DETERMINANTS OF SOLAR PHOTOVOLTAIC SYSTEM PERFORMANCE IN SRI LANKA

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Abstract. Given the rapid development of solar technology over the past few decades, and its location in the equatorial belt, Sri Lanka has experienced a rapid expansion of solar photovoltaic (PV) systems in recent years. As solar energy becomes a significant portion of the national energy balance and a substantial financial commitment, it is essential to ensure the optimal performance of a solar PV system. The performance of a solar PV system is primarily affected by the quality and reliability of the system itself, which is dependent on its manufacturing, construction, and installation aspects. However, solar PV system performance is also greatly affected by several other factors during its operation. Accordingly, this study specifically investigates the determinants of solar PV system performance in Sri Lanka during the operational stage. An extensive literature review identified operational, maintenance, and environmental determinants, and through expert interviews, the applicability of the identified determinants in the Sri Lankan context was examined. In addition, the research identified outdated grid infrastructure and voltage fluctuations as external factors that can also affect the performance of solar PV systems.

Keywords. *Solar PV Systems, Solar Performance, Sri Lanka, Factors*

1. Introduction

Sri Lanka has a tropical climate and gains numerous benefits from renewable energy, like solar power. Throughout the year, Sri Lanka has a considerable amount of sunlight because of its geographical location (Koswatte et al., 2024). In Sri Lanka, the Suryabala Sangramaya initiative, launched in collaboration with the Sri Lanka Sustainable Energy Authority, Ceylon Electricity Board, and Lanka Electricity Company, allows customers to generate and consume electricity on their properties. By the end of 2022, rooftop solar installations in Sri Lanka had gathered significant momentum as part of the country's shift toward renewable energy, with 45,845 PV systems producing 660 MW of capacity (Sri Lanka Sustainable Energy Authority, 2022). As a result of the increase in the installation, performance variations become more noticeable during the operational phase. The variation between expected and actual performance occurs due to several influencing factors, and a detailed review is required by incorporating all the factors affecting the performance variations of the system operation stage, because attention is increasingly being directed toward overcoming challenges that impact the long-term performance of these systems.

In a global context, existing research on factors affecting the performance variations primarily examined several factors under environmental factors, PV construction factors, installation factors, and operation and maintenance factors (Hasan et al., 2021). Although individual factors and technical factors are extensively reported by many researchers

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(Vidyanandan, 2017), in the Sri Lankan context, existing research on solar PV systems in the country has primarily identified the factors influencing PV solar technology adoption (Subasinghe & Jayawardane, 2025; Dheerasingha & Jayasekara, 2024). Even though many studies have already determined the main technical and environmental factors of solar PV performance, there remains a considerable contextual research gap in Sri Lanka, especially with the new saturation phase of the solar PV market and infrastructure limitations (Ileperuma & Dharmadasa, 2026). Thus, this study is needed to go beyond a traditional analysis of factors and focus on the impact of a combination of environmental, operational, and infrastructure-related factors on the performance of PV systems in a saturated market. Therefore, this study focuses on investigating determinants of the performance of solar PV systems during their operation stage to advise on how to enhance solar PV performance. The paper comprises a literature overview on solar energy and PV systems, and then it presents the methodology employed in the research. The findings of the study are then presented, followed by the conclusions and further research directions.

2. Literature Review

The below section describes key literature on solar PV systems, solar PV performance and the factors affecting the performance of solar PV systems during the operational phase.

2.1. SOLAR PV SYSTEMS AND THEIR PERFORMANCE

The solar PV system is a technology which is used to directly convert sunlight to direct current (DC) electricity by the PV effect, with the use of a material based on the semiconducting material silicon crystals. The main elements of the operating system are PV modules named solar panels, an inverter to turn the DC into the appropriate alternating current (AC), mounting structures, and optional storage batteries to be used during the night or when the light is scarce. They usually fall into grid-connected (on-grid) systems, where they get connected to the utility system so that they can sell the excess power; standalone (off-grid) and hybrid systems (Lapsongphon & Somna, 2024).

