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Economic Evaluation of Solar Powered 7HP Water Pumping Unit in a Rural Area of Jhunjhunu District of Rajasthan

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ABSTRACT: The energy efficient product can be operated with longer duration. When compared to other conventional water pumping systems, they provide outstanding solutions because they require less maintenance, are easy to install, use no fuel, have a longer lifespan, are extremely reliable, and also don't damage the environment. For the rural area of Rajasthan's Jhunjhunu district, a solar water pumping system with a 7HP AC motor pumping set was evaluated for its economical feasibilities. The estimated cost of the solar PV water pumping system ₹ 3,48,000/-. Life cycle cost (LCC) of PV system was ₹ 9,04,800/- while that of diesel engine was found to be ₹ 2,200,708.80/-. Net present worth (NPW) of the PV system after 20 years was found to be ₹ 4,17,270.60/-, and internal rate of return (IRR) was found as 14 per cent. The benefit cost ratio was found to be 1.78 with a payback period of 3.8 years.

KEYWORDS: Solar energy, Solar water pumping, Sustainable energy, Economic feasibility, Cost estimation

I. INTRODUCTION

India has a booming economy, and the country's population has been steadily rising alongside the economy's exceptional development rate. Energy independence must be our nation's number one priority in light of the current circumstances. It can be challenging to get there. Our country's per capita energy consumption is only a third of the global average. India only uses about 6% of the world's primary energy despite having about 18% of the global population. Coal accounts for up to 46% of energy output, natural gas for 6%, nuclear energy for 1.09 percent, hydroelectric power for 4%, and renewable energy for 3.40 %. (India Energy Handbook 2019)

The market for solar irrigation pumps in our nation has enormous potential. 70 % of India's population is engaged in agriculture, and the country's small, subsistence farmers are completely reliant on erratic rainfall and groundwater. It is projected that the Indian government subsidises power for irrigation to the tune of Rs 30000 to 40000 corers per year. In India, there are an estimated 21 million irrigation pumps, with over 9 million using diesel and 12 million using electricity. Irrigation pump sets alone consume between 10% and 15% of India's total electricity consumption. In comparison to those utilised in other regions of the world, irrigation pumps in India are also regarded to be less effective. PV not only reduces this enormous power consumption but also provides a potential gasoline and kerosene replacement for the remaining 9 million pumps. (Subramanya *et al.*, 2009)

II. METHODOLOGY

To be successful and commercialised, a new technology must first be proven to be economically feasible. As a result, an effort was made to evaluate the economics of the developed solar water pumping system. The essential components of an economic analysis of any business are capital cost, variable cost, fixed cost, total cost, revenue, and net profit. In the economic analysis, various economic indicators were used.

The following metrics were used to conduct an economic study of the system.

1. Life cycle cost (LCC)
2. Net present worth (NPW)
3. Benefit cost ratio (BCR)
4. Internal rate of return (IRR)
5. Payback period (PBP)

1. Life cycle cost

This is a way for calculating the total cost of ownership of a facility. It considers all costs associated with purchasing, owning, and disposing of a system. The LCCA method is used to assess the total costs of project

alternatives and to choose the design that assures the facility has the lowest overall cost of ownership while maintaining its quality and functionality.

The life-cycle cost of both alternatives listed in the given project can be evaluated using the formula:

$$LCC = CC + MC + EC + RC - SC$$

Where,

CC-Capital cost

MC- Maintenance cost

EC-Energy cost

RC-Replacement cost

SC-Salvage value.

2. Net present worth

The net present value was the simplest straightforward discounted cash flow metric of project worth (NPW). By deducting the total discounted present worth of the expense streams from the benefit stream, the net present worth can be calculated. The incremental net benefit was calculated by subtracting the gross cost from the gross benefit or subtracting the investment cost from the net benefit.

The quantitative statement about net present value was as follows:

$$NPW = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

Where,

B_t = Benefit in each year

C_t = Cost in each year

$t = 1, 2, 3, 4, \dots, n$

i = Discount rate

3. Benefit cost ratio

This was the ratio determined by dividing the present value of the benefit stream by the present value of the expense stream. Accepting projects with a benefit cost ratio of one or above was the formal selection criterion for the benefit cost ratio as a measure of project worth.

The present value of the benefits divided by the present value of the cost was known as the benefit cost ratio. The benefit-to-cost ratio will be stated mathematically as,

$$\text{Benefit cost ratio} = \frac{\sum_{t=1}^{t=n} B_t}{\sum_{t=1}^{t=n} C_t}$$

Where,

C_t = Cost in each year

B_t = Benefit in each year

$t = 1, 2, 3, \dots, n$

i = Discount rate, %

4. Internal rate of return

The internal rate of return can be determined through a systematic process of trial and error to determine the discount rate that will result in a net present value of zero for the additional net benefit stream.

