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Financial Analysis of 18kW Solar Photovoltaic Baidi Microgrid at Baidi, Tanahun, Nepal

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Abstract: This study presents financial evaluation of 18 kW solar photovoltaic powered Baidi Micro Grid implemented by Alternative Energy Promotion Center (AEPC) in Dubung village, Rising Gaupalika, Tanahun district of Nepal. The grid is built and is operational under Baidi Micro Grid Pvt. Ltd, a Special Purpose Vehicle (SPV) established under "Pro-Poor Public Private Partnership (5P)" concept supported by United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) & International Fund for Agricultural Development (IFAD). It is pilot project under 5P concept in Nepal. People from Dubung and Mauribas village as well as Saral Urja Nepal Pvt Ltd (SUN) jointly owns the SPV strengthening not only technical, managerial and financial support but also the community participation and engagement in all decision making process. The total cost of the project is NPR 13,395,000.00 at 2015 AD. The grant for the project was of value NPR 11,295,000.00 from AEPC, IFAD and UNESCAP and remaining was equity of SUN. The net present value of NPR -10,978,605.76 is obtained at 3% discount rate due to unavoidable replacement cost of batteries, charge controllers, inverters and high initial investment without the consideration of the grant amount. Whereas, with 84.32% utilization of available grant, the NPV worth of NPR 384,394.22 is obtained for the project. In breakeven analysis, a breakeven point of the project is obtained at 81.87% utilization of the grant. Without grant, project like Baidi Micro Grid will not sustain. In addition, average unit cost of electricity is found to be NPR 37.08 but it varied from NPR 16.67 to NPR 80.81. Household consuming more electricity has to pay less unit cost of electricity whereas household consuming less electricity had to pay higher unit cost of electricity.

Keywords: Net Present Value, Grant, Pro-Poor Public Private Partnership, Unit Cost of Electricity

1. Introduction

Alternative Energy Promotion Centre (AEPC) with United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) started Pro Poor Public Private Partnership concept (5P) business model in Nepal since 2015 through Baidi Microgrid at Tanahun Nepal. Baidi Micro-Grid (BMG) is a solar photovoltaic 18kW pilot project under Pro-Poor Public-Private

Partnership (5P) Concept. It is located 83 km far from the Byas municipality with latitude 27°51’54” N, longitude 83°15’3.6” E in Dubung village, Rising Gaupalika (former Baidi VDC) of Tanahu District, Nepal [14]. It is a flagship business model promoted from Cinta Mekar, Indonesia [3]. It is seen that people in rural areas do not acquire required technical knowledge to sustain the established energy projects. The involvements of private energy company with certain equity on investment makes operational scheduled and maintenance tasks when necessary. This necessity is seen in existing Nepalese rural energy project therefore in 5P concept private companies are also involved as partner so that they would be always available in any kind of situation. The 5P aims the participation of private sector by bringing their expertise throughout the project cycle. Such energy project uplifts and support rural livelihood of rural communities not only by lightening them but also by raising entrepreneurial capabilities. Baidi Micro-grid and Raksirang Solar water pumping are the two examples of 5P Concept projects that are implemented in Nepal [14]. It is special purpose vehicle (SPV) with ownership of community and Saral Urja Nepal (SUN) a private energy company with equity injection in terms of land, money or labor. The responsibilities of SPV is to control tariff, manage instrument, and perform maintenance when necessary [8]. Houses in Dubung and Mauribas are still far from national grid. However, few works in transmission line and transformer have been completed. In order to lighten houses of Dubung village, Kadoori Agricultural Aid Association had donated stand-alone type of PV home system [4]. Due to lack of proper maintenance and operation, a lot of equipment’s have already been damaged and remaining has very poor performance.

Electricity in BMG is closely monitored by smart meters. Smart meter is a digital meter that sends readings to the energy supplier for billings. Every user of BMG has a smart meter that alarms when their energy is about to exceed the rated limit for that day. If the user still uses and exceeds the energy limit then the power is disconnected for the day. In addition, the smart meter limits peak loading of an individual user. The smart meter provides operators to configure the system and devices, monitor performance, and access data logs through the web-based user interface. The objective of this study to perform financial analysis of social projects like BMG so that the results could be reference to other similar projects in the nation.

