Review on Standalone and Grid Connected Photovoltaic System with Benefits

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Abstract: - Using solar energy during peak load hours relieves the strain on online generators to increase production. As a result, the focus of current research has shifted to grid-connected solar photovoltaic systems. For grid-connected Photovoltaic system, synchronisation with utilities and power quality problems such as voltage/current harmonics, power factor correction, volatility flashing, and energy restrictions are key concerns. We shall examine standalone photovoltaic systems and their evaluation criteria in this article. Also highlighted were the solar tracking technology and the advantages of energy photovoltaic (PV) systems.

Keywords: Renewable Energy, Solar Energy System, Energy Storage system, Battery storage system

I. Introduction

Electricity networks around the world are evolving. Global demand for and reliance on electrical is growing, and as environmental concerns grow more urgent, so does the focus on reducing greenhouse gas emissions (Energy World, 2015). As a result, a drive toward a decarbonized electrical system based on a high volumes of variable renewable generating, primarily from wind and solar photovoltaics, is underway (PV). Solar PV is one of the renewable technologies that has the potential to design a future electrical system that is cleaner, reliable, scalable, and inexpensive. Given this, governments across the world are promoting the development and implementation of solar PV technology. PV materials are accessible in a wide variety of shapes and sizes all around the world. Hundreds of businesses across the world manufacture PV modules, each with different efficiency and restrictions. Installation costs, on the other hand, vary from situation to systems and projects to project [1].Using solar energy during peak usage hours alleviates the need for online generators to meet power demands.

As a result, the focus of the current research has shifted to grid-connected solar photovoltaic systems. For grid-connected Photovoltaic system, synchronizing with utilities and power quality problems such as voltage/current harmonic, power factor correction, volatility flicker, voltage restrictions, and so on are key concerns [2]. In a grid-tied PV system, however, modern power electronics conversions such as interlaced boosting, quadratic boost, inverters, and others make it appropriate for operations. Fast tracking and improved maximum power point tracking techniques (MPPTs), such as hybrid MPPT approaches, are used to collect the greatest power from the solar. Online/offline approaches for setting the maximum power point and computational intelligence methods for fine tweaking are among these technologies. With the help of a DC-DC converter, the solar electricity is switched to a different voltage level for the intended application. With the help of an inverters, the shifting energy at DC level is converted into Electric for standalone systems or grid interface.

Photovoltaic (PV) systems are widely acknowledged as a dependable, efficient, and environmentally beneficial energy source. Despite the fact that solar energy has a low environmental and human health impact, this does not mean that it is fully devoid of these repercussions throughout its life cycle. When PV panels, inverters, and battery energy storage systems (BESS) come to the end of their respective life cycles, a considerable amount of electronic waste will be generated [3]. Using a multilayer inverters and boost converter, a PV system can operate in grid connected and freestanding modes, extracting maximum output and feeding it to the power system and standalone systems [3].

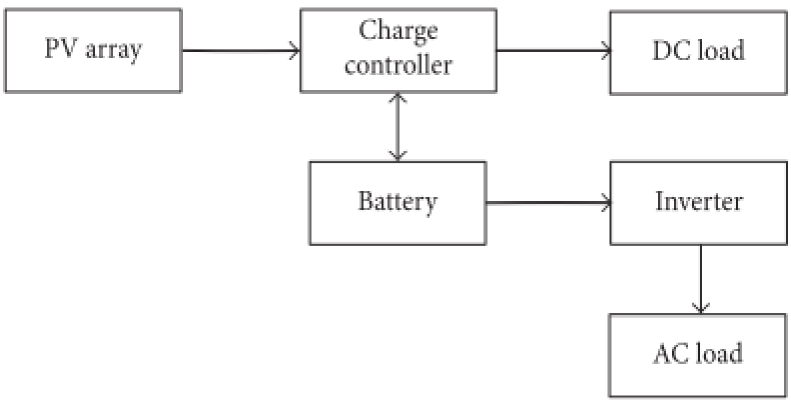

Figure 1: Standalone PV system with battery storage powering DC and AC loads [4]

