RESEARCH ARTICLE

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# Solar Renewable Energy System (SRES) for an Educational Institute

Haripriya H. Kulkarni[1*], Vidula S. Jape[2], Bhavesh R. Dhamone[3], Prathamesh S. Rajapure[4]

[1*] Marathwada Mitra Mandal's College of Engineering, Karvenagar, Pune, India; e-mail:haripriyakulkarni@mmcoe.edu.in

[2-4] PES's Modern College of Engineering, Pune, India.

## ABSTRACT

This paper highlights a Solar energy generation plant as Renewable energy source (SRES) on the criterion of cost involvement using net present value (NPV) method and its payback period. The reliability of the system and economic considerations of SRES are analyzed in depth for an educational institute. This is an installed off-grid system which comprises a wind energy source of 1.5 kW and solar energy source of 6 kW. The present work is focused on cost and performance analysis of solar energy systems only.

The SRES considered here is connected to the light load of the department containing all lights, fans, personal computers, printers and LCD display. The results obtained proves that SRES has the potential to fulfill the demand reliably throughout the year. The cost analysis using NPV method is included with the existing MAHADISCOM as one of the projects and SRES as another project. Both the projects are analyzed by assuming the lifespan of 11 years. The payback period of the SRES system is 3.3 years and hence after that the energy will be available free of cost through the mentioned system. This analysis is done for the site located in the state of Maharashtra, India, and can be used as very useful research for future perspectives.

**Keywords:** Renewable energy source (RES), Solar Renewable Energy System (SRES), Net Present Cost (NPC), Net Present Value (NPV) and Cost of energy (COE).

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## INTRODUCTION

Solar energy is one of the Renewable Energy Sources (RES) which is available in plenty all over the world. The solar plant described in this paper is a part of a hybrid wind – solar off grid project installed on the rooftop of an educational institute in Maharashtra. Solar radiations are available in plenty throughout the year in the state of Maharashtra. The government is also promoting use of solar energy as a major source to reduce the burden on conventional sources of energy.

The solar off grid plant installed can generate enough power which can be utilized to run the daily necessary light load. This in turn helps in reducing the use of grid power supplied by the State electricity Board.

**Corresponding Author :** Marathwada Mitra Mandal's College of Engineering, Karvenagar, Pune, India; e-mail:haripriyakulkarni@mmcoe.edu.in

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The promising way to deal with the difficulties of electrification using renewable sources is to fabricate the arrangement of the decentralized energy creation. This paper focuses on how the installed SRES fulfills the daily energy demand. Such projects provide the best economical and environmentally sustainable

solution. To accomplish the parts of studying such a project, there is a need to study the points given beneath:

1. Resource Evaluation
2. Selection of system Parameters
3. Assessment of Load profile
4. Assessment with special features
5. Assessment with financial aspect

This paper shows the specialized and economical appraisal of a SRES for Educational establishment. The load of roughly 6kwh can be utilized as a system to give power in the Campus. The SRES framework comprises Photovoltaic Solar, and a wind energy system providing a 100 % environmentally friendly power based framework. If the demanded power is more than that of the generated power then and then only the power is taken by the grid.

## HYBRID RENEWABLE ENERGY SYSTEM

The combined generation of renewable (Solar-wind energy sources) is an undeniably significant innovation to further develop energy proficiency and dependability. Figure 1A depicts the SRES system developed at the mentioned educational institute. Such systems developed provide sustainable power because of its negligible fuel cost, tidiness, accessibility, and simplicity of establishment. Amongst the different environmentally friendly power sources, solar photovoltaic (PV) and wind turbines (WT) are becoming exceptionally appealing because of the plentiful nearby accessibility in nature, innovative advancement, and financial advantages.

**Figure 1A:** SRES System developed at the Institute

The hybrid combination of both distributed energy resources eliminates mutual intermittences because of their destructive nature [4] consequently, the reliability of the system can be upgraded. The primary goal of this system is electricity generation by adapting non-conservative and smooth electricity with minimal contamination. Drawbacks of a renewable energy system are overcome by the SRES system The operating version of the Wind & Solar hybrid electricity has been proved as an efficient system. Figure 1B. depicts the basic operating diagram of a wind & Solar combined energy generation system.

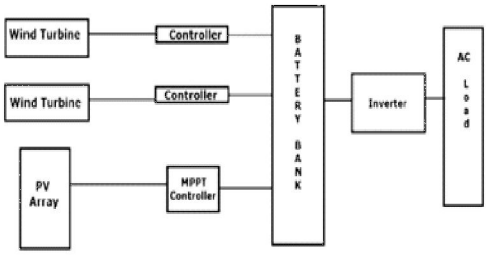


**Figure 1B:** SRES System developed at the Institute

Degree of profit is described as a benchmark of the desirability of a proposed system. An earnings measure is considered as the basis for selection of projects. There are several techniques that can be used to find if the investment made is a good one or a bad one.Every technique used can give the indication of profit or net gain for the assignment under interest.

