Tropical Field Observation of Weed Permanent Shading on Solar PV Surface

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Abstract: Solar Photovoltaic (PV) largely depends on the sun irradiation or insolation level (in W/m^2) on its surface for electricity conversion process. Cloud movement especially thick cloud near to earth surface creates a non-permanent shading on solar PV farms top surface which significantly reduce the electricity yield. Improper weed management in large scale solarfarms would create a permanent shading to the PV surface especially with creeping plants. Thus, this work implies freely available application namely Pl@ntNet and Canopeo to analyse the impacts of weed surface cover in Solarfarms. Images of specified weed growing above the solar PV surface are captured and identified using Pl@ntNet application to determine the type of weed. Weed identification is the first stage of efficient weed management to aid in a fundamental understanding of the life cycle and biology of the weeds for proper control measures. The same images are used in Canopeo application to determine the surface coverage by means of Quadrat sampling. This information will be invaluable to solarfarm operators showing the significant energy reduction when the solar PV surface are covered by weeds.

Key words: Pl@ntNet Apps, canopeo apps, PV surface coverage, weed management, agrivoltaic system

1. Introduction

In Malaysia, Renewable Energy (RE) becomes the agenda to help mitigating the impacts of energy crisis. The energy dependency currently remains on coal mainly composed of non-renewable resources. Malaysia have pledged to reduce its carbon emission intensity per GDP by 35% in 2030 relative to the 2005 level during the 21st Conference of Parties (COP21) in 2015. Reinforcing the COP21 commitment, the Government has revised the national RE capacity mix target from 20% to 31% by 2025 for Malaysia. In achieving the 31% RE capacity mix target for Malaysia by 2025, a total of 1,178MW1 of new RE capacities will be developed in Peninsular Malaysia from 2021 onwards as shown in Fig. 1 which the additional RE capacities consist of 1,098MW of solar and 80MW of non-solar resources [1]. Typical example of large scale Solarfarm is shown in Fig. 2 with the generating capacity of 2MWp in Puchong Selangor.

