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Transformation Efficiency of Grid Interconnection by Photovoltaic Power Generation

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Abstract: Using photovoltaic power generation has become common because of the North FIT system, and at present, there is a possibility that it may hinder the stability of the power supply, and some electric power companies suspend contracts. Installation of solar cell module, which is the central equipment of photovoltaic power generation, and the power controller for connecting it to the grid based on the performance has provided by the manufacturer. But in reality, it is subject to drastic fluctuations in solar radiation. It does not reveal the following ability of solar cell modules and power controllers. In this study, we consider the fluctuation characteristics of the solar power generated by the grid in response to the sudden fluctuations in the sum of solar radiation and consider the stable supply of renewable energy.

Key words: transformation efficiency, photovoltaic power generation, grid interconnection

1. Introduction

Most countries are working towards achieving the goal like green energy. The energy is being supplied from fossil-fueled power generation that contributes to greenhouse gas (GHG) emissions, which affects global climate conditions [1, 2]. In contrast to fossil fuels, renewable energy (RE) sources like solar, wind, hydro, geothermal, tidal, biomass are the most suitable alternatives for providing emission-free, sustainable and clean energy for society.

Because of high initial investment and maintenance costs, governments in developing countries are becoming more reluctant to provide capital funding for grid extensions to deliver electricity to remote locations or rural areas. Hence, rural areas have either no electricity. Some have small-scale stand-alone power systems, such as diesel generator-based power systems, often without renewable energy sources or with only small-scale solar photovoltaic (PV) systems to supply power. A re-integrated system concentrating on a small entity encourages interest worldwide in providing more sustainable forms of energy to remote populations. Therefore, a compact unit of such a power system is called a microgrid (MG) or mini-grid. A microgrid is a low-voltage distribution network, and it can either be grid-connected or an off-grid autonomous system [1, 3, 4]. From the research, hybrid power systems with RE sources can be reliable, cost-economic, effective, and more sustainable compared to either grid-connected or stand-alone generators using a single fossil fuel-based power source [1, 3, 4].

Many countries around the world like; Bangladesh, India, South Africa, and Australia are doing in-depth research to deploy microgrid-based energy-efficient and reliable power systems for rural communities [3-8]. In Bangladesh, 75% lives rural areas have no electricity in their homes [9].

Access to consistent and sustainable electricity can help support income-generating activity, in particular,

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to support irrigation which contributes 16% of the country's GDP [10]. Bangladesh possesses a significant potential for electricity generation from renewable energy resources such as solar PV, wind, hydro, and biomass. Solar PV has been an emerging technology for the last decade in Bangladesh. A few off-grid mini-grid hybrid systems developed with solar PV are in operation now [6, 7, 11].

Bangladesh's government has taken many initiatives to use renewable energy sources, solar PV, to address the electricity crisis of remote areas [12]. The solar home system (SHS) started in 2003 to provide electricity to the remote communities of Bangladesh and gained worldwide recognition. Until May 2017, 4.12 million SHSs were installed throughout the country under this program which is, cost-effective and environment-friendly [13]. These small electricity access systems comprise a 20-100 Wh solar panel, a lead-acid battery, a charge controller, and loads providing reliable electricity to over 16 million people in off-grid remote areas.

However, the proposed system is not viable if the consumer uses high-volume energy, which requires significant upfront costs. A large-scale mini-grid also introduces energy losses during the off-peak period. Therefore, the purpose of the study is to increase the transformation efficiency of grid interconnection by photovoltaic power generation. Electricity is also a critical need for irrigation in agriculture, which employs 47% of the total labor force in Bangladesh [14].

