

# **Study and Design of a Hybrid Solar Power System Applicable for a Urban / Rural House in Bangladesh**



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in Partial Fulfillment of the Requirements for the Degree of  
Bachelor of Mechanical Engineering**

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## **DECLARATION**

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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## **CERTIFICATION**

This is to certify that this project entitled “**Study and Design of a Hybrid Solar Power System Applicable for an Urban/Rural House in Bangladesh** ” is Submitted by the Md. Ar Rafi, (ID: ME2201026058), Md Zobair Hossain Opu, (ID: ME2201026293), Tanzim Shekh, (ID: ME2201026227), Md. Saiful Islam, (ID: ME2201026041), and Md. Jahid Hasan Akash, (ID: ME2201026118) under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Mechanical Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

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First, we would like to show our gratitude to the University authority for permitting us to do our practicum. Specially, we would like to thank our honorable supervisor A M M Shamsul Alam, Associate Professor, Department of Mechanical Engineering, SU – Sonargaon University Dhaka, for his valuable and patient advice, sympathetic assistance, cooperation, contribution of new ideas. Deep theoretical and hardware knowledge & keen interest of our supervisor in this field influenced us to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stages have made it possible to complete this project.

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## **ABSTRACT**

The Hybrid Solar Power System for residential applications is designed to provide a reliable, efficient, and sustainable source of electricity by combining solar photovoltaic (PV) energy with conventional grid power or battery storage. This project focuses on maximizing energy utilization from renewable sources while ensuring uninterrupted power supply during low-sunlight conditions or grid failures. The system integrates solar panels, a charge controller, an inverter, and a hybrid management unit that automatically switches between solar, battery, and grid power based on availability and demand. Real-time monitoring is implemented to track energy production, consumption, and battery status, enhancing system performance and user awareness. By reducing dependency on the main grid and optimizing the use of clean energy, the hybrid system significantly lowers electricity bills and carbon emissions. This project demonstrates a practical solution for households, especially in areas with frequent power outages or high energy costs. The hybrid configuration ensures efficiency, reliability, and long-term sustainability, making it a versatile option for modern smart homes. Overall, the system highlights the potential of renewable energy integration to promote cleaner and more resilient residential power infrastructures.

## **LIST OF ABBREVIATIONS**

AC	Alternating Current
DC	Direct Current
Tx	Transmitter
Rx	Receiver
SU	Sonargaon University
IDE	Integrated Development Environment
IoT	Internet of Things

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# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

In today's world, the demand for electricity is growing at an unprecedented rate, driven by societal development, industrialization, and the increasing number of electrical appliances in households. At the same time, the depletion of conventional energy sources like coal, oil, and natural gas, along with rising environmental concerns, has created a pressing need for sustainable and reliable alternatives. Among these alternatives, solar energy stands out due to its abundance, cleanliness, and low environmental impact. Solar photovoltaic (PV) systems have witnessed rapid development in recent years and are being widely adopted across urban and rural areas.

However, conventional solar PV systems often operate in either grid-connected or off-grid (island) mode, and these modes are generally not compatible, making switching between them challenging. Grid-connected systems require an anti-islanding function to prevent safety hazards during grid faults, while off-grid systems rely solely on batteries or local generation to supply power. This limitation poses a challenge, particularly in areas where grid reliability is inconsistent or in regions aiming for energy self-sufficiency.

To overcome these challenges, the concept of a Hybrid Solar Power System has emerged, integrating both grid-connected and off-grid operation into a single, intelligent system. This system combines solar PV panels, a battery storage unit, and an automatic switching mechanism to manage energy flow efficiently. During normal operation, solar energy charges the battery and powers connected loads. When battery voltage falls below a minimum threshold or when grid power is available, the system seamlessly switches to the grid supply. In case of a grid failure, the system automatically shifts to off-grid mode, ensuring uninterrupted power supply.

By integrating these two modes, the hybrid system not only provides continuous and reliable electricity but also enhances energy efficiency, reduces dependence on fossil fuels, and promotes sustainable energy usage. Such a system is particularly valuable in

residential, commercial, and rural applications, where power outages are common and reliable energy access is critical. Furthermore, this project demonstrates the practical implementation of renewable energy technology in everyday life, highlighting how intelligent energy management can optimize resource usage, improve grid stability, and provide a resilient solution for modern energy challenges.

## **1.2 Problem Statement**

In many residential and rural areas, electricity supply is often unreliable due to grid fluctuations, outages, or lack of infrastructure. Conventional solar PV systems are typically designed to operate in either grid-connected or off-grid mode, and switching between these modes is not seamless. This limitation results in inefficient energy utilization, dependency on the grid during outages, and interrupted power supply for essential loads. Additionally, households without proper backup systems cannot make optimal use of renewable energy, leading to energy wastage and higher electricity costs. There is a clear need for a smart hybrid energy system that can intelligently switch between solar, battery, and grid sources, ensuring uninterrupted power supply, maximizing renewable energy usage, and improving energy efficiency. Addressing this problem is crucial for promoting sustainable living, enhancing grid reliability, and providing a practical solution for areas with inconsistent or limited electricity access.

