

3. ENERGY PRODUCED AND CONSUMED IN INDIA

India is regarded as one of main countries with large production of energy from renewable sources. As of 31st March 2020, 35.86% of India's installed electricity generation capacity is from renewable sources, generating 21.22% of total utility electricity in the country [2]. The generation of electrical energy has although changed its course from generation from the conventional sources to non-conventional source, still significant amount of energy for the country is generated from conventional resources like coal, natural gas, oil etc.

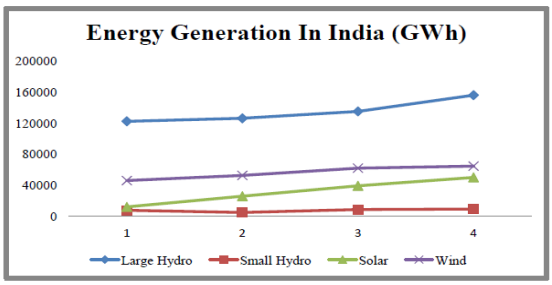

Figure 2: Energy Generation in India (GWh) [2]

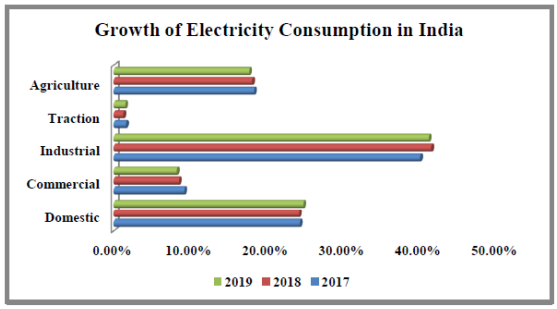

Figure 3: Energy Consumption in India [3]

Energy Consumption pattern in India from the period 2018 to 2019 (sector wise) is listed in Figure 2. From the consumption pattern, it is clear that industrial sector has the highest uses during these times.

3.1 Power Supply Positions in India

India is currently facing a peculiar problem of demand-supply gap in power. The power scenario in India continues to be grim even as the country gears up to expand its power supply to bridge the large demand- supply gap [8]. Economic growth, increasing prosperity and urbanization, rise in per capita consumption, and spread of energy access are the factors likely to substantially increase the total demand for electricity. Thus there is an emerging energy supply demand imbalance [4].

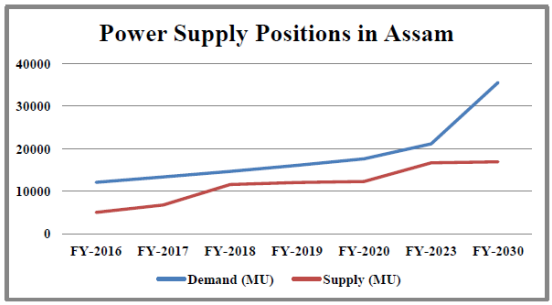

Figure 4: Power Supply Positions in Assam [3]

4. SOLAR RADIATION VARIATIONS WITH VARIATION IN PR IN ASSAM

Total solar radiation is the sum total of beam and diffused radiation on a given surface. If the surface is horizontal then total solar radiation is referred to as global radiation. Radiation data for solar electric (photovoltaic) systems are often represented as kilowatt-hours per square meter (KWh/m2) [6]. This report lists five random districts across various states of India in order to show the solar radiation pattern around India. The districts are as follows: Jorhat, Sivasagar, Golaghat and Kamrup. These are five major districts of Assam. Here the analysis have been carried out considering the variations in performance ratio and slop angles. The performance ratio is varied in between 0.5 to 0.9 whereas the slope angle varies between 0 degree to 45 degree.

4.1. Solar Variations in Jorhat (Assam) with variations in PR

Solar radiation values have been collected for Jorhat, Assam. The performance ratio (PR) is the loss coefficient which is responsible for variations in

energy output from use of solar panel and is varied from 0.5 to 0.9.

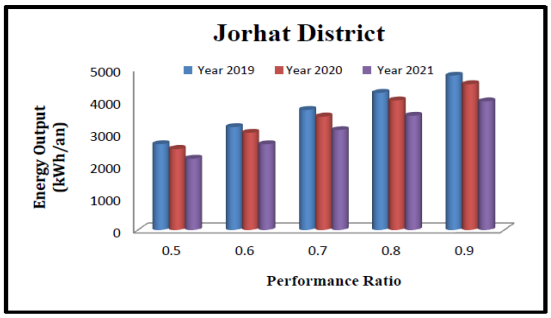

Figure 5: Variation of Solar output with PR.