Standalone Photovoltaic Systems are primarily designed to operate independently of the electric power grid and are sized to provide specific DC or AC needs. A direct-coupled Photovoltaic system is the most basic sort of standalone PV system. This only works during daylight hours, and no energy is stored in the battery system. Ventilation fans, pumping systems, and tiny pumping systems for solar energy water heaters are some of the most common applications [4]. Figure 1 shows a block diagram of a direct-coupled PV system. Several studies are studied to different loading for above direct-coupled PV system, including continuous fluctuations in solar radiation, load matching grade, geographic area, climate studies, degree of usage, and accurate design.

Classification of stand-alone and grid-connected PV systems

Stand-alone and utility-interactive or grid-connected photovoltaic systems are the two types of photovoltaic systems. PV systems are classified according to their operational and functional needs, component configurations, and connections to other load demand and sources of power. PV systems can either run independently or in conjunction with the power system. They can be linked to energy storage devices and other alternative energies, and they can supply AC and/or DC power. Energy PV systems, as previously said, are designed to run in parallel and be linked to the electric power grid. The main component of energy PV systems is the power conditioning unit (PCU), also known as an inverter, which directly convert the DC power produced by the Pv system into AC power that meets the utility grid's voltage and power performance standards for direct use on appliances or for sending to the utility grid to earn feed-in tariff compensation. The PCU automatically ceases sending electricity to the grid when the grid is not powered. When the Photovoltaic systems voltage is greater than the on-site load demand, a bi-directional interfaces situated at an on-site distribution board or services entry allows the AC power generated by the Pv system to either serve on-site power requirements or back-feed the network. The balance of power required by the demands is received from the electricity company when the power supplies are larger than the PV system output, notably at night as well as during cloudy periods.

This is a safety element that ensures the PV system does not continue operating and offer feedback into the power system when the network is down for servicing [9]. Grid-connected PV systems without the need for a backup energy storage (ES) system are environmentally benign and popular since they required less maintenance and are less expensive. However, if there is a power loss at night or on a cloudy day, the system must shut down operations until network power is restored. Photovoltaic systems with a backup ES that are energy are commonly connected to the power grid. This setup has various benefits, including selling excess PV electricity to the grid, charging the battery system during off-peak hours, and purchasing power from the grid to feed the loads when PV and battery energy are insufficient. Renewable PV systems cannot guarantee a consistent energy supply and may cause a generation-demand imbalance, particularly during off-peak hours when PV generates more power and during peak periods when load demand becomes too higher. Storage enables intermittent sources like as PV to meet demand on a timely basis and increases load control flexibility [5].

PV systems that run independently of the electric power grid are known as stand-alone Photovoltaic system. They typically provide a well-sized DC and/or AC electrical demand and can be supplied solely by a PV array or by a PV hybrids method that integrates a PV array with a diesel engine-generator as an auxiliary power source. The inverters in these off-grid solutions converts the DC voltage of the PV modules into AC electricity for direct use with the appliances. The simple sort of stand-alone Photovoltaic system is a direct-coupled systems, wherein the Output current of a PV module is composed is directly connected to a Power load. In the previous setup,, Because there is no electrical energy storage devices and the power delivered from the PV source to the load is not ideal, the load only functions during daylight hours, making the whole thing ineffective. To boost the effectiveness of such devices, it is critical to match the impedance of the load demand to the maximum power output of the PV array at the design stage. To optimise the achievable array maximum power output, an electronics DC-DC converter called a maximum power point tracker (MPPT) is usually coupled between both the arrays and the loads. They are frequently used in conjunction with battery as energy storage systems in selected households to ensure that power is delivered to the load at all times, including at night and in overcast situations.