## **1.3 Objectives**

The objectives of this project:

- 1.3.1** To Study the concept, components, and working principle of a hybrid solar power system.
- 1.3.2** To design a reliable hybrid solar power system that combines solar energy with grid or battery backup.
- 1.3.3** To Construct a basic model of the proposed hybrid solar power system. To demonstrate its configuration, operation, and practical feasibility for residential use.

## 1.4 Project plan

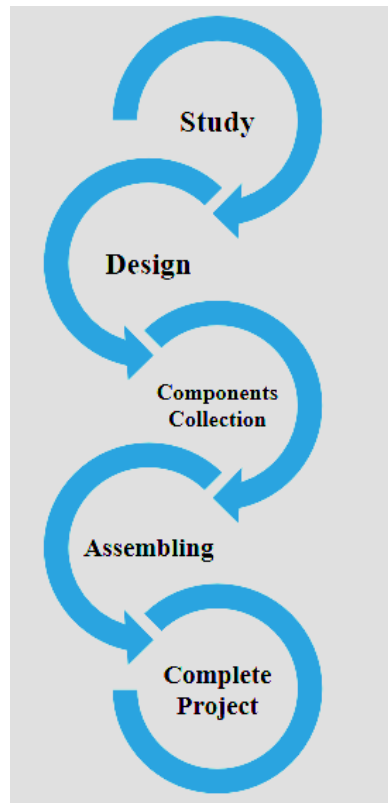


Figure 1.1 : Work Flow Diagram

## 1.5 Methodology

Our methodologies for the project:

### 1.5.1

Creating an idea for design and construction of an **Study and Design of a Hybrid Solar Power System Applicable for a urban/Rural House in Bangladesh** and designing a block diagram and circuit diagram to know which components we need to construct it.

### 1.5.2

In this step, the electrical load demand of typical urban and rural households in Bangladesh and solar system required for such will be studied.

Both single-storey and double-storey residential buildings are considered for load estimation. Common household appliances such as lights, fans, televisions, and refrigerators are identified. The study mainly focuses on estimating the overall electricity consumption pattern of households. Approximate load values are

considered based on standard household usage and existing data. The load estimation is used as a reference for proposing a suitable hybrid solar power system. This approach helps in understanding the general energy requirement of urban and rural houses.

### **1.5.3**

Based on the calculated load demand, a suitable hybrid solar power system will be constructed.

The design includes solar photovoltaic panels, battery storage, inverter, and grid. Battery capacity is selected to ensure power availability during grid failure or low solar radiation. System configuration is designed to provide uninterrupted and reliable power supply. Efficiency, safety, and cost-effectiveness are considered in the design process. The proposed hybrid system is made applicable for both urban and rural houses in Bangladesh.

## **1.6 Research Outline**

This project book consists of five chapters. The first chapter contains the statement of the introduction, Problem Statement, Project plan, objectives of the study and Methodology. Chapter two contains system Literature Review details. Chapter three Discussed in importance of hybrid solar power system in Bangladesh, working principle of a hybrid solar system, design of hybrid solar system for a typical house in Bangladesh, load calculation and management with hybrid solar system for house. Chapter four describes the discussion, project outcome, advantages, limitation and application. In the final chapter, we have discussed the Future Scope, conclusion of the project.

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 Introduction

In this chapter we discuss our system overview. In this paper they also work about **Study and Design of a Hybrid Solar Power System Applicable for an urban/Rural House in Bangladesh**. In the section below we will describe some previous literature reviews. From previous literature we gathered more knowledge to build this project and we successfully made it .

### 2.2 Literature Review

Dinesh C. Sharma, et-al, 2007 [1] discussed transforming rural lives through decentralized green power. Technology has shown the way to lighting up rural India, now it is up to the government to enable an environment policy that can ensure that the lights do not go off. Access to electric power remains a distant dream for the majority of the poor living in developing countries. Per capita electricity consumption in developing countries is far lower than the developed countries. It is not sufficient due to per capita electricity consumption in developing countries being 1155 kWh, compared to 10,262 kWh for high-income OECD countries. The technologically available options for decentralized power generation are mainly biomass, solar and mini hydro. Statistics show that local ownership of a power plant can go a long way in ensuring sustainability. Electricity in rural homes should be viewed as an extension of an urban facility in rural areas. A policy paradigm shift is needed to make electrification integral to all rural development plans.

Abolfazl Shiroudi,et-al,2013 [2] has presented Stand-alone PVhydrogen energy systems in Taleghan-Iran using HOMER software: optimization and techno economic analysis. The idea is RE sources can open new ways to solve this environmental issue. The simulation results demonstrate that the energy system is composed of a 10-kW PV array, 3.5-kW electrolyzer, 0.4-kW proton exchange membrane fuel cell, 2.5-kW inverter, and 60 batteries (100 Ah and 12 V). The related work is integrated and worked at the Taleghan renewable energies' site in Iran. The hydrogen produced by the electrolyzer is compressed and stored in a hydrogen vessel and provides energy for the fuel cell to meet the load when

the solar energy is insufficient. There is a one year gap. Renewable energy (RE) sources are attracting more attention as alternative energy sources nowadays. Depletion of energy sources and global warming plays a big role in this movement. RE sources can open new ways to solve this environmental issue. They are free of pollution during operation might be enough. PV systems have the advantage of minimum maintenance and easy expansion (up sizing) to meet growing energy needs. Hydrogen storage has an economic advantage over lead-acid batteries for long-term storage.

