ISBN 978-9937-0-4872-9
September 27, 2018

ANALYSIS OF THE PHOTOVOLTAIC SOLAR ENERGY CAPACITY OF ROOFTOPS IN GORKHA BAZZAR NEPAL

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Abstract*—As the fossil fuel energy resources are becoming increasingly scarce, it is no doubt that the development of renewable energies has become a major priority in the world today. Nepal, with a mean solar radiation of 4.7 kWh/m2 per day and a surface area of 1, 47,181 km2, is the region in south East Asia with the highest solar energy potential. This research study determined the solar energy potential in Gorkha Bazzar of Gorkha Municipality of Nepal for grid-connected photovoltaic systems installed on rooftops. A methodology was developed, which first involved a description of building characteristics, followed by the calculation of the useful roof surface area where photovoltaic arrays could be installed. In the next phase of the study, the mean solar irradiation characteristics were defined as well as the technical parameters of the photovoltaic systems. Finally, with all these factors, an estimation of the amount of electricity that could be potentially generated per year by solar panels is performed.

Keywords: Renewable Energy, Solar Energy, Solar Irradiation, Grid Connection

I. INTRODUCTION

Solar energy is becoming more economically attractive as technologies improve and the cost of electricity generated by fossil fuels rises. By 2020, hundreds of billions of dollars of investment capital will probably boost global solar-generating capacity 20 to 40 times higher than its current level [1]. In particular, the direct conversion of sunlight into electricity by solar photovoltaic (PV) technology possesses great untapped potential and represents a technically viable and sustainable solution to energy demands. Solar power offers many advantages in the generation of electricity. It has zero raw fuel costs, unlimited supply and no environmental issues such as transport, storage, or pollution. Solar power is available everywhere, even on the moon [2].

Nepal, with a mean solar radiation of 4.7 kWh/m2 per day and a surface area of 1, 47,181 km2, is the region in south East Asia having tremendous amount of solar energy potential [3]. The region of Gorkha is located in central region of Nepal and is in state number 3. At the time of the 2011 Nepal census it had a population of 49,272 people living in 13,127 individual households [4]. For this research we have taken the population of ward no 6 of Gorkha Municipality which has altogether 550 household.

Furthermore, the large number of buildings construction in recent years in the ward and the deficit of conventional energy sources justify any initiatives conducive to the construction of self-sustainable buildings that are capable of producing their own energy for illumination, HVAC, electrical appliances, etc. The installation of building-integrated photovoltaic systems is a viable option for the achievement of energy sustainability. So this research is focused on the estimation of the solar energy potential from the solar panel installed in the roof top of the buildings of the ward of Gorkha Municipality. This research would be a stepping stone for the achievement of the energy sustainability in the Municipality and can be replicate the concept for other ward of gorkha district.

II. METHODOLOGY

The Primary objective of this research is to estimate the energy capacity of photovoltaic solar energy systems that could be installed on the rooftops of buildings in a ward of Gorkha Municipality of Gorkha district Nepal. In order to achieve this research goal, we carried out the following actions. The buildings was described in terms of construction data provided by the municipality. After getting the data, we have performed a sample survey in the buildings and get the information about the useful roof surface area where we can install the photovoltaic solar panel. We selected a representative sample of buildings, and statistically analyzed their roof surface area.

The geometric characteristics of three building types (i.e. RCC rooftop type residential building, Fabric or metallic roof top type residential building and Commercial or Institutional building. This made it possible to obtain the useful roof surface where photovoltaic arrays could be installed. The photovoltaic solar array was then designed, and the energy generation potential was calculated for each of the buildings using the following relation:

$$E = A * r * H * PR \quad [5]$$

Where,

E = Energy (kWh)
A = Total solar panel Area (m2)
r = solar panel yield or efficiency (%)
H = Annual average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75) [2]

After calculating capacity of each building the calculation is done for all the three types of buildings and total capacity of the ward is calculated.

A. Building Characterization and Total roof Surface Area

The building characterization is done through the data of building construction within the region compiled by the municipality. The total number of buildings in the region is 550, among them 223 are building having RCC rooftop, 300 are building having fabric or metallic rooftop and remaining 27 are commercial or institutional buildings.

Figure 1: Roof top of buildings of Gorkha Muncipality seen through the google earth

The calculation of the number of buildings and their total roof surface area allowed us to obtain the mean roof surface area for each building.

Figure 2: RCC and fabric/metallic rooftop seen through google earth.

Figure 3: Commercial or Institutional Buildings roof top.

B. Useful Roof Surface Area

After getting the data of available roof surface area of three different types of buildings, the useful roof surface area is calculated. The useful roof surface area is defined by the survey taken form the building owners i.e how much area they use for other propose and can allocate for installation of solar panel.

Type/Other Characteristics	RCC rooftop	Fabric /Metallic rooftop	Commercial RCC rooftop
Numbers	225	300	25
Floor Surface Area	700-900 Sq. Ft	500-700 Sq. Ft	1700-2000 Sq. Ft
Useful Surface Area	60 %	50 %	80 %

Table 1: Building Characterization and useful roof surface area.

