MAINTENANCE ROUTINE FOR A SOLAR POWER SYSTEM

Ayodeji B. Balogun[1], Timothy O. Matthew[2]
[12]Department of Electrical/Electronic Engineering,
The Federal Polytechnic, Ilaro, Ogun State, Nigeria
Email: ayodeji.balogun@federalpolyilaro.edu.ng
WhatsApp Phone No: 08036181212

Abstract

The solar power system is the cleanest method of generating electricity and is effective and environmentally benign. After installation, a solar system necessitates minimal upkeep, provided that it remains unimpacted by environmental influences. If solar panels are regularly maintained and kept free from debris, they are expected to operate efficiently without any further intervention from the user for an extended period of time. This research aims to provide a practical method for increasing the efficacy of solar power systems and ensuring their durability through a predefined and preventive maintenance approach. Biodegradable soap and a wet, soft-textured cloth are recommended to be used to prevent damage, cracking, or breakage on the surface of the panel. It is advised to check the battery's tightness and carbon buildup every two weeks and quarterly. If debris is continuously cleaned from the panel's surface and other equipment is inspected and maintained on a regular basis, the system's efficiency and lifespan would be high, reducing users' costs.

Keywords: Maintenance Routine, Solar PV System, Electricity, Efficiency

Introduction

Solar panels are the most prevalent form of personal renewable energy that is not connected to the power infrastructure, despite being a relatively new and extensively adopted energy source (Adedeji et al., 2023). Due to its independence from the infrastructure, solar energy is a viable option for providing electricity to the 770 million people who lack it (*SDG7: Data and Projections – Analysis - IEA*, n.d.). As the globe enters the digital era, electricity becomes increasingly essential for improving the standard of living for many people in developing nations. Extending the electrical network to accommodate a billion people is not a viable solution because it would be expensive, dangerous, and detrimental to the environment.

Solar energy is one of the few portable energy sources that can provide enough electricity for household use from 4 gigawatt hours in 2004 to 12,138 gigawatt hours in 2021 (Statista, 2023). However, solar panels are costly, and many individuals who urgently need them cannot afford them. One option is to construct a solar panel from the inside out, but this method can require excessively expensive materials, result in the production of even more costly panels, and has no effect on solar efficiency. There are currently no external solar panel structures that are both simple and effective to construct. Installing an external structure would increase the amount of light that strikes the solar panel, thereby increasing the solar panel's ability to generate energy. Thus, fewer solar panels may be able to produce the required quantity of electricity to power a residence. Fewer solar panels are healthier for the environment because they cost less to produce and purchase and supplant more fossil fuels.

The Use of Solar Panels Today and its Efficiency

Solar panels have a wide variety of applications in the present day such as Solar Fabrics, Solar Skins, Solar-Powered Roads, Floating Solar Farms, Solar Storage, PV Solar Noise Barriers, Solar at Night (7 Creative Applications of Solar Energy - ASME, n.d.). In a number of these instances, solar panels replace fossil fuels as an energy source. Satellites, structures, and various modes of conveyance are all powered by solar energy. (Bagher, 2015)

Solar panels are the most prevalent source of energy for buildings. Solar energy powers illumination, automatic entrances, and wall outlets in residential, commercial, and retail buildings. Importantly, solar panels have supplanted fossil fuels in the buildings they power, such as coal and oil. In order to reduce a home's reliance on conventional power sources, solar panels can be used to generate a portion of its electricity (Shahan, 2012). In 2013, the United States produced 8.3 million megawatt-hours (MWh) of solar energy that was not produced by coal or hydrocarbons.

Additionally, solar energy has been utilised in transportation. Despite the experimental nature of this solar panel application, the results have been promising. A car entirely propelled by solar panels set a new distance record of 1,000 kilometres. The sun is one of the finest alternative energy sources for automobiles and solar-powered vehicles are 100 percent pure. Solar aircraft have also been developed. In 2015, one of these aircraft, the Solar Impulse 2, accomplished a multi-leg voyage around the globe (AZoCleantech.com, 2022). As a result of this trip and subsequent Solar Impulse initiatives, aeroplanes will soon be powered by solar panels. The majority of commercial aeroplanes produce large amounts of carbon dioxide, which increases the quantity of greenhouse gases in the atmosphere and reduces the amount of light that can escape, warming the planet (Shahan, 2012). Current jet fuel sources are exceedingly harmful to the environment, and they also contribute to the abundance of greenhouse gases in the atmosphere. One of the world's principal carbon dioxide emissions will be eliminated in the future if solar-powered jet aircraft are developed. (*All-in-one Solar-powered Tower Makes Carbon-neutral Jet Fuel*, 2022)

With all of these uses, however, if solar power panels that absorb solar energy, the charge controller, batteries and inverters are not correctly maintained and cleansed, the system's individual efficiency will decrease, resulting in a reduction in the system's overall efficiency. This maintenance must be performed on a consistent basis.