Evaluation criteria for sizing a standalone PV system Selecting

One of the most significant tasks in achieving the best PV design is deciding on the evaluation criteria for building a standalone PV system for a specific location. The performance characteristics are used to analyze and predict the availability and feasibility of a standalone PV system, which can assist designers in building a system that is appropriate for a particular application. Some of these variables are depicted in the diagram below:

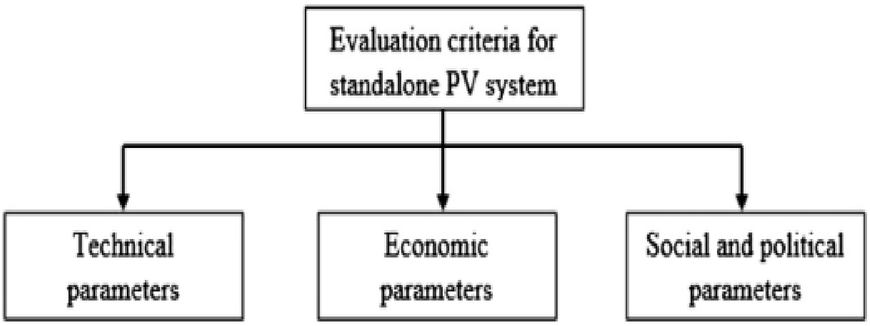

Figure 2: Evaluation criteria for standalone PV system size optimization [6]

MPPT Methods

One of the key disadvantages of PV systems is the significantly higher cost of electricity generation comparison to that provided by traditional power generation systems and even other renewable technologies like wind power. As a result, tracking the maximum power point to maximize the efficiency of power supplied to the outputs is crucial for effective PV system performance. DC–DC converters are used to link the PV system to the grid. The PV terminal voltage (or current) can be adjusted in PV systems to accomplish MPPT by sending a control signal to the converts. A wide range of methods have been suggested and implemented to achieve MPPT [7].

Offline techniques- Offline methodologies, also known as intended to establish, generates control commands by using the performance parameters of the PV panel. The open circuit voltage technique (OCV), the short circuit current method (SCC), and the MPPT method based on artificial intelligence are all methodologies that are solely employed for PV systems (AI).

The control signals are frequently generated using the resulting from a given of the PV output voltage and current in electronic methods, also called as model-free methodologies. The perturbation and observation technique (P&O), the extremum seeking control method (ESC), and the incremental conductance approach are all online methods (IncCond).

Hybrid approaches - Hybrid methods are predicted to be more effective at tracking MPP. The control signal linked with the algorithms in these approaches is split into two pieces. Each section is created using a different computational cycle. The first part is calculated as a constant value, which is dependent on the PV panel's atmospheric pressure and reflects the fixed steady state value, using one of the simplest offline approaches. This portion of the control signal is designed to roughly follow the MPP and is only required to respond quickly to environmental changes. This section can be created and use one of the previously offline approaches or simplifications based on relationship among output power characteristics and ambient temperature. The second portion of the control signal represents attempts to track MPP precisely [7], which might be achieved using one of the online approaches utilizing steady state searching.

II. Literature review

(Mohammed et al., 2021) [8] The goals of this study are to present a complete overview of recent developments in developing SAPV systems using multi-objective optimization (MOO) and multi-criteria decision-making (MCDM) approaches, as well as simulation results for evaluating PV module and storage battery output power.. Finally, the techno-economic parameters for evaluating the SAPV system's performance are addressed. This will assist engineers and consumers in selecting the best layout for the SAPV systems before it is installed.

(Sing et al., 2017) [9] The usage of electrical energy generated by solar photovoltaic (PV) is unavoidable in order to alleviate the energy crisis and satisfy emissions reduction targets. PV power capability will be enhanced to meet the growing global energy needs, working with large (from ten to several hundred MWs) PV farms at high and medium voltages to kilowatt home Photovoltaic system at lower power. With the retirement of traditional carbon-emitting energy plants, it is projected that PV penetration would rise in power networks. Solar energy is diurnal in nature, yet it is highly uncertain in practice due to a variety of disturbance effects. . Electrical energy storage (EES) could be used to improve the program's performance and stability, thanks to recent technological improvements and quick cost savings. This study provides an overview of EES for PV systems as well as a complete evaluation of the emerging penetration level of PV. The most important component, the solar panel's building block, and the solar cell are examined. The latest cell technology are discussed.