Buljit Buragohain, et-al, 2009 [3] estimated that the total power potential of renewable energy resources in India is about 80GW among which the contribution of biomass based power is about 20 GW. This is because biomass gasification-based power plants in rural areas offer several advantages like easy availability of biomass, flexibility of installation and operation as well as other socio-environmental benefits like employment opportunities for local people and reduced CO<sub>2</sub> emission. The feasibly and operationally successful decentralized biomass based village electrification program in Karnataka, Tamil Nadu and West Bengal has already proved the accountability of this system.

Sonaton Ghosh, et-al, 2004 [4] has found that in order to have a long-term solution for rural electrification, the government of India installed an off-grid woodfuel-based 500 KW power plant at Gosaba island of West Bengal in July, 1997. The analysis of the plant revealed a moderate success in terms of diesel replacement (59%) at optimum load condition of 64%. The COE for unit generation of reference year has been estimated at Rs 4.27/KWh. The system suffers 13 % of T&D loss which is very high considering a decentralized power plant. The plant was found to be self-sufficient in terms of fuel wood and local laborers, however ways for the fulfillment of future increase in demand needs to be addressed.

Alam Hossain Mondal, et-al, 2010 [5] In this research paper, various combinations of wind, photovoltaic (PV), diesel generator and battery has been analyzed using HOMER to find out the optimum size of system to fulfill the requirements of 50 households of three remote villages of Bangladesh namely; Cox's bazar, Sylhet and Dinajpur having 50 KWh per day primary load with 11KW peak load. It was found that the most economically feasible system would consist of PV (6 KW)-diesel Generator (10KW)-battery (2V, 800

Ah) having per unit cost of electricity 25.4 Tk/KWh. The system also offers many benefits such as local employment, reduction in diesel consumption and CO<sub>2</sub> emission.

M. Hiloidhari, et-al, 2011 [6] has presented the analysis of crop areas of Sonitpur District of Assam using the Indian remote sensing satellite estimates that the total crop residue biomass (CRB) available in the district is about 0.28 million tonnes out of which 0.17 million tonnes are practically available having the power potential of about 16.94 MW. The crop residue intensity (tonne km<sup>-2</sup>) varies from village to village and it was found that out of 1223 villages, 453 villages come under medium intensity CRB range while 439 and 331 villages come under low and high intensity range respectively. The highest village level power potential of 71.86 KW was observed in No. 1 Charaibari of Pub-Choiduar DB followed by 65.55kW (Bengabari village) of Behali DB and 62.74kW (Keheru Khanda) village of Dhekiajuli DB

Daning Hao et.al [7] – Solar energy harvesting technologies for PV self-powered applications, 2022: This paper gives detailed information on solar energy harvesting by PV technology. In housing, health care, and transport, there is more demand for electricity which is fulfilled by conventional energy sources and which cause pollution, so we can replace this system with a PV system. This paper gives you where we can use this system and also gives the design of a self powered system, various components of a PV system. It gives you maximum power point tracking (MPPT) techniques and power management systems. This paper gives you analysis of solar radiation, system design for PV applications and hybrid energy system design like hybrid PV – wind system and hybrid PV – wave system.

Mochamad Choifin et.al [8] –A study of renewable energy and solar panel literature through bibliometric positioning during three decades, 2021: This paper gives collected data of renewable energy and solar panel by using bibliometric technique. The research was carried out using bibliometric techniques. Data analysis as well as visualization utilizing VOS Viewer program and the Scopus function for analyzing search results. The study reveals that National University of Singapore and India Studies were the most active affiliated institutions of scientists and nations in renewable energy and solar panel literature. In renewable energy and solar panel literature, the Engineering and Energy Procedia were the most areas of study and dissemination sources.

Sumedha R.G. Weliwaththage et.al [9] –Solar energy technology, 2020: In this paper focus on solar energy, improvement in the technique of solar energy. This paper gives weakness in solar energy technique and new technique of solar energy harness i.e. solar cell and its material. It discussed about increase in the efficiency of power generation with solar energy

Deepak Purohit et.al [10] – A review paper on solar energy system, 2020: This paper gives information on solar energy conversion into electrical energy. Many solar cell combinations form solar panels which are connected to each other. Solar energy falls on solar panels and converts into electrical energy. It gives calculation of finding the size of solar panel, load on battery and inverter and installation of solar thermal system.

Samuel et.al [11] – Awareness and use of solar energy as alternative power sources for ICT facilities in Nigerian university libraries and information centers, 2019: In this paper get information and use of solar energy as renewable energy source for ICT facilities in Nigerian library and information centers. A survey method was used for the study and a questionnaire was designed and the survey found that the people who participated in the survey had good knowledge about solar energy.

Ehsanul Kabir et.al [12] – Solar energy: potential and future prospects 2018: In this paper the advantages and disadvantages of solar energy technologies are also discussed in technical problems in a research of alternative energy sources. They disused solar energy technology with respect to potential, capacity, prospects, limitations and future policies. This assists you to understand how much to count on solar energy to meet the upcoming energy demand. There are few drawbacks of solar energy technology but this is the energy source will meet the future demand of energy

### **2.3 Summary**

From the literature discussed above, we gained a lot of knowledge and we were inspired to do this project. We were able to do it with everyone's tireless work.