Some of the techniques imply the scale of the income at a particular time, others present the charges of return in step with period whilst the capital is in use or when reinvestments of the early earnings also are covered. One can use the appropriate technique as per the requirement to find the returns of the investment. It takes just a few seconds to compute these profit measures using computer-based total evaluation. These techniques must be defined precisely.

## NET FUTURE VALUE AND NET PRESENT VALUE

Whenever any project is selected by an organization, it is required to calculate the net valuation of the project in future with a predefined lifespan of the project. Net present value can be found out by taking the difference between present value of cash inflows and present value of cash outflows for the estimated number of years of that project. The benefit is envisioned through the net future worth (NFV) which is the net return towards the finish of the arranging horizon above what may additionally have been received by means of contributing elsewhere. The net present well worth (NPV) of the assessed earning over

the arranging horizon is the constrained well worth of the NFV to the existing. A positive NPV for a venture demonstrates the contemporary well worth of the net increase relating to the challenge earning [5].

## EQUIVALENT UNIFORM ANNUAL NET VALUE

The stable Net Uniform Value (NUV) is a regular flow of advantages with much lower fees in addition to separated time intervals over the normal organizing horizon of a project. This value is also referred to as Net Present Value(NPV) multiplied by "capital recuperation factor." Net return of a task is to be said as an extent to the NPV, on an annual basis or repayment of assets. The Equivalent Uniform Annual Cost (EUAC) as it is gained by considering the same as the present value to a legitimate capital recovery factor. The use of EUAC enables that the specific benefits of all expected undertakings above the organizing horizon are unclear, and restricted costs of various ventures ought to be considered. Thus this is only the discounted price that needs to be considered.

## BENEFIT-COST RATIO

The " Benefit-Cost Ratio" (BCR), defined as the ratio of discounted benefits to the discounted costs at the same point in time, is a profitability index based on discounted benefits per unit of discounted costs of a project[9]. This is occasionally referred to as the "Savings-to-Investment Ratio" (SIR) , benefits are obtained from the reduction of unwanted results. Hence economical can be explained as a bad fee to cut from the denominator or as a high-quality advantage to be introduced to the numerator of the ratio, the BCR or SIR isn't a totally arithmetic degree[9]. Whatever, the proportion of prevailing price, the advantage of prevailing fee of profit surpasses one and the venture is worthwhile regardless of extraordinary explanations of such good prices.

## INTERNAL RATE OF RETURN

The markdown percentage which places the net present value of a progression of incomes above the arranging skyline which is equivalent to zero is named as Internal Rate of Return (IRR). IRR is the concept of net present value or NPV considered on discounted cash flow. It utilizes the idea of net present worth, however it converts computation itself as opposed to choosing a markdown percentage and using the suitable rebate variables of task incomes to deliver a net present worth. That rebate cost would be expected to create a NPV of zero in the task, rate that recreates the profit from speculation presented by the venture and empowers an examination with different undertakings going after a similar financing all contending activities or investments that has NPV of zero, however their contrasting IRRs address the markdown percentage which were needed to deliver the NPVs of zero consider the following cash flows of an investment. Notwithstanding, this might imply that activities might be chosen that don't return the most cash in outright terms.

One more thought of choosing projects is that IRR ought to surpass the expense of funding to the association. In our example, if the organization's cost of capital is 7% then it can repay more than the cost invested considering that this is purely in monetary aspect. The task couldn't be compelling. For example, there is likewise a specialized issue with the IRR that in case the income is non regular for instance or in case there is a negative income followed by a positive one then, at that point, there might be more than one IRR making it difficult to apply the procedure adequately.

## ADJUSTED INTERNAL RATE OF RETURN

Assuming the funding and investment strategies are consolidated toward assessment of a task, an "Altered Internal Rate of Return" (AIRR) who shines analogous schemes might be a valuable sign of productivity in limited conditions. As a result of the intricacy of funding and investment strategies utilized by an association over the existence of a venture, the AIRR can sometimes reflect the truth of real income. In any case, it offers a worth of the yield on a speculation for which at least two sign inversions in the incomes will produce in many values of IRR. The change inside pace regarding payback is typically determined as inward pace is about to come back to venture. Thus income is altered and it's every expense is limited as it exists and every advantage is accumulated as for the furthest limit of this arranging skyline.