Maintenance Analysis

In broad terms, a solar energy system can be characterised as being straightforward in nature. Fundamentally, the system lacks any components that exhibit mechanical motion. This aspect has a significant role in minimising operational and maintenance expenses. A system that is meticulously planned and expertly implemented will require minimal ongoing maintenance. However, it should be noted that no system is impervious to the effects of wear and tear, and there exist several unforeseen factors that have the potential to detrimentally impact both system performance and safety. In addition, it is important to note that there exist specific instances, such as trackers and certain types of batteries, wherein regular active maintenance plays a crucial role in ensuring optimal long-term performance. (Pawliw, 2021)

Wear and tear on outdoor equipment can be caused by various factors, including weather, UV degradation, heat, pests, plants, insects, thermal cycling, vandalism, and product failures. Weather impacts are unpredictable, and UV degradation can cause materials to degrade, while heat can cause electronics to heat up and shorten their lifespan. Pests and insects can also impact electrical devices, while thermal cycling can cause materials to shrink and expand with temperature changes. Vandalism can occur through rocks and golf balls, while product failures can lead to roof leaks, poor performance, and safety hazards.

Equipment can suffer from negative effects, including movement, damage from sharp surfaces, cracking, disintegration, pest chewing, water or insect intrusion, corrosion, loose connections, and degradation from chronic overheating, which can lead to safety issues.

The solar array, comprising solar modules, racking, wiring, and additional equipment, is subject to significant weather exposure, resulting in various challenges such as movement, wire loosening, UV deterioration, and water infiltration. Inverters, which possess a design life exceeding 20 years, may also encounter challenges such as product failures and weather ingress. The dominant factors influencing the balance of system, which encompasses cables, conduits, switches, breakers, and fuses, are suboptimal installation practises, heat cycling, and intrusion. According to Adetona et al. (2020) batteries required replacement every five (5) years, different types of batteries necessitate regular maintenance, whereas trackers, which mechanically rotate the solar array to ensure that the modules are constantly oriented towards the sun, can enhance energy production but entail greater expenses for installation and involve components that are subject to movement. Routine maintenance is important in order to conduct inspections for signs of deterioration and guarantee sufficient lubrication.

Before performing maintenance on the solar power system, each system component must be disconnected from the system in order to prevent bridging of connections and any resulting danger. This requires turning off the circuit breakers leading to and from the battery bank and solar panels. This would enable for more effective cleansing of each system component.

Maintenance Requirement

Solar energy systems exhibit a relatively low maintenance requirement in comparison to alternative types of energy generation. Nevertheless, it should be noted that photovoltaic systems are not devoid of maintenance requirements. In

fact, the effective implementation of an operations and maintenance (O&M) programme plays a crucial role in optimising the performance, availability, and electricity generation of the solar power plant. Additionally, a well-executed O&M programme is vital to mitigating potential hazards and minimising associated costs. Maintenance can be categorised into two distinct types:

a) Scheduled maintenance refers to a planned activity that is undertaken with the objective of preventing system failures, prolonging the lifespan of the systems, and optimising power generation.

b) Unscheduled maintenance refers to the type of maintenance that is conducted after the occurrence of a failure.

The distinction between these two types of maintenance is not absolute, and in reality, there exists a dynamic equilibrium between them. The implementation of a comprehensive and well-designed schedule for maintenance activities will lead to a reduction in the occurrence of unscheduled maintenance events, thereby minimising system unavailability and mitigating unforeseen financial expenditures. (McHatton, n.d.)

Battery Maintenance

The batteries are complicated, not expensive and decrease overall system efficiency. To extend the useful life of the battery, they should be regularly maintained. A quick check will be carried out on the batteries daily or weekly. While a proper and general cleaning will be done on a monthly or bi-monthly basis.