# CHAPTER 3

## SYSTEM ARCHITECTURE

### 3.1 Introduction

The previous chapter discussed the project objectives, methodology, and related literature in detail. This chapter focuses on the practical implementation of the hybrid solar power system, including system operation, performance analysis, and real-time monitoring results. It explains how solar energy, battery storage, and control units work together to ensure reliable and efficient power supply for residential applications.

### 3.2 Importance of hybrid Solar Power System In Bangladesh

Bangladesh is a developing country where the demand for electricity is increasing rapidly due to population growth, urbanization, and industrial expansion. The national power grid is often under heavy load, leading to problems such as load shedding, voltage fluctuations, and unreliable power supply in many areas. In this context, the Hybrid Solar Power System is a highly necessary and practical solution for Bangladesh. Solar energy is a renewable, clean, and widely available resource in the country throughout the year, making it suitable for large-scale and residential power generation.

The hybrid solar system combines solar panels, battery storage, and optional grid support to ensure uninterrupted power supply during both day and night. This system is especially beneficial for rural areas, industrial zones, and regions prone to frequent power outages. By reducing dependence on the national grid, it helps lower electricity bills, minimize fossil fuel consumption, and reduce carbon emissions, contributing to environmental sustainability.

Land availability is a major concern in Bangladesh due to its high population density and limited land resources. Therefore, installing solar systems on the rooftops of residential buildings and industries is an effective solution. Rooftop solar installations utilize unused space, prevent the loss of valuable agricultural land, and avoid land acquisition issues.

Industrial buildings usually have large rooftops, allowing significant solar power generation without affecting production activities.

Additionally, rooftop solar panels help reduce building heat gain, lowering cooling costs. Government initiatives and renewable energy policies further support rooftop solar adoption. Overall, the hybrid solar power system plays a crucial role in ensuring energy security, land conservation, cost savings, and sustainable development in Bangladesh.

### **3.3 Working Principle of a Hybrid Solar System**

The Hybrid Solar Power System provides a practical and sustainable approach to meeting residential electricity demands by combining renewable solar energy with intelligent power management and reliable backup support. In this system, solar panels act as the primary energy source, converting sunlight into DC electrical power. The integration of an MPPT charge controller plays a crucial role in improving system efficiency by continuously tracking the maximum power point of the solar panel. This ensures optimal energy extraction even under fluctuating sunlight conditions, which is particularly important in real-world residential environments.

The harvested energy is safely stored in a battery, allowing uninterrupted power supply during nighttime, cloudy weather, or sudden grid outages. To support low-voltage electronic components, a buck converter is used to regulate and step down the battery voltage to stable levels suitable for devices such as the Arduino Nano, current sensor, LCD display, and DC fan. This voltage regulation enhances system safety and protects sensitive components from electrical damage.

The Arduino Nano functions as the central monitoring and control unit of the system. By continuously analyzing solar input, battery charge status, and load current through the current sensor, the system enables effective energy management. Real-time system parameters displayed on the LCD provide users with clear insights into power generation and consumption patterns.

For household AC loads, the inverter converts stored DC power into AC power, while the transformer stabilizes the output voltage to ensure safe and reliable appliance operation.

When solar energy is insufficient, the system seamlessly switches to battery backup or grid support, maintaining continuous power supply.

Overall, the hybrid solar configuration enhances energy efficiency, minimizes dependence on the conventional power grid, reduces electricity costs, and contributes to environmental sustainability. It demonstrates a reliable and scalable renewable energy solution suitable for modern residential applications.

### 3.4 Design of Hybrid solar System for a Typical House in Bangladesh

The design of a hybrid solar system for a typical house in Bangladesh integrates solar panels, battery storage, and inverter technology to ensure reliable, cost-effective, and uninterrupted power supply with reduced grid dependency.

