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Grid connected solar photovoltaic system as a tool for green house gas emission reduction in Turkey

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ABSTRACT

Energy production in a safe and hazard free manner is one of the world's greatest concern. Since the inception of Kyoto Protocol, which was adopted in 1997 and entered into force in February 2005, countries have started to adopt different measures for emission reduction such as electricity generation from renewable energy sources; as the source is free from green house gas (GHG) or CO_2 emission. Legislations and financial incentives have been provided by some governments for encouragement and ensuring good returns to the investors in renewable energy sector. This paper analyzes how a 500 kWp solar photovoltaic (PV) system for electricity generation contributes significantly in the GHG emission reduction and also the potential impact of introducing CO_2 emission reduction cost in the solar PV electricity generation. The result shows that the emission reduction is of the order of hundreds of tons of CO_2 and CO_2 emission reduction cost has a positive impact on the cumulative cash flow of the system.

Contents

1. Introduction

Energy production in a safe and hazard-free manner is one of the world's greatest concerns. Many analyses have shown that substituting conventional energy sources (such as natural gas, coal, etc.) with

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non-conventional sources (such as solar, wind, etc.) for electricity generation would result in drastic green house gas (GHG) emission reduction [1–7]. Since the inception of Kyoto Protocol, which was adopted in 1997 and entered into force in February 2005 [8], countries have started to adopt different measures for emission reduction ranging from generating electricity from non-conventional or renewable energy sources; pricing policy in significant GHG emission reduction and preferential price known as feed-in-tariff for encouragement and ensuring good returns to the investors in renewable energy sector [1]. This paper analyzes how 500 kWp (kiloWatt peak) electrical power generated from solar photovoltaic (PV) system design based on the solar data of Gaziantep city in Turkey contributes significantly in the GHG emission reduction and also the potential impact of introducing CO_2 emission reduction cost in the solar PV electricity generation has been analyzed for the proposed power case.

2. Solar photovoltaic

Solar PV modules (or group of PV cells) are made of semiconductor material and are normally arranged as arrays of individual modules use to convert sunlight into direct electric current, which later is converted into alternating current through an inverter if the system output is to be connected to the grid [9]. In 1950s, the first cell was built with less than 4% efficiency [10] since then the efficiency of the cell is substantially improved over time with a drastic decrease in its price. The current PV cell available for commercial has an average efficiency ranging from 15% to 20% [11]. Turkey has a good geographical location to develop solar power plants as it lies in a sunny belt between 36° and 42° North latitudes and between 26° and 45° East longitudes, bordering the Mediterranean, Aegean, and Black Seas [12]. The Mediterranean Sun Belt goes through the country, placing Turkey in one of the most strategic positions in Europe for the purposes of generating solar power [13]. Every year, the expected average solar irradiation in Turkey is 1311 kW h/m^2 per-year and 3.6 kW h/m^2 per-day and the total annual insulation period (amount of solar energy striking a flat surface overtime) of approximately 2460 h per-year and 7.2 h per-day [14]. Translating these insulation values to usable electricity depends on the PV conversion efficiency, the inverter loses, wiring, and other system component losses [10]. Fig. 1 provides an overview of annual variation of solar electricity generated by 1 kWp PV system in different cities of Turkey [14]. Turkey has seven regions that are divided according to climate, location, flora and fauna, human habitat agricultural diversity, transportation, topography, etc. Each region has different solar potentials as shown in Table 1 [14]. It is seen from Table 1 that the southeastern Anatolia region has the best condition of solar energy and Gaziantep is one of the biggest city in the region. For these reason, Gaziantep is chosen as a case study; as the city is experiencing intensive investments such as modern buildings and new industries. Gaziantep has good solar energy potentials with an average irradiation of 1460 kW h/m^2 per year and approximately sunshine duration hours of 2993 annually [14]. Therefore, solar energy has a big role to play in satisfying energy demand of the city as well as reducing its GHG emission [15].

3. Factors affecting potential availability and price of PV generated electricity

3.1. Intermittence

Intermittence is the variability of the solar resources which results from the variation in the generation that depends on the

Table 1
Regional distribution of Turkey's annual solar energy potential [20].

Regions	Total solar energy (kW h/m^2-year)	Sunshine duration (h/year)
Southeast Anatolia	1460	2993
Mediterranean	1390	2956
Eastern Anatolia	1365	2664
Central Anatolia	1314	2628
Aegean	1304	2738
Marmara	1168	2409
Black Sea	1120	1971

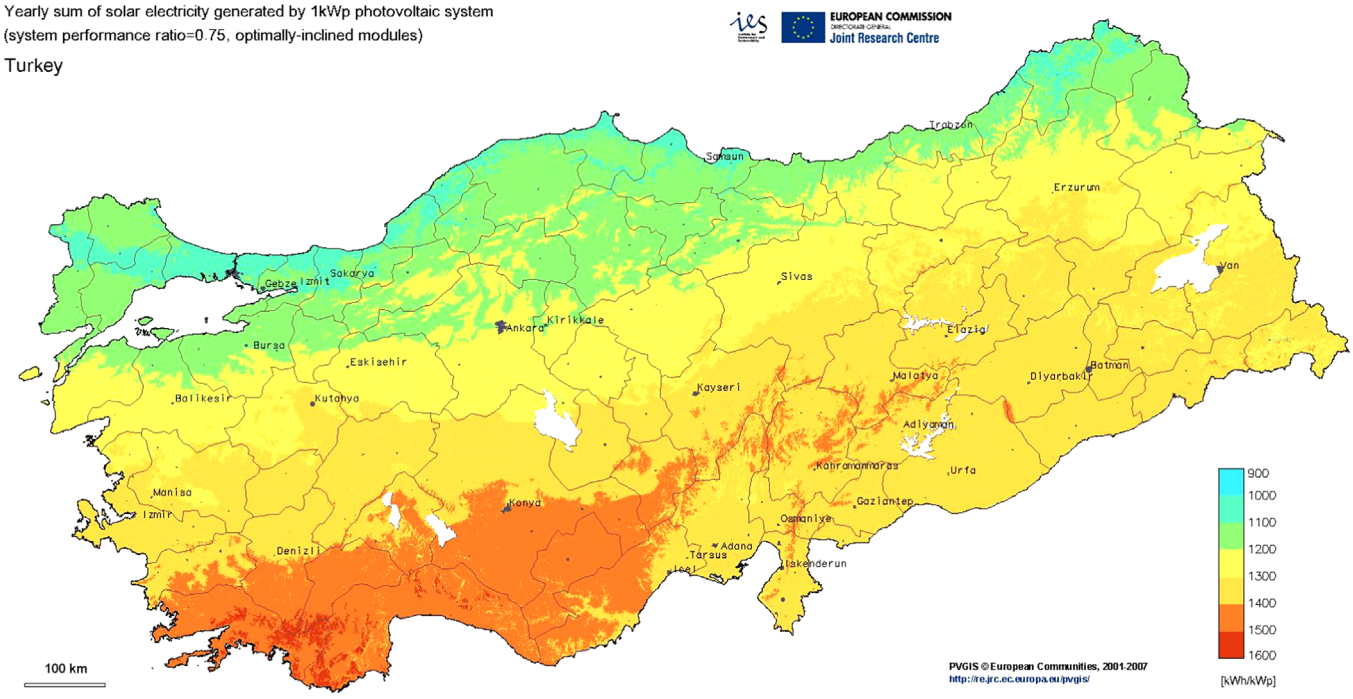

Fig. 1. Annual variation of solar electricity generated by 1 kWp PV system [20].