The battery will be regularly and carefully maintained to extend their useful life. These activities include:

- Inspecting and cleaning regularly
- Checking the electrolyte level of the battery
- Keeping in a high state of charge often.

Battery Inspection and Cleaning

A visual inspection will be done to assess the general condition of the system's batteries. Cracks, electrolyte leaks and corrosion at the terminals or connectors will be checked and cleaned.

Solar batteries need to be clean, dry and free from electrolyte and corrosion. Corrosion at battery terminals is seen as a white coating around the battery terminals. Cleaning of this should be done once monthly.

To maintain a long-lasting battery and avoid hazard that might arise, the following approach is employed when carrying our maintenance on the battery:

1. Safety goggles will be worn when performing battery maintenance.
2. Metal files will not be used to remove corrosion.
3. Tools with insulated handles are used to carry out any maintenance.
4. Smoke and fire should be avoided where batteries are because batteries produce hydrogen gas which is highly inflammable.

Solar Panel Maintenance

Solar modules are widely regarded as the most reliable component within a solar facility. The issues encountered within the modules are associated with a decline in operational effectiveness over a period of time, mostly attributable to various causes including ambient conditions, exposure to dust and pollutants, and installation-related challenges. Figure 1 shows the solar panel used for the study.

Figure 1: Picture of the Stand-alone Solar Panel Used

The maintenance procedure for a module entail doing a visual examination to identify potential issues such as cracks, delamination, opacity of the glass, water infiltration, and difficulties with connectors. In solar systems lacking current monitoring by String, the examination of interconnections between modules becomes of greater significance as the identification of such issues becomes increasingly challenging. In systems equipped with such monitoring capabilities, the identification of connection issues can be achieved through a performance comparison of Strings possessing the same number of modules.

Maintenance and Inspection of Wiring and Connections

Wiring Installation will be checked for any cracks, breaks or deterioration in installation or conduits. The panel boxes will be inspected to ensure that they have not become a home for rodents and insects. Also, connections for any corrosion or burn will be checked regularly. Figure 2 shows the wire connection of the charge controller and inverter.

Figure 2: Image Showing the Inverter, Data Logger and the Connection

The following section of conduits wiring will be checked for any sign of damage.

- Solar panel to the charge controller
- Charge controller to the battery section.
- Inverter to the battery bank
- Battery to the loads.
- Maintenance Schedule

Table 1: Solar Power System Maintenance Schedule

Maintenance Task	Daily	Weekly	Bi- Weekly	Monthly	3 Months
Visual Inspection of System and Wiring	✓				
Solar Panel Cleaning and Maintenance				✓	✓
Battery Inspection		✓			
Battery Cleaning			✓		
Inverter Cleaning			✓		
Charge Controller Inspection			✓		
Wiring Inspection	✓				
Battery Top- Up					✓

As shown in table 1, a daily visual check of the system and wiring is recommended. Weekly battery inspections are necessary to detect the presence of powdery corrosion buildup resulting from sulfuric acid leakage in the battery fluid, which may come into contact with the battery terminals or cable connections. Regular check of the charge controller on a biweekly basis, as well as cleaning of the battery terminals and inverter. In light of prevailing weather conditions, it is recommended that the solar panel undergo regular monthly cleaning and that a scheduled maintenance routine be implemented for the solar power system. Additionally, it is advised that the battery electrolyte be replenished on a quarterly basis.

Discussion

The evaluation of the system is conducted according to a pre-established maintenance schedule. The aforementioned experiment yields observations regarding the impact of maintaining the solar power system on the maintenance of individual components and the system as a whole, thereby influencing the overall efficiency of the solar power system. The analysis of system maintenance has demonstrated that increased monitoring and proactive measures to prevent failures are positively correlated with a higher probability of the system achieving an extended operational lifespan. The system exhibits optimal performance during daylight hours, resulting in superior results. If effectively managed over an extended period, this will lead to minimal volatility in the system over time. Therefore, the system will exhibit optimal performance throughout a period of time. Nevertheless, in the event that the panel, in particular, is not cleaned for an extended duration, the presence of dirt on its surface might impede the efficient capture of solar energy by the panel. Additionally, if the battery is not adequately inspected for chemical levels, its longevity is diminished.