### 3.5 Proposed System Design

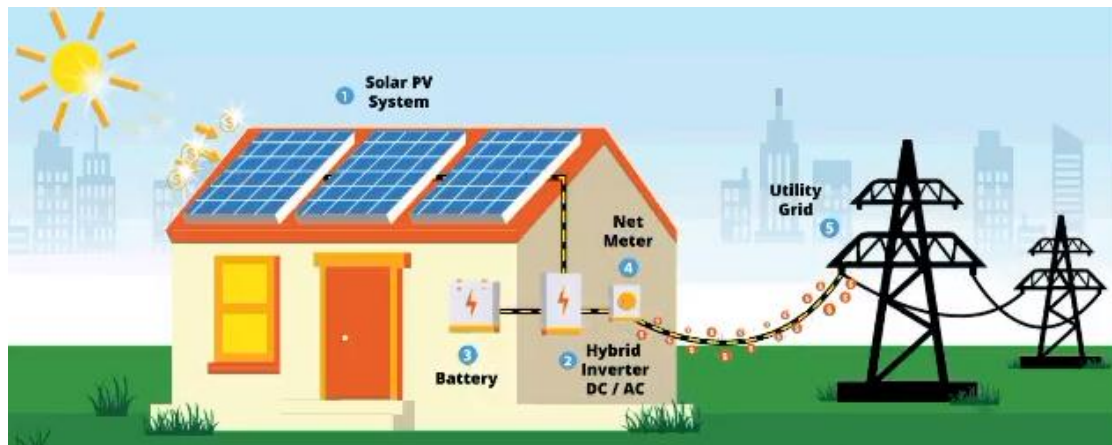


Figure 3.1: Hybrid Solar Sharing System

A Hybrid Solar Sharing System is an advanced energy solution that combines solar power generation, battery storage, and utility grid interaction to ensure reliable and efficient electricity supply. In this system, solar panels generate DC power from sunlight, which is regulated by a charge controller to safely charge the battery bank. The hybrid inverter converts DC power into AC power for household use and intelligently manages energy flow between solar, battery, and grid sources. During daytime, solar energy primarily supplies the home load, while excess power is shared or exported to the utility grid through a bidirectional net meter. This sharing mechanism prevents energy wastage and allows users to receive credits or financial benefits. At night or during low solar availability, the system automatically draws power from the battery or grid, ensuring

uninterrupted supply. Overall, the Hybrid Solar Sharing System reduces electricity costs, enhances energy efficiency, supports grid stability, and promotes sustainable and eco-friendly power utilization for residential and small commercial applications.

### 3.6 Circuit Design

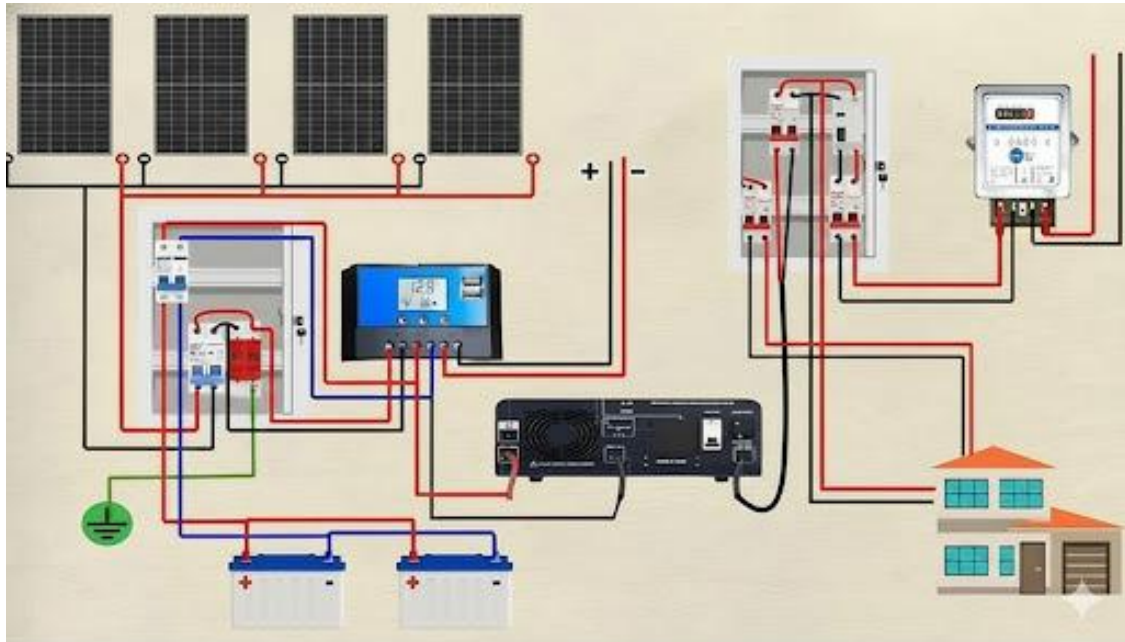


Figure 3.2: Circuit Diagram of Hybrid Solar Sharing System

This Circuit Diagram is a hybrid solar power system for a house. Solar panels generate DC power, which is regulated by a charge controller to charge batteries. A hybrid inverter converts DC to AC for household use, while excess energy is exported to the utility grid through a meter.

### 3.7 Load Calculation and Load Management with Hybrid Solar System for a Typical House

Table 1 : Load Calculation Table (For 1 Storey House)

Types of Load	Quantity	Power Consumption per Quantity	Total Power Consumption
LED Bulb	5	12 W	60W
Fan	3	80 W	240W
LED TV	1	120 W	120W
Refrigerator	1	150 W	150W
AC (1 Ton)	1	1200 W	1200W
Washing Machine	1	450 W	450W
Water Motor / Pump (1 HP)	1	800 W	800W
Iron	1	1000 W	1000W
Oven	1	1000 W	1000W
		Total	5020 W

Table 2 : Hybrid Solar System Cost Analysis As Available in local market (For 1 Storey House)

Sl No.	Component Name	Specification	Brand	Quantity	Unit price (Tk)	Total Price (Tk)
1	Solar Panel	550 W Mono PERC	Walton	10	32,000	320,000
2	Hybrid Inverter	5 kW, 48V	Walton	1	95,000	95,000
3	MPPT	100A, 48V	Smarten	1	28,000	28,000
4	Battery	12V 200Ah	Hamko	4	32,000	128,000
5	DC Cabling & Accessories	DC cable, Fuse, MCB,	Local Market	1set	12,000	12,000
6	Installation Cost	Labor & Mounting	Local Technician		15,000	15,000
					Total	598,000/=