The performance of solar PV can be defined as the effectiveness with which the system transforms sunlight into useful electricity under real world conditions and emissions at the same time. It is based on the output energy produced by the system. Performance can fluctuate over time due to a number of factors (Pradhan & Panda, 2017). Even though PV modules are developed to produce electricity with high efficiency, the actual output of the devices is usually lower than the laboratory or modelled results. This variance is caused by a number of energy production-related parameters, which are the main determinants of solar PV systems and have a major impact on the efficiency of electrical conversion (Aslam et al., 2022). The performance of a solar PV system is determined by factors such as Construction and installation aspects, which are primarily technical aspects that determine the quality and reliability of the system, both initially and in the long term. These are the quality of the PV modules, the choice of the inverter, the mounting systems, the wiring system, the tilt, the orientation, the analysis of shading, and the standards conformity. Proper engineering design and proper installation practices will lead to optimum energy production and fewer technical losses. However, as the system progresses into the operational phase, environmental, operational, and maintenance factors are the primary factors that affect its performance. Hence, although construction and installation are very important technical building blocks, the environment, operational activities, and maintenance management have preeminent roles in determining the performance of the PV systems in the operational phase.

2.3 DETERMINANTS OF SOLAR PV PERFORMANCE IN OPERATIONAL PHASE

Solar PV performance is established by a two-stage process, including the design and installation stage, which involves critical one time technical choices varies with PV construction factors and installation factors. According to Hasan et al., the performance in the operational phase varies depending on various environmental, operation and maintenance variables (refer Figure 1), which have been discussed below.

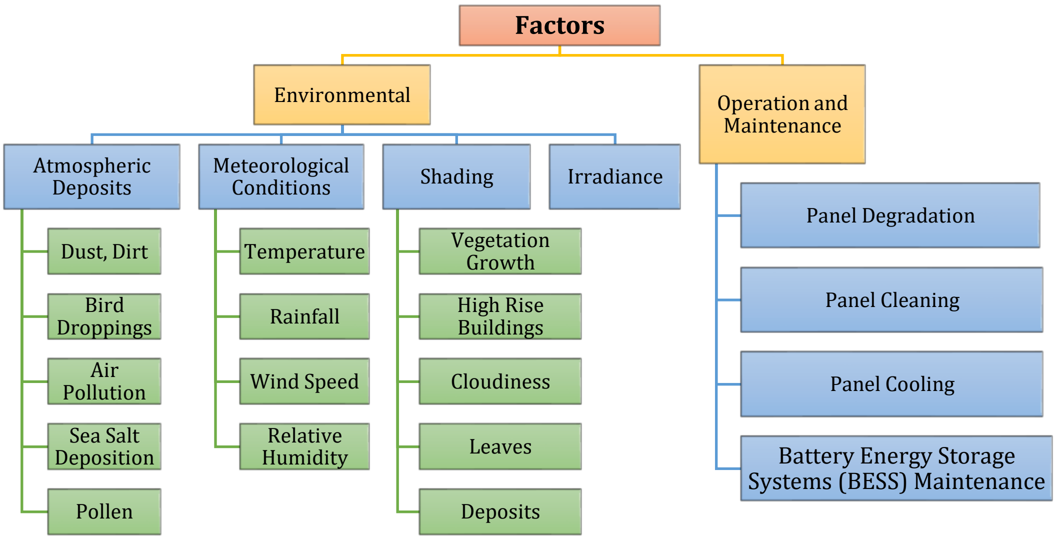

Figure 1: Determinants of Solar PV SYSTEM Performance during their operation (Sources: Hasan et al., 2021; Sepúlveda-Oviedo, 2025; Mustafa, Gomaa, Al-Dhaifallah, & Rezk, 2019)

2.3.1. Environmental Determinants

- *Atmospheric Deposits*

Atmospheric deposits refer to the accumulation of dust, dirt, bird droppings, smoke and any other organic or inorganic contaminants that deposit on PV modules (Maghami et al., 2016; Vedulla, Geetha, & Senthil, 2022). It can significantly impact their performance by providing physical protection from the solar radiation entering the PV cells. This blockage has the direct effects of decreasing the production of photocurrent, causing a great decrease in conversion efficiency and power output. This is harmful for the performance of the solar PV system even in the short term. These deposits are very location-specific in their formation and nature, size, and form of dust particles are location-dependent (Ghosh, 2020).