## RETURN ON INVESTMENT (ROI)

At the point when power audits pay in 12 months of a multiple year mission, the movement of incomes should be separated into yearly expenses of return for those years. The Return Of Investment (ROI) as used by an accountant normally approaches the accountant's charge of return for every year of the assignment length dependent on the proportion of the profit (deals

considerably less devaluation) for consistently and the un-deteriorated resource cost for that equivalent year. Subsequently, the ROI is not old as a year, with a totally low cost inside the initial years and an exorbitant cost inside the later years of the test.

## METHODS OF ECONOMIC EVALUATION

The target of facility funding inside the personal area is usually acknowledged to be income boost in a particular period body. Similarly, the goal inside the public quarter is the maximization of internet social gain which is analogous to income maximization in personal organizations[6]. Given this goal, a technique of financial evaluation can be judged with the aid of the reliability and ease with which a accurate conclusion can be reached in task choice.The primary motive underlying the choice for accepting and selecting investment initiatives is that if an agency can lend or borrow as a whole lot cash as it desires at the MARR, or by selecting the challenge with the most nonnegative net present price among a fixed exceptional proposals[8]. The average current price standard displays this postulate and is maximum trustworthy and obvious while there may be no account imperatives. Different techniques of financial assessment, when well implemented, will create the equivalent outcome assuming that the net present worth model is utilized as the reason for the choice. For the ease of calculation, a straight forward table representation of element is given;

### Payback Period

The payback period (PBP) alludes back to the period of time inside which the advantages gained from a financing can take care of the expenses caused over the span of the time being referred to while disregarding the last time stretches inside the making arrangements skyline. Indeed, even the limited restitution length showing the "capital recuperation period" doesn't reflect the importance or way of the coins streams in a definitive span. Notwithstanding, assuming an undertaking is found to be beneficial via various measures, the restitution time frame might be utilized as an optional proportion of the financing necessities for a task.

### Net Present Value Method

Let BPVx be the present value of benefits of a project x and CPVx be the present value of costs of the project x, then, for MARR = i over a planning horizon of n years[9],

$$BPV_x = \sum_{t=0}^{n} B_{t,x}(1+i)^{-t} \sum_{t=0}^{n} = B_{t,x}(P|F, i,t).....(1)$$

$$CPV_x = \sum_{t=0}^{n} B_{t,x}(1+i)^{-t} \sum_{t=0}^{n} = C_{t,x}(P|F, i,t).....(2)$$

where the image (P|F, I, t) is a rebate factor equivalent to (1+i)- t and peruses as follows: "To track down the current worth P, given the future worth F=1, limited at a yearly markdown rate I over a time of t years." When the advantage or cost in year t is increased by this variable, the current worth is gotten. Then, at that point, the net present value of the undertaking x is determined according to the equation III or equation IV [8]:

$$NPV_x = BPV_x - CPV_x \quad .....(3)$$

Or

$$NPV_x = \sum_{t=0}^{n} (B_{t,x} - C_{t,x})(P|F,i,t) = \sum_{t=0}^{n} A_{t,x}(P|F,i,t) \quad .....(4)$$

Assuming there is no spending plan imperative, then, at that point, all free tasks having net present value more prominent than or equivalent to zero are satisfactory. That is, project x is satisfactory as long as

$$NPV \geq 0 \quad (5)$$

For totally unrelated recommendations (x = 1,2,...,m), a proposition j ought to be chosen in case it has the most extreme non-negative net present value among every single m proposition,

$$NPV_j = \max_{\pi \upsilon m} \{NPV_\pi\}$$

given that $NPV_j \geq 0$ (6)

## OBSERVATIONS AND ANALYSIS

The SRES project has been installed in Maharashtra state at an educational institute. The observations are recorded on a daily basis. Following table 1 show the energy generated by the installed SRES system. The readings are taken from 2/8/2021 to 11/10/21 on a regular basis. A few readings are shown in the table I below. The period considered here is when least output is available from Solar as August and September are monsoon months. The atmosphere was cloudy most of the time and solar radiation availability was very less. As seen from the table around 500 units were generated in 70 days. Annual average of 25-30 units per day can be expected from the installed 6kw SRES and additional 5-10 units from the battery bank. So an annual average of 30 units per day is generated and used to fulfill the load demand.

**Table-1:** Observations of SRES system

| Date | Cumulative Solar Units Generated |
|---|---|
| 2/8/21 | 34 |
| 9/8/21 | 76.3 |
| 17/9/21 | 119.3 |
| 25/8/21 | 165.5 |
| 31/8/21 | 196.5 |
| 7/9/21 | 236.8 |
| 14/9/21 | 270.8 |
| 23/9/21 | 317.1 |
| 30/9/21 | 377.6 |
| 11/10/21 | 509.8 |

Total Units generated in 365 days will be 365*30 = 10950.

