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Feasibility Study of a Solar Charging Station for Charging Auto-rickshaw in Bangladesh

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Abstract

This paper presented the feasibility study of a solar charging station for three wheeler auto-rickshaw with an aim to reflect the viability of the concept and highlight the benefit using solar energy for charging auto-rickshaw. The result showed that, total annual revenue estimated is 2.57 Million Taka and net present value for 20 years life time is found to be positive. The minimum acceptable rate of return is 5% and payback period is 10 years. Hence, the concept is found to attractive. This study will promote to adapt the concept in developing countries and contributes on global energy security challenge. Government can take suggestions from this study to reduce the energy consumption within the country.

Keywords: Feasibility study, Solar charging station, Auto-rickshaw, Bangladesh.

1. Introduction

Three wheeler auto-rickshaws are very common now in developing country like Bangladesh in short distance travel around the city. People usually feel comfortable with this vehicle due to low travel cost and convenient. Auto-rickshaw uses lead acid batteries as a power source and has no direct impact in the environment. The batteries are charged by grid electricity. The daily energy consumption by the auto-rickshaw is significant [1] making stress on limited distribution of electricity over the country. Hence, solar charging system for charging auto-rickshaw can play an important role to mitigate the use of fossil based electricity.

There are limited numbers of research paper based on three wheeler auto-rickshaw found in online [4-8]. It is found that, performance simulation integrated with PV [2-3, 5], socio economic aspect and conceptual framework [5, 6] is highlighted in the available literatures. Technical, environmental, financial hypothetical constraining issues are also well reported in this literature.

Integration of auto-rickshaw is increasing in small distance travel of developing countries and the battery charging issues using solar energy concept is appear immature and not established yet. Hence, appropriate design the solar charging station, financial analysis, economic analysis and revenue analysis is important. This can be done to reflect weather the concept will be viable or not to be implemented in practice considering entire life time of solar system. Such study is unusual in the available literatures.

Addressing the above issues, design and feasibility analysis the solar charging station for auto-rickshaw has been undertaken in a developing country Bangladesh with an aim to reflect the viability of the concept. The monthly average daily solar radiation at Rajshahi is 4.22-5.71 kWh/m^2 over the year and this is the good number to exploit the solar energy for auto-rickshaw charging station.

2. Methodology

This section describes the detail of methodology to conduct the study. The methodology includes the system description, assessment procedure and assumption.

2.1 System description

Survey of existing auto-rickshaw charging station shows that, average number of auto-rickshaw receive by the station is 30 at a time. Average time required to full charge at new condition is 8 hours where at old condition is 10 hours. Payment received by the station manager per full charge per auto-rickshaw is BDT 160. Monthly average electricity bill paid by the station is BDT 85,000-90,000.

Based on the above preliminary survey, proposed solar charging station is considered for charging 30 auto-rickshaws at a time. There are several components in a solar charging system namely, solar PV, inverter, battery and charge controller. The schematic of the proposed model station is shown in Figure 1.

Figure 1: Schematic of proposed solar charging station for auto-rickshaw

The daily electricity consumption by the auto-rickshaw at new condition measured is 8 kWh. The daily electricity required for 30 auto-rickshaws is 240 kWh. The amount of energy need to deliver by the solar PV is 290 kWh/day including system loss. The number of panel of 250 Wp required is 260 and area required to install the panel is 5476 ft^2. This area is over estimated for the placement of 30 auto-rickshaws at a time. So, the extra area is considered for shopping mall as a source of income.

2.2 Assessment procedure

Economic feasibility analysis was considered to assess the viability of the proposed system as it is has an important role for the assessment of a project viability or not [7]. Net present value (NPV), minimum acceptable rate of return (MARR), financial internal rate of return (FIRR) and payback period (PBP) are used in this study. NPV is the difference between sum of cash outflows including initial cost and sum of cash inflows over the entire life of the system. The NPV is calculated by the following equation:

$$NPV = \sum (B - C)/(1 + r)^n \quad (1)$$

Where, B is the benefit, C is the cost, r is the interest rate and n is the system life time. When value of NPV is greater than zero than the system will be accepted otherwise the system has to be rejected [7]. Higher the value of NPV means higher the profitable of the system in practice.

MARR is the minimum rate of return or target rate at which the project manager considers acceptable the project before initiating a project [8]. Lower the MARR value means higher the risk of the project. MARR is determined by the trial technique in cash flow model on excel sheet at which the NPV become positive.

Financial internal rate of return (FIRR) is the indicator to measure the financial return on investment is used to make the investment decision. This is estimate by equating the present value of investment cost (cash out flows) and the present value of net income (cash inflows) and find out the interest rate [9]. The decision rules are as follows:

If FIRR> MARR; Accept the project
If FIRR=MARR; then remain indifferent
If FIRR<MARR; then reject the project

PBP is the time required to receive total investment through profit gain. Cash inflow in this study is uneven. So, cumulative net cash flow for each period is calculated and then PBP is estimated using the following equation [10]:

$$PBP = A + \frac{B}{C} \quad (2)$$

Where, A is the last period with a negative cumulative cash flow; B is the absolute value of cumulative cash flow at the end of the period A; and C is the total cash flow during the period after A.