(Emmanuel & Rayudu, 2017) [10] focuses on photovoltaic (PV) systems as a new power generation paradigm allowed by the smarter system's evolution. One of the most serious drawbacks of this game-changing technology is the high chance of a mismatch between its power output and loaded profiles features, which might result in severe voltages violations, high losses, and a high reversing power under low loads. As a result, for networking modernization in the twenty-first centuries, the concept of dispatchability with load-following functionality for various PV deployments is crucial. When used in conjunction with storage solutions, the distributed energy PV unit output may be controlled, making it ideal for supplementary services and demand-side management software. Dispatch ability also refers to the ability to start and stop a PV unit's operation remotely in order to ensure grid stability. This article discusses several dispatch able PV unit companies plan and their implications for the emerging smart network. This paper also examines the progression of active distributed generation control, tracking, and communications networks, power inverter information technology, distributed power energy hybrid energy devops, and communications infrastructure configuration for base load power distributed energy resource (DER) unit integration into the electric power system (EPS).

(Jeremy, 2020) [11] The DC-DC converter is used to connect a PV system to a grid load or a stand-alone systems by balanced the energy between both. Because the Power converter plays such a key part in the overall performance of the PV system, choosing the right one is crucial. Various nonisolated conventional DC-DC different topologies are examined, contrasted, and discussed in this work. Each converter's review and discourse is based on current developments in terms of effectiveness, steady flow oscillations, amount of component, power transference, and tracing speed. This paper also discusses the merits and downsides of contemporary topology in this context.. The perturbation and observer MPP tracking algorithm was used to validate the performance of all of the examined converters under a variety of irradiance and temperature conditions.

(Bhandari et al., 2015) [12] outlines current trends in the use of renewable energy sources. Physical modelling of renewable energy sources is discussed, as well as several approaches and criteria for optimizing the Hybrid Renewable Energy System (HRES). In the current climate of environmental and energy concerns, HRES is gaining popularity. On the basis of the published literatures, we give a detailed evaluation of the current status of optimisation approaches specifically tailored for tiny and isolate power systems in this work. According to a recent trend in optimization in the field of hybrid renewable energy systems, machine learning may provide good optimization without enough long-term weather information.

III. Solar tracking systems

As shown in figure 3, a solar tracker monitors the position of the sun and keeps the photovoltaic solar module at the optimal angle for maximum power generation. To monitor the sun effectively, several sun - tracking principles and approaches have been developed. The goal of a solar tracking is to position solar photovoltaic modules in such a way that they can track the sun's movement across the sky and catch as much sunlight as possible. To maximise the electricity generation output, the tracking device should be situated in a location where it can obtain the best angle of incidence. Designing such a device to generate electrical energy is both fascinating and crucial. It does, however, necessitate considerable mathematical calculations as well as precise observations of many solar factors. The daily average solar irradiation is one of the most essential metrics. The global daily average sun irradiation ranges from 4–7 kilowatt-hours per square meter (KWh/m2) [13]. Because of the significant quantity of daily sun irradiation, solar energy is being used to generate power in a variety of applications, including water pumping, telecommunications, and lighting. The amount of light emitted by the sun varies depending on the monthly, time of day, meteorological conditions, geographical location, and position of the sun in the sky. When planning, implementing, and installation tracking devices, certain solar characteristics must be taken into account.

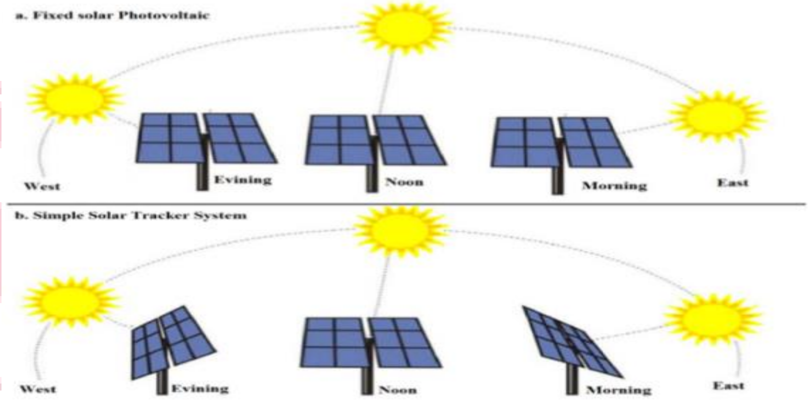

Figure 3: Fixed angle solar panel (a) and solar panels with a tracking system (b) [13]