Monthly bill for the institute is given as table-2.

- Total average rate per unit considering information in table II is Rs. 21.38/-
- Monthly charges for consideration of daily consumption of 30 units=30*24=720 units.
- Therefor charges incurred to fulfill this demand with a rate of Rs. 21.38 will be Rs. 15394/-
- Monthly saving due to SRES is Rs. 15394/-
- Yearly saving due to SRES is Rs 184728/-
- Simple pay back = Investment/ saving per year =610000/184728

  = 3.3 years.

**Table-2:** Electricity consumption and its billing

| Month | No. of units consumed | Bill amount in INR |
|---|---|---|
| September 2020 | 6494 | 139819/- |
| August 2020 | 7247 | 147528/- |
| July 2020 | 8514 | 163575/- |
| June 2020 | 7585 | 152628/- |
| May 2020 | 4195 | 113958 |
| April 2020 | 2878 | 99007 |
| March 2020 | 8923 | 163704 |

Table 3 depicts the observations of fulfilling the load with two different options. One is the SRES system and the other one is with the Maharashtra electricity board.

**Table-3:** Observations of project 1(SRES) and 2(MSEB)

| | Project 1 (Renewable Solar) | Project 2 (Electricity Board) |
|---|---|---|
| **Capital Cost** | **-3,80,000** | **-64,280** |
| **Years** | **Net annual amount at the end of the year in** | **Net annual amount at the end of the year in** |
| 1 | 52790 | 54990 |
| 2 | 52790 | 54990 |
| 3 | 52790 | 54990 |
| 4 | 52790 | 54990 |
| 5 | 52790 | 54990 |
| 6 | 52790 | 54990 |
| 7 | 52790 | 54990 |
| 8 | 52790 | 54990 |
| 9 | 52790 | 54990 |
| 10 | 52790 | 54990 |
| 11 | 52790 | 54990 |

Both the methods are analyzed with the NPV technique with the assumption of 11 years as active span at a discount/interest rate of 7%

R = 7%  Ri = 0.07  1+Ri = 1.07

NPV analysis valuation of project 1:

$$= -380000 + \frac{52790}{(1.07)^1} + \frac{52790}{(1.07)^2} + \frac{52790}{(1.07)^3}$$

$$+ \frac{52790}{(1.07)^4} + \frac{52790}{(1.07)^5} + \frac{52790}{(1.07)^6} + \frac{52790}{(1.07)^7}$$

$$+ \frac{52790}{(1.07)^8} + \frac{52790}{(1.07)^9} + \frac{52790}{(1.07)^{10}} + \frac{52790}{(1.07)^{11}}$$

= – 380000 + 49336 + 46145 + 43093 + 40293 + 37653 + 35193 + 32890 + 30727 + 28721 + 26836 + 25080 = 15977

NPV analysis valuation of project 2:

$$= -64280 \quad \frac{54990}{(1.07)^1}+\frac{54990}{(1.07)^2}+\frac{54990}{(1.07)^3}+\frac{54990}{(1.07)^4}$$

$$= \frac{54990}{(1.07)^5}+\frac{54990}{(1.07)^6}+\frac{54990}{(1.07)^7}+\frac{54990}{(1.07)^8}$$

$$= \frac{54990}{(1.07)^9}+\frac{54990}{(1.07)^{10}}+\frac{54990}{(1.07)^{11}}$$

= - 64280 - 51392 - 48030 - 44888 - 41951 - 39207 - 36642 - 34245 - 32004 - 29911 - 27954 - 26125 = - 476629

We compared values of project 1 and project 2 and as per the comparison between SRES and Electricity Board, we can observe a payback period of 11 years.

## CONCLUSION

This paper elaborates an example of an SRES for an educational institute. It represents the example of SRES in context of economic analysis in terms of net present value after a time span of 11 years and it's payback period to fulfil daily load demand of 30 units . It is analyzed emphasizing the payback period and NPV method considering the developed SRES system and State electricity board as two separate projects. Project 1 (SRES) has an NPV of Rs.15977/- and NPV of project 2(State Electricity board) is Rs.-476629/-. As SRES NPV is positive, it indicates that the investment in SRES is more beneficial over a period of 11 years compared with State electricity board project. The SRES is one of the suitable energy sources with NPV analysis. The payback period is 3.3 years. This case study is a very good example or as a framework for providing one of the economical electricity options to provide sustainable solution in an educational institute. The rooftop space can be smartly utilized for developing such power projects.

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