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Comparative case study analysis of conventional and solar energy systems

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Abstract---Energy management is the process for the conservation of energy as energy consumption tends to rise day by day, as energy demand rises. The process involved is to determine when, where, why, and how energy is used in a plant or building. This paper aims to carry out electrical load management in organizations /domestic/industries. The main objective is to evaluate the use of Electrical energy in an organization for different appliances and determine the opportunities for energy saving with energy-efficient equipment or techniques to make it more energy-efficient. This paper presents mathematical modeling, examination, and analysis for the institution and estimates the savings obtained by switching from a conventional energy source to a solar energy source.

Keywords---Conventional, Solar, case study, NSM, NMEE

Introduction

Worldwide energy request expanded quickly in the twentieth century and a similar pattern is proceeding in the 21st century too. A significant portion of the worldwide energy request has been met with fossil derivatives. The extraction,

transformation, transmission (transport), dispersion, and usage of non-renewable energy sources lead to the arrival of an assortment of ecological contaminations including CO₂ [1]. Expanded centralization of ozone depleting substances, for example, CO₂ in the climate has showed as far as an Earth-wide temperature boost and numerous other antagonistic ecological impacts.

An enormous number of nations on the planet have started eager projects toward this path and impressive achievement has been accomplished in both tackling the inexhaustible wellsprings of energy just as in improving the productivity of energy use. As a result, the energy blend is changing on a worldwide scale. The complete power age from inexhaustible represented practically 23.7% of worldwide power production. The overall introduced limit of power age dependent on sustainable wellsprings of energy (barring enormous hydropower and siphoned stockpiling) came to 1070 GW.

In places where the network accessibility is zero or high examples of a force cut, Off-framework are an able answer for alleviation from power cuts [2]-[3]. It is very well may be introduced with an independent inverter with a different or incorporated charge regulator. In the event that the off-matrix framework is planned with proper sun based boards and battery, it can supply power over time while never depending on the network power.

Offgrid Rooftop Solar PV System

The methodology utilized in the examination is to think about a framework - associated PV framework where a negligible part of energy is produced from an inexhaustible source. The PV age limit is assessed from the space accessibility, even consider the techno-financial perspectives off-matrix sun powered PV framework which needs to help all the interest. The target of this examination is to introduce a procedure for techno-financial investigation of housetop sun powered PV to assess the advantages of customers exchanging over from lattice to sun based PV.

In this methodology, an instrument is created to figure the quantity of sun based boards required, number of batteries required and furthermore did an expense investigation of the sunlight based gear and contrasted it and the expense of regular power[4]-[5]. The square outline of the off-matrix roof nearby planetary group is appeared in Fig. 1.

Sun oriented force is changed over into DC power when the sun beams episode on the sunlight based boards. To keep up steady voltage a charge regulator is utilized by controlling the force produced. DC power is then put away in the battery and an inverter changes DC power into AC power and the force is then associated with the heap.

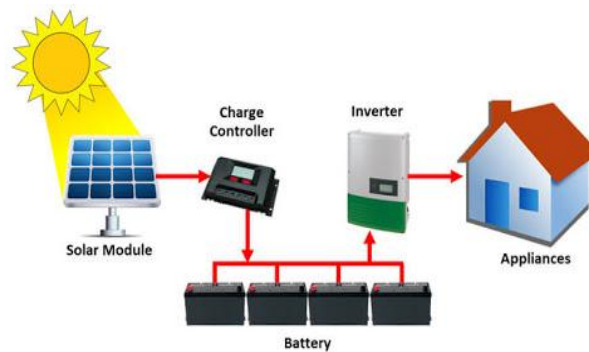


Fig 2.1. Block diagram of rooftop PV system

The idea of housetop PV has been effectively shown in an undertaking under the Italian PV roof program. Around there, the compositional framework plan, information obtaining framework has been introduced, alongside the estimation of compensation time and monetary productivity of the task. The advantages of an off-network housetop sun based PV framework can be summed up as follows [6]-[7].

- The customer gets a continuous force supply.
- The profit from venture is superior to other elective sources.
- Diminishes reliance on the utility lattice.
- Stay away from the utilization of a dirtying diesel generator set.
- Low support, and no compelling reason to buy fuel routinely, contrasted with the diesel generator set.
- Just one-time introductory venture is required and power produced is for all intents.
- Protection from raising ordinary force levies.

Government policies and schemes

Policies

- *NSM*: The National Solar Mission is a drive of the Government of India and State Governments to advance sun based force (solar power). The goal of the National Solar Mission is to set up India as a worldwide forerunner in sun oriented energy, by making the approach conditions for its dispersion the nation over as fast as could be expected. Under the arrangement, the Public authority intended to accomplish an absolute introduced sun powered limit of 20 GW by 2022.
- *NMEEE*: “National Mission for Enhanced Energy Efficiency (NMEEE) is one of the eight missions under the National Action Plan for Environmental Change taken by the Indian government”.
- Its foundations lie in the general goal of “The Energy conservation Act of 2001”. The Mission, upon its total execution, conceives accomplishing absolute kept away from limit expansion of 19,598 MW, fuel investment funds of around 23 million tons each year, and ozone harming substance outflows decreases of 98.55 million tons each year.