- *Meteorological Conditions*

Meteorological conditions refer to atmospheric and environmental parameters that characterise weather and climate at a specific location and time. According to Sağlam (2010), primary atmospheric conditions that determine the operational efficiency and longevity of PV systems can be identified as ambient temperature, relative humidity, wind speed, and air pressure. Ambient temperature is a leading cause of panel heat, since PV panels are very sensitive to heat (Al-Smairan et al., 2024).

- *Shading*

Shading is established to be the most dominant environmental parameter in terms of efficiency and reliability of PV systems, which is a physical interruption whereby the solar radiation does not reach the active cells (Ramezani & Mirhosseini, 2025). The condition where the sunlight reaching the PV modules is obstructed by external or environmental factors such as nearby buildings, trees, poles, clouds, leaves, or dust deposits on the panels (Living et al., 2026). This has been classified as hard shading, which is due to objects of distinct objects like buildings, trees, bird droppings, and leaves, and soft shading, which is attributed to atmospheric conditions such as smog, fog or smoke, which diffuses the intensity of the incoming irradiance. This obstruction limits the quantity of solar irradiance incident on the solar cells, which significantly declines the energy production and general performance of the PV system (Duranay & Guldemir, 2025).

- *Irradiance*

The quantity of solar energy that strikes a solar panel's surface is referred to as solar radiation, or irradiance. It refers to the power that the sun emits on an area basis, specifically electromagnetic radiation. It is also a crucial factor in determining the project's orientation while the solar PV system is being installed (Barros et al., 2018). Irradiance and power output are directly related to strong radiation conditions, giving more photons to be converted into electricity. The maximum power of solar panels is normally determined at Standard Test Conditions (STC), which is an irradiance of 1000 W/m and a cell temperature of 25°C (Razak et al., 2016).

2.3.2. Operational and Maintenance Related Determinants

- *Panel Degradation*

Solar panel degradation is the process of the gradual reduction of the power generation and efficiency of the PV system over its operational lifespan. Modern modules are typically defined to have a normal life span of between 25 and 30 years, it is believed that they would not perform well because of environmental forces, ageing of the materials, and flaws in manufacturing. Typically, quality panels degrade at a rate of 0.4% to 0.5% within a year. Accordingly, a quality panel may retain most of the original power of 87.5% after 25 years (Obaid et al., 2024)

- *Panel Cleaning*

There is a direct proportional relationship between the performance of a solar PV system and the cleaning of the system (Olorunfemi et al., 2022). Therefore, it is necessary to brush off the surface of PV modules in order to eliminate the accumulated dirt, dust, and debris, or soiling, on the module. As per section *2.4.1.,* it acts as a shield that prevents the entry of solar radiation to the PV cells and the scattering and absorption of photons, which directly decreases the generation (Wang et al., 2022). The cleaning techniques are as varied as simple manual methods of cleaning to complex automated cleaning techniques.

- *Panel Cooling*

Solar panel cooling is an important factor that removes undesired heat in PV modules to ensure that they operate optimally with proper thermal management. Since the PV cells can normally transform the solar energy into power, the rest of the energy is lost as heat, elevating the temperature of the module and greatly weakening the efficiency of the system. Cooling systems can be categorised into active, passive, and hybrid systems depending on their power demand and mechanisms of physical dissipation (Parthiban & Ponnambalam, 2022). Active cooling makes use of external apparatus like fans, blowers, or pumps to move air or water; although such may dramatically cool down temperatures. In passive cooling, natural thermodynamics, including convection, radiation, or evaporation, is used, and no external source of power is needed (Bukar et al., 2025). Hybrid cooling systems combine elements of both active and passive, as an attempt to have a high-performance rate through balancing the effectiveness of cooling and the energy consumption (Eid et al., 2022).