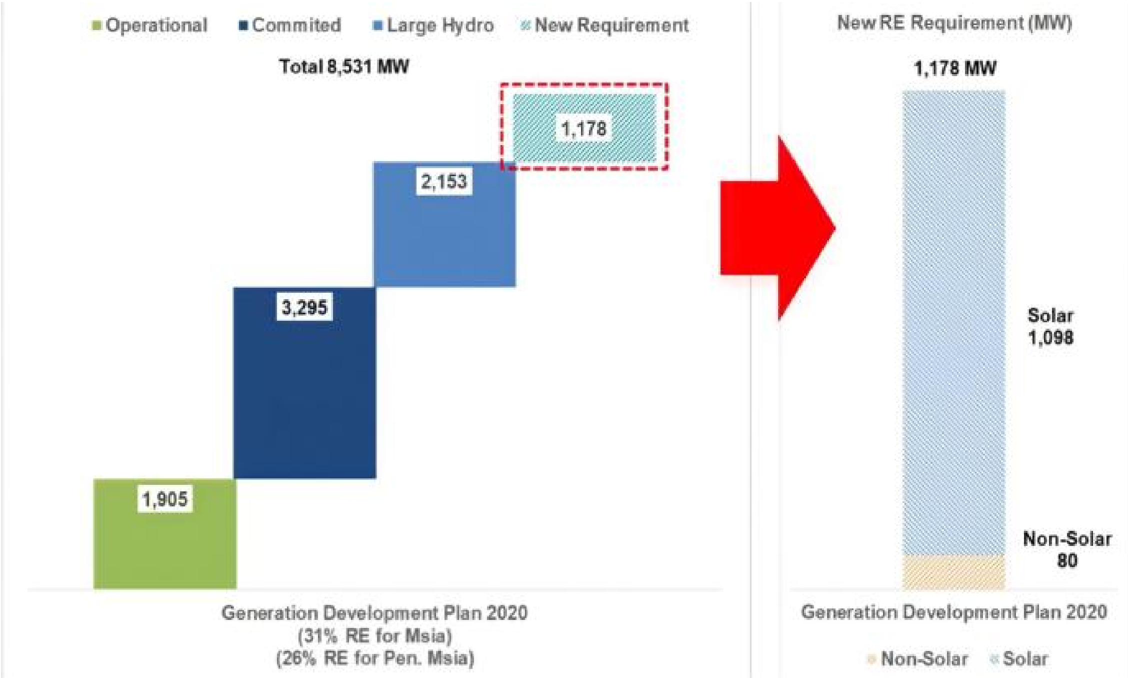

Fig. 1. Proposed Requirement for Peninsular Malaysia to Meet 31% RE Capacity Mix by 2025.

Fig. 2. 2MWp Solar Farm in Puchong, Selangor.

2. Agrivoltaic System

Solar Photovoltaic (PV) largely depends on the sun irradiation or insolation level (in W/m^2) on its surface for electricity conversion process. In the PV systems, photons, tiny energy packets made up of the Sun's Irradiation, strike a solar panel to produce an electric current (DC). Generally, it is a power generation system that incorporates several parts, namely PV Modules, solar inverter, mounting, cabling and other electrical components which is integrated in Balance of Systems (BOS) [2, 3]. The evolution of PV materials has created pathways for research and development with the emerging solar materials shown in Fig. 3 with multiple functions and methods of installation [4].

Agrivoltaic systems, which integrates agricultural operations with the production of solar PV energy, are a crucial topic of discussion recently. The idea of agrivoltaic is to use land areas optimally for both agriculture and solar PV power generation at the same time to develop cost-effective solutions

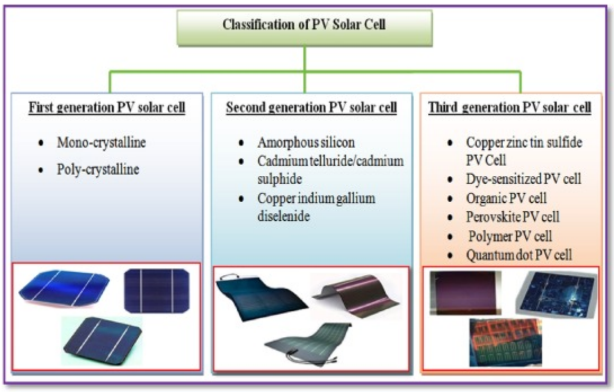

Fig. 3. Evolution of Solar PV materials worldwide.

The concept of Agrivoltaics or solar farming aspired the creative conversion of agriculture to photovoltaics applied on the same land to maximize the yield via contemplating specific plant attributes; height, productivity, water consumption and shading resistance under solar PV structures or within the Solarfarm area. This method of farming under the solar panel is an innovation of incorporating green energy into agriculture and it is a part of introducing modern aspect to the agriculture community in line with sustainable solution for food security and urban land scarcity [5, 6].

3. Shading Effect

The performance of a photovoltaic (PV) system can be impacted by a variety of factors. One of the most important problems that solar PV designers and installers must deal with is the shading issue at site. Typically, shade refers to a shadow that falls over PV panels, lowering the system's energy output. PV shading concerns can make it difficult to address actual PV derating factors since the three main attributes of PV electrical conversion process which is the DC power, voltage, and current that might be influenced differently and to varied degrees. The phenomenon of shading is complex. Infinitely varying shade can be produced by haze, cloud, dust, trees, bird droppings, buildings, and roof-top structures. Different tilt angle and orientations might also result in various shading patterns depending on the location of installation.