Schemes

- *Government Yojana (solar energy subsidy scheme):* The Indian government launched this scheme for a few northeastern states including Sikkim, Himachal Pradesh, Jammu and Kashmir, and for Andaman Nicobar Islands and Lakshadweep. According to this scheme, we can get up to 70% discount on solar system setup. This subsidy is applicable to the household, industrial, and social sectors. The Indian government allotted a budget of 5000 crores for a period of 5 years till 2019-20 as a part of the Government Yojana subsidy scheme.
- *Development of Solar Park Scheme:* Ministry of New and Renewable Energy (MNRE) has attracted a plan to establish number of sunlight based parks across different states in the country, each with a limit of over 500 MW. The Plan proposes to offer monetary help by the government of India to set up sun oriented parks to work with the production of foundation essential for setting up new sunlight based force projects.
- *SECI scheme:* Solar Energy Corporation (SECI) has recently awarded a tender for 500 MW rooftop solar projects to specific solar EPC companies that participated in the project. The SECI scheme is mentioned in table 1 [8]-[10].

Table 3.1 SECI scheme

Category	Project size in MW	Capacity allocated	Project type	Subsidy for general category states
PART A	200 MW	500 KW – 10 MW	CAPEX	30% OF L1 project cost of state
PART B	200 MW	2 MW – 20 MW	RESCO	30% of benchmark cost i.e. Rs. 22.5/ wp
PART C	100 MW	100 KW – 2 MW	CAPEX	Rs. 22.5/ wp, whichever is lower

Mathematical model of rooftop PV system

Suitable estimating of the housetop PV framework as far as the quantity of PV boards and the measuring of the battery are significant parts of the plan. This segment present a numerical model, the articulations for estimating and number of sun based boards and battery as an element of burden necessity. The model incorporates both the specialized and monetary investigation just as natural examination.

Technical Analysis

No of solar panels required: $N_p = P_{pv} / P_o$

Where,

$$P_{pv} = E_{day} / (S_d * D)$$

$$E_{day} = \sum_{i=1}^N U_i * P_i * \frac{n_i}{100} \text{ KWH}$$

U_i = no. of hours used per day by i_{th} device type

P_i = Power rating of i_{th} device type

N_i = no. of devices of i_{th} type

E_{day} = Energy per day

S_d = avg no. of day light hours

D = De-rating factor

P_{pv} = Total power generated by PV

P_o = Power output

The number of batteries can be obtained as follows

$$N_{bat} = E_{day} * nd / (V_{bat} * IH * DOD)$$

Where,

nd = No. of days for backup power required

V_{bat} = Voltage rating of the battery

IH = Ampere- Hour rating of the battery

DOD = Depth of discharge of Battery system

The expected peak demand of the load determines the capacity of the inverter

$$P_{inv} = \sum_{i=1}^N (P_i * n_i) / DF$$

Where,

DF = Diversity factor

= Max Demand / Connected load

P_i = Power rating of i_{th} device type

n_i = no. of devices of i_{th} type

Economic analysis:

To perform economic analysis, it require the following data

1. Cost of inverter
2. Cost of solar panels
3. Cost of batteries
4. Subsidy provided by the government
5. Cost of payback period

Calculation of Payback period:

$$Y_{pay-back} = C_{pu} / (E_{day} * C_u * 365)$$

Where C_{pu} = Total cost of the system

C_u = Cost of unit energy charged

Environmental Analysis

Environmental Analysis is the investigation of decrease of Carbon dioxide outflow because of moving to housetop sun based PV framework.

$$\text{Co2emission} = \text{Eday} * 0.82 * 365 * 25 / 1000 \text{ t/MWh}$$

Case Study 1 (Domestic purpose)

In this case, the specialized, financial, and ecological examination is completed a typical household using the mathematical modeling mentioned above. In this example, a typical household consists of

Table 4.1
House hold appliances

Name of the device	No of hours	Power rating (w)	No of devices	Total load (kwh)
Light	8	40	4	1280
Fan	12	60	4	2880
Refrigerator	12	200	1	2400
Television	5	150	1	750
Washing machine	0.2	50	1	10
Exhaust fan	10	25	1	250

Calculation:

- Total energy burned-through each day
= 9.57KWH
- Power rating of sun powered boards.
= $9.57 / (7 * 0.8) = 1.7\text{KW}$
- No. of sun oriented boards needed with a force rating of 250 W each. = N_{pv}
= $1.7 * 1000 / 250$
= $6.83 \approx 7$
- Cost of each sun based board of 250 watts
= 13,100 Rs
- The complete expense of sun based boards
= $7 * 13,100 = 91,700 \text{ Rs}$
- No. of batteries required to have backup for 3 days =
 $(9.57 * 3 * 1000) / (12 * 220 * 0.5) = 22$
- Total cost of batteries = $22 * 12,000$
= 2, 64,000 Rs
- Inverter size = (Installed capacity/Diversity factor)
= $1025 / 1.7 = 603 \text{ W}$
- Cost of Inverter = $603 * 7.4 = 4,462 \text{ Rs.}$
- The complete expense of the entire gear
= $91700 + 264000 + 4462 = 360162 \text{ Rs.}$

