A Project Report

on

Hybrid Power Generation Using Rooftop PV: A Case Study

in partial fulfillment for the award of the degree

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BACHELOR OF TECHNOLOGY (B. TECH)

IN

ELECTRICAL ENGINEERING

Submitted by:

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CANDIDATE'S DECLARATION

I/We hereby declare that the project titled **"Hybrid Power Generation using Rooftop PV : A Case study"** submitted for the award of **Bachelor of Technology** degree in **Electrical Engineering** is my original work and the project has not been submitted elsewhere for the award of any other degree, diploma, fellowship, or any other similar titles.

Shivam Shivhare (0901EE191112)

Place: Gwalior

Date: 26.05.2023

This is to certify that the above statement made by the candidate is correct to my knowledge and belief.

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ABSTRACT

Currently these days electricity is most needed facility for us. All the non-renewable energy resources are depleting day by day. So we need to transition from non-renewable to renewable energy resources. In this the combinations of different energy resources is takes places but we would talking regarding solar energy. This approach reveals the utilization of renewable energy resources without causing harm to the environment. By employing a hybrid energy system, we can provide uninterrupted power supply. Essentially, this system combines different energy sources to ensure a continuous flow of power. Solar panels play a crucial role in converting solar energy into electrical energy, which can be employed for various applications. The generation of electricity through this method proves to be cost-effective, offering affordable rates. Solar power is acquiring significant prominence in the contemporary world. The objective of the project is to create a hybrid power generation system that is connected to the grid, utilizing solar energy as its primary source, after that the upcoming benefits of solar etc.

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LIST OF ABBREVEATIONS

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1. PV – Photovoltaic
2. VC – Voltage Controller
3. CC – Current Controller
4. PWM – Pulse width modulation
5. kWp - Kilo Watt Peak
6. RESCO – Renewable energy service company
7. EED - Economic Emission dispatch

CHAPTER I: INTRODUCTION

Hybrid power generation using Solar involves combining solar power with another form of power generation. This approach allows for more reliable and consistent power production, as well as the ability to generate power even when the sun is not shining.

The basic idea behind hybrid solar power generation is to combine the strengths of multiple power sources to create a more robust and efficient system. The hybrid power generation system consists of solar photovoltaic (PV) panels, batteries, inverters, and a backup power source such as a inverter For example, during the day, solar panels can generate electricity from the sun's energy, while at night or during periods of low sunlight, a backup power source, such as hybrid power generator, can provide additional power to meet the electricity demand.

Hybrid solar power systems are experiencing growing adoption in distant regions where access to grid electricity is limited or unreliable. These systems can provide reliable and affordable electricity for households, businesses, and communities, while reducing their dependence on fossil fuels and lowering their carbon footprint.

That's why the institute MITS Gwalior also uses these hybrid solar grid system since 2019.

Conversion of sun light into electricity by solar cell

Solar cells or photovoltaic cells, converts the sunlight directly into electricity known as photovoltaic effect. Sunlight (which is made up of photons) hits the solar cell. The solar cell is made up of a semiconductor material such as silicon that contains both positively and negatively charged layers. When photons hit the solar cell, they transfer their energy to electrons in the semiconductor material, causing some of them to break free from their atoms and form an electric current. The electric current generated by the freed electrons is captured by the metal contacts on the solar cell, which then conducts the electricity out of the cell and into a circuit. The solar cell continues to generate electricity as long as it is exposed to sunlight. By combining multiple solar cells into a solar panel, larger amounts of electricity can be generated. This electricity can be used to power homes, businesses, and other electrical devices.

Material is used for construction of PV panel for maximum power generation

Silicon semiconductor is used in PV cell. Crystalline silicon is the most common material that used in solar cells due to the lifespan of crystalline silicon which is approximately more than 25 years, due to the band gap and energy efficiency of silicon 1.34 eV and 22% respectively.