2. Methodology of the Study

This study is based on primary and secondary data collection. Financial variables have been identified and are followed by data collection. Primary data have been collected from the power plant by survey. The research methodology followed is displayed in Fig. 2.1.

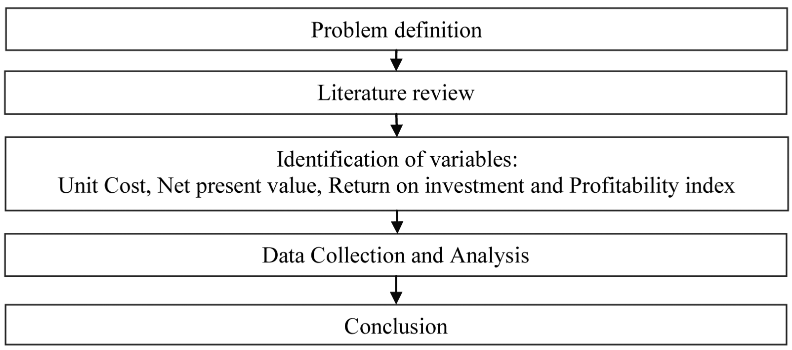

Fig. 2.1: Methodology

The collected data have been analyzed and per unit cost of electricity is obtained using equation (1).

$$Unit\ Cost = \frac{Revenue\ collection\ per\ month}{Electricity\ Consumption\ per\ month} \tag{1}$$

Scenario analysis is carried out in two different scenarios. First scenario is analysed without considering the grant offered by the donors and net present value is obtained [5]. Similarly, in the second scenario, grant amount is considered and net present value is computed using equation (2).

$$NPV(i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^N} \tag{2}$$

where, R_t= *net cash flow, i=discount rate, t=time, N=number of terms in year*

Return on investment (ROI) is defined as a ratio of the net profit and investment cost resulting from an investment of some resources. It is used to evaluate the efficiency of any investment [2]. It is computed using equation (3).

$$ROI = \frac{\text{gain from investment} - \text{cost of investment}}{\text{cost of investment}} \tag{3}$$

Profitability index (PI) attempts to identify the relationship between the cost and benefits of a proposed project [9]. Benefit cost ratios are most often used in corporate finance to detail the relationship between possible benefits and costs, both quantitative and qualitative, of undertaking new projects or replacing old ones. Equation (4) is used to calculate PI of the Microgrid [12].

$$\text{PI} = \frac{\text{PV of Net Positive Cash Flow}}{\text{Cash Flow}} \tag{4}$$

3. Results and Discussions

A five-member committee was formed to register Baidi Micro-Grid. Three members were from Saral Urja Nepal (SUN) a private company that has 60% equity in return and takes backing on technical and managerial support. Two of the board members were from the community themselves [11].

3.1 Investment Details and Share

The total cost of the project is NPR 13,395,000.00. The power plant was made with a partnership of NPR 11,295,000/- from AEPC / IFAD / UNESCAP and of NPR 2,100,000.00 from Saral Urja Nepal Pvt Ltd (SUN). Physical support and assistantship were provided by the people from the community. Although the share of private company (SUN) is only 15.68% the profit share for it is 60% due to operation and maintenance responsibility [10]. Rest of the profit goes to Baidi Micro Grid.

3.2 Expenditure in Investment

From a total expense of NPR 13,098,938.33, 11.68% was invested in solar PV modules, 16.03% on inverter and charge controller. 14.29% of total investment was in batteries, 6.87% in safety and BoS, 0.46% in lightening protection, racking cost 1.15% of total budget, 7.63% in civil works, transmission cost a maximum of 20.61%, house wiring and meter cost was 11.07%, installation took 2.29%, insurance cost was 0.76% and others 5.63%.

3.3 Tariff and Package Details

Daily peak power, maximum energy consumable, alarming are set in smart meter and it regulates all the parameter. Tariff rate has been incorporated based on the willingness of the community to pay. Economic status, investment of private company and subsidy from the government were taken into consideration while assigning the tariff. For example if a house had purchased package A then under this package the user can use the specified electrical appliance whose rated peak power is not more than 45W. If the power exceeds the limit, the supply for that house for that day would be interrupted. Similarly, per day energy consumption is limited to 165Wh. User exceeding this limit would have to suffer power cutoff. In order to alert user, smart meter alarms 20 units before completion of energy limit for that day. All these operations are monitored by smart meter. This unique feature of smart meter has made very easy to monitor power in the community. Similar monitoring is applicable for television package (B), commercial package (C) and special package. Consumers under package "A" can use seven LED lamps of 3 to 5 W, and two to three mobile chargers under lightening package. Consumer under package "B" can use all lightening package with a television or similar equipment. Consumer under package "C" can use all package of television package with other commercial appliances like refrigerator or cybershop or electric shop. Monthly tariff and their package details have been tabulated in table 3.1.

