

A review on micro grid using solar photovoltaic system

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Abstract-A microgrid using a solar photovoltaic (PV) system is a small-scale electric power grid that generates electricity from solar panels and can operate independently or in conjunction with a larger grid. A microgrid is designed to provide reliable, low-cost, and environmentally friendly energy to a small community or facility, such as a residential neighbourhood, a hospital, or a military base. The primary components of a microgrid using a solar PV system include solar panels, batteries for energy storage, inverters to convert DC electricity to AC electricity, and a control system to manage the flow of electricity. The solar panels capture energy from the sun and convert it into electricity, which is then stored in batteries for later use. The inverters convert the DC electricity from the solar panels and batteries into AC electricity that can be used to power homes or businesses. A microgrid using a solar PV system can operate independently of the larger grid during power outages, making it a reliable source of electricity for critical facilities. It can also operate in conjunction with the larger grid to provide energy during peak demand periods or to sell excess electricity back to the grid. Overall, a microgrid using a solar PV system is an efficient and cost-effective way to generate and distribute electricity for small communities or facilities. It reduces dependence on traditional energy sources, improves energy reliability, and lowers carbon emissions.

Keywords: Solar photovoltaic system, solar energy, power grid, solar panels, microgrid.

1. Introduction

The world is facing an energy crisis. The demand for energy is increasing day by day, while the sources of non-renewable energy are limited and depleting rapidly. Moreover, the use of non-renewable energy sources is a major contributor to greenhouse gas emissions, which are causing climate change and other environmental problems. In this context, the use of renewable energy sources such as solar photovoltaic systems and the adoption of micro grids have emerged as promising solutions to meet the growing energy demands in a sustainable way.

Energy access is a critical issue that affects millions of people around the world. According to the International Energy Agency, around 789 million

people still lack access to electricity, and approximately 2.8 billion people rely on traditional biomass for cooking and heating. Lack of access to energy has a significant impact on the quality of life, health, education, and economic development of communities, particularly in rural and remote areas.

At the same time, the world is facing a pressing need to transition to a more sustainable and low-carbon energy system. The burning of fossil fuels for energy production is a major contributor to greenhouse gas emissions, which cause climate change and its associated impacts, including rising temperatures, sea level rise, and extreme weather events. In order to mitigate climate change and its impacts, it is essential to shift to renewable energy sources and increase energy efficiency.

Micro grids are small-scale electrical grids that can operate independently or in conjunction with a larger power grid. They are decentralized electricity systems that can provide reliable and sustainable power supply to remote and underserved areas. Micro grids using solar photovoltaic systems have gained popularity in recent years as a solution to the problem of energy access in remote areas. Solar photovoltaic systems are a mature and widely used renewable energy technology that can generate electricity without producing greenhouse gas emissions. When combined with energy storage systems, solar photovoltaic systems can provide reliable and stable electricity supply even in off-grid areas.

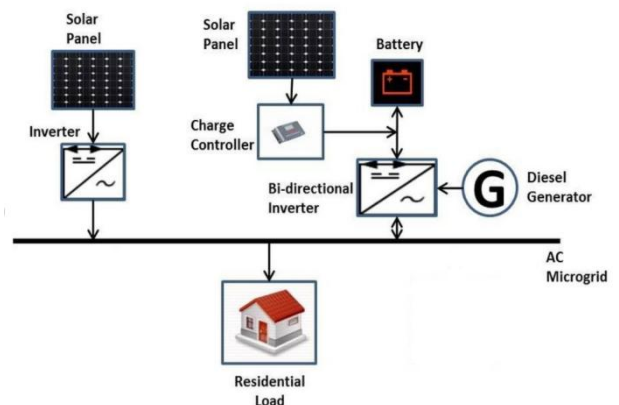


Fig.1. Typical microgrid system with solar panel.

