Table 13.2-3 Comparison of Electrification Methods for Village Households

	SHS only	SHS/BCS
Electrification rate	× - Not affordable for low income households to have a limited effect to achieve the objective of rural electrification - Requiring a larger installed capacity (Wp) to achieve the same electrification rate.	○ - Capable of providing electricity at an affordable cost to allow increased accessibility among low income households, resulting in a higher electrification rate. - Requiring a smaller installed capacity (Wp) to achieve the same electrification rate.
Investment cost	○ The investment cost per installed capacity is lower than the SHS/BCS system.	× The investment cost for the BCS system per household is five times that for the SHS, because of the high auxiliary equipment cost and the need for provision of an additional set of battery box at user's premise for the recharging purpose.
System operation	○ System operation is easier than the SHS/BCS system.	× Additional work burdens, such as recharging and transportation of batteries × Difficult to manage batteries by users
Profitability	○ More profitable than the SHS/BCS system	× Poorer profitability due to the high investment and operating costs for the BCS
Government subsidy	○ Less subsidy is required than the SHS/BCS system to attain the same level of IRROI.	× More subsidy is required than the SHS only.

13.3 Economic Analysis

Financial analysis examines and estimates how much profit the Implementation Body will be able to make from the implementation of the project. On the other hand, economic analyze concerns with benefits and costs incurred by the project to the national economy or the society as a whole. For the purpose of the present study, economic analysis is carried out to estimate costs and benefits on the basis of the above assumptions and to determine an economic internal rate of return (EIRR) as a principal indicator to allow evaluation.

(1) Assumptions

① Investment cost

Tax

Taxes are treated as transfer payment and do not constitute expenditures in the national economy, thus they should be excluded from the investment cost. Assuming that the equipment purchase cost, e.g., the PV system,

battery and controller, as calculated in the financial analysis, is divided into the materials cost 80% and the labor cost 20%, the former is imported and subject to the 15% tariff and the conversion factor (CF) from the financial price to the economic price can be calculated using the following formula:

$$C.F. = 0.8 \div 1.15 + 0.2 = 0.9$$

Subsidy and long-term loan

Financial analysis in 13.2 calculated the IRR on the total investment less the subsidy. As the subsidy to be granted to the project is considered as the country's expenditures, economic analysis calculates the EIRR under the assumption that the total investment cost including the subsidy is entirely funded from its own source.

② Operating cost

Local operation cost

As the commission on collection of the service charge and the deposit, the wage of system monitoring agents, sales commission, and other local operation costs are not incurred if the project is not implemented, the conversion factor is assumed to be zero for the purpose of economic analysis.

Implementation body

Salaries and wages of staffs of the Implementation Body (head office and local office) are assumed to be shadow wages used in the "without project" case. Then, the following conversion factors are applied (assuming that engineers and skilled workers are in short supply, while the unemployment rate is high among unskilled workers).

* Head office
  - Director/manager 1.0
  - Officer 1.0
  - Assistant 1.0
  - General worker 0
* Local office
  - Maintenance engineer 1.0
  - Officer 1.0
  - Assistant/general worker 0

Other operating costs

* General administration 1.0
* Office rent..... 0
* Insurance premium/tax 0
* Interest 0

③ Benefits

Revenue

Project revenues, such as the monthly service charge and deposit (user charge in amount used for the field survey, which consumers have willingness to pay), are treated as benefits under the economic analysis. The conversion factor for financial revenues is assumed to be 1.0.

External benefits

i) At present, un-electrified households in rural villages use paraffin oil, candles and batteries (dry and automotive) for lighting and radio-cassette recorder. The project is expected to substitute for these imported products. Based on the results of the survey entitled "Urban and rural energy in Botswana: needs and requirement" (July 2001: EAD), households with below-average income in villages are assumed to spend 19P/m for paraffin, 12P/m for candles, and 12P/m for batteries. Assuming that these expenses are replaced with the 50Wp SHS, the benefit is assumed to be 5.09P/kWh.

ii) CO_2 reduction

As paraffin oil and candles, used for lighting, are replaced with the PV system, reduction of CO_2 gas is expected, at a rate of around 