- *Battery Energy Storage Systems (BESS) Maintenance*

BESS maintenance has become an important subject in solar performance due to the fact that the reliability, efficiency, and the overall life of a particular PV system significantly rely on the battery design and its particular operating options (Manimekalai et al., 2013). Batteries may fail prematurely without proper maintenance and monitoring, and this is especially critical considering that the storage unit is also the most expensive element in a solar installation to purchase in most cases. In order to achieve a good long-term performance, a modern BESS management frequently employs smart scheduling algorithms, to achieve a balance between energy yield and the estimated remaining useful life of the battery (Liao et al., 2018). Hence, a thorough probing of the literature identified four key factors under the environmental category and four under the operation and maintenance category, and these factors were used for the subsequent data collection during the expert interviews.

3. Methodology

This study aims to identify "which factors affect the performance of solar PV systems in Sri Lanka, and how do they affect the performance during their operational phase?” To carry out this study, a qualitative approach was adopted and expert interviews, which is a common technique in a qualitative approach used to learn and gain insight or investigate a certain area of study (Döringer, 2020). Qualitative research studies suggest that fewer expert interviews can be sufficient if the data they offer is rich and relevant to the research question. In the interviews, common opinions and themes emerged, which helped to substantiate the findings of the study (Malterud et al., 2016).

Accordingly, five experts with over 10 years of experience in the field of study were selected for data collection. The profiles of the experts are listed in Table 1.

Table 1: Profile of Experts

Expert	Designation	Overall Experience
E1	Electrical Engineer	10
E2	Assistant Facility Manager and Electrical Engineer	12
E3	Solar Engineering, Procurement, and Construction Provider and Radio Frequency Expert	15
E4	Electrical Engineer and Solar Engineering, Procurement, and Construction Provider	17
E5	Electrical Engineer	11

During the expert interviews, the gathered data from the literature was examined for their relevancy for the Sri Lankan context, while the experts were also asked to identify the level of impact of each determinant for the performance of solar PV systems as either low, medium or high. The overall impact of the determinants on the performance of the PV system in Sri Lanka was determined based on the expert views, as shown in Table 2. As part of the qualitative method, thematic analysis was chosen to examine the collected data from expert interviews. According to Braun & Clarke (2012), thematic analysis is a simple method used to identify and analyse patterns in qualitative data such as interviews. The study utilized five expert interviews as part of a qualitative research approach. The selected experts were chosen based on their experience and expertise relevant to the research, and the emphasis is on depth of understanding.

Once the interviews were recorded and transcribed. The transcripts were checked against the original audio to ensure that everything was accurate. Then read the transcripts several times to familiarize with the data and to identify patterns and themes. The codes were created manually by searching for common ideas among the experts. This allowed the barriers to be grouped, while also highlighting different viewpoints. Based on that, key themes, including environmental, operation, maintenance and grid infrastructure issues were identified.

4. Research Findings

When discussing the overall solar PV systems in Sri Lanka, E4 mentioned that "*in 2016 there was a boom in the industry, and that was mainly influenced by two reasons, including the cost subsidy and the solar panel cost reduction with bulk manufacturing. As of today, excess solar generation can be recognised, and there is a dip we can identify in the industry because this solar excess cannot be managed*". According to E1, "*from 2009 to 2016, solar power systems were mainly installed based on performance. After a rapid boom in the solar industry, there were 1000+ suppliers in the market, and then it converted to a competition-based installation".* Similarly, E3 stated that, "*In the current situation, almost all the suppliers are using almost the same designs as per the clients'* *requirements in Sri Lanka, so there are no specific variations that can be identified during the design and installation stage".* Hence, the research findings confirmed that the operational stage performance is dependent on environmental, operational, and maintenance determinants, as discussed below, since the other factors are embedded in the system, which is generally chosen at the system selection stage. Apart from the identified factors, the expert interview findings introduced a new determinant that affected the solar performance in the operation stage, called 'Grid infrastructure and stability factors'. As it was mentioned in Section *3,* experts were asked to identify the level of impact of each factor on the solar PV system performance and the summary of the interview findings is shown in Table 2.