4.2. Solar Variations in Sivasagar (Assam) with variations in PR

Radiation from solar data has been collected for Sivasagar, Assam. The performance ratio (PR) is varied from 0.5 to 0.9 and the corresponding solar output is shown in figure 6.

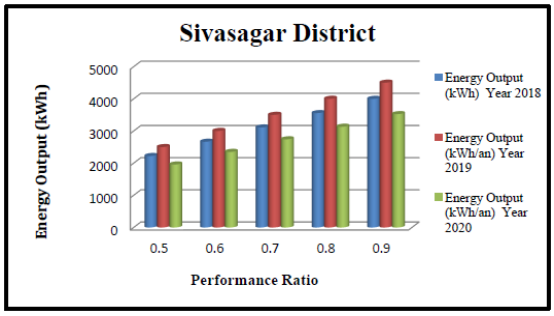

Figure 6: Variation of Solar output in Sivasagr with PR

4.3. Solar Variations in Sivasagar (Assam) with variations in PR

Radiation from solar data has been collected for Golaghat, Assam. The performance ratio (PR) is varied from 0.5 to 0.9 and the corresponding solar output is shown in figure 7. PR 0.9 has the highest power output as compared to other PR. PR 0.5 has the lowest.

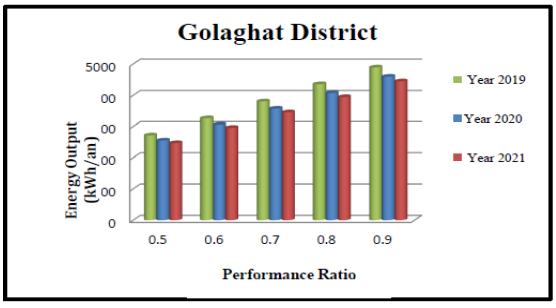

Figure 7: Variation of Solar output in Golaghat with PR

4.4. Solar Variations in Kamrup (Assam) with variations in PR

Radiation from solar data has been collected for Kamrup, Assam. The performance ratio (PR) is varied from 0.5 to 0.9 and the corresponding solar output is shown in figure 8. PR 0.9 has the highest power output as compared to other PR. PR 0.5 has the lowest.

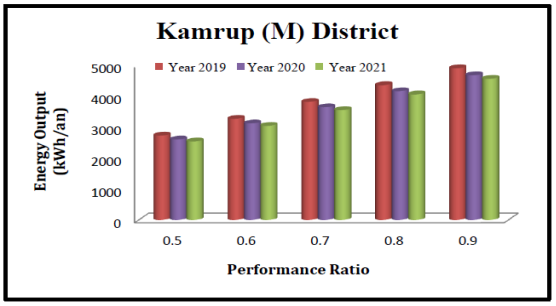

Figure 8: Variation of Solar output in Kamrup with variation in PR.

5. SOLAR RADIATION VARIATIONS WITH VARIATION IN SLOPE ANGLES IN ASSAM

The slope angle plays an important role in variation of solar power output. We have considered four districts of Assam for the calculation of output Solar for different slope angles. The slope angles are taken as 25 degree, 35 degree and 45 degree. The variations were calculated for the year 2021.

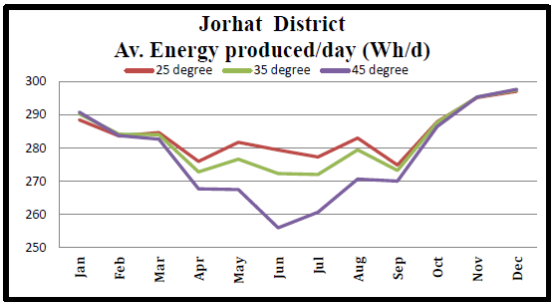

Figure 9: Variation of Solar output(produced) in Jorhat with variation in slope angle.

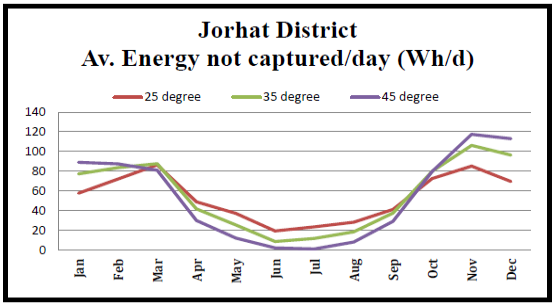

Figure 10: Variation of Solar output (lost) in Jorhat with variation in slope angle.

Here two components are taken for calculations- Average Energy captured (per day) and Average Energy not captured per day. In both the cases the variations in output power has been investigated for the year 2021.