Energy storage devices are an important part of today's power generation networks, both for conventional and renewable energy networks [14]. They're known as distributed energy resources (DERs), and they're used in a variety of ways in energy systems, such as on and off-grid power generation. Only a few of their primary applications include balancing the fluctuating characteristics of renewable energy sources, offering ancillary services such as frequency control stabilization, assuring a constant supply of electricity, and encouraging the deployment of renewable energy technology. Storage systems for commercial applications include hydropower, compressors, superconducting magnetic, capacitor and super-capacitors, flywheels, pumped heaters, and battery technology. Battery tech are one of the most promising storage options for industrial uses due to their maturation and ease of supply and manufacture comparing to other storage systems.
Modern electrical power networks are confronted with a number of difficulties that have drew the attention and coordinated efforts of energy professionals, engineers, and researches. A few of these problems include system frequency consistency, power quality problems like voltage variations and sag, intermittent renewable energy output, voltage regulation, peak usage, power generation serviceability, bi-directional line current, and the development of renewable electric utility micro-grids and massive wind energy. [14-16].A battery pack, battery management system (BMS), power condition system (PCS), and energy management system make up a basic energy storage system (EMS). The battery pack is designed in a modular format that allows for easy integration, deployment, and expansion. The BMS keeps track of the battery's properties, calculates its available capabilities, and regulates the device as a whole. The PCS performs the essential rectification and inverted functions for the converting of AC to DC electric energy. The energy management system is responsible for the successful schedule and administration of the energy storage device in satisfying the smooth connection need between both the communications and schedule of the station's propulsion system based on the modes settings or load changes.

IV. Benefits of Grid-Connected PVS

In 2007, the World Energy Council conducted a survey on various accessible energy supplies, and it was discovered that the energy acquired from sun is directly turned into electrical power only in the photoelectric energy conversion process. It's also been determined that there really is no heat exchanger influence in this procedure. PVS devices are built to be extremely durable and simple, allowing them to provide the most advantages with the lowest number of upkeep. They can generate output voltages ranging from microwatts to megawatt as stand-alone devices.. As a result, they are widely used in a wide range of applications, including water pumping, intersections, remote structure, inverted osmotic systems, sun-oriented home framework, space probes, spacecraft, and even megawatt-scale controlling plants. As a result, interest in PVS applications is growing year after year. Solar energy is almost generally available and does not necessitate imports from different parts of the country or the planet. As a result, it reduces transportation's environmental impact while also lowering customers' and power system engineers' reliance on imported fuels. PVS are modular, have a simple installation, is environmentally friendly, do not consume any fuel, do not pollute the environment, have a longer lifespan, and cheap operation and maintenance expenses. Energy PVS [18] are the most common source of power generation, and demand is met by all RES [17] in the power network. Despite the numerous benefits of employing energy PVS, its installation requires a significant amount of capital. As a result, government entities in a lot of nations have taken efforts to promote customers to install PVS at their homes by offering feed-in-tariff (FIT) and net-metering (NEM) incentives [19, 20].

V. Conclusion

Every year, worldwide power consumption rises, and a variety of techniques are employed to meet this demands. Solar PV, one of the emerging technologies, is discussed in this article. Solar PV technologies has been quickly increasing and being a mainstream participant within the electricity system during the last decade. The relevance of solar PV is demonstrated by the fact that several counties install considerable amounts of solar PV plants each year (see 'Leading PV countries worldwide' section). We talked about standalone photovoltaic systems and their evaluation criteria in this essay. We've also talked about solar tracking and the advantages of energy photovoltaic (pv) systems.

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