2. Methodology

We will consider the fluctuation characteristics when the electric power had regulated and consider the stable supply of log renewable energy. We conducted this study in lake city, Dhaka, which is in the middle part of Dhaka. The building where the solar power generation had installed a reinforced concrete fifteen-story apartment and a solar cell module with a rated output of about 10 kW had installed on the roof surface. The site of the building is on the slope rising north from the main highway route, and on the south side there is a shopping mall and open lands such as the national highway and the riverbed of the unknown river beyond it, but the north side which is the hinterland are some highrise building, and the top of the building is same the roof of the building since the building has located parallel. Therefore, it has no obstacle for solar radiation from the north side when the sun altitude is low, such as in the morning and evening in summer, but there is almost zero obstruction to solar radiation from the south side also, and it has the suitable terrain for solar power generation. The building is a typical multi-corridor-type apartment house that is long from north to south and has openings on the east and west sides. The photovoltaic module is in the mountains across the staircase in the center of the roof.

We install a photovoltaic power module in two 5 kW systems, with a steel frame stand attached to each of the rooftops, d split into two parts, east and west, with the staircase ratio in the center of the roof. These two lines are flying has shown in Fig. 1. Fig. 1 has shown, the view of the PV side through the photovoltaic module. Fig. 2 shows the outlook of the building on the north side. On the north side, some buildings are of a sunlight obstacle. The installed photovoltaic power generation modules made by domestic electric manufacturers have 5 cells of 156 mm square polycrystalline silicon type solar cells (north-south direction) and 10 cells east-west direction, for 10 cells. It comprises mounted units. Since; the cells organized several millimeters separately. The external dimensions of a part are 858 mm × 1657 mm.

We have arranged four units in the north-south direction and seven units prepared in the east-west direction, and it composes one system of 20 units, excluding one in the northeast corner as for the installation situation on the roof surface. It lines all the units up in the inclined surface like the affection of 5° to the south side. The nominal output is 185 W per unit. However, the efficiency of the breed of solar cells has

not been announced yet. Unit dimensions and input of solar radiation are 1 kW. The simple power generation efficiency is about 13%, but the energy conversion efficiency got from the total effective power generation area of the solar cell (156 mm × 156 mm × 50 sheets = 1.2168 m) is about 14.6%. As a recent polycrystalline type solar cell, we can see it as a catalog value of general power generation efficiency.

Fig. 1 View of the roof of the apartment where the experiment was conducted.

Fig. 2 North view of the roof of the apartment where the experiment was conducted ltnic Suctem before Grid Connection.

It connects the power generated by the photovoltaic power generation module to the power controller for each system, converted to AC 200V, and then linked to the system through the switchboard. It connects the power measured before this energy controller to the grid. Here, the eastern line is E, and the western line is W. The total amount of solar radiation on the horizontal surface and the amount of solar radiation on the same slope as the slope on which the photovoltaic power generation module is installed and measured on the

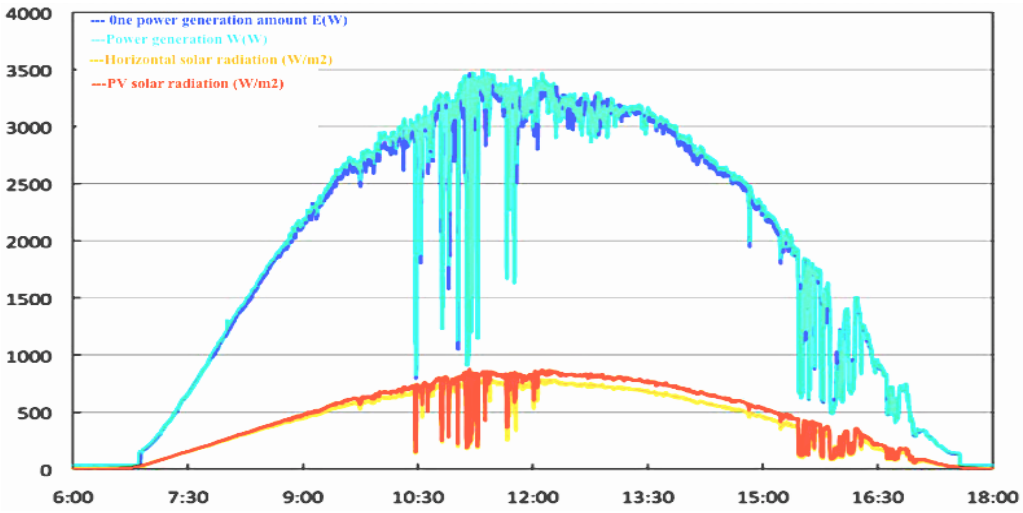
roof surface. It sets the measurement time interval of each measurement item to 20 seconds which is determined from the detailed fluctuation status and the period during which they can record data.