Micro grids using solar photovoltaic systems have emerged as a promising solution to address both energy access and climate change concerns. These systems can provide electricity to off-grid or underserved areas using clean, renewable energy sources. Moreover, micro grids can increase the resilience of the energy system by providing a decentralized and distributed energy system that is less vulnerable to disruption from natural disasters, cyber attacks, or other hazards. The use of solar photovoltaic systems in micro grids has several advantages. First, solar photovoltaic systems are a mature and reliable technology that has undergone significant improvements in efficiency and cost reduction in recent years. Second, solar photovoltaic systems can be installed quickly and easily in remote areas without the need for large infrastructure investments. Third, solar photovoltaic systems generate electricity without producing any harmful emissions or pollutants, contributing to environmental sustainability and reducing greenhouse gas emissions.

However, the deployment of micro grids using solar photovoltaic systems also faces several challenges. Technical challenges include the need to optimize the design, operation, and control of the micro grid to ensure reliability and stability of the energy supply. Economic challenges include the high upfront costs of installation and maintenance, as well as the need for innovative financing mechanisms to make the systems affordable and accessible to local communities. Social challenges include the need to involve local communities in the planning, implementation, and operation of the micro grids to ensure their acceptance and sustainability. Finally, regulatory and policy challenges include the need to create an enabling policy and regulatory environment that supports the deployment of micro grids using solar photovoltaic systems.

The objective of this research paper is to provide a comprehensive review of the literature on micro grids using solar photovoltaic systems. The paper aims to examine the benefits and challenges of using micro grids with solar photovoltaic systems, and to identify the key factors that influence the design, operation, and performance of micro grids. The paper will also explore the existing policies and regulations that govern the deployment of micro grids using solar photovoltaic systems.

The paper begins with a brief overview of micro grids and solar photovoltaic systems, followed by a discussion of the benefits and challenges of using micro grids with solar photovoltaic systems. The paper

then analysis the design and operation of micro grids using solar photovoltaic systems, and the factors that affect their performance. The paper also examines the existing policies and regulations that govern the deployment of micro grids using solar photovoltaic systems, and the potential barriers to their adoption. The paper concludes with a discussion of the key findings and implications for future research.

Overall, this research paper aims to contribute to the growing body of knowledge on micro grids and renewable energy systems. By providing a comprehensive review of the literature on micro grids using solar photovoltaic systems, this paper provides valuable insights for policymakers, researchers, and practitioners in the field of renewable energy. The paper also highlights the potential of micro grids using solar photovoltaic systems to provide sustainable and reliable electricity supply to remote and underserved areas, and the need for supportive policies and regulations to enable their deployment at scale.

2. Historical review of micro grid system

The concept of micro grids dates back to the early 20th century when isolated communities in rural areas relied on small-scale power generation to meet their electricity needs. However, it was not until the 1990s that the term "micro grid" was first coined to describe a small-scale, self-contained electric power system that can operate independently or in parallel with the main grid. The use of solar photovoltaic systems in micro grids can be traced back to the 1970s when NASA began experimenting with solar cells for space applications. The first solar photovoltaic systems for terrestrial applications were installed in remote areas without access to the main grid, such as rural electrification projects in developing countries. However, these early systems were often unreliable and inefficient, and their high cost limited their widespread adoption. In the 1990s, the development of new materials, manufacturing techniques, and system designs led to significant improvements in the efficiency and reliability of solar photovoltaic systems. This led to the emergence of a new market for small-scale solar systems, particularly in off-grid and underserved areas. Governments, non-governmental organizations, and private companies began investing in solar photovoltaic systems to provide electricity to remote and rural areas, and to power small-scale applications such as telecommunications, water pumping, and lighting. The integration of solar photovoltaic systems into micro grids gained



