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Enhancing the Reliability Analysis of Solar Photovoltaic Systems for Different Types of Solar

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Abstract- *The method of the reliability of some crystalline photovoltaic cells was proposed and implemented. Different solar panels were collected and their power rating calculated. From the data sheet available for the monocrystalline (DSP 210), the manufacturer's rated power for this type of cell is 210Watts and the calculated power is 191.134 watts. For the polycrystalline (SPP 280W)the rated power is 280watts while the calculated power using all the parameters is 267.80watts and comparing this to the calculated power for the same models, it shows that they are relatively reliable under perfect conditions. In general for Mono 210D, it will be deducted that this solar cell is most reliable/gives power to rated in January through May but gives approximately low power in July/Aug because of low solar radiation in that period. Pick up again in September to December at different hour of the day. Reliability of the cells shows that it dependents on the solar radiation at a particular period of time of the day. For the polycrystalline in question, SPP 280W, In January, the panel output current is at maximum that gives the highest power output for the panel in January at 12hr Feb and in March at 14th hr to its fully rated power through May. While June- August because of drop in solar radiation the generated power output drop far below rated power of the panel.*

Keywords: *Solar PV Technology, Photovoltaic Cell and Reliability.*

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I. Introduction

Solar Isolation is a measure of solar radiation energy received in a given surface area in a given time.(Solar Radiation/National Climatic Data Centre, www.ncdc.noaa.gov/data). Solar energy is one of the most significant types of the sustainable and renewable energy sources that have been used in Nigeria. However, development of solar photovoltaic energy in Nigeria is still low due to the investment costs are still expensive. An efficient system design and PV technology (e.g. PV module) selection suitable to the Nigeria climate becomes very important. Although, PV modules manufactures are present on the market claiming high performance and high reliability of their products, but the rated values of PV modules provided by the manufacturer are based on the Standard Test Conditions (i.e., irradiance 1000 W/m2, module temperature 25□C, and AM 1.5), do not meet operating outdoor conditions due to the varying outdoor parameters. Therefore, the performance testing of PV modules at outdoor conditions is required to have an accurate estimation of output of PV modules under specific climate. Different researches and scientists have worked on the performance evaluation of photovoltaic system under different climates. Markus Schweiger, Ulrike Jahn, Werner Herrmann (2011) conducted an experimental study to evaluate the performance of 12 different types of PV modules: two crystalline modules (mono- and poly- crystalline silicon to compare with thin-film specimens), three CI(G)S modules (CIS and CIGS), one CdTe module and six amorphous silicon modules (a-Si; a-Si/a-Si, a- Si/µ -Si), in Germany/European climates. The results showed that with respect to the low irradiance behaviour, the CdTe, the c-Si and some of the a-Si specimens showed good performance. The best efficiency curves of tested thin-film modules were achieved by CI(G)S. Carr and Pryor (2004) evaluated and compared the performance of five different PV modules using an outdoor facility in the climate of Perth for one year. They found that amorphous silicon module has highest performance ratio with maximum energy produced at that site. Akhmad et al 1997 investigated the outdoor performance of polycrystalline and amorphous silicon module and found that amorphous silicon module has better efficiency and output power in summer. A similar study was conducted by Midtgard et al 2010 at the site of Norway to investigate the performance of three PVmodules (monocrystalline, polycrystalline, and micromorphsilicon). They concluded that monocrystalline module was better in terms of module efficiency and overall power production. Module temperature affects the output of PV modules. The temperature effect of the module output has been reported by different researchers. Meneses-Rodrıguez et al 2008 investigated the effect of ambient temperature on PV modules for three years and found a linear behaviour between output power and ambient temperature. One important factor associated with the amorphous silicon module is the effect of photo-degradation. The a-Si modules undergo some degradation resulting in a decrease in module performance. This paper deal with an extensive PV modules monitoring activity carried out at outdoor testing facility of the Energy Technology Center, Nigeria. The purpose of the work was to evaluate and compare the performances of different PV modules during a medium term outdoor exposure at the tropical climate Nigeria, with an optimized tilted angle, north facing.

