Study on Analysis of Solar Panel Efficiency in Vietnam- A Power Comparison before and post cleaning

Surender Rangaraju[1], Shakthi Bharath K[2], Amiya Bhaumik[3], Phu Le Vo[4] and Khuong Vinh Nguyen[5] ,

[1,3] Department of Business and Accountancy, Lincoln University College, Malaysia.

[1] Faculty of Business Administration, Van Lang University, Ho Chi Minh City, Vietnam.

[2] Department of Instrumentation and Control Engineering, PSG College of Technology - India

[4] Faculty of Environment and Natural Resources, Ho Chi Minh City University of Technology – Vietnam.

[4] Vietnam National University Ho Chi Minh City, Ho Chi Minh City, Vietnam

[5]School of Science, Engineering & Technology, RMIT University, Ho Chi Minh city, Vietnam

[5]Faculty of Electrical Engineering and Computer Science VSB - Technical University of Ostrava, Czech Republic

Abstract

Vietnam is developing as a solar energy powerhouse, ranking eighth in the world in terms of installed solar capacity. With a long coastline and continuous high solar irradiation levels, the country makes a strong push toward renewable energy to meet its rising demands for energy to drive economic growth. The effectiveness of solar panels installed in Vietnam are decreased due to mass accretion of dust, dirt spots, muddy build-ups and bird's droppings etc. Maintaining high-capacity panels would be a problematic if it is not consistently cleaned. In the PV sector, O&M aids in the effective cleaning process and ensures solar cell sustainability. Systematic polishing of solar panels leads to increase in the output power generation and tends to maintain a consistent performance in solar cells, allowing the country to meet its energy needs.

Keywords: Solar Panel maintenance, Solar efficiency analysis, O&M, PV cell sustainability

1. Introduction

Solar energy is expected to contribute for 0.5 percent of total energy output in 2020, 1.6 percent in 2025, and 3.3 percent in 2050, according to the Vietnam Renewable Energy Development Project to 2030 with a view to 2050. As a consequence, by 2050, total solar power output will have increased from a negligible level today to 12,000 MW. Massive financial investment in solar energy capacity is necessary to attain this goal. The continuous maximum effective energy absorbed from the sun particularly the solar panel, as the principal component in the supply system decreases installation and production costs while also making peak electrical power needs easier to meet (Duong Vu, 2021).

The experts have researched that the life expectancy of solar panels is 30 years (Surender Rangaraju O. I., 2021). The accumulation of dust has an impact on the net output power and reduces solar panel system performance dramatically. As a result, physical impurities such as dust, debris, dirty rain, bird droppings, and other potentially harmful elements must be kept away from the solar panels. The duration of the PV is determined by the scratching action on its surface (Energy & Natural Resources, 2017).

To clean solar panels, regular maintenance and monitoring activity is important; otherwise, the output efficiency would be dramatically reduced. Regular maintenance and the utilization of resources entail a significant expense, but conventional O&M services have guaranteed the yield of solar panels for a while. Yield for current and forthcoming new solar projects in Vietnam, an periodic O&M services will be the best alternative. As a consequence, cleaning PVs in line incessantly will make huge difference in output energy efficiency (Surender Rangaraju O. I., 2021).

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2. Literature survey

For the solar system to perform at its best, it must be clean. A crucial part of solar panel maintenance is routine cleaning. The amount of electricity delivered from a solar PV array varies daily, monthly, seasonally, and annually depending on the amount of dust that has accumulated on the solar panels. (Peng, 2023)

The quantity of irradiance that reaches the solar cells has a major impact on how much power a photovoltaic module can produce. The optimum yield or ideal output of a solar module depends on a variety of factors. However, one of the contributing factors that has a direct impact on photovoltaic performance is the environment. The performance of such systems may be compromised by environmental and natural variables such the accumulation of soil, salt, bird droppings, snow, etc. on the PV module surfaces. (Mohammad Reza Maghami, 2016)