Table 3 : Load Calculation Table (For 2 Storey House)

Types of Load	Quantity	Power Consumption per Quantity	Total Power Consumption
LED Bulb	10	12 W	120W
Fan	6	80 W	480W
LED TV	2	120 W	240W
Refrigerator	2	150 W	350W
AC (1 Ton)	2	1200 W	2400W
Washing Machine	2	450 W	900W
Water Motor / Pump (1 HP)	1	800 W	800W
Iron	2	1000 W	2000W
Oven	2	1000 W	2000W
		Total	9240 W

Table 4 : Hybrid Solar System Cost Analysis (For 2 Storey House)

Sl No.	Component Name	Specification	Brand	Quantity	Unit price (Tk)	Total Price (Tk)
1	Solar Panel	550 W Mono PERC	Walton	20	32,000	640,000
2	Hybrid Inverter	5 kW, 48V	Walton	2	95,000	190,000
3	MPPT	100A, 48V	Smarten	2	28,000	56,000
4	Battery	12V 200Ah	Hamko	8	32,000	256,000
5	DC Cabling & Accessories	DC cable, Fuse, MCB,	Local Market	2 set	12,000	24,000
6	Installation Cost	Labor & Mounting	Local Technician		15,000	30,000
					Total	1196,000/=

### 3.8 Battery



**Figure 3.3: Battery**

#### **Overview of Hamko 12 V 200 Ah Battery**

The **Hamko 12 V 200 Ah battery** is a deep-cycle lead-acid battery commonly used in IPS/UPS systems and entry-level solar hybrid systems in Bangladesh. It stores electrical energy for later use when solar production is low or at night.

#### **Typical specifications (varies by exact model):**

- **Voltage:** 12 V nominal.
- **Capacity:** ~200 Ah (amp-hours).
- **Technology:** Lead-acid (flat plate or sometimes tubular plate).
- **Application:** Solar, IPS, UPS, emergency backup.
- **Weight:** ~50–60 kg.
- **Warranty (typical):** 18–24 months (varies by seller/model).

There are similar variants like **HPD-200**, **Superior PCV-29**, and **HPD-200T tall tubular battery**, but all are 12 V, 200 Ah class batteries suitable for backup storage.

#### **2. How It Works in a Hybrid Solar System**

A **hybrid solar system** combines solar panels, a solar inverter/charger, battery bank, and grid (or generator) supply:

1. **Solar Panels:** Generate DC power from sunlight.
2. **Solar Charge Controller (MPPT/ PWM):** Manages charging the batteries safely.
3. **Battery Bank:** Stores excess energy for night or low sunlight periods.
4. **Inverter:** Converts DC (from the batteries/solar) to AC for household use.

5. **Grid/Generator:** Acts as backup or supplement when solar + battery can't meet demand.

The **12 V 200 Ah Hamko battery** acts as the storage point — it receives charge from solar via the charge controller and supplies DC power to the inverter when needed.

### 3.9 Solar Panel



**Figure 3.4: Solar Panel**

#### **Overview of 550 W Mono PERC Solar Panel**

A **550 W Mono PERC solar panel** is a **high-capacity photovoltaic (PV) module** designed to generate electricity from sunlight with **high efficiency**. It is widely used in **home, commercial, and industrial solar systems**, including **hybrid solar setups**.

#### **Breakdown of the term:**

- **550 W (Watt):** The **maximum power output** the panel can produce under ideal test conditions.
- **Mono (Monocrystalline):** Made from **single-crystal silicon**, which offers **higher efficiency** and better performance than polycrystalline panels.
- **PERC (Passivated Emitter and Rear Cell):** An advanced cell technology that improves energy conversion by capturing more sunlight, especially in low-light conditions.

## Main Technical Features (Typical)

Feature	Description
Rated Power	550 Watts
Cell Type	Monocrystalline PERC
Efficiency	~20–21%
Output Voltage (Vmp)	~40–42 V
Output Current (Imp)	~13–14 A
Lifespan	25+ years
Degradation	~0.5% per year

Table 5 : Main Technical Features (Typical)

## Function of a 550 W Mono PERC Solar Panel

### 1. Convert Sunlight into Electricity

The panel absorbs sunlight and converts it into **DC (Direct Current) electricity** using photovoltaic cells.

### Supply Power to a Solar System

The DC electricity generated is:

- Used **directly** by appliances (in hybrid/on-grid systems)
- Sent to a **charge controller** to charge batteries
- Converted to **AC power** by an inverter for home use

### Charge Batteries (Hybrid / Off-Grid Systems)

In a hybrid system:

- The panel charges batteries during daytime
- Stored energy is used at night or during power cuts

### Works in Low-Light Conditions

Thanks to **PERC technology**, the panel performs better:

- In cloudy weather
- Early morning and late afternoon sunlight

### 3.10 Hybrid Inverter



**Figure 3.5: Hybrid Inverter**

#### **Overview of 5 kW 48 V Walton Hybrid Inverter**

A **5 kW 48 V Walton Hybrid Inverter** is a **smart power-management device** that combines the functions of:

- **Solar inverter**
- **Battery charger**
- **Grid (or generator) interface**

into **one unit**. It is designed to run home or office appliances using **solar energy, batteries, and grid power together**, automatically selecting the best available source.