2.3 Assumptions

The following key assumptions are considered to conduct the study:

- Total of 30 auto-rickshaw will stand for charging at a time in the station
- Cost of land 15 Lakh/Katha
- The material for base frame is aluminum
- Two person will take care the station and their monthly salary Tk. 4000/each
- Time interval for battery replacement is 8-9 years
- Number of days of autonomy 2
- Working capital is one lakh
- Depreciation method is straight line
- Life time of the solar system is 20 years

Bank loan cover 50% of the investment with 5% interest

3. Results and discussion

The detail results of this study are presented and discuss in this section.

3.1 Cost estimation

Cost estimation is an important step for feasibility study of a model to be implemented. There are significant numbers of cost option need to consider before analysis. In this study, cost is divided into two categories namely, investment cost, operation and maintenance cost. Investment cost includes land purchase, land development, PV panel, storage battery, base frame for panel installation, inverter, charge controller, connecting wire, accessories and construction of office room. Since, the shaded area will not fully utilized by 30 auto-rickshaws, the extra space is considered for shops. The estimated total investment cost is 24.11 Million Taka. Operation and maintenance cost includes replacement of battery, inverter, charge controller, electrical accessories and manpower cost. The estimated total operation and maintenance cost is 0.68 Million Taka.

3.2 Revenue estimation

The sources of revenue are from shopping mall and selling the electricity. Annual revenue from shopping mall estimated is 0.3 Million Taka and annual generation of electricity is 113.51 MWh. The total annual revenue estimated is 2.57 Million Taka with electricity selling price is Tk. 20/kWh. Hence, annual gross profit estimated is 1.88 Million Taka.

3.3 Feasibility analysis

Based on the above estimated costs and revenue, annual net cash flow for 20 years life time for the system is presented in Figure 2. It is seen that, initial investment for the system is USD 150,000 shown on negative y axis. It is the investment at the beginning of first year. This is also called negative cash flow or cash out flow. Net cash flow found at the end of 1st year is positive and its value is USD 11207. This is also called positive cash flow or cash inflow.

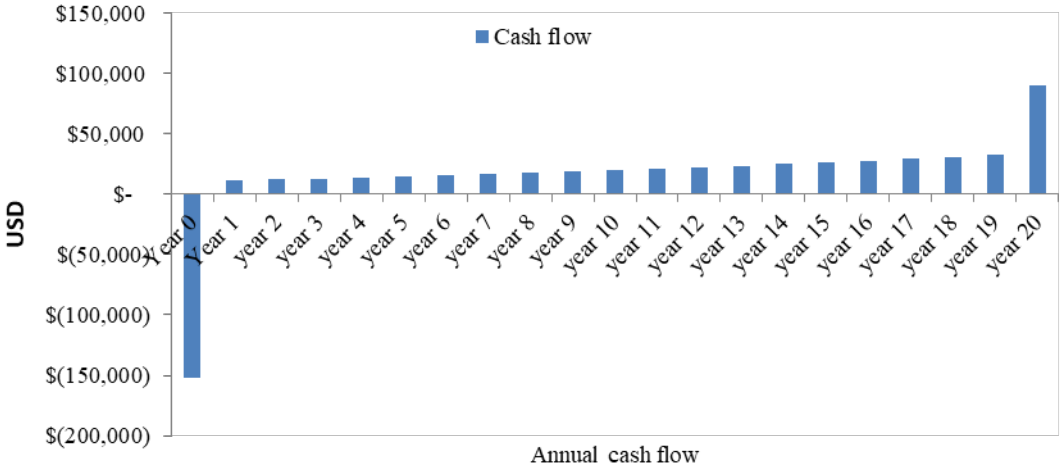

Figure 2: Annual cash flow for 20 years life span of the system

The magnitude of cash inflow increases slowly until the year before the last year. The magnitude of cash inflow at the last year shows significantly higher than the other years because of addition of salvage value at the end of life. Hence, the net present value (NPV) for 20 years life time is found to positive and the value is BDT 3, 03,200 which is attractive. The minimum acceptable rate of return estimated is 5%. The FIRR estimated is 10.53% and the inflation adjusted MARR estimated is 10.25%. Since, estimated FIRR is greater than MARR so the project is feasible and can accept. The payback period estimated is 10 years.

4. Conclusions

The economic feasibility study of a solar charging station for charging auto-rickshaw in Bangladesh has been conducted in this work. The result shows that, the total annual estimated revenue is 2.57 Million Taka and gross profit is 1.88 Million Taka. Based on the estimated cost net present value (NPV) found to positive for 20 years life time. The minimum acceptable rate of return (MARR) estimated is 5% and payback period for the system is 10 years. The internal rate of return estimated is 10.53%. The output of investment decision rules highlighted that the concept is quite attractive and can accept. It implies that huge amount of energy as well as electricity could be possible to save upon implementing this concept.

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