It is becoming more crucial than ever to manage PV sites optimally and analyze their predicted performance. The summertime, when there is the most solar resource, is when soiling can have the biggest impact on efficiency. Sea salt, pollen, and other particulates from anthropogenic and natural causes like building, agriculture, and air pollution build up on the panels until they are washed off or cleared by rain. (Felipe A. Mejia, 2013)

The two main environmentally degrading variables that affect solar panels are high ambient temperatures and high levels of air dust. All solar plants across the world experience a significant reduction in energy generation due to the degradation of solar collector performance brought on by soiling. Transmission loss is brought on by the deposition of soil and other particles on solar collectors, or soiling. Due to the absorption and scattering losses of the incident light, the so-called "soiling" effect, which refers to particulate contamination of the optical surfaces, has been observed to significantly worsen energy yield. (Arash Sayyah, 2014)

Solar cleaning is a requirement in most solar manufacturers' warranties. The solar panel could not be covered by the warranty if it sustains damage and becomes inoperable. This is true if we are unable to show the manufacturers that the PV panels have been maintained properly. According to research, cleaned solar panels can operate up to 10% more efficiently than those that aren't constantly cleaned. The effectiveness of solar panels must therefore be maintained through routine cleaning. (Conserve Energy Future, n.d.)

Solar panels will need more regular and comprehensive maintenance if they are located in dust-prone places, such as close to busy roads and agricultural areas. Solar production may suffer if dust isn't removed from panels set in these locations. According to research, dust on PV panels reduces solar effectiveness by about 40%' in dust-prone areas. (Energy Matters, 2022)

The longevity of a solar panel system may be increased with regular cleaning. Solar panels that are dirty and aren't maintained and cleaned on a regular basis might not even survive as long. Solar panels are an expensive investment and ought to be handled accordingly. They can become soiled and damaged if they are not frequently cleaned, especially if material like bird droppings is left on them for an extended period of time. Maintaining PV panels and keeping them clean will not only help them produce the most electricity possible but will also ensure that they are not deteriorating more quickly than they should. In the end, routine cleaning makes sure you get the best potential return on your investment. (Karlsson, 2021)

Trina Solar, one of the top solar panel manufacturers in the world, includes the following in a maintenance and care manual... "A solar module's ability to produce energy is directly related to the amount of light that strikes it. Because a module with shaded cells will produce less energy, maintaining the module's cleanliness is crucial. (Solar Panel Cleaning LTD, n.d.)

What maintenance is necessary for my solar panels, advises Panasonic, a renowned global firm and producer of solar photovoltaics? Your solar panels should be cleaned of dust and debris twice a year. The following are some of Panasonic's limited warranty exclusions: "Inadequate maintenance" and "damage or corrosion brought on by environmental pollution like soot and mold." (Solar Panel Cleaning LTD, n.d.)

Canadian Solar, one of the top producers of solar pv modules, advises cleaning the panels if a lot of debris accumulates on them. They also suggest that the optimum water has a PH that is close to neutral and has a low mineral concentration.

First Solar states that "In locations with heavy soiling, properly timed module cleaning can improve energy yields." They also claim that "RO water provides the best results." (Solar Panel Cleaning LTD, n.d.)

According to 8.33 Solar, a company that has been providing services to the European solar sector since 2006, "Over time, dirt and dust can build up on the module's glass surface, decreasing its power production. To guarantee maximum power generation, Solar 8.33 advises routine cleaning of PV modules. (Solar Panel Cleaning LTD, n.d.)

Currently, it is estimated that cleaning solar panels uses roughly 10 billion gallons of water annually, which is enough to supply drinking water for up to 2 million people. Waterless cleaning methods require a lot of labor and can leave surfaces scratched permanently, which lowers their effectiveness. Now, a team of MIT researchers has developed a method of mechanically cleaning solar panels or the mirrors of solar thermal plants in a waterless, no-contact technique that might greatly minimize the dust issue. (Chandler, 2022)

At Google's 1.6 MW solar farm in Mountain View, California, a ground-breaking experiment was carried out, and it was discovered that cleaning solar panels was "the number one way to maximize the energy they produce." 15-month-old solar panels that had been operating for cleaning nearly increased their electrical production. (Singh, n.d.)