momentum in the early 2000s as the need for decentralized and renewable energy systems became increasingly evident. Advances in energy storage technologies, particularly in batteries and capacitors, enabled solar photovoltaic systems to store excess energy and supply power during periods of low solar radiation. This increased the reliability and stability of the micro grid, and reduced the need for backup generators or diesel engines. Since then, the deployment of micro grids using solar photovoltaic systems has continued to grow, particularly in developing countries where energy access remains a major challenge. Governments, development agencies, and private companies have launched several initiatives to support the deployment of micro grids using solar photovoltaic systems, including subsidy programs, financing mechanisms, and capacity building activities. The use of solar photovoltaic systems in micro grids has also gained popularity in developed countries, particularly in remote and island communities where access to the main grid is limited or expensive. In conclusion, the historical review of micro grids using solar photovoltaic systems shows that the technology has come a long way since its early days, and has the potential to play a significant role in providing sustainable and reliable energy supply to off-grid and underserved areas. However, the deployment of micro grids using solar photovoltaic systems still faces several challenges, including technical, economic, social, and regulatory issues, which need to be addressed to ensure their successful implementation and widespread adoption. As the world transitions towards a more sustainable energy system, microgrids using solar PV systems are becoming an increasingly attractive option for many communities and businesses. In addition to providing reliable and cost-effective electricity, these systems offer a range of benefits, including increased energy security, reduced dependence on fossil fuels, and improved resilience to power outages and disruptions. Moreover, the ongoing deployment of microgrids using solar PV systems is also contributing to the growth of renewable energy and the reduction of greenhouse gas emissions. By reducing reliance on centralized power systems and promoting the use of renewable energy sources, microgrids are helping to accelerate the transition towards a more sustainable and low-carbon energy system. However, despite the many benefits of microgrids using solar PV systems, there are still several challenges that must be addressed in order to promote their widespread deployment and scalability. These challenges include technical issues related to

integrating different energy sources and managing system stability, regulatory and policy barriers that may limit the growth of microgrids, and economic factors that can impact the affordability and accessibility of these systems. In order to overcome these challenges, ongoing research and development efforts are focused on improving the performance and efficiency of microgrids, developing new regulatory frameworks and policies to support their deployment, and finding innovative financing mechanisms to make these systems more affordable and accessible to a wider range of users. In conclusion, the history of microgrids using solar PV systems reflects a long-term trend towards more decentralized and sustainable energy systems, driven by advances in technology, changing economic and political realities, and growing concern about the environmental impacts of fossil fuels. As the world continues to face the challenges of climate change and energy access, microgrids using solar PV systems are likely to play an increasingly important role in providing reliable, affordable, and sustainable electricity to communities around the world.

Table 1 System parameters

Parameter	Rating
PV array	9 kW
Input capacitor (C_{pv})	100 μ F
Inductor (L)	12 mH
DC link capacitor (C_1)	2200 μ F
Switching frequency of boost converter	20 kHz
Switching carrier frequency of H-bridge inverter, f_c	1.5 kHz
Reference voltage state vector, Z_{m2}	$250\sqrt{2} \sin(2\pi \cdot 50 \cdot t)$
Filter inductance, L_o	2 mH
Filter capacitance, C_o	10 μ F
Rated output power, P_o	7.5 KVA

Table 2 Electrical parameters of solar PV module

Maximum power (P_{MAX})	250 W	Temperature = 25 °C Solar irradiation, $G = 1000 \text{ W/m}^2$ (standard test condition)
Voltage at MPP (V_{MPP})	30.43 V	
Current at MPPT (I_{MPP})	8.22 A	
Open circuit voltage (V_{OC})	37.70 V	
Short circuit voltage (I_{SC})	8.69 A	

Solar photovoltaic (PV) systems are becoming increasingly popular as a means of generating renewable energy. These systems convert sunlight into electricity using photovoltaic cells made of semiconductor materials such as silicon, which



generate a flow of electrons when exposed to light. While solar PV technology has made significant advances in recent years, the performance of a solar PV system is still affected by a number of key parameters, including.

Efficiency

Efficiency refers to the amount of sunlight that is converted into usable electricity. The efficiency of a solar PV system depends on a number of factors, including the quality of the photovoltaic cells, the amount of sunlight that reaches the cells, and the temperature of the cells. The higher the efficiency, the more electricity a system can generate for a given amount of sunlight.

Capacity factor

The capacity factor of a solar PV system is the ratio of the actual output of the system to its maximum possible output. It takes into account factors such as weather conditions, shading, and system downtime, and is expressed as a percentage. A high capacity factor indicates that a system is generating electricity more consistently and efficiently.

Energy yield: The energy yield of a solar PV system is the amount of electricity it generates over a given period of time. It depends on the efficiency of the system, as well as the amount of sunlight that the system receives. Energy yield is an important parameter for assessing the financial viability of a solar PV system, as it determines the amount of revenue that can be generated from the sale of electricity.