Table 3.1: Tariff and package details

Package Type	**Power (W/day)**	**Energy (kWh/day)**	**Alarm (Wh)**	**Tariff (NPR/Month)**
Light Package A	45	0.165	20	400
Television Package B	100	0.495	40	700
Commercial Package C	2,000	2.000	100	1,000
Below Poverty Line (Special)	45	0.165	20	250

3.4 Demand per Unit Cost

From the tariff rate, demand and unit cost is calculated. For a user purchasing only 4.95 kWh of energy in a month has to pay NPR 80.81/kWh whereas user-consuming 60kWh of energy in a month has to pay only NPR 16.67/kWh. The average cost of electricity from demand analysis is NPR 48.20 per kWh. Increase in demand would lower the cost of electricity as displayed in Fig. 3.1.

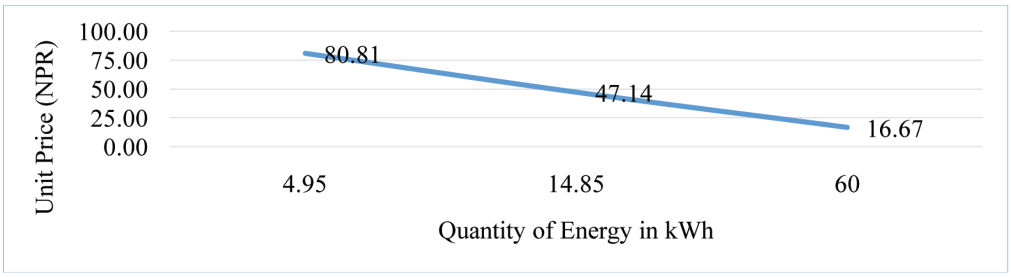

Fig. 3.1: Demand per unit cost

3.5 Revenue Collection and Unit Cost

The monthly revenue collection for given time period has been plotted in Fig. 3.2. NPR 50,350 is collected monthly from the 115 households. Revenue collection for the month of December/January, January/February, July/August and August/September were discounted to 50% due to load shedding in peak hours. Unit cost of electricity is obtained from the value of NPR 21.01 to NPR 47.10. The average cost of electricity is NPR 37.08 per kWh as shown in Fig. 3.4 which is relatively high compared to the tariff of NEA [7]. This is due to the overall cost of plant that includes solar PV panels, battery bank, inverters, charge controller, transmission line, and powerhouse.