The solar panels shouldn't be trodden on while being cleaned. Water and other substances that may penetrate the panels through tiny holes might seriously damage the facility. In order to improve energy efficiency and assure sustainability in power plants, robot cleaning produces expert solutions. (Robsys, n.d.)

Solar panel cleaning robots are a solution that makes it possible to produce renewable energy more effectively without using any more precious natural resources. (Leichman, 2022)

The extent to which automation and robot module cleaning are being used by owners and operators of large-scale PV projects has been revealed through a first-of-its-kind survey. The use of robotics in solar operations and maintenance (O&M) is growing, and there is growing awareness of their advantages in terms of increased power production, maximized return on investment, and improved efficiency. This is the clear trend, which is reflected in the geographical expansion of solar and the growth of projects. Its capacity to effectively clean thousands of modules is one of the most important factors to take into account when selecting a robotic cleaning solution. Cleaning modules by hand is no longer feasible due to the hundreds or even thousands of megawatts of solar site capacity, both physically and monetarily. (PV MAGAZINE, 2022)

Solar panels' ability to convert sunlight into electricity is reduced when they are dirty. Solar panels perform worse when covered in dust and dirt. This causes a significant loss in both money and renewable energy. A fully automated solar panel cleaning service employs drones to install cleaning robots on solar panels. The panels can be made more effective, resulting in more green energy production and increased financial gain. (Neira, 2022)

3. Research Problem

Sao Mai PV1, one of the large scale solar project in Vietnam with the area of 275 hectares Which produces about 210MW of peak capacity. It is researched that there is a huge power production loss recent days. The assumptions are accumulation of dust and poor solar panel maintenance will be the reason for the losses occurred. So, research is carried out whether the augmentation of dust particles and dirt spots really a problem for shrinkage of average output efficiency.

4. Methodology and Tools

The experimental study on power comparison before and after cleaning is done. At First, readings are taken 7 times according to the company standards from 8:55 AM to 3.00 PM. All strings are connected to the string monitoring box and the readings are derived from the process display. For the research, a total of six sets of uncleaned solar strings (i.e. 1 to 6) and two sets of cleaned strings (i.e. 7 and 8) taken into account. A Continues cleaning of strings 7 and 8 immediately after every reading is done. It is observed that there is a tremendous difference in the output efficiency from the cleaned strings compared to the uncleaned strings. The research methodology concludes poor panel maintenance and accretion of dust caused a recurring loss.

We used a SCADA system (Supervisory Control and Data Acquisition), an efficient asset management system that use state of technology to efficiently and proactively manage huge solar farms to collect the readings. With the integration of CMS (Central Management System) asset managers and O&M provider can Optimize and control energy assets and maintain a productive environment. This study utilized the SCADA system deployed

by Inaccess company to monitor and control the solar panels deployed at Sao mai solar farm- Vietnam.

5. Efficiency Analysis in a Solar Farm

The energy from the solar panel is crucial. Maintaining the efficiency of the solar panel is necessary. The analysis was done at Sao Mai group solar farm in Vietnam. The study gone through the farm and analyzed certain factors that the panels are cleaned 100 days in a year and the efficiency is exceptionally high from cleaned string of panels when compared to uncleaned one.

Fig 1 : Sao Mai PV1 solar farm at vietnam

6. Cleaning Analysis

Traditional cleaning of solar panels at Vietnam requires manpower, water, water truck, cleaning liquid and cleaning equipment's. The total installed strings of panels are 17,967. For one string of panel, it consists of nearly 60 - 90 panels wired together. The cleaning and maintenance of the panels is done at frequency of twice a year.

Fig.2 : Traditional cleaning of panels

Generally, for cleaning a string a panel at least 9-10 individuals involved and a total of 200 individuals are employed for the entire cleaning process and the green vegetation grown also provide a disturbance for cleaning the panels and additional 20 employees are employed for clearing the ground.