4.1. Environmental Determinants

According to Bamisile et al. (2025), the quantity of sun energy changed to electrical energy can greatly depend on local climate conditions and atmospheric properties. All the experts noted that environmental factors adversely affect solar performance in Sri Lanka.

4.1.1 Atmospheric Deposits

Atmospheric deposits such as dust, dirt, bird droppings, smoke, and pollutants adversely affect solar power generation in Sri Lanka. E1 stated that "s*oiling losses can range from 5% to 20%, depending on location and maintenance frequency*". Similarly, E5 specified, "*in normal conditions, 20% loss can be predicted without proper cleaning".* Also, E4 mentioned that "*there are some worst cases that can happen. Based on the experience in one scenario, performance dropped around 50% because of carbon deposits on solar panels in a polythene manufacturing factory*". According to E3, "*under atmospheric deposits, pollutants cannot create a major impact for the Sri Lankan context like India if there is a special event that occurs, such as polluted air from other countries and industrial emissions like rubber manufacturing".* Bird droppings are also a factor that affects the performance to some extent. However, rainfall helps to clean panels, but E4 stated that "t*here are some exceptions that can be identified for bird droppings, like around grain factories".* All the experts mentioned that dust creates a greater impact than other deposits on performance losses. According to E2, "*as an impact mitigation strategy, panel cleaning is essential at least three times per year in dusty environments. But it is not limited to the same intervals, and it is good to adjust the schedule based on the rainfall".*

4.1.2 Meteorological Conditions

According to Sepúlveda-Oviedo (2025), primary atmospheric conditions that determine the operational efficiency and longevity of PV systems can be identified as ambient temperature, relative humidity, rainfall, and wind speed. Among these parameters, all experts identified temperature as the most significant factor affecting the performance of the solar PV systems in Sri Lanka. E2 mentioned that "in *higher temperatures, there is a voltage drop that can be identified because solar performance basically depends on good sunlight, not the high temperature*". Similarly, E1 stated that "*if the temperature rises above the standard test condition (STC), it affects the performance of the system".* Also, E3 similarly mentioned *that temperature is directly related to the performance; as an example, in high-temperature areas like Ambilipitiya and Amunakolapalassa, the cables and MCBs also need to perform at high temperatures because they overheat in extreme temperature conditions*". In the Sri Lankan context, rainfall is another factor that affected the performance. According to E1, "*rainfall helps to clean the solar panels, and then it increases the generation*". However, as E3 stated "*with the rainfall, cloudiness hardly creates the shading, and it affects overall performance.* E4 specified that *"humidity and wind speed do not have a specific contribution to the performance".* Similarly, E5 mentioned that *"there can be a loose connection between the connectors because of poor workmanship. Then the water drops enter through that, and it creates an issue". Other than that, humidity does not have a significant impact on the performance in Sri Lanka.* Also, E2 mentioned that *"wind speed also helps to clean dust to some extent, but if there are some high wind speed situations, then the system structure must be designed with good strength".*

4.1.3 Shading

There are several reasons that obstruct the sunlight from reaching the PV modules. E3 mentioned that "*except for cloudiness, the main cause for the shading in Sri Lanka is coconut trees, and also high-rise buildings are the main cause for shading around Colombo and urban areas".* Similarly, E2 stated that "*even leaves also create the shading of the systems. From that, overall performance can be reduced*". According to E3, "*Solar Engineering, Procurement, and Construction (EPC) providers sometimes totally rejected the project during the site inspection because of the shading". E5* stated that "there is *some partial shading that also affects the overall performance of the system because the series string connection reduces the power output".* All experts mentioned that "*micro inverters are the option to reduce the shading losses". Also, E1 and E2 stated that "optimizers also can be used to reduce the shading loss".*

4.1.4 Irradiance

According to the E2, "*solar generation and solar irradiation have a directly proportionate relationship".* Also, E1 mentioned that "to maximize the solar radiation collection, PV modules may be mounted at optimal tilt angles and in the direction". Further, according to all experts, *"Sri Lanka has good irradiance, and it helps to increase the solar performance," but in any location, high temperature negatively affects the performance as well. According to E3, "then solar panel cooling is required to reduce the heat of the module".*

4.2. OPERATION AND MAINTENANCE RELATED DETERMINANTS

Operation and maintenance factors are the processes that are undertaken once a solar system has been installed to make sure that the system remains productive for at least 25 to 30 years of life.