#### **Key meanings:**

- **5 kW (5000 W):** Maximum AC load the inverter can supply at one time.
- **48 V battery system:** Uses a **48 V battery bank** (usually **4 × 12 V batteries in series**).
- **Walton:**  
A trusted Bangladeshi brand offering solar and power-backup solutions with local service support.

### Main Technical Features (Typical)

Feature	Description
Rated Power	5 kW (5000 W)
Battery Voltage	48 V DC
Output Voltage	230 V AC
Output Frequency	50 Hz
Solar Input	High-voltage MPPT
MPPT Range	~120–450 V DC
Efficiency	~95–98%
Waveform	Pure Sine Wave
Display	LCD / LED
Protection	Overload, short-circuit, over-temp

Table 6 : Main Technical Features (Typical)

### Functions of a 5 kW Walton Hybrid Inverter

#### 1. Converts Solar Power to AC Power

- Takes **DC power** from solar panels
- Converts it to **230 V AC**
- Runs household or commercial appliances directly

#### 2. Charges Batteries Automatically

- Stores extra solar energy in the **48 V battery bank**
- Can also charge batteries from **grid power** when needed

#### 3. Manages Grid + Solar + Battery Power

The inverter intelligently decides:

1. Use **solar first**
2. Then **battery**
3. Then **grid power** (if solar/battery is insufficient)

This reduces electricity bills and ensures backup during load-shedding.

#### 4. Provides Uninterrupted Power Supply (UPS)

- Automatically switches to battery during power cuts
- Keeps lights, fans, TV, computers, fridge running smoothly

#### 5. Smart Monitoring & Control

- LCD screen shows:
  - Solar generation
  - Battery voltage & charging status
  - Load consumption
- Some models support **Wi-Fi / mobile app monitoring**

### 3.11 MPPT Smarten



**Figure 3.6: MPPT Smarten**

#### Overview of MPPT Smarten

**MPPT Smarten** refers to a **solar MPPT charge controller** manufactured by **Smarten Power Systems**, a well-known brand for solar and power-backup equipment in South Asia.

An **MPPT (Maximum Power Point Tracking) Smarten charge controller** is an intelligent device used in **solar power systems** to **regulate and optimize the charging of batteries from solar panels.**

**MPPT = Maximum Power Point Tracking**

It is a technology that:

- Continuously tracks the **maximum power point** of a solar panel
- Extracts the **maximum possible power** from the panel at any moment
- Converts higher panel voltage into usable charging current efficiently

## **Main Functions of MPPT Smarten**

### **1. Efficient Battery Charging**

- Converts **high-voltage DC** from solar panels into correct battery voltage
- Charges batteries **faster and safer**
- Prevents **overcharging and deep discharging**

### **2. Maximizes Solar Power Output**

- MPPT controllers are **30–40% more efficient** than PWM controllers
- Especially effective in:
  - Morning & evening sunlight
  - Cloudy weather
  - Cold or variable temperature conditions

### **3. Smart Power Management**

MPPT Smarten:

- Adjusts charging automatically based on:
  - Sunlight intensity
  - Battery condition
- Uses multi-stage charging:
  - Bulk
  - Absorption
  - Float

### **4. Protects System Components**

Built-in protections include:

- Over-voltage
- Over-current
- Short-circuit

- Reverse polarity
- Battery over-temperature

### Typical MPPT Smarten Specifications

Feature	Description
Type	MPPT Solar Charge Controller
Battery Voltage	12 V / 24 V / 48 V
Charging Current	30 A / 40 A / 60 A / 80 A
Max PV Voltage	100 V – 450 V
Efficiency	Up to 98%
Display	LCD / LED
Communication	RS-485 / Wi-Fi (some models)

Table 7 : Typical MPPT Smarten Specifications

### How MPPT Smarten Works (Simple Flow)

**Solar Panel → MPPT Smarten → Battery → Inverter → Load**

- Solar panel produces DC power
- MPPT Smarten finds the best voltage/current combination
- Battery gets optimal charging
- Inverter supplies AC power to appliances

### Why MPPT Smarten Is Better Than PWM

Feature	MPPT Smarten	PWM Controller
Efficiency	High (95–98%)	Low (70–80%)
High-power panels	Supported	Limited
Long cable runs	Good	Poor
Battery life	Longer	Shorter

Table 8 : Why MPPT Smarten Is Better Than PWM

### Where MPPT Smarten Is Used

- Home solar systems
- Hybrid solar systems
- Off-grid systems
- Solar IPS/UPS
- Agricultural solar systems

# **CHAPTER 4**

## **EXPECTED FEEDBACK ANALYSIS**

### **4.1 Project Outcome plan**

After finally completing this project, design we had the objective to construct and run the project but due to paucity of time and budget shortage we couldn't construct the project.

