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Performance improvement techniques for photovoltaic systems in Qatar: Results of first year of outdoor exposure

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Abstract

The state of Qatar has established firm renewable energy deployment targets for the next decade, using primarily solar photovoltaic technologies.
Qatar, in the Arabian Peninsula, is in the MENA Region, where the solar resource is fairly abundant, but local environmental conditions are challenging, particularly, high ambient temperatures all-year round, a dusty atmosphere due to high aerosol content, and water scarcity, which impact negatively on PV system performance and reliability.
The Solar Test Facility (STF) at the Qatar Science & Technology Park (QSTP) was founded in 2012 for the main purpose of contributing to the achievement of Qatar's sustainable energy technology deployment targets. STF provides scientific and technical capabilities for testing and evaluation of solar technologies under the specific local climate conditions.
This paper presents the results of outdoor exposure of a specific model of multicrystalline silicon (mc-Si) photovoltaic (PV) modules after their first complete year of operation at STF. The impact of module cleaning frequency, use of commercial anti-soiling coatings and module mounting on either fixed, one-axis-tracking or two-axis-tracking systems was studied.
These results give some indication of the next steps to be taken and the solutions that would eventually work for the improvement of both the energy yield and the durability of PV systems deployed in this region.

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Keywords: solar energy; poly-silicon; dust soiling; sun-tracking systems

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1. Introduction

Qatar is a peninsula located between 24° and 26° latitude north. The peninsula is only 160 km north-to-south, with an area of 11.586 km^2. Much of the country consists of sand dunes and salt flats across a low, barren plain.

Qatar has a dry, subtropical desert climate, with low annual rainfall (~ 80 mm) and intensely hot summers. Temperatures are warm but not hot in spring and autumn, and the evenings use to be pleasantly cool. Temperatures in June to September are very high, with means of the daily maximum values around 42 °C for June, July and August, but it is not unusual for the mercury to rise as high as 50 °C. In the winter months, temperatures are cooler but still warm, with means around 23 °C from December to February [1].

The region is rich in the solar resource with a reported value of 2.113 kWh/m^2 for the global horizontal irradiance (GHI), as the average of measurements taken at ten existing radiometric stations spread all over the country in the period ranging from 2009 to 2012 [2].

It is well known that performance of photovoltaic modules is affected by environmental variables, beginning logically with the solar radiation available, but also by others such as the ambient temperature and presence of dust in the air causing soiling [3, 4, 5]. This paper presents for the first time a study on the effect of those environmental factors on the performance of certain model of mc-Si PV modules in Qatar after their first year of operation. The results have been obtained at the Solar Test Facility (STF), an experimental facility developed by Qatar Science and Technology Park (QSTP) which is located at the Qatar Foundation's Education City premises.

2. Test set-up

2.1. The Solar Test Facility at QSTP

The Solar Test Facility (STF) at the Qatar Science and Technology Park (QSTP) contributes to the adoption of sustainable energy in Qatar by evaluating solar technologies under local climate conditions. It has been developed and is operated in partnership by QSTP, the local company *GreenGulf Inc*. and the Qatar Environment and Energy Research Institute (QEERI). Testing campaigns on around 30 photovoltaic and solar thermal technologies from manufacturers around the world are currently on their way.

The STF is a 35.000 m^2 (7 acre) open-field, grid-connected test site, located at Education City, about 10 km from the Doha coast (Fig. 1). It was inaugurated on December 2012 and testing activities began in March 2013. They are planned to continue for several years carrying out long-term studies like:

- Evaluation of single PV modules
- Evaluation of small PV arrays and inverter assessment
- Evaluation of PV arrays in specific mounting configurations
- Evaluation of concentrated PV (CPV) generators

2.2. The PV array and multi-crystalline silicon module test benches

A certain type of multicrystalline silicon modules has been used for this study. These modules were installed in strings of eight, with total nominal power ranging between 1.700-1.800 W_p (see Fig. 2). Up to 10 strings have been used, so the effects of a variety of factors in their electricity yield could be studied.

The data acquisition system measures current, voltage, yield power and yield energy for each module or array installed at the STF at 'maximum power point' (MPP) conditions, which are secured through the inverter's electronics.