3. Result and Discussion

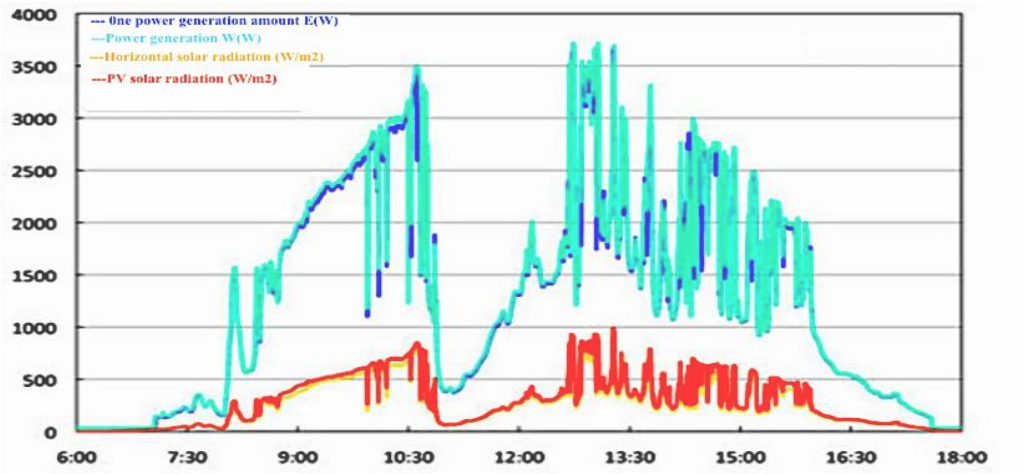
The study was measuring the actual condition of PV's fluctuation. We set the measurement time interval for each measurement item to 20 seconds, which has controlled from the detailed fluctuation status and the period during which it can record data.

3.1 Changes in Power Generation and Solar Radiation Over Time

The actual measurements had carried from the latter half of October to November 2015, but valid data without missing data is from October 24 to November 1 got for 9 days. Fig. 3 shows the changes in the amount of solar radiation on October 25 and 26, when the characteristic changes in the total of solar radiation had collected, and the amount of power generated by each system. The two amounts of solar radiation are the values on the horizontal plane and the PV module surface, but the PV module surface has shown the greater value. There may be a slight difference in the volume of power generated by the two east and west systems. The power generated by photovoltaic power fluctuates the following fluctuation the amount of solar radiation even before the grid connection after passing through the power controller.