Orientation of PV panel for maximum power generation

In India, the optimal orientation for a photovoltaic (PV) panel to achieve maximum power generation is facing due south (i.e., oriented towards the equator) with a tilt angle equal to the latitude of the location. This orientation ensures that the PV panel receives maximum sunlight throughout the year, as the sun is at its highest point in the sky at solar noon and during the summer months in India, it is located in the northern hemisphere. This configuration ensures that the panel receives maximum direct sunlight during the peak sun hours of the day. However, the optimal orientation and tilt angle may vary depending on the specific location, the type of PV panel being used, and the desired level of power generation. It is recommended to consult with a solar energy expert to determine the most appropriate orientation and tilt angle for a specific PV panel installation.

Microgrid

A microgrid is a localized group of electrical generation, distribution, and consumption units that operate together as a single system, often including renewable energy sources and energy storage systems. It is designed to provide reliable and resilient electricity to a specific geographic area, such as a campus, neighborhood, or community. Micro grids can operate either connected to the main power grid or as an independent system.

In institute of MITS Gwalior generally we uses the voltage controller, current controller, PWM controller for the microgrid.

Voltage controller: A voltage controller is a device that regulates the voltage level in the microgrid by adjusting the power factor and reactive power flow. It can adjust the output voltage of the power source to match the voltage requirements of the load, ensuring that the voltage remains within a specific range to prevent overvoltage or under voltage conditions.

Current controller: A current controller is a device that regulates the current flow in the microgrid by adjusting the active power flow. It can adjust the output current of the power source to match the current requirements of the load, ensuring that the current remains within a specific range to prevent overcurrent or under current conditions.

PWM controller: A PWM (Pulse with modulation) controller is a device that regulates the power flow by adjusting the duty cycle of the power signal. It operates by switching the power on and off rapidly, and by varying the width of the on-time and off-time of the signal, the average power delivered to the load can be regulated. PWM controllers are commonly used in microgrids to control the voltage and frequency of the AC power output from the inverter, ensuring that it matches the grid requirements and maintaining the stability of the microgrid.

CHAPTER II: SYSTEM DESCRIPTION

Details of equipment's installed in MITS Gwalior.

A solar module consisting of 308 panels with a total capacity of 50kW was installed by Vikram Solar Company in November 2019. The total cost of the installation was approximately 70 lakh, with 2 inverter of 50 kW capacity of Sungrow Company.
The 100 kWp solar rooftop PV plant was installed in November 2019 and is running successfully since then at MITS Gwalior under Renewable Energy Service Company (RESCO) scheme of MP Urja Vikas Nigam, Bhopal and installed by and maintained by Azure Power Rooftop Five Pvt. Ltd. This plant is Net-metered grid Connected with MPMKVV Co Ltd.

Economic Emission Dispatch of Microgrid in MITS Gwalior

Economic Emission Dispatch (EED) is an optimization problem that involves determining the optimal power output of generators in a power system that minimizes the operating cost and reduces the emission of pollutants simultaneously. In a microgrid, the EED problem is solved to optimize the power dispatch between various distributed energy resources (DERs) in the microgrid. The objective is to minimize the total operating cost of the microgrid while meeting the power demand of the loads and satisfying the operational constraints of the DERs.
The EED problem can be formulated as a nonlinear optimization problem with constraints. The optimization objective is to minimize the total operating cost of the microgrid, which includes the fuel cost of the generators, the cost of purchasing electricity from the grid, and the cost of emissions from the generators. The constraints include the power balance equation, which requires that the power output of all the DERs in the microgrid must match the power demand of the loads at all times, and the operational constraints of the DERs, such as the upper and lower thresholds of power output, ramp rate limits, and voltage and frequency constraints. The solution to the EED problem

provides the optimal power dispatch of the DERs in the microgrid, which can be used to operate the microgrid in an efficient and environmentally friendly manner. The EED problem can be solved using various optimization techniques, such as linear programming, quadratic programming, and particle swarm optimization.

In summary, the EED of microgrid is an important aspect of microgrid control that optimizes the power dispatch of DERs in the microgrid to minimize the operating cost and reduce the emission of Through the simultaneous integration of renewable energy sources, there is an observed decrease of 18% in fuel costs and a reduction of 3.4% in emissions during static load demand analysis. Similarly, when considering multiple load demands over a 24-hour period, fuel costs decrease by 14.95%, and emissions are reduced by5.58%.