II. Review Of Related Works

Numerous case studies have revealed the formulation of the problem statement of this work. Various literatures were studied. Few of the literatures are presented below. Allen Zielnik, 2009 proposed Atlas Material Testing, PV Durability and Reliability Issues, While there are initial PV qualification tests, such as the IEC and UL requirements, among others, they are neither intended to, nor capable of, predicting long-term performance. As a result, there has been an evolution in the application of accelerated life testing (ALT) and accelerated environmental testing (AET) to the service life prediction (SLP) of PV modules and systems. no test program can predict with 100% certainty that a module will properly perform in an environment for 25+ years (except for real-time 25 year testing, of course). T. McMahon, G. Jorgensen, R. Hulstrom, 2000 define what they mean by a 30-year module life and the testing protocol that they believe is involved in achieving such a prediction. However, they do not believe that a universal test (or series of tests) will allow for such a prediction to be made. They can test for a lot of things, but they believe it is impossible to provide a 30-year certification for any PV module submitted for test. According to John Wohlgemuth (BP Solar), “Today, BP Solar offers a 25-year warranty on most of its crystalline silicon PV modules…while the modules have to last for 25 years of outdoor exposure, we cannot wait 25 years to see how they perform… no BP/Solarex module has been in the field longer than ten years. Even the oldest 20-year warranty modules have only been in the field 15 years.”

III. Solar Pv Technology

Photovoltaic (PV) solar cells directly convert sunlight into electricity, using the photovoltaic effect. The process works even on cloudy or rainy days, though with reduced the production and conversion efficiency. PV cells are assembled into modules to build modular PV systems that are used to generate electricity in both grid-connected and off -grid applications, such as residential and commercial buildings, industrial facilities, remote and rural areas and power plants (i.e. utility PV systems). Over the past decades PV technology has been constantly improving performance and reducing costs. Most recently, rapid cost reductions are enabling PV plants to become economically competitive not only in niche markets such as off -grid installations, but also for on-grid applications.

Commercial PV technologies include wafer-based crystalline silicon (c-Si) (either mono-crystalline or polycrystalline silicon) and thin-films (TF) using amorphous Si (a-Si/uc-Si), cadmium-telluride (CdTe) and copperindium [gallium]-[di]selenide-[di]sulphide (CI[G]S). The c-Si systems accounted for 89% of the market in 2011, the rest being TF.

IV. Methodology

The Photovoltaic(Pv) Cell

PV use special semiconductor materials to utilize the solar energy by converting it to an electrical energy. Doping two different semiconductor materials by different imputes forms two types of semiconductor layers that are use to fabricate solar cells. This connection is called (p-n junction), which is the basic building block of the PV system. This semiconductor is the material that can conduct electricity when the temperature raises or when exposed to light. Solar cell or PVs cell directly convert the solar energy into electricity by the photovoltaic effect. This phenomenon is similar to the photosynthesis in the plant that converts the sunlight into bio-energy. The commercial solar cell is made of wafer-based technology of semiconductor materials, such as Crystalline Si (C-Si) and thin film. Different types of silicon can be used to fabricate the solar cell i.e. mono-crystalline silicon, poly-crystalline silicon, and amorphous. The variations between these types are distinguished by the conversion efficiency of the PV cell.

Photovoltaic Effect

When irradiance hits the surface of solar PV cell, an electrical field is generated inside the cell. This process separates positive and negative charge carriers in an absorbing material (joining p-type and n-type). In the presence of an electric field, these charges can produce a current that can be used in an external circuit. This generated current depends on the intensity of the incident radiation. The higher the level of light intensity, the more electrons can be unleashed from the surface, the more current is generated.

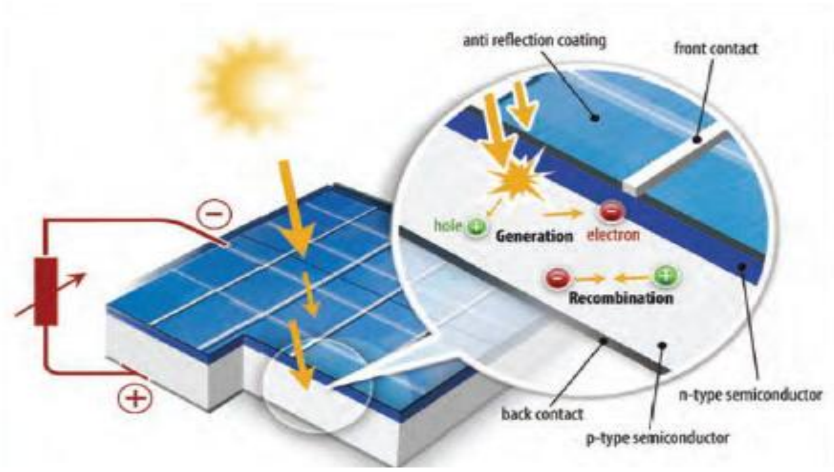

Figure 1: Schematic cross-section of a typical solar cell

Effect Of Solar Radiation On Efficiency

We can safely assume that the short circuit current is proportional to the intensity of radiation. Also, expression for Voc can be written as

$$V_{oc} = \frac{kT}{q}\ln\left(\frac{I_L}{I_o}+1\right) = \frac{kT}{q}\ln\left(\frac{I_L}{I_o}\right) \quad (1)$$