A field study conducted by Gholami *et al.* [7] to study the impact of dust covering PV surface after 70 days without rain. A significant reduction of 21.47% in the DC power output was analyzed during the experimental work with dust surface density increased up to 6.0986 g/m^2. Sulaiman *et al.* [8] also supports the findings on PV shading with the investigation of the impact of dust on the performance and peak power of 50 W PV panel with two types of artificial dusts were scrutinized with constant solar radiation (from a simulator). The results showed that maximum power and efficiency were reduced by 18% and 50%, respectively, with slight differences in results obtained from mud and talcum.

Mustafa *et al.* [9] explains that the impact of PV partial shading condition on PV module performance depends on parameters including the reduction level of solar irradiance, the distribution of shadows above panel surfaces, the presence of bypass diodes, and the configuration of the panels in the array.

The findings in Fig. 4 shows reduction in efficiency equal to 11.86% with findings that these reductions in power and efficiency were caused by decreasing the short circuit current of the PV module with dust accumulation.

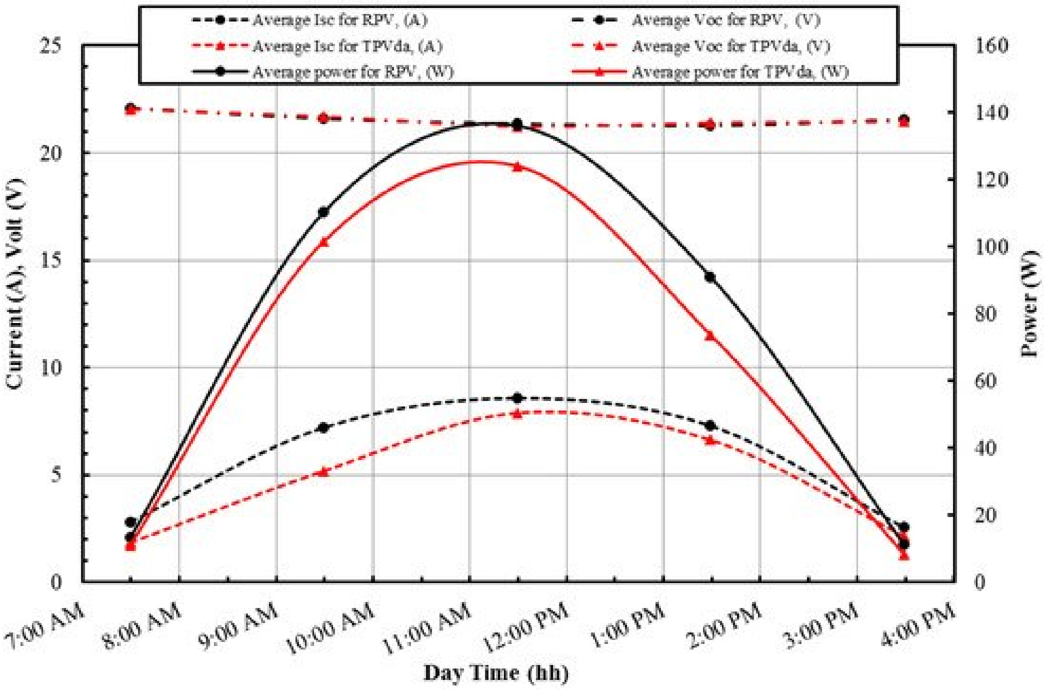

Fig. 4. Dust shading effect for polycrystalline modules Normal clean, Rpv and Dusted, Tpv [9].

Furthermore, the team continued shading in a sequence of a quarter, half, and three quarters of the surface area as shown in Fig. 5 where the results of the open circuit voltage decreased by 3.2%, 16.6%, and 25.3%, respectively.