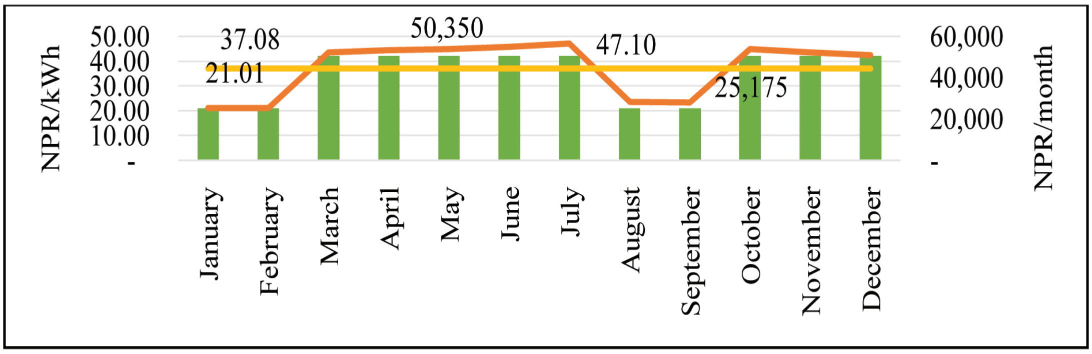

Fig. 3.2: Electricity per unit cost and revenue collection

3.6 Operation of Baidi micro Grid and key Assumptions

Project Life of BMG is assumed 25 years [6]. The life of battery is assumed to be of seven years with company warranty of five years and two-year assurance from battery supplier [1]. Likewise, the life of the inverter and charge controller life is 12 years guaranteed by the company. The life of rack, wiring, and transmission system is assumed 25 years. The discount rate and inflation rate are 3% and 5% respectively [13]. Net yearly income after deduction of cost is NPR 371,500/-. During 25 years of operation, battery has to be changed in every 7 years. Therefore, in the year 7, 14 and 21 batteries need replacement that would cost NPR 2,634,091.99, NPR 3,706,431.95 and NPR 5,215,321.97 respectively after 5% adjustment of inflation. The average life of the inverter is 12 years so a complete replacement of inverter in year 12 would cost NPR 3,771,298.28 after the adjustment of inflation. The operation cost of Baidi micro grid has almost NPR 11,000 as fixed monthly cost (can vary with periodic maintenance).

3.7 Scenario I- Net Present value Analysis without Grant

Monthly revenue collection is annualized reducing the monthly operational and maintenance cost in the power plant. Yearly revenue collection would be increased by 5% due to inflation. Salvage cost from replaced batteries, inverters would be the source of revenue. The obtained NPV is NPR -10,978,605.76 without grant from the donors at a discount rate of 3% that shows a negative feasibility that is demonstrated in Fig. 3.3. It is not avoidable due to high investment and high replacement cost of battery and inverters.

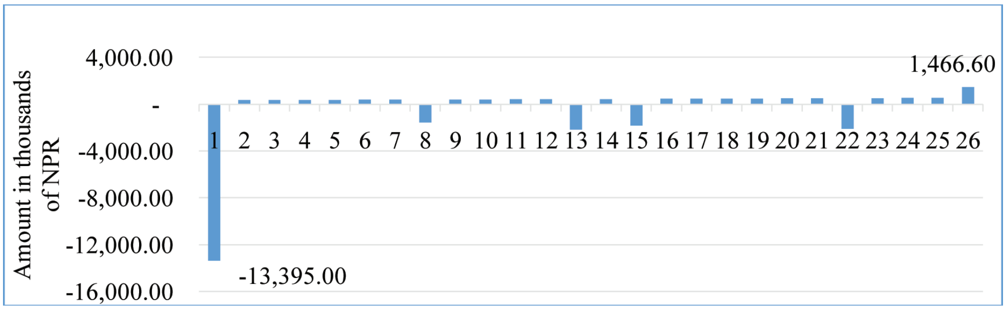

Fig. 3.3: Cash flow diagram of BMG for 25 years without grant

3.8 Scenario II- Net Present value Analysis with Grant

The obtained NPV is NPR 384,394.22 with grant from the donors that shows a positive feasibility of the project that is demonstrated in Fig. 3.4.

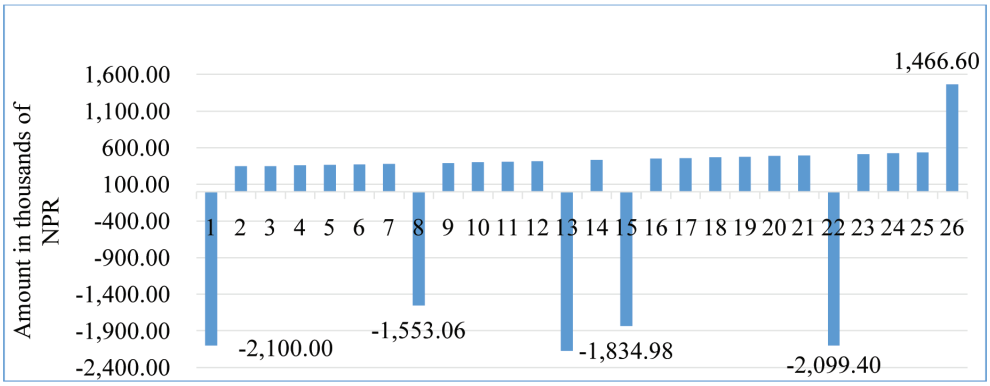

Fig. 3.4: Cash flow diagram of BMG for 25 years with grant

3.9 Breakeven Analysis

The project received 84.32% of grant that makes NPV of NPR 384,394.22 at a discount rate of 3%. With grant of 81.87%, the NPV would have been zero that is demonstrated in Fig. 3.5.