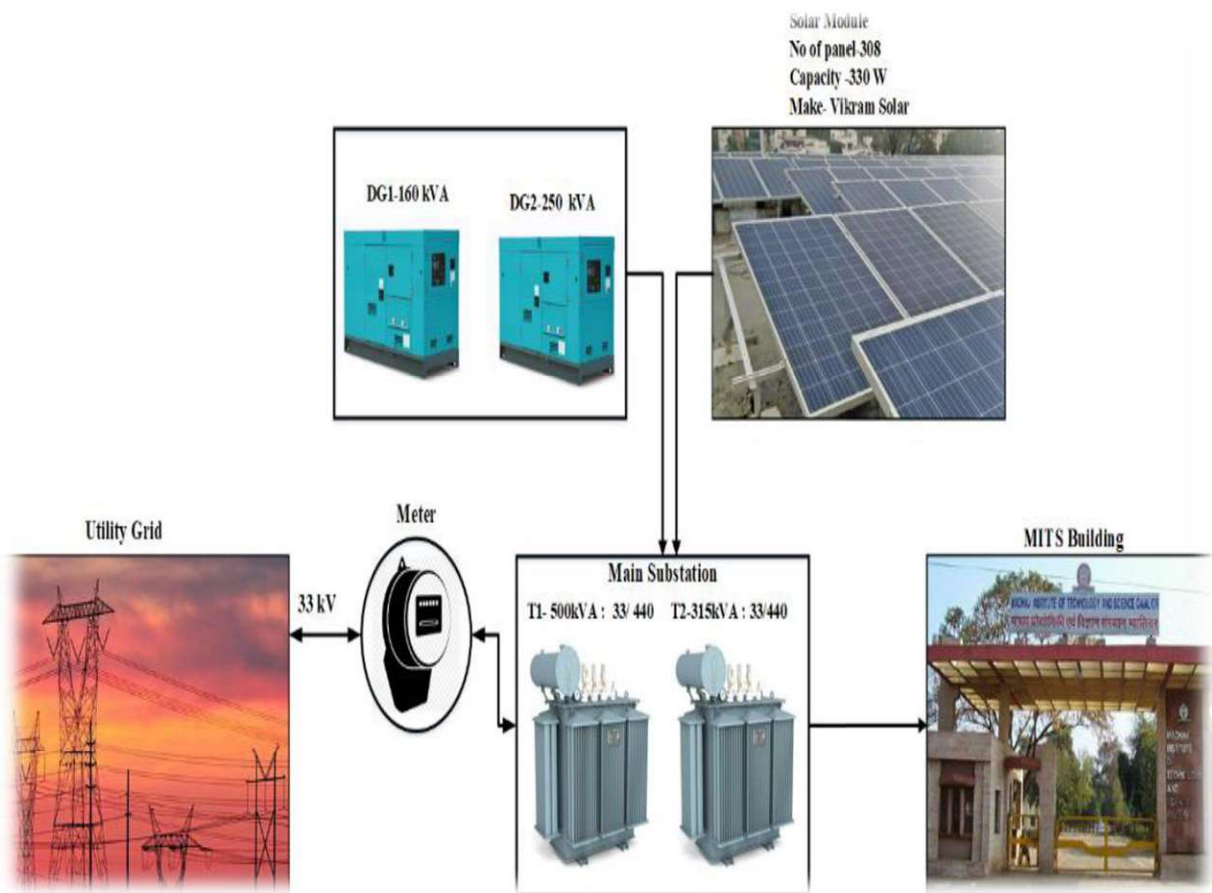

Figure 1. MITS POWER SUPPLY SYSTEM

Power flow diagram of MITS Gwalior

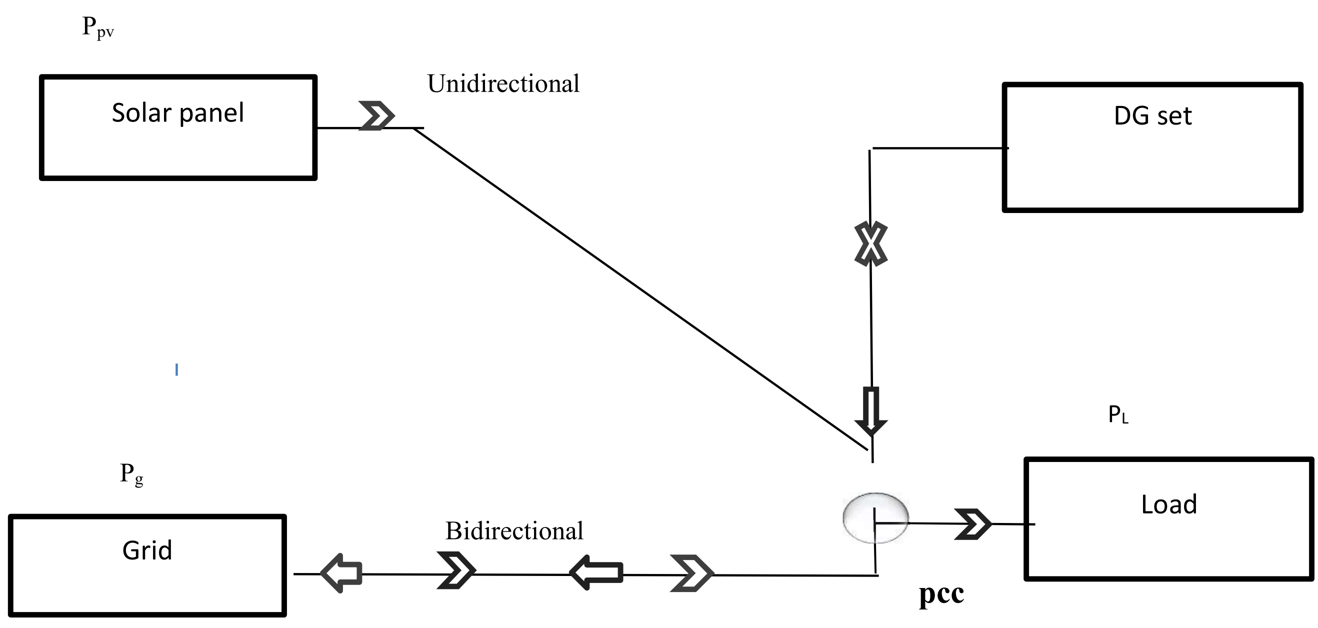

Figure 1. Connection diagram

Case 1: Unidirectional

In this case,

- The power is flow from source to load.
- Like as Solar panel, DG set and load is working as unidirectional

Case 2: Bidirectional

- The power is flow both the directions.
- Like as source to load and load to source

CHAPTER III: METHODOLOGY

The maximum power point (W_P):

It is the point at which the panel generates maximum power. It is the operating point at which the product of the voltage and current is maximum.

The maximum power voltage (Vmp):

It is the voltage at which the panel produces maximum power. At this voltage, the panel is operating at the MPP.

The open circuit voltage (Voc):

It is the voltage at which the panel is not connected to any load and no current is flowing through the circuit. At this voltage, the current is zero and the panel produces its maximum voltage.

The maximum power current (Imp):

It is the current at which the panel produces maximum power. At this current, the panel is operating at the MPP.

The short circuit current (Isc):

The short circuit current is the current that flows when the positive and negative terminals of the solar panel are connected directly together. At this point, the voltage is zero and the panel produces its maximum current.

The fill factor (FF):

The fill factor is the ratio of the maximum power that can be obtained from the solar panel to the product of its open circuit voltage and short circuit current. It is a measure of the efficiency of the panel in converting sunlight into electrical energy. A higher fill factor indicates a more efficient panel.

$$FF = V_M * I_M / V_{OC} * I_{SC}$$

$$= P_M / V_{OC} * I_{SC}$$

These all parameters are helpful for measuring the load, battery size calculation, solar array design, etc