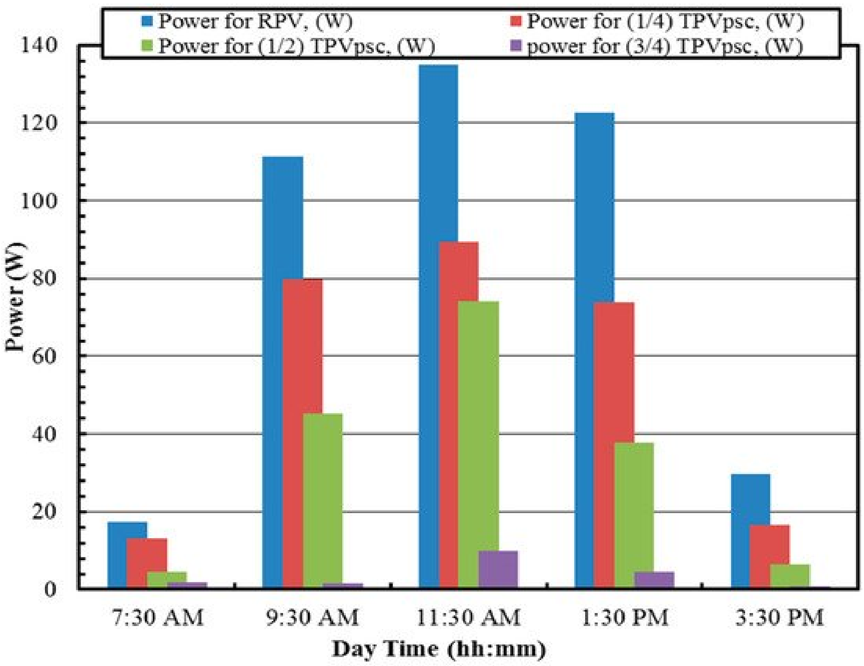

Fig. 5. Shading effect based on coverage surface area.

Solar PV panels are made up of a number of solar PV cells that are wired in series thus, a shaded cell produces significantly less current than an unshaded one which decreases the cumulative current flow to the system as shown in Fig. 6 with energy losses up to 33%. As a result, Alzahrani et al. [10] emphasize that the more problematic situation is when the PV module burns out due to the shadowed cells being heated to such high temperatures, resulting in long-term damage.

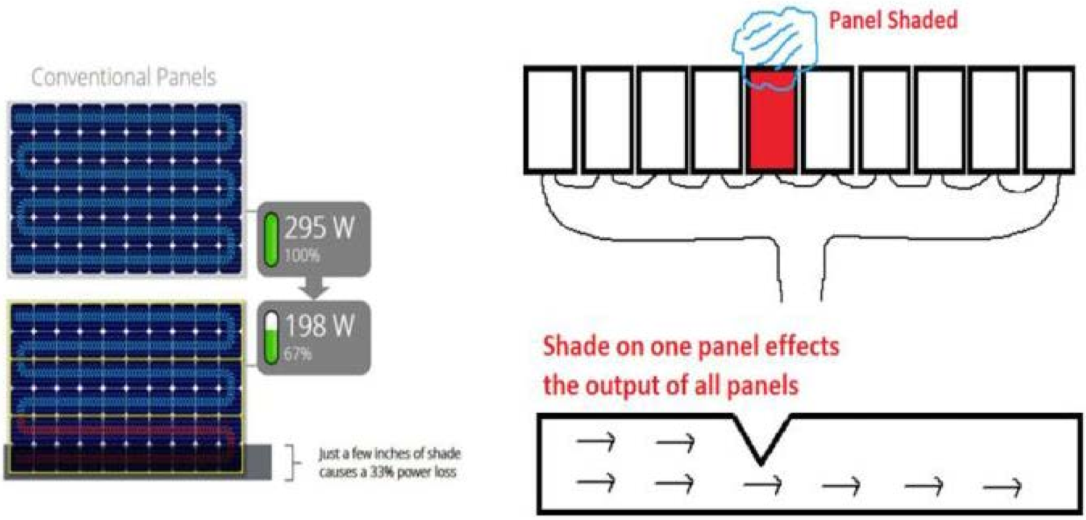

Fig. 6. Illustration of shading towards decreasing power output [10].