4.2.1 Panel Degradation

According to E1, "*panel degradation is mentioned in the panel data sheet. It is the constant, slow decrease in the performance of the module throughout its operating lifetime*". Also, E5 specified that "*operational lives of 25 to 30 years are expected in Sri Lanka". E3* mentioned that "*there are no laboratories to test the degradation of the panels, but some factors are accelerating the panel degradation".* Similarly, E4 stated that "*extreme weather conditions accelerate the panel degradation. High temperatures cause microcracks to form in the panel".* Also, E2 mentioned that "*moisture ingress causes corrosion".* All experts showcased that "*regular maintenance is the way to reduce panel degradation and get maximum performance during its operational phase".*

4.2.2 Cleaning

According to Section *4.1.1,* soiling is a major factor that affects performance losses. For that, E4 states, "cleaning is the best method to reduce performance losses from soiling". E2 mentioned that "*only manual cleaning methods are used to clean panels in Sri Lanka".* Similarly, E1 stated that "*some people are using mops to clean panels, and it is not good practice at all".* Because it creates a shield on the panel, it affects the performance for a long time. E5 mentioned that "*with the climate in Sri Lanka, natural cleaning like wind and rainfall also helps to clean the panel".* Cleaning is not just about maintaining performance; it also extends the lifespan.

4.2.3 Cooling

Cooling is also another important factor when maintaining the solar performance in Sri Lanka. Performance drop can be identified because of the high temperature. E1 mentioned that there are some active, passive, and hybrid cooling methods available in the global market". But according to E3, "Cost-effectiveness *is the main concern in Sri Lanka because of the system design done with a 5-6 inch gap between the roof and the panel for natural cooling.* Similarly, E4 mentioned that "*the Sri Lankan climate helps to reduce temperature, and then it helps to reduce additional cost as well".* E5 stated that "*all the factors are considered when designing the stage, and if the location has a high heat environment, then even the cables are also designed in a heat-resistant way".*

4.2.4 Battery Energy Storage Systems (BESS) Maintenance

According to the insights of all experts, "*lithium-ion solar batteries are the most suitable for the current situation". E2 mentioned that "to maintain them properly, they need to maintain optimal temperature with proper maintenance".* Also, E3 stated that "*In Sri Lanka, earlier battery-used solar systems were very rare because of the price. But now it is encouraged to use batteries because of the rapid reduction in the price of batteries.*

4.3. GRID INFRASTRUCTURE AND STABILITY RELATED DETERMINANTS

Based on the interviews, it was observed that there exist other factors that impact solar PV system performance in Sri Lanka, other than the identified factors. According to experts' insights, there is a major issue that can be identified by the outdated grid infrastructure and voltage fluctuations in the current context. E2 mentioned that "*the grid is not stable to feed total generation in off-peak hours, and it causes some shutdowns as well*". Then solar generation also stopped at that time. Similarly, E4 mentioned that "*the grid is not upgraded to absorb variable renewable energy, and there is no single tiniest measure taken to overcome this issue in the sense of upgrading or updating.* According to E3, "*if the facility has a dedicated transformer, then the problem is solved. Other than that, a hybrid system is the way to reduce losses that arise from the grid side*". This indicates that despite the performance of the PV system itself, grid conditions may have a direct effect on the export of energy, system reliability and general performance results.