Conclusion

Solar energy production exhibits a diurnal pattern, with higher generation occurring during daylight hours, specifically between 9 a.m. and 2 p.m. The zenith of solar energy output is typically observed around noon, specifically between 12 p.m. and 1 p.m. In order to ensure thorough cleaning, it is recommended to first separate the system and thereafter clean each piece of equipment independently. The effectiveness and efficiency of a solar power system can be significantly enhanced by the diligent inspection and regular maintenance of all its components. The efficiency of the system is enhanced through frequent maintenance performed on a pre-established maintenance schedule.

The effectiveness of this solar power system diminishes over time; however, regular cleaning of the solar panels and monitoring of the electrolyte level might help mitigate this depreciation.

Recommendations

When considering the implementation of a solar power system for home or industrial purposes, it is recommended to use Mono-crystalline solar panels due to their superior efficiency compared to other types of solar panels. The optimal height and angle of mounting should be carefully taken into account in order to ensure the effective maintenance of a solar power system. The optimal height for accessibility purposes should be of moderate magnitude, allowing individuals of varying statures to comfortably reach it. Additionally, it is recommended that the solar panel be inclined at an angle ranging from 30 to 45 degrees, since this inclination facilitates effective sun exposure and capture. Furthermore, it is imperative to ensure that the entire surface of the panel is exposed to direct sunlight during the mounting process.

It is recommended that the surface of the solar panel not be cleaned with conventional soap or a coarse rag. Instead, a soft-textured, moist cloth and a biodegradable soap should be employed for this purpose. Regular removal of debris and dust from the surface of solar panels, as well as periodic checks of the batteries' chemical composition at the terminals, are recommended practises to prevent a decrease in their efficiency. Regular maintenance of battery water levels is crucial, as it has the potential to diminish the overall effectiveness of the system.

It is imperative to adhere to all specified processes and recommendations in order to ensure the seamless and efficient functioning of the solar power system. It is recommended that all cleaning and maintenance activities be conducted during the evening hours, when solar energy is not being collected or when the sun has set. Furthermore, it is imperative to ensure that the system is properly isolated prior to doing any maintenance activities. Additionally, it is recommended that consumers employ a predefined and preventive maintenance approach for their solar power system.

References

7 Creative Applications of Solar Energy - ASME. (n.d.). https://www.asme.org/topics-resources/content/7-creative-applications-of-solar-energy

Adedeji, I., Deveci, G., Salman, H., & Abiola, I. (2023). The Benefits of Solar Energy on the Provision of Sustainable Affordable Housing in Nigeria. *Journal of Power and Energy Engineering*, *11*(06), 1–15. https://doi.org/10.4236/jpee.2023.116001

Adetona, Z., Ogunyemi, J., & Bitrus, I. (2020). Maintenance Management regime for Off-Grid Solar PV renewable energy system in Nigeria. *European Journal of Engineering Research and Science*, *5*(11), 1376–1382. https://doi.org/10.24018/ejers.2020.5.11.2233

All-in-one solar-powered tower makes carbon-neutral jet fuel. (2022, July 22). ScienceDaily. https://www.sciencedaily.com/releases/2022/07/220720121020.htm

AZoCleantech.com. (2022, December 21). *Recent advancements in Solar-Powered aircraft*. https://www.azocleantech.com/article.aspx?ArticleID=1639

Bagher, A. M. (2015). Types of solar cells and application. *American Journal of Optics and Photonics*, *3*(5), 94. https://doi.org/10.11648/j.ajop.20150305.17

McHatton, D. (n.d.). *10 ways preventative maintenance can assist in reducing downtime*. https://www.sageautomation.com/blog/10-ways-preventative-maintenance-can-assist-in-reducing-downtime

Pawliw, J. (2021, February 10). *What Maintenance is Required For Solar Electric Systems? - Generation Solar*. Generation Solar. https://www.generationsolar.com/solar-101/what-maintenance-is-required-for-solar-electric-systems/#:~:text=An%20electrical%20inspection%20to%20confirm,loose%20connections%20and%20hot%20spots

SDG7: Data and Projections – Analysis - IEA. (n.d.). IEA. https://www.iea.org/reports/sdg7-data-and-projections

Shahan, Z. (2012, July 24). 10 ways you can use solar panels to help you save or make money. *CleanTechnica*. https://cleantechnica.com/2012/08/06/10-ways-you-can-use-solar-panels-to-help-you-save-or-make-money/

Statista. (2023, July 28). *Solar photovoltaic energy production in the United Kingdom 2004-2022*. https://www.statista.com/statistics/223332/uk-solar-power-generation