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Dye-Sensitized and Amorphous Silicon Photovoltaic (PV) Devices' Outdoor Performance: A Comparative Study

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Abstract—**The performance of a dye-sensitized solar module (DSSM) has been investigated under different air mass (*AM*), irradiance intensity and temperature conditions in Nairobi, Kenya. The good response of the DSSM to short wavelength radiation made it perform well at increased *AM* values as compared to what is reported of Amorphous Silicon (a-Si) photovoltaic (PV) devices. The DSSM performed better compared to what is reported of a-Si PV devices under irradiance and temperature dependence. The results are useful in PV sizing, especially in the area of Building Integrated Photovoltaics (BIPV) in Kenya and the tropics.**

Keywords— **Dye-Sensitized, Amorphous Silicon, Outdoor Performance, Air Mass, Irradiance, Temperature**

I. INTRODUCTION

The need to switch to using renewable energy is on the rise world over. Fossil fuel reserves that have been depended on for energy supply are quickly diminishing, [1], leading to volatility in energy prices, [2]. The geopolitical issues experienced by countries with fossil fuel reserves further compound the grim situation. These factors have been key in denying many people access to energy, with those at the bottom of the economic pyramid being the most affected, [3]. The over-reliance upon fossil fuels by the world, [4] has also been associated with environmental effects, like global warming and its consequences, [5]. These have adversely affected life on earth, [6]. Adoption of energy sources that are alternative to fossil fuels is imperative. Renewable energy sources offer the most sustainable way forward, [7]. These include biomass, geothermal, tidal or wave power, water cycle or hydro, wind, and solar radiation.

The most abundant and fairly distributed of these is solar radiation – with about 3.9×10^{24} joules of solar energy reported to be reaching the earth annually, [8]. Apart from being abundant in supply, solar energy is used to produce heat for direct use or for further conversion to electricity through the thermal conversion pathway. It is also converted directly to electricity through the solar photovoltaic (PV) conversion pathway by exciting electrons in a solar cell.

The PV conversion pathway is the most espoused, [8], though the cost of PV systems is currently still high. However, efforts aimed at reducing solar PV prices, including enhancing efficiency and using cheaper fabrication materials have been on-going. Work on dye sensitized solar cells (DSSCs) has been part of these extensive efforts, [9].

Apart from using cheaper fabrication materials, DSSCs also promise cheaper electricity because they can be fabricated under less stringent conditions, [10]. Despite these accolades in respect of the DSSC technology, not much is being done to enhance its adoption in developing economies, but instead, Amorphous Silicon (a-Si), despite its performance challenges, is preferred by solar PV consumers in these countries to mono and poly crystalline silicon. In this work, the performance of a commercially available DSSC modules investigated under different air mass (*AM*), irradiance intensity and temperature values is reported and the results compared with what has been reported of a-Si PV devices operating under similar outdoor weather conditions.

II. THEORY

Current density-Voltage (J-V) Characterization

A PV device's response is determined by its *J-V* characteristics. *J-V* characteristics are modeled according to the equation, [11],

$$J = J_L - J_s \exp\left[\frac{V + R_s J}{mV_T}\right] - \sigma V \quad (1)$$

Where J, J_L, J_s, V, m, V_T, R_s, J, and σ are the ideal current density, current density from the source, saturation current density, voltage across the PV terminals, the ideality factor, series resistance and shunt conductance respectively.

From equation 1, the photo-generated current density can be plotted as a function of the applied bias voltage. This results in a curve typically known as the current density-voltage (*J-V*) characteristic curve.