CHAPTER IV: RESULT

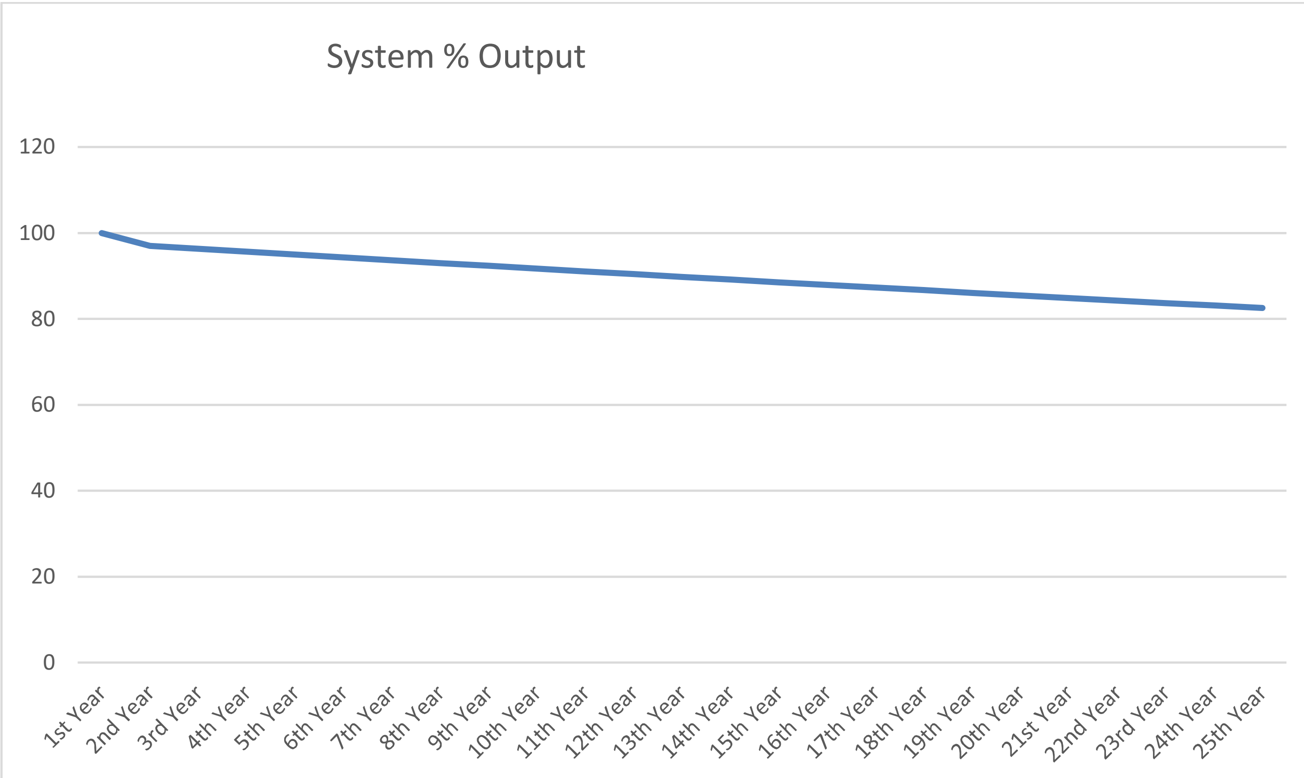

Fig. 2 System percentage output

The output of a hybrid power solar generation system can reduce over time due to various factors, such as:

Aging of solar panels: Solar panels have a limited lifespan and their efficiency decreases as they age. Exposure to sunlight, temperature fluctuations, and other environmental factors can cause the panels to degrade over time, leading to reduced efficiency and output.

Accumulation of dirt and debris: Dust, dirt, leaves, and other debris can accumulate on the surface of solar panels, which can reduce the amount of sunlight that is absorbed and converted into electricity. This can lead to a decrease in the output of the solar panels and the overall efficiency of the system.

Battery degradation: Hybrid power solar generation systems often use batteries to store excess energy for later use. However, the batteries have a limited lifespan and can degrade over time, reducing their capacity and overall efficiency.

Poor maintenance: Regular maintenance of the solar panels, batteries, and other components is essential to keep the system running at optimal efficiency. Neglecting maintenance can lead to system failures, reduced output, and other problems.

Changes in environmental conditions: Changes in weather patterns, such as cloudy or rainy weather, can reduce the amount of sunlight that reaches the solar panels, leading to decreased output. Similarly, changes in energy demand can also affect the overall efficiency of the system.