The discount rate I such that the internal rate of return was

$$\sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} = 0$$

5. Payback period

It's probably the simplest way to assess one or more investment opportunities. It calculates the amount of time it takes to recoup investment costs. It will be calculated by accumulating the project's net cash flow until the total net cash flow equals the initial investment. The strategy was known as "simple payback" when the time value of

money was ignored (assuming a zero-discount rate) (SPB). When the time worth of money was considered (assume a positive discount rate). "Discounted payback" was the name of the procedure (DPB). DPB was a more accurate payback measure than SPB.

III. EXPERIMENTAL RESULTS

In this paper economic feasibility of 7 hp solar water pumping unit carried out at Ranveerpura village, Jhunjhunu district of Rajasthan. This system consists of 28 arrays of 300 watt each and 7 hp AC submersible pump.

Life cycle cost analysis of system

A comparison of the diesel and PV water pumping units in terms of life cycle cost analysis is shown in the Table A

Table A System cost comparison by life cycle cost analysis

Sr. No.	Cost (₹)	PV system cost (₹)	Diesel Engine cost (₹)
1	Capital Cost (CC)	3,48,000	35712
2	Maintenance Cost (MC)	4,87,200	49,996.80
3	Fuel/Energy Cost (EC)	None	2,115,000
4	Replacement Cost (RC)	None	35712
	Total Cost, ₹	8,35,200	2,193,566.40
5	Salvage Cost (SC)	69,600	7142.4
	Life Cycle Cost (LCC)	9,04,800	2,200,708.80

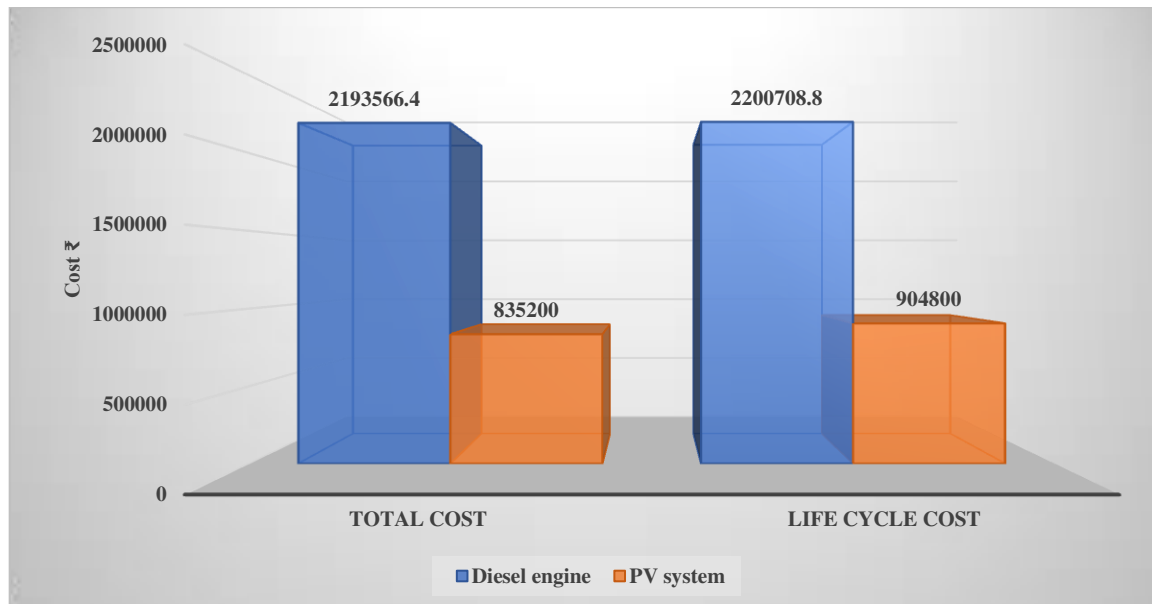


Fig. A Total cost and life cycle cost in 20 years

The techno economic indicators i.e., NPW, BC Ratio, Payback period and IRR of the solar water pumping system were calculated for economic feasibility of the operating system. Table B shows the results of above study.

Table B Economic indicators of the solar water pumping system

Sr. No.	Economic indicators	Value
1	Net Present Worth	₹ 4,17,270.60
2	Benefit cost Ratio	1.78
3	Pay-back Period	3.8 years
4	Internal Rate of Return	14 %

IV.CONCLUSIONS

- 1) Total cost of the PV system considering life span of 20 years was found to be ₹ 8,35,200/- and total cost of diesel engine was ₹ 2,193,566.40/-
- 2) Life cycle cost (LCC) of PV system was ₹ 9,04,800/- and life cycle cost of diesel engine was found to be ₹ 2,200,708.80/-
- 3) Net present worth (NPW) of the system after 20 years was found to be ₹ 4,17,270.60/-, and internal rate of return (IRR) was found as 14 per cent.
- 4) The benefit cost ratio was found to be 1.78 with a payback period of 3.8 years.

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