7. Efficiency Analysis Before and After cleaning

The efficiency of the panel has produced a low output from string 1 to 6 and 7,8 in Fig 3.Since the string reading are taken at low irradiance level at 8:55 AM.The results shows that there is a slight increase in the average power comparing the values 6503.9 W and 6588.4 W.

uncleaned string -1,2,3,4,5,6				
Cleaned string - 7,8				
	Before Cleaning			
Time	**8:55 AM**			
String	**current I(A)**	**Voltage (V)**	**Power(W)**	**Average value(W)**
1	5	1267	6335	6503.9
2	5	1267	6335	
3	4.9	1267	6208.3	
4	5.2	1267	6588.4	
5	5.3	1267	6715.1	
6	5.4	1267	6841.8	
7	5.3	1267	6715.1	6588.4
8	5.1	1267	6461.7	
	performance before Cleaning			1%

Fig.3: Performance of the strings before cleaning

The readings taken at 10:30 AM, the average power value gets gained comparing values 3402.8 W and 3801 W . Thus after the cleaning procedures gets over we can see the average power value gets a drastic increases when compare to uncleaned strings at rate of 12 percent.

Time	**10:30 AM**			
String	**Current DC I(A)**	**Voltage DC (V)**	**Power DC (W)**	**Average value (W)**
1	3.2	1086	3475.2	3402.8
2	3	1086	3258	
3	3.1	1086	3366.6	
4	3.2	1086	3475.2	
5	3.1	1086	3366.6	
6	3.2	1086	3475.2	
7	3.5	1086	3801	3801.0
8	3.5	1086	3801	
	Performance after Cleaning			12%

Fig. 4: Performance of the cleaned strings at 10:30 AM

The readings taken at 11:30 AM, the average power value gets surged comparing values 11022.9 W and 12706.2 W at rate of 15 percent.

Time	11:30 AM			
String	Current DC I(A)	Voltage DC(V)	Power DC(W)	Average Value (W)
1	9.3	1086	10099.8	11022.9
2	9.6	1086	10425.6	
3	9.7	1086	10534.2	
4	10.8	1086	11728.8	
5	10.9	1086	11837.4	
6	10.6	1086	11511.6	
7	11.8	1086	12814.8	12706.2
8	11.6	1086	12597.6	
	Performance after Cleaning			15%

Fig. 5: Performance of the cleaned strings at 11:30 AM

The readings taken at 12:15 PM, the average power value gets stepped-up comparing values 15973.3 W and 18267.8 W at rate of 14 percent.

Time	12:15 PM			
String	Current DC I(A)	Voltage DC(V)	Power DC(W)	Average Value (W)
1	14.6	1059	15461.4	15973.3
2	14.6	1059	15461.4	
3	14.9	1059	15779.1	
4	15.2	1059	16096.8	
5	15.5	1059	16414.5	
6	15.7	1059	16626.3	
7	17.3	1059	18320.7	18267.8
8	17.2	1059	18214.8	
	Performance after Cleaning			14%

Fig. 6: Performance of the cleaned strings at 12:15 PM

The readings taken at 2:00 PM, the average power value gets boosted comparing values 13707.9 W and 15055.6 W at rate of 10 percent.

Time	2:00 PM			
String	Current DC I(A)	Voltage DC(V)	Power DC(W)	Average Value (W)
1	12.7	1064	13512.8	13707.9
2	12.8	1064	13619.2	
3	12.8	1064	13619.2	
4	12.9	1064	13725.6	
5	13	1064	13832	
6	13.1	1064	13938.4	
7	14.2	1064	15108.8	15055.6
8	14.1	1064	15002.4	
	Performance after Cleaning			10%

Fig. 7: Performance of the cleaned strings at 2:00 PM

The readings taken at 2:30 PM, the average power value gets incremented comparing values 6480 W and 7614 W at rate of 18 percent.