Using expression no 5 the expression for cell efficiency can be written as:

$$\eta = \frac{I_{sc}V_{OC}\,FF}{P_{in}} = \frac{n I_L \frac{kT}{q}\ln\left(\frac{I_L}{I_o}\right) FF}{P_{in}} \quad (2)$$

Where P_{in} is intensity of solar radiation and n is the factor accounting for radiation intensity (wherein n=1 for one sun, n=0.5 for half sun or half radiation intensity, etc.). Here, dependency of FF on radiation is not considered. From equation 2 one can say that as the radiation intensity decreases, the efficiency of solar cell should decrease. This will happen because of decrease in V_{OC} with decrease in I_L.Following the same line, the cell efficiency increases if the radiation intensity is increased beyond 1 sun intensity

Reliability

Reliability measures the ability of the system to perform its function in stipulated time. Reliability has to do with the quality of measurement.

$$\text{Reliability (R)} = e^{-\lambda t} \quad (3)$$

Where, λ = failure rate
t = time interval

V. Result Analysis And Implementation

Implementation Of Reliability Algorithm

Algorithm in Engineering describes a set of rules that must be followed to be able to implement a developed programme or idea. This can be translated in form of flow chart. The flow chart is a diagrammatic way to represent the algorithm. Ones idea can be implemented using a developed algorithm and flow chart. The reliability analysis of solar photovoltaic systems for different types of solar was realized using the flow chart in figure 2

Flow Chart:

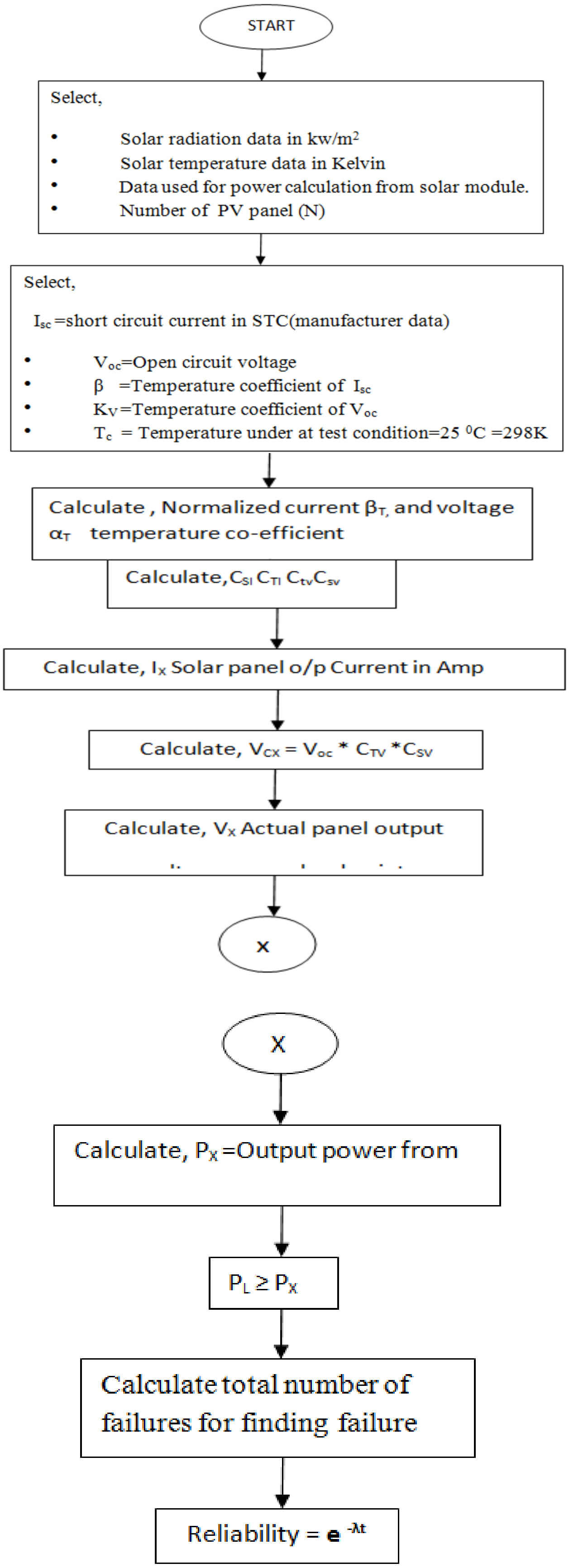

Figure 2: Flow Chart for solar power calculation

Reliability Analysis Of Different Types Of Spv Systems

Table 1: different types of solar panels

Sl. No	**Different Types of Panels**	**Reliability of the Panels**							
		n=600	**n=750**	**n=900**	**n=1050**	**n=1200**	**n=1350**	**n=1500**	**n=1650**
1	DSP 210D Mono			0.5134	0.7165	0.7788	0.9200	0.9200	1.0000
2	KS-M 280W Mono	0.4346	0.7165	0.7788	0.9200	0.9200	1.0000		
3	SPP-280-24 Poly		0.6065	0.7788	0.9200	0.9200	1.0000		
4	BPSX 150S Poly					0.5134	0.7165	0.7165	0.7788
5	ZKX-240D-24 Mono		0.4346	0.7165	0.7788	0.7788	0.9200	1.0000	
6	ZKX-240P-24 Poly		0.4346	0.6593	0.7165	0.7788	0.9200	0.9200	1.0000

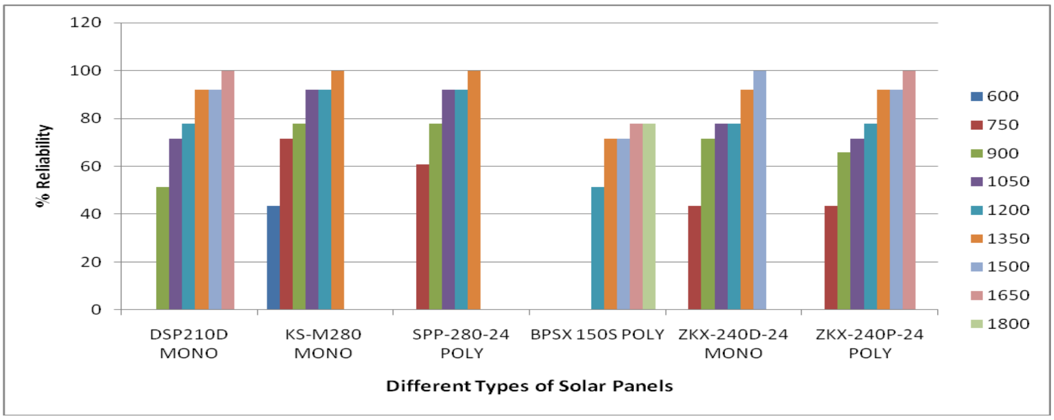

Figure 3: % Reliability vs Different Types of Solar panels for different no of panels

To understand reliability, we must first define what we mean. For simplicity, we will say a PV module fails to provide service if its power output decreases by more than 20% after 30 years in its use environment. Also, “a high probability” means that 95% of the modules in the field will achieve this success” or the like. From the data sheet available for the monocrystalline (DSP 210), the manufacturer’s rated power for this type of cell is 210Watts and the calculated power is 191.134 watts. For the polycrystalline (SPP 280W)the rated power is 280watts while the calculated power using all the parameters is 267.80watts and comparing this to the calculated power for the same models, it shows that they are relatively reliable under perfect conditions. In general for Mono 210D, it will be deducted that this solar cell is most reliable/gives power to rated in January through May but gives approximately low power in July/Aug because of low solar radiation in that period. Pick up again in September to December at different hour of the day. Reliability of the cells shows that it dependents on the solar radiation at a particular period of time of the day. For the polycrystalline in question, SPP 280W. In January, the panel output current is at maximum that gives the highest power output for the panel in January at 12hr Feb and in March at 14^{th} hr to its fully rated power through May. While June- August because of drop in solar radiation the generated power output drop far below rated power of the panel

CONCLUSION

Service life prediction of complex products is an evolving discipline that often requires data and techniques that are not available. But while this methodology does not purport to address true SLP, it does have a 95-year foundation in empiricism shown to provide practical results. While no test program can predict with 100% certainty that a module will properly perform in an environment for 25+ years (except for real-time 25 year testing, of course), an improved methodology that more closely simulates the real environment while still maintaining reasonable acceleration can certainly be a valuable tool to answer the question, “Will my module last 25+ years?”

In this paper, PV system using different technique and the reliability analysis of Solar Photovoltaic system has been studied. It is proposed to develop reliability analysis for photovoltaic system for different types of solar panel.

In all the solar cell/panel investigated, their reliability directly depends on solar radiation.

Recommendation

The reliability analysis of PV system should be done during raining and dry season to compare the output of the two seasons.

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