C. Solar Potential in the region

The solar potential is different for different regions on the earth. For this research, an irradiance of 1 kw/m2/hr and the panel efficiency of 14%, the power generated from the solar panel from 1 Sq. m area is obtained to be 140 w [5] [6]. Thus the power generated by the panel that are placed at the roof top of individual useful surface area of all three types of building are:

Building types	Useful surface area	Useful surface are in Sq. m	Power generated in individual unit/day	Total power generated
RCC	480 Sq. Ft	44.59 Sq. m	22 kwh	4.95 MWh
Fabric /Metallic rooftop	300 Sq. Ft	35 Sq. m	17.25 kwh	5.17 MWh
Commercial RCC rooftop	1480 Sq. Ft	137.49 Sq. m	67.8 kwh	1.69 MWh
Total per day capacity				11.81 MWh

Table 2: Total Electrical Potential

Hence, the total capacity of the rooftop of buildings of the ward number 4 of the Gorkha Municipality is 4157.12 MWh in a year, taken 12 days for the maintenance of the solar panel per year.

Figure 4 shows the Grid connected PV system. One of the major concerns using the inverter is the harmonics. The increase in THD may result in increase in total current, increased core losses in motor and electromagnetic interference with other electronics equipment. However, present day Grid Tie Inverter are equipped with system such that TDH is less than or equal to 5% which is within the required threshold.

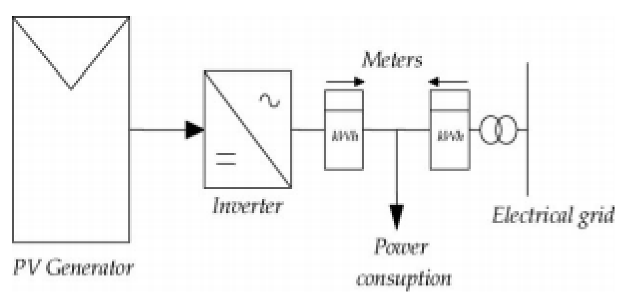

Fig 4: Diagram of Grid Connected PV System

D. Suggestion for improvement

This research is very basic research done from the undergraduate students. So there are many more things which can be added to make the research more effective. The following aids are can be adopted for improving the efficiency of the system.

Solar Tracker: In photovoltaic systems, trackers help minimize the angle of incidence (the angle that a ray of light makes with a line perpendicular to the surface) between the incoming light and the panel, which increases the amount of energy the installation produces. Concentrated solar photovoltaic and concentrated solar thermal have optics that directly accepts sunlight, so solar trackers must be angled correctly to collect energy. All concentrated solar systems have trackers because the systems do not produce energy unless directed correctly toward the sun.

Online Data logger: The data logger helps to log the current and voltage output from the panel. The proposed data logger not only records the current and voltage but also indicated the 3 day peak power. This helps us to identify whether the output from the panel is less due to absence of sun or due to dust accumulation in the panel.

Sun-Path Diagram: To get the most out of a solar panel or solar array, it has to be pointe or “orientated” directly at the suns radiant energy because as we know, the more surface area that is exposed to direct sunlight, the more output the photovoltaic panel will produce, but here lies the problem.

While the photovoltaic solar panel may be perfectly aligned to receive the suns energy, it is a stationary object being fixed to either a roof or mounted directly onto a frame. With regards to a solar panel, the sun however is not in a stationary position and is constantly changing its position in the sky relative to the earth from morning through to night making the correct solar panel orientation difficult. So the proper arrangement of the solar panel should be done so that we can get maximum power output from the system.

Fig 5: Sun Path Diagram

III Conclusion

Solar energy is becoming more economically attractive as technologies improve and the cost of electricity generated by fossil fuels rises. In Nepal, Solar PV is becoming more popular in the off grid community for the rural electrification. But this research is done to estimate the amount of electricity that could be potentially generated per year by solar panels installed in the roof top of the ward no 4 of the Gorkha district, which is not an off grid community. The estimation is done to supply the generated electricity to the grid. The total estimated per day capacity of the ward is 11.81 mwh. And the total estimated per year capacity of the ward is 4157.12 MWh. As this research is just a basic research done by the undergraduate students there are many more things to work out on this research. So capacity can be improved by incorporating Solar Tracker, Online Data logger and design according to Sun-Path Diagram. This research can be replicated to the household of whole Gorkha district and many more cities of Nepal and create energy sustainability in the region.

ACKNOWLEDGMENT

This study acknowledges the Gorkha Municipality of Gorkha District Nepal for providing data of construction of buildings in their Municipality. Moreover, the authors would also like to acknowledge the Alternative Energy Promotion Center Nepal for providing data of solar PV installation in Nepal. The authors would like to thank the Kantipur Engineering College, Dhapakhel, Lalitpur, Nepal for providing platform to dissipate our research findings.

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