#### **Expected check list of the reconstructed project**

**4.1.1** The system can manage up to \_\_\_ kW load using solar panels and battery storage.

**4.1.2** Direct power usage from solar panels during daytime, with battery charging for backup.

**4.1.3** Uninterrupted electricity supply at night or during cloudy days via battery backup.

**4.1.4** Significant reduction in dependence on the national grid.

**4.1.5** Electricity bills can be reduced by approximately \_\_\_%.

**4.1.6** Environmentally friendly, reduces carbon emissions.

**4.1.7** Utilizes rooftop space, no land is wasted.

**4.1.8** Operates small AC and DC loads, such as fans, LED lights, TV, washing machine, and other household appliances.

**4.1.9** The system is easily expandable in the future by adding more panels or batteries.

#### **Industry Section**

With inverter and battery backup, the system can handle 20–50 kW load.

Provides uninterrupted power for production units day and night.

Supports small industrial machinery, lighting, and power tools.

Minimizes the impact of grid load shedding and voltage fluctuations.

Significantly reduces electricity costs and operational expenses.

Environmentally sustainable, reduces carbon footprint, and enhances industrial sustainability.

Uses rooftops or unused spaces for solar installation, avoiding land wastage.

Capacity can be increased in the future by adding more panels or batteries.

Ensures stable industrial operation with minimal interruptions and equipment downtime.

## **4.2 Discussion**

From literature study we have learnt that the Hybrid Solar Power System with grid support is an efficient and reliable solution for residential electricity supply in Bangladesh. It integrates solar panels, battery storage, and the national grid to ensure continuous power for a typical house. During the daytime, solar panels generate DC electricity, which is optimized by the MPPT charge controller and used to power household appliances directly. Excess energy is stored in batteries, providing backup during nighttime or cloudy weather.

A key feature of this system is the grid connection, which automatically supplies electricity when solar generation or battery storage is insufficient to meet household demand. This ensures uninterrupted power supply for critical appliances like lights, fans, refrigerators, and small AC loads. The system also includes a buck converter to safely regulate DC voltage for low-voltage devices and a transformer with inverter to supply stable AC power.

This hybrid approach reduces dependence on the national grid, lowers electricity bills, and minimizes carbon emissions, promoting environmental sustainability. It is particularly suitable for areas prone to load shedding or voltage fluctuations. Additionally, rooftop installation maximizes space efficiency and prevents land wastage. Overall, the project demonstrates a practical, scalable, and sustainable solution for reliable residential energy management while integrating renewable and conventional power sources effectively.

## **4.3 Advantages**

There are certainly many advantages of our project and some of the major ones have been given below:

**4.3.1** Provides uninterrupted electricity using solar, battery, and grid.

**4.3.2** Reduces electricity bills significantly.

**4.3.3** Environmentally friendly, lowers carbon emissions.

**4.3.4** Supports critical household loads during power outages.

**4.3.5** Rooftop installation saves land and space.

**4.3.6** Scalable for future expansion with more panels or batteries.

**4.3.7** Reduces dependence on the national grid, improving reliability.

**4.3.8** Lowers operational and maintenance costs over time.

## **4.4 Limitations**

Through the project has many advantages it has also some limitation, they are given below:

- 4.4.1** Weather-dependent performance; efficiency drops during cloudy or rainy days.
- 4.4.2** Battery cost is high .
- 4.4.3** Grid dependency remains during prolonged low-sunlight periods if batteries are insufficient.
- 4.4.4** Voltage fluctuations can affect sensitive appliances if system components are not properly managed.

## **4.5 Recommendation**

Due to land shortage it we can utilize the roof tops that will be helpful to generate huge solar power. At the same time government need not to pay for this because as per the government regulation for electric supply in high rise building. The house over supped to pay for the cost of his rooftop solar system.

The application areas for this project in this modern and practical world are huge and some of these are given below:

- 4.5.1** It can be used in House
- 4.5.2** It can be used for Industrial work.
- 4.5.3** It can be used in factories.
- 4.5.4** It can be used in a School / College / University

# CHAPTER 5

## CONCLUSION

### 5.1 Conclusion

The Hybrid Solar Power System with grid support is a reliable and sustainable solution for residential energy needs, particularly in Bangladesh, where power outages and load-shedding are common. This system combines solar panels, battery storage, and the national grid to ensure uninterrupted electricity for a typical household. During the day, solar panels generate DC electricity, which is optimized by the MPPT charge controller to maximize energy harvest. Excess energy is stored in batteries, providing backup power at night or during cloudy conditions.

Grid support acts as an additional energy source, automatically supplying electricity when solar generation or battery storage is insufficient to meet household demand. The inverter and transformer convert DC power from the battery into stable AC voltage for household appliances, while a buck converter ensures safe DC voltage for low-power devices. This hybrid setup improves energy efficiency, reduces electricity bills, and minimizes dependence on the conventional grid.

Rooftop installation makes efficient use of available space without wasting land, and the system can be easily expanded in the future by adding more panels or batteries. Overall, this project demonstrates a practical, cost-effective, and environmentally friendly approach to energy management, providing continuous, reliable, and sustainable electricity for modern homes while supporting long-term energy security and environmental sustainability in Bangladesh.

### 5.2 Future Scope of Work

The future scope of this hybrid solar power system includes integration of IoT-based remote monitoring for real-time data access through mobile applications. System capacity can be expanded to support higher household loads. Advanced battery technologies such as lithium-ion batteries can improve efficiency and lifespan. Grid-tied functionality and net metering can also be added to export excess solar power. Additionally, AI-based energy management can optimize power usage automatically.

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