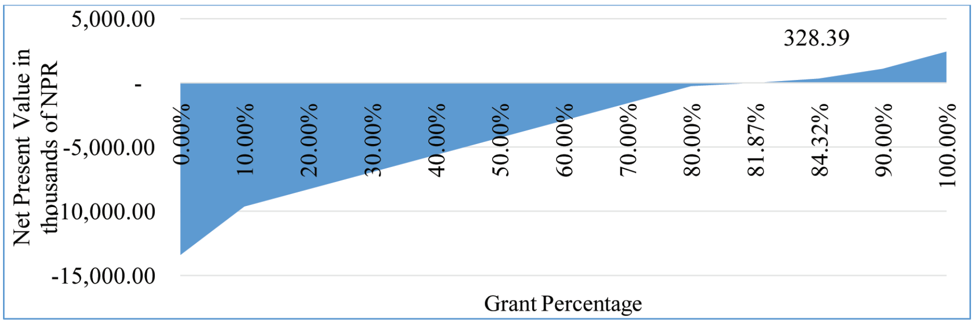

Fig. 3.5: NPV with different percentage of grant amount

3.10 Return on Investment

Based on initial investment, monthly revenue collection details, tariff rates, operational and maintenance charges return on investment (ROI) is computed and is presented in table 3.2. The computed ROI is 10.61% on SUN's investment, 12.36% on net cash outlay, 20.59% on initial cash outlay on net income and 3.84% on initial investment.

Table 3.2: Return on investment

S.No.	Particulars	Amount (NPR)
1	Total Initial Project Cost	13,098,938.33
	Less: Grant by AEPC/IFAD/UNESCAP	11,295,000.00
	Net Cash Outlay	1,803,938.33
2	Income generated From Power House	503,500.00
	Less: Wages to worker and Operational Expenses	148,600.00
	Net Income	371,500.00
	Income Proportion to SUN (60%)	222,900.00
	Income Proportion to BMG (40%)	148,600.00
3	Total Investment by SUN	2,100,000.00
4	Return on Investment on SUN's actual investment	10.61%
5	Return on Investment of SUN on Net Cash Outlay	12.36%
6	ROI on Initial Cash Outlay on Net Income	20.59%
7	Return on Investment on Initial Investment	3.84%

3.11 Profitability Index

Cash inflow of Baidi micro grid is 503,500.00 per year while the net present value on revenue would be of Rs 7,726,554.06 during the project life. From this cash flow analysis, Profitability Index (PI) would be negative and is not applicable for this type community based project but the PI on the revenue would be 0.58. However, on the SUN investment the profitability index would 15.638, which is seen in table 3.3.

Table 3.3: Profitability index

S.No.	Particulars	Amount (NPR)
1	Total Initial Project Cost	13,395,000.00
	Less: Grant by GON	11,295,000.00
	Net Cash Outlay	2,100,000.00
2	Net Cash Inflows	371,500.00
	Total Present value of 25 years with grant	328,394.22
	Total Investment	13,395,000.00
	Investment by SUN	2,100,000.00
3	PI on SUN Investment	15.638

4. Conclusion

Annual energy generation from the Baidi Micro grid is 13,601.41 kWh. The net present value of NPR -10,978,605.76 is obtained at a discount rate of 3% due to unavoidable replacement cost of batteries, charge controllers, inverters and high initial investment without the consideration of the grant amount. The grant for the project is of value NPR 11,295,000.00 from AEPC, IFAD and UNESCAP. Whereas, with 84.32% utilization of grant, NPV worth of only NPR 384,394.22 is obtained for the project. In breakeven analysis, a breakeven point of the project is obtained at 81.87% utilization of the grant. Without grant project like this will not sustain. In addition, average unit cost of electricity is found to be Rs 37.08 but it varied from Rs 16.67 to Rs 80.81. Household consuming more electricity are paying less unit cost of electricity whereas household consuming less electricity are paying higher unit cost of electricity. The return on investment is found to be 10.61% on SUN's investment, 12.36% on net cash outlay, 20.59% on initial cash outlay on net income and 3.84% on initial investment.

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