Time	2:30 PM			
String	Current DC I(A)	Voltage DC(V)	Power DC(W)	Average Value (W)
1	5.8	1080	6264	6480.0
2	5.8	1080	6264	
3	6	1080	6480	
4	6	1080	6480	
5	6.1	1080	6588	
6	6.3	1080	6804	
7	7	1080	7560	7614.0
8	7.1	1080	7668	
	Performance after Cleaning			18%

Fig. 8: Performance of the cleaned strings at 2:30 PM

The readings taken at 3:00 PM, the average power value gets hiked comparing values 3730.1 W and 4519.2 W at rate of 21 percent. The average power value is calculated in watts tends to be increase in efficiency of the string and total average power of cleaned strings surged at the rate 15 percent.

Time	3:00 PM			
String	Current DC I(A)	Voltage DC(V)	Power DC(W)	Average Value (W)
1	3.5	1076	3766	3730.1
2	3.3	1076	3550.8	
3	3.3	1076	3550.8	
4	3.5	1076	3766	
5	3.6	1076	3873.6	
6	3.6	1076	3873.6	
7	4.2	1076	4519.2	4519.2
8	4.2	1076	4519.2	
	Performance after Cleaning			21%
Average performance increase after Cleaning				15%

Fig. 9 : Total average performance of cleaned Strings

Consequently, the strings will always provide superior efficiency when the strings are scrubbed in a frequent manner.

8. Findings

The study was carried out on cleaned and uncleaned solar strings. It is found that dust spots and muddy build-ups drastically decrease output power value .The Test carried out cleaning 2 strings out of 8 strings on a regular basis. . From the study, the results showed an absolute contrast between the efficiency of the panels If the strings are not cleaned or maintained appropriately it will not only rupture the panel but also cause monumental damage to energy production.

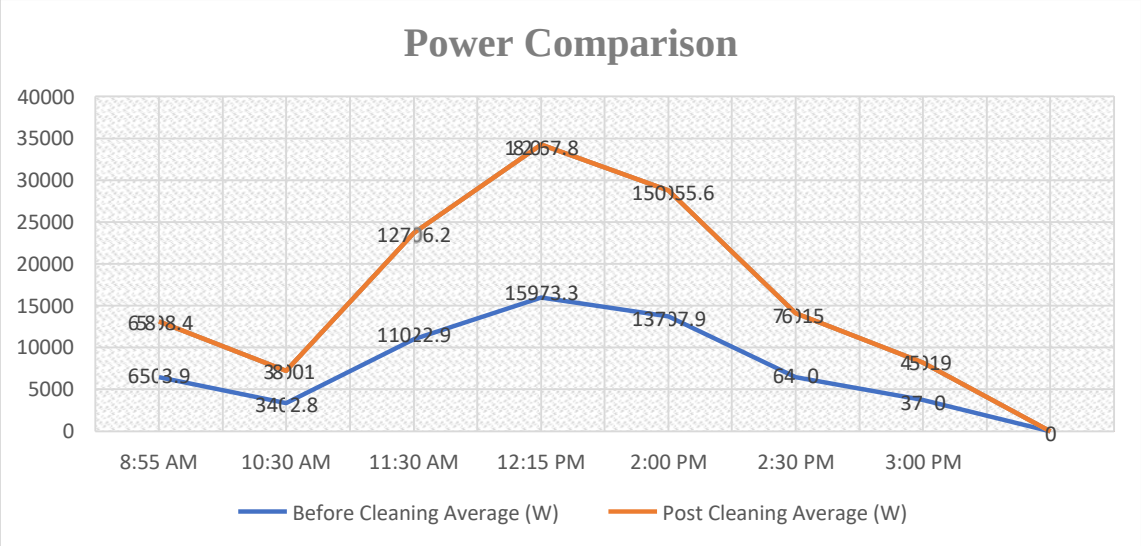

Fig. 10: Power Comparison Chart

9. Conclusion

Based on the study we emphasize that regular O&M services are extremely crucial in power generation that uses renewable energy sources, particularly solar energy. Even though, the maintenance includes labor expenses and other costs. Consistent washing is efficient in solar panel O&M which ensure panel free from dust and wrecks. More importantly in this efficiency analysis, the result from the solar farm shows tremendous surge of energy after cleaning compared to prior to cleaning of strings. As different methods of dusting are implemented to regulate strings tenability. The periodic serviceability on panels is indispensable in case of cell efficiency and durability.

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