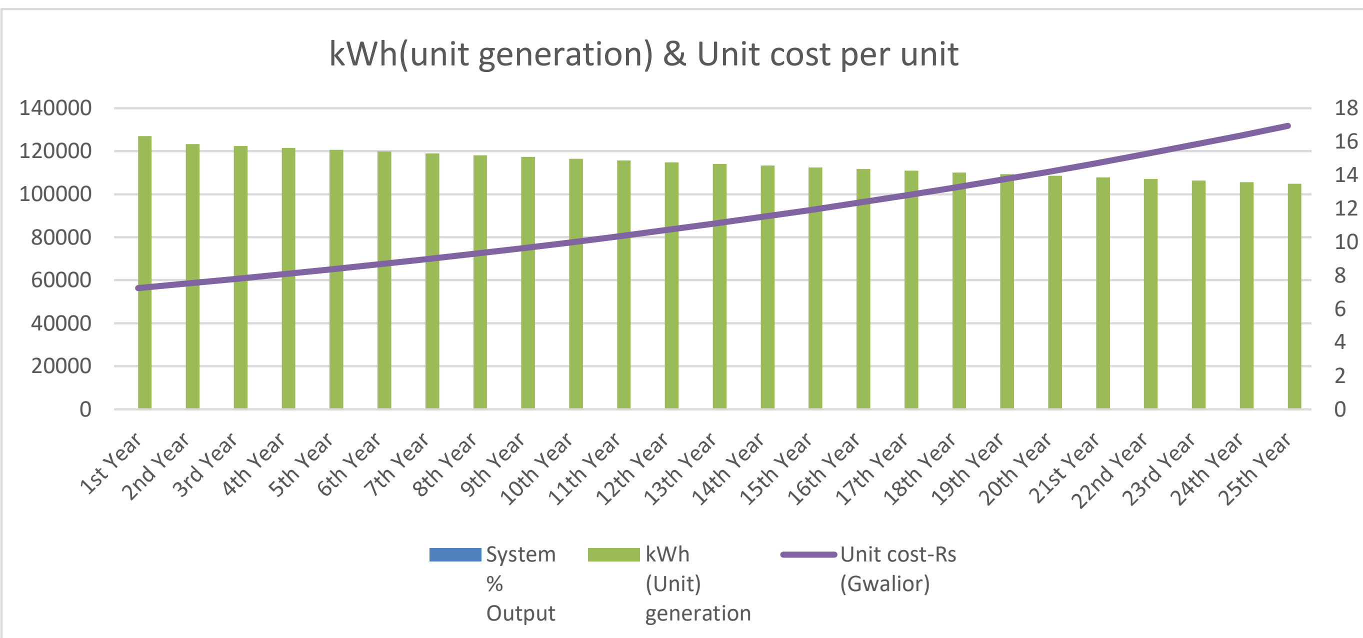

Fig.3 Graph showing unit generation per unit cost

The kWh unit generation of a solar hybrid power generation system may reduce and the unit cost may increase over time due to several factors, including:

Degradation of solar panels: Over time, the efficiency of solar panels can degrade due to exposure to environmental factors such as heat, moisture, and dust. This can lead to a reduction in the amount of electricity generated by the system, which can increase the unit cost of electricity.

Battery degradation: Hybrid solar power generation systems often use batteries to store excess energy for later use. However, batteries have a limited lifespan and can degrade over time, reducing their capacity and the amount of energy they can store. This can lead to a reduction in the amount of electricity generated by the system, which can increase the unit cost of electricity.

Maintenance costs: Maintenance costs for solar hybrid power generation systems can increase over time, as components may require repair or replacement. For example, if the batteries need to be replaced or the solar panels require cleaning or repairs, this can increase the unit cost of electricity.

Changes in energy demand: As energy demand increases, solar hybrid power generation systems may struggle to keep up with demand. This can lead to the need to install additional capacity, which can increase the unit cost of electricity.

Changes in government policies: Government policies regarding solar power incentives and subsidies can change over time. These changes can affect the cost of electricity generated by solar hybrid power generation systems, and can increase the unit cost of electricity if incentives are reduced or eliminated.

Overall, it is important to regularly monitor and maintain solar hybrid power generation systems to ensure optimal performance and to keep costs under control. Regular maintenance, component replacement as needed, and careful monitoring of energy demand can help to mitigate the factors that can lead to a reduction in kWh unit generation and an increase in unit cost over time.