Table 2: Determinants of Solar PV System Performance in Sri Lanka during its Operational Phase (High: H; Moderate: M; Low: L)

Factors	E1	E2	E3	E4	E5	Overall Impact
Environmental Determinants						
Atmospheric Deposits on Panels						
Dust, Dirt	H	H	H	H	H	H
Bird Droppings	M	M	M	M	M	M
Air Pollution	M	M	M	M	M	M
Sea Salt Deposition	M	M	L	L	L	L
Pollen	L	L	L	L	L	L
Meteorological Conditions						
Temperature	H	H	H	H	H	H
Rainfall	M	M	M	M	M	M
Wind Speed	M	M	M	M	M	M
Relative Humidity	L	L	L	L	L	L
Shading						
Shading by Vegetation Growth	H	H	H	H	H	H
Shading by High Rise Buildings	M	M	M	M	M	M
Shading by Cloudiness	M	M	M	M	M	M
Shading by Leaves	L	L	L	L	L	L
Shading by Deposits	H	H	H	H	H	H
Irradiance						
Solar Irradiance	H	H	H	H	H	H
Operation and Maintenance Determinants						
Panel Degradation	L	L	L	L	L	L
Panel Cleaning	H	H	H	H	H	H
Panel Cooling	M	M	M	M	M	M
BESS Maintenance	L	L	L	L	L	L
Grid Infrastructure and Stability Determinants						
Stability of the Grid Infrastructure	M	M	M	M	M	M
Voltage Fluctuations	M	M	M	M	M	M

5. Discussion

This study identified the factors that define the performance of the solar PV systems in the operating phase. Interview findings demonstrated that environmental aspects and operational and maintenance aspects have major impacts on energy production in the Sri Lankan context. According to the research findings, all the factors identified from the literature were recognized as relevant to the solar performance, and two new factors were also identified as specific factors to Sri Lanka, which were grouped and named as 'Grid infrastructure and stability factors. According to experts, the influence of environmental factors was discovered to have a direct effect on electricity generation. The main variable in determining PV electricity generation is the solar irradiance, which varies in almost a linear relationship with the current output (Abiem & Igbawua, 2023). In the Sri Lankan context, the solar irradiance has a high level of impact on defining the energy generated, while high temperatures decrease power output. Also, experts show that one of the most commonly known limiting factors to the efficiency of PV modules has been temperature. PV modules exhibit the best performance at standard test conditions of 25°C, and the performance decreases with the rise in operating temperature (Hasan et al., 2021). The shade of surrounding buildings blocks the sunlight, resulting in performance reductions. The buildup of dust on the panel surfaces absorbs the sunlight, and as time passes by, it will end up depleting the energy production unless cleaning is performed on a regular basis. Based on the expert insights, the major factors that affect the energy generation capacity and performance of the system in Sri Lanka are dust and dirt, shading due to high-rise buildings, and temperature. Also, cleaning plays a major role during the operation stage to achieve high performance of the system. Besides, existing literature does not highlight the grid-related considerations, including fluctuation of voltages and limitations associated with outdated infrastructures, which were also found to be important as factors that can limit the performance of the system. Specifically in the Sri Lankan context, the fluctuations in grid voltage can reduce PV output, and also, when it is too high, then inverters automatically cut down power output. Also, the grid instability can have a considerable impact on the functionality and performance of the systems by creating an imbalance between the supply and demand of electricity. All these interruptions lower the amount of energy produced as well as the overall system reliability. These results highlight that while the technical design of a system is of great significance, the actual performance realised in the process of operation is highly dependent on how environmental, operational, maintenance, and grid-related factors are managed.

6. Conclusion

This study examined the factors affecting solar performance in the Sri Lankan context. The operational performance of PV systems is determined by environmental, operational, and grid factors. Grid conditions also play an important role in determining the amount of electricity utilised by PV systems. Therefore, inadequate grid infrastructure and voltage fluctuations directly affect solar performance. In this context, the use of battery storage is a timely solution.

These findings provide a clearer understanding of the key factors influencing the performance of PV systems in Sri Lanka and support further research on operational performance and grid integration. For practitioners and experts, this paper highlights the need for routine monitoring, preventive maintenance, and consultation with utility operators to maximise system performance. These insights can assist users in making informed decisions regarding PV system management and investment to ensure reliable energy production and cost savings. Future research can examine variations in the performance of solar PV systems in the Sri Lankan context. Addressing grid-related limitations can further improve understanding and support effective policy guidelines for the sustainable implementation of solar PV systems in Sri Lanka.

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