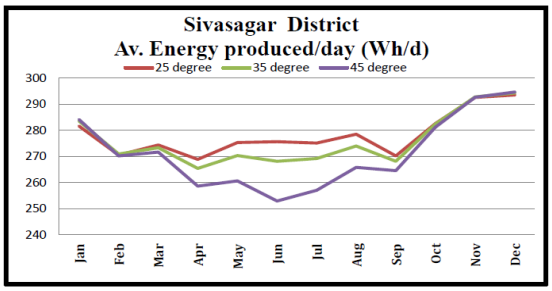

Figure 11: Variation of Solar output (Produced) in Sivasagar with variation in slope angle.

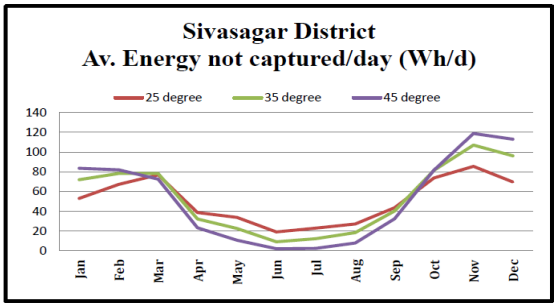

Figure 12: Variation of Solar output (Lost) in Sivasagar with variation in slope angle.

During the months of April to September it is found that the solar power intensity is very low with comparison with other durations. It is highest in the months of November and December.

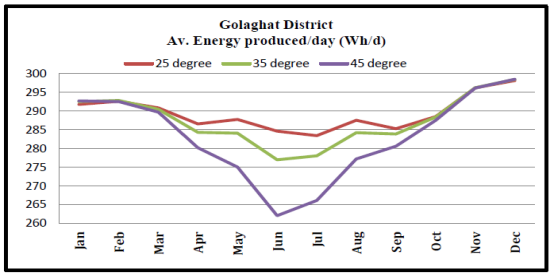

Figure 13: Variation of Solar output (Produced) in Golaghat with variation in slope angle.

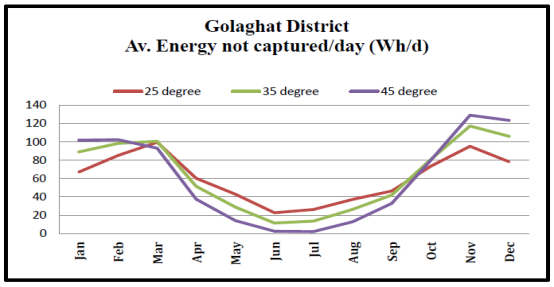

Figure 14: Average Energy not captured per day

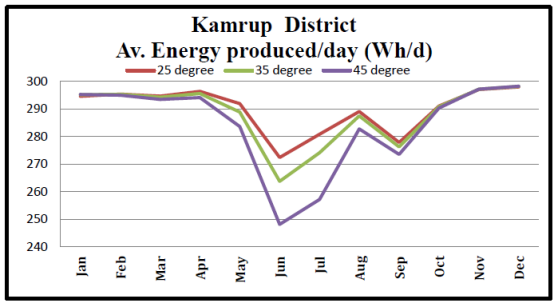

Figure 15: Average Energy output (produced per day) of Kamrup District with variations in Slope

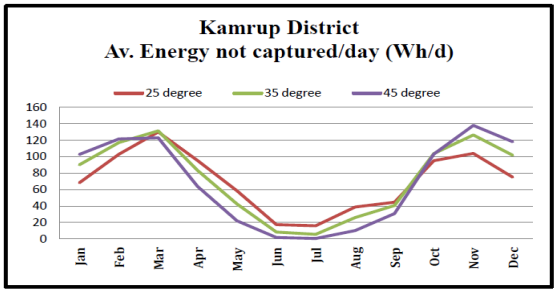

Figure 16: Average Energy not captured per day of Kamrup District with variations in Slope

The same sequence is followed for all the districts with increasing pattern in January to March and September to November.

6. CONCLUSIONS

Greater solar radiation results in larger amount of electric energy production over a specific area. If solar radiation is greater over an area then the lower number of solar PV systems can generate the necessary amount of energy, resulting in lower amount of land or space used for generation of electricity. On the other hand a place with lower value of solar radiation requires large number of same capacity PV systems to meet the same necessary demands of energy.

From the investigation in the paper, we can conclude that a very high amount of energy is lost due to the wrong configurations and placing of panels. At slope angle 45 degree, the lost is minimum during the middle months whereas maximum values occur in Jan-Feb and Nov-Dec. Further investigation can be performed with change in seasonal paramers.

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