Degradation rate

Over time, the performance of a solar PV system can degrade due to factors such as exposure to sunlight, temperature, and humidity. The degradation rate is the rate at which the performance of a system declines over time. A lower degradation rate indicates that a system will maintain its performance for a longer period of time.

Temperature coefficient: The temperature coefficient is a measure of how the performance of a solar PV system is affected by changes in temperature. It is expressed as a percentage change in the system's output for every degree Celsius change in temperature. A lower temperature coefficient indicates that a system will perform better in hot weather, which is important for systems located in regions with high levels of solar radiation. Reliability and durability: A solar PV system must be reliable and durable in order to provide a consistent and long-lasting source of electricity. This includes factors such as the quality of the materials

used in the system, the design and construction of the system, and the maintenance and servicing of the system over its lifetime.

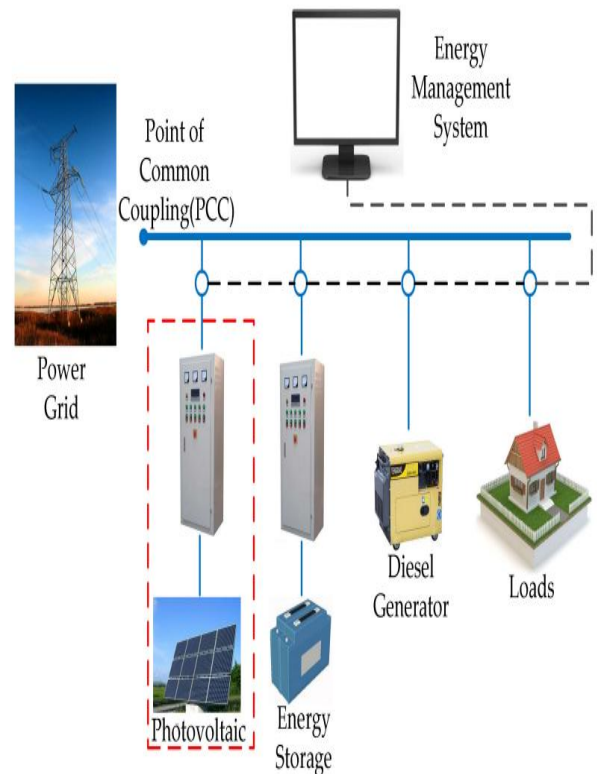


Fig. 2 The photovoltaic (pv) using micro-grid system [1]

A microgrid is a small-scale electrical system that operates independently or in conjunction with a larger grid, and is designed to provide reliable and sustainable energy to a local community or facility. A microgrid typically consists of multiple distributed energy resources (DERs), such as solar photovoltaic (PV) systems, wind turbines, batteries, and generators, which can be used to generate and store electricity. Microgrids using solar PV systems are becoming increasingly popular as a means of generating renewable energy and improving energy security, particularly in remote or off-grid areas. Solar PV microgrids are typically designed to provide energy to a specific location, such as a building, a community, or an industrial facility. These systems use photovoltaic cells to convert sunlight into electrical energy, which is then stored in batteries or fed into the local grid. The performance of a solar PV microgrid depends on a number of factors, including the capacity and efficiency of the PV system, the size of the battery storage system, and the overall energy demand of the facility. One of the key benefits of solar PV microgrids is their ability to provide energy independence and resilience to local communities and facilities. By

generating and storing their own energy, these microgrids can continue to operate even in the event of a grid outage or other disruptions to the local power supply. This is particularly important in remote or off-grid areas where access to reliable electricity may be limited or non-existent. Another key benefit of solar PV microgrids is their potential to reduce carbon emissions and improve the sustainability of energy systems. By using renewable energy sources such as solar PV, these microgrids can reduce reliance on fossil fuels and help to mitigate the impacts of climate change. However, there are also several challenges associated with the deployment of solar PV microgrids. These include the high upfront costs of installing a solar PV system and battery storage, as well as the need for ongoing maintenance and servicing of the system. In addition, the performance of a solar PV microgrid is highly dependent on local weather conditions, which can impact the amount of sunlight available for energy generation. Despite these challenges, the increasing availability and affordability of solar PV technology, coupled with advances in energy storage and management systems, are making solar PV microgrids an increasingly viable option for local communities and facilities looking to improve their energy security and sustainability. With continued investment and innovation in this area, solar PV microgrids have the potential to play an important role in the transition to a more sustainable and resilient energy system.

5. Conclusion

Micro grids using solar photovoltaic systems represent a promising solution to the challenge of providing sustainable and reliable energy access to off-grid and underserved areas. As demonstrated by the historical review, the integration of solar photovoltaic systems into micro grids has gained momentum due to advances in technology, including energy storage, and the increasing need for decentralized and renewable energy systems.

The benefits of micro grids using solar photovoltaic systems are numerous. Firstly, they can improve energy access and quality of life for individuals and communities who are currently without electricity or who are experiencing unreliable grid supply. This is particularly important in developing countries, where millions of people still lack access to modern energy services. Secondly, micro grids using solar photovoltaic systems can provide a reliable and affordable source of electricity for critical infrastructure, such as hospitals, schools, and water

treatment plants, which are often located in remote areas. This can help to improve the delivery of essential services and contribute to local economic development. Finally, micro grids using solar photovoltaic systems can reduce carbon emissions and support climate change mitigation efforts, by promoting the use of renewable energy and reducing the reliance on fossil fuels.

However, the deployment of micro grids using solar photovoltaic systems still faces several challenges that need to be addressed to ensure their successful implementation and widespread adoption. These challenges include technical, economic, social, and regulatory issues, such as the need for standardized technical specifications, financing mechanisms, community engagement, and supportive policies and regulations.

One of the key technical challenges facing micro grids using solar photovoltaic systems is the need for efficient and reliable energy storage solutions. Although advances have been made in battery technology, there is still a need for cost-effective and scalable storage options that can meet the demands of a wide range of applications. Another technical challenge is the need for standardized technical specifications and interoperability standards, to ensure that different micro grid systems can work together seamlessly and efficiently.

Economic challenges include the high initial costs associated with micro grid deployment, which can be a significant barrier to adoption, particularly in developing countries. Financing mechanisms, such as subsidies and concessional loans, can help to make micro grids using solar photovoltaic systems more affordable and accessible to a wider range of users. Innovative business models, such as pay-as-you-go and leasing options, can also help to reduce the upfront costs and improve affordability.

Social challenges include the need for effective community engagement and participation in the design and implementation of micro grid systems. This can help to ensure that the systems meet the needs and preferences of local users, and that the benefits are distributed fairly across the community. In addition, capacity building and knowledge sharing initiatives can help to enhance the technical and managerial skills of local stakeholders, and to promote the exchange of best practices and lessons learned.

Regulatory challenges include the need for supportive policies and regulations that encourage the deployment of micro grids using solar photovoltaic systems. This can include policies that support the development of



renewable energy, such as feed-in tariffs and net metering schemes, as well as policies that promote private sector investment and innovation. In addition, standardization and certification schemes can help to ensure that micro grids using solar photovoltaic systems meet high standards of safety, quality, and performance.

To overcome these challenges and realize the full potential of micro grids using solar photovoltaic systems, it is important to establish multi-stakeholder partnerships that involve governments, private sector, civil society organizations, and local communities. Such partnerships can help to mobilize resources, build capacity, and promote innovation and knowledge sharing. In addition, policy and regulatory frameworks that support the deployment of micro grids using solar photovoltaic systems should be developed and implemented at the national and international levels. Overall, micro grids using solar photovoltaic systems have the potential to transform the way we produce and consume energy, by providing reliable and sustainable electricity access to off-grid and underserved areas, while promoting climate change mitigation and local economic development. However, to realize this potential, it is important to address the technical, economic, social, and regulatory challenges facing micro grid deployment, and to establish multi-stakeholder partnerships that can support innovation, knowledge sharing, and capacity building. In conclusion, micro grids using solar photovoltaic systems represent a promising and exciting development in the field of renewable energy and energy access, and their continued growth and success will be crucial in achieving the sustainable development goals and promoting a more equitable and resilient energy future for all.

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