(a) power generation and solar radiation

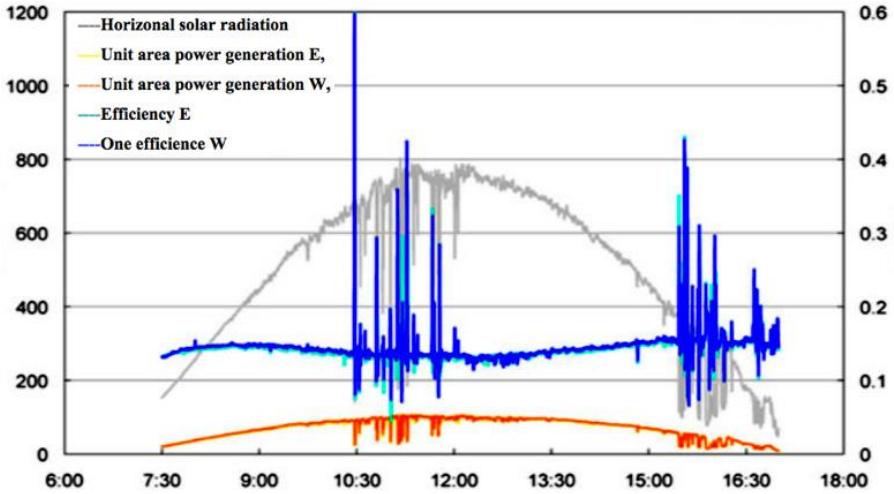


(b) power generation and solar radiation

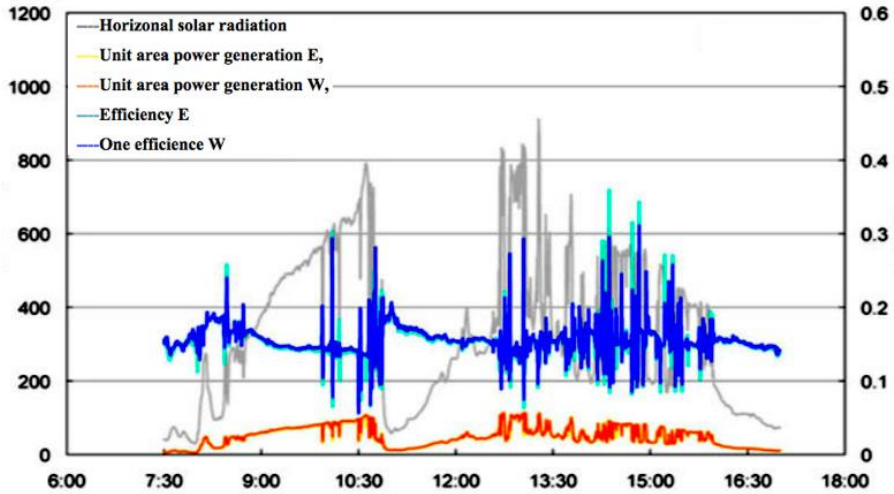
Fig. 3 Change over the time amount of solar radiation and the amount of power generation by each system.

3.2 Changes Has in the Conversion Efficiency Over Time Divide the Amount of Power Generation by the Area of the Solar Cell That Is Effective for Power Generation and to Get the Amount of Power Generation Per Unit Area. Even Just Before the Grid Connection and After Passing Through the Controller, It Fluctuates Considerably Violently Following the Fluctuation of the Amount of Solar Radiation.

If we take the ratio of this unit area equivalent power generation amount to the total amount of solar radiation on the horizontal plane as the conversion efficiency, it can get the instantaneous conversion efficiency for each instantaneous value. This conversion efficiencies have shown in Fig. 4. Besides, although these power measurements include the conversion efficiency of the power controller, this is a high efficiency of 97.5% according to the catalog value provided by the manufacturer, so the efficiency of the power controller here have regarded as almost 1. I'm ignoring it. With a cloudy sunny day with a lot of fluctuations in the amount of solar radiation, the conversion efficiency may change sharply, and if the fluctuations in the amount of solar radiation on October 25 are relatively mild, the conversion efficiency is also moderate. It shows an almost constant value of about 15%. Combined Solar fields with a fairly detailed measurement interval of 20 seconds. The conversion efficiency of solar radiation is also moderate, showing an almost constant value of about 15%.



(a) Isolation in first day



(b) Isolation in second day

Fig. 4 Fluctuations in solar radiation and instantaneous conversion efficiency.

4. Conclusion

We had examined the follow-ability of solar radiation to changes in the amount of solar radiation by using a detailed measurement interval of 20 seconds. As a result, it becomes clear that; the amount of power generated by solar power follows the fluctuations in the amount of solar radiation in detail. If the amount of solar radiation fluctuates drastically, the power supply becomes unstable due to terminal interconnection. To prevent such instability, it will be necessary to use large-capacity capacitors in the future.

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