- Presently consider subsidy as 40%
- Absolute expense of hardware after subsidy
= 360162-144064 = 216097 Rs
- The Absolute power bill for a very long time without utilizing sun based force considering Rs.6 per unit =5, 23,957 Rs
- The all out benefit utilizing sunlight based PV framework system = 523957-216097
= Rs.307860 in 25 years
- Total CO₂ reduction = $9.57 \times 0.82 \times 365 \times 25 / 1000$
= 71.6tons
- Payback period = $(218797 / 523957) \times 25$
= 10.5 years
- Therefore for a typical household, the initial investment incurred for the rooftop PV system will be recovered in a period of about 10.5 years through the savings in electrical bill.

Case Study 2:

Table 4.2
Total load in A-block per day=559.920kwh

Block-A:

Type of load	Number of hours	Power rating (w)	Number of devices	Total load (kwh)
Light	8	40	114	36480
Fan	8	60	174	83520
AC	4	1830	50	366000
Systems	4	105	142	59640
Laptops	5	60	16	4800
Sockets	3	100	30	9000
Ex-fans	8	15	4	480

Table 4.3
Total load in B-block per day =616.696 kwh

Block - B:

Type of load	Number of hours	Power rating (w)	Number of devices	Total load (kwh)
Light	8	40	114	36480
Fan	8	60	174	83520
AC	4	1830	50	366000
Systems	4	105	142	59640
Laptops	5	60	16	4800
Sockets	3	100	30	9000
Ex-fans	8	15	4	480

Table 4.4
Total load in C-block per day=772.392 kwh

Block-C

Type of load	Number of hours	Power rating (w)	Number of devices	Total load (kwh)
light	8	40	169	54080
Fan	8	6	198	95040
AC	4	183	38	278160
Sockets	4	100	45	18000
Systems	4	105	74	31080
Laptops	5	60	46	13800
Machines	4	3704	16	237056
Lift	8	5587.5	1	44696
Ex-fan	8	15	4	480

Table 4.5
Total load in D-block per day=478.594 kwh

Block-D

Type of load	Number of hours	Power rating (w)	Number of devices	Total load (kwh)
Lights	8	40	125	40000
Fan	8	60	158	75840
Ac	4	1830	38	278160
systems	5	105	6	3150
Machines	4	723	17	49164
Laptops	5	60	76	22800
Sockets	3	100	30	9000
e-fans	8	15	4	480

Calculation:

- Total load in A-block per day =559.920 kwh
- Total load in B-block per day =616.696 kwh
- Total load in C-block per day =772.392 kwh
- Total load in D-block per day =478.594 kwh
- Total load in Central block =369.280 kwh
- Total load in New block =859.894 kwh
- Total load per day =3656.776 kwh
- No.of panels in new block =460
- No.of panels in remaining =352
- Cost of each panel in NB = 20475 Rs.
- Cost of each panel in RB = 15750 Rs.
- Total cost of solar panels
= (460*20475) + (352*15750) = 14962500 Rs.
- Subsidy given by government = 30%
- Inverter cost = (inverter size/diversity factor)*7.4
= (929544/1.9)*7.4 = 3620324 Rs.

- Now total cost of whole equipment
= $14962500 + 3620324 = 18582824.2$ Rs
- Total cost after subsidy = $18582824 - 5574847$
= 13007976 Rs
- Electricity bill without solar = Rs. 737681.12
- Total no.of units generated per month using solar
= 10358 kwh
- Electricity bill with solar = 657303.04 Rs
- Savings per month using solar = $737681 - 657303$
= 80378 Rs.
- Pay-back period in years
= $(13007976 / 80378.08) / 12 = 13.48$ years
- Total profit obtained using solar =
 $(15 - 13.48) * 12 * 80378.08 = 1460078.4$ Rs.
- Reduction in CO₂ = $(3656 * 0.82 * 365 * 15) / 1000$
= 16413.612 tons

Conclusion

From the above case study table 4.1 Rooftop Solar Energy systems conclude that for a typical house hold having load it is the profit obtained by using solar power is 305160 Rs in 25 years and the initial investment on solar PV system will be obtained in a span of 10.5 years.

Considering load, the absolute expense of a rooftop PV framework is about Rs.130.079 lakhs, with a lifetime benefit of Rs.14.60 lakhs in 15 years. The compensation period is 13.48 years with a decrease in CO₂ outflows of 16413.61 tons. In spite of the fact that the underlying expense is high, changing to sun based is valuable over the long haul. One more added advantage is that the outflow of carbon dioxide in the environment is decreased extensively by utilizing solar based system.

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