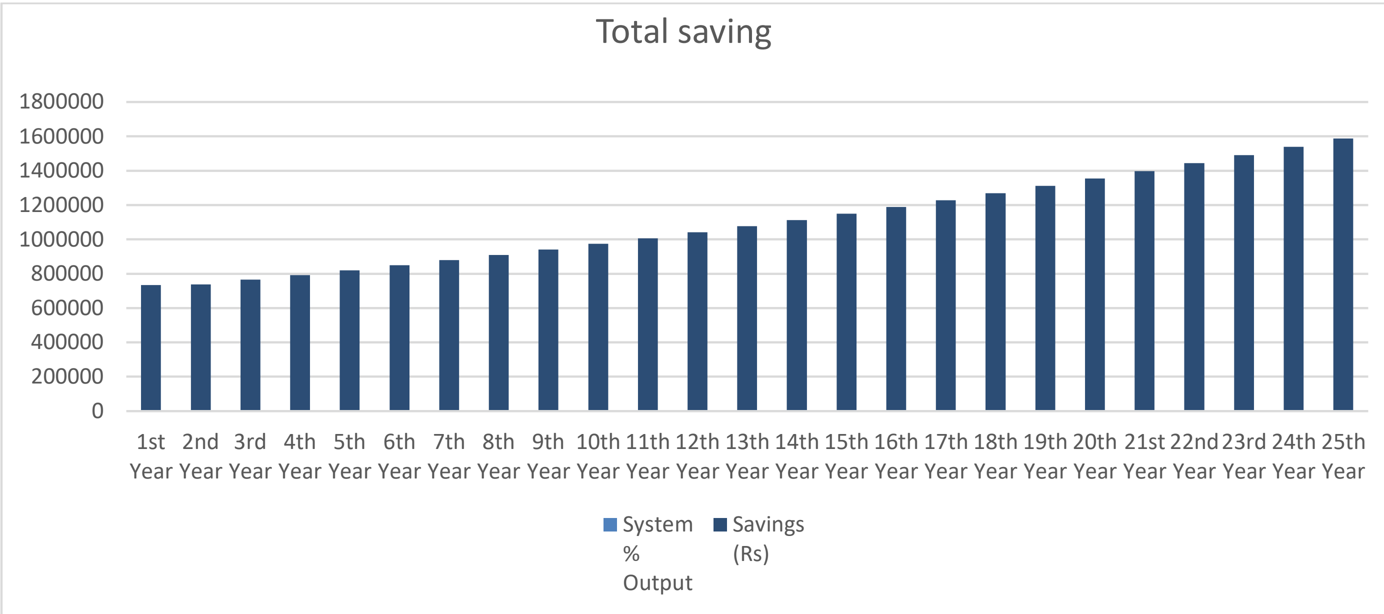

Fig.4 Total Savings

As per above graph, we can conclude the total savings cost by using solar of 25 years respectively

- In every upcoming year the savings increases i.e. it gives the benefits more if we using solar as long term.
- By installing solar it gives us to minimize or negligible electricity bills.
- Majorly the total saving decided by the total electricity bill with including the total cost of up-fronts of solar and solar systems.

CHAPTER V: CONCLUSION

With the escalating usage of fossil fuels, the environment is facing detrimental consequences, while the depletion of these fuels continues to accelerate. A future without reliance on fossil fuels is imminent. Given the indispensability of energy sources for electricity generation, a substantial shift towards renewable energy sources becomes imperative. Expanding our dependence on renewable energy and maximizing its utilization is crucial. The implementation of smart poles presents an opportunity to augment the utilization of solar power. Once this system undergoes necessary advancements, it can potentially replace existing energy systems. Moreover, the installation of rooftop solar power plants on the premises has demonstrated a significant reduction in CO_2 emissions, contributing to a substantial decrease in atmospheric pollution over the course of a year. Hybrid power generation using solar energy is an efficient, reliable, and sustainable approach to meet the energy needs of today's world. With advancements in technology and increasing demand for clean energy, this approach is expected to gain widespread adoption in the coming years.

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