4. Methodology

The approach of this work implies freely available application namely Pl@ntNet and Canopeo to analyse the impacts of weed surface cover in Solarfarms. Images of specified weed growing above the solar PV surface are captured and identified using Pl@ntNet application to determine the specific type of weed. The same images as shown in Fig. 7 are used in Canopeo application to determine the surface coverage by means of Quadrat sampling. The freely available software application applied in this study for the field analysis is shown in Fig. 8.

Fig. 7. Weeds growing on top of PV surface creating a permanent shading condition. The lining is used as quadrant reference for measurements.

Fig. 8. The two available applications used in this work. Source from play.google.com

5. Results and Discussion

Based on Pl@ntNet results shown in Fig. 9, the creeping weed on top of the solar module surface is most likely from the *Mikania micranthe Kunth* which is a Climbing hemweed. The weed is from a tropical plant in the family Asteraceae; known as bitter vine, climbing hemp vine, or American rope. It is also sometimes called mile-a-minute vine (source from wikipedia.org).

The same approach for identifying *Annona cherimola Mill.* Shown in Fig. 10 which is a species of edible fruit-bearing plant in the genus *Annona*, from the family *Annonaceae*. The fruit tree grows heavily spurring out from between PV module gap in Solarfarm Puchong. This tree will not only create permanent shading, but it will also damage the solar PV structures if it is not properly cut and maintain.

Fig. 9. Weed Identification exercise using Pl@ntNet apps.

Fig. 10. Different weed type spreading out between solar PV gaps which creates permanent shading.

Based on Canopeo results shown in Fig. 11, the canopy coverage area on top of the solar module exceeds 59% coverage. Some field measurements are done manually by measuring the quadrant linings which shows similar results of approximately 35 shaded quadrants with 58.33% weed coverage at 0.84 squared meter.

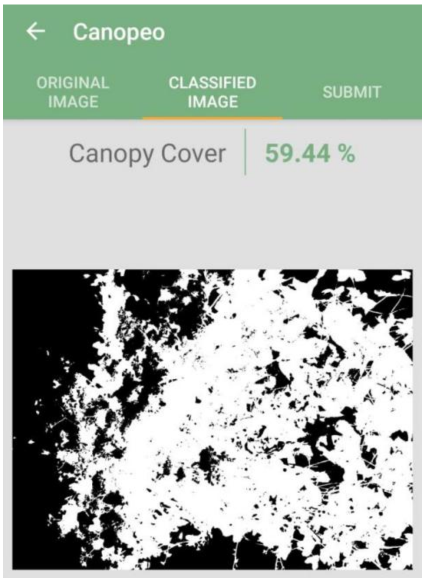

Fig. 11. Image analysis using Canopeo for canopy coverage.

6. Conclusion

This work shares some important weed identification approach in large scale solar Photovoltaic farms where ground vegetation especially creeping weed will create great monetary loss in DC generation. Previous studies have supported the fact that partial shading does reduces conversion efficiency which significantly reduces the power generation. Weed surface coverage in this case is a permanent shading to the solar PV operation and the growth rate can be exponentially uncontrollable especially during rainy seasons. It is suggested that large scale solar operator would benefit from the outcomes of this work with some emphasis on efficient weed management to aid in a fundamental understanding of the life cycle and biology of the weeds for proper control measures.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, M.E.Y, and N.F.O; methodology, M.E.Y and W.A.W.M.; software and validation, W.A.W.M and M.A.F.Z.; formal analysis and investigation, M.E.Y, W.A.W.M and M.A.F.Z.; resources, M.E.Y.; data curation, writing M.E.Y, W.A.W.M, M.A.F.Z and N.F.O.; visualization, W.A.W.M.; supervision, M.E.Y.; project administration and funding acquisition M.E.Y, and N.F.O. All authors had approved the final version.

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