

# Chapter Two

## 2.0 Literature Review

### 2.1 Introduction

The global energy sector has witnessed a growing shift from conventional fossil fuel-based systems to renewable energy technologies due to concerns over environmental degradation, rising fuel costs, and energy security. Among the various renewable sources, **solar photovoltaic (PV) systems** have gained significant traction because of their sustainability, scalability, and relatively low maintenance. This chapter reviews existing literature on solar power systems, battery energy storage, charge controllers, and inverter technologies relevant to the development of a 2kVA solar-powered inverter system.

#### 2.1.1 Solar Photovoltaic Technology

Photovoltaic (PV) technology is the process of converting sunlight directly into electricity using semiconductor materials such as silicon. According to Green et al. (2019), solar PV systems are among the fastest-growing sources of energy worldwide, largely due to advancements in panel efficiency and reductions in cost. There are various types of solar panels, including monocrystalline, polycrystalline, and thin-film. Monocrystalline panels, used in this project, offer higher efficiency and longer lifespans, making them suitable for limited-space installations.

The power output of solar panels depends on several factors including solar irradiance, temperature, orientation, and shading. Effective system design requires careful consideration of these factors to ensure optimal performance.

### 2.1.2 Battery Energy Storage Systems

Energy storage is a critical component of any standalone solar system. It enables energy generated during sunlight hours to be stored and used during periods of low or no solar radiation (e.g., at night or during cloudy weather). Traditional systems relied heavily on **lead-acid batteries**; however, recent studies highlight the superiority of **lithium-ion batteries** in terms of energy density, charge-discharge efficiency, lifecycle, and maintenance requirements (Luo et al., 2015).

Lithium-ion batteries are also better suited for deep-cycle applications and support faster charging, making them ideal for modern solar applications. However, they require **Battery Management Systems (BMS)** to monitor cell voltage, temperature, and protect against overcharge/discharge.

### 2.1.3 Charge Controllers

A **charge controller** regulates the voltage and current coming from the solar panels to the batteries, thereby preventing overcharging and prolonging battery life. There are two major types: **Pulse Width Modulation (PWM)** and **Maximum Power Point Tracking (MPPT)**.

According to Esram and Chapman (2007), **MPPT charge controllers** are significantly more efficient than PWM types, especially under fluctuating sunlight conditions. MPPT technology continuously adjusts the electrical operating point of the modules to ensure maximum power transfer from the panels to the battery bank.

The 60A MPPT charge controller used in this project ensures optimal solar harvesting and efficient battery charging, especially under varying weather conditions.

## 2.2 Inverter Technologies

Inverters play a vital role in solar power systems by converting the stored **Direct Current (DC)** from the batteries into **Alternating Current (AC)**, which is the standard for most household and office appliances. There are various types of inverters: square wave, modified sine wave, and **pure sine wave**.

Pure sine wave inverters produce a waveform similar to grid power and are compatible with sensitive electronic devices such as computers, televisions, and medical equipment. They are more expensive but offer higher efficiency and less electrical noise (Kjaer et al., 2005). The 2kVA pure sine wave inverter selected for this project ensures stable and safe power output for connected loads.

## 2.3 Related Works

Several studies and projects have been carried out on small-scale and medium-scale solar inverter systems. For instance, Ogueke et al. (2014) successfully implemented a 1.5kVA solar-powered inverter for rural electrification, emphasizing the cost-effectiveness of such systems in off-grid communities. Similarly, Adaramola et al. (2017) highlighted the role of hybrid solar-inverter systems in improving energy access in sub-Saharan Africa.

These projects show the growing interest in decentralized power systems and the

feasibility of solar technology in reducing dependence on erratic grid supply. However, many systems still suffer from design inefficiencies, lack of proper battery management, and underutilization of modern MPPT controllers.

## **2.4 Summary**

This literature review has explored the key technologies that form the foundation of solar inverter systems—solar panels, batteries, charge controllers, and inverters. The review highlights the importance of component selection and system integration for performance optimization. By leveraging high-efficiency monocrystalline panels, lithium battery storage, MPPT regulation, and a pure sine wave inverter, this project aims to address the limitations of earlier designs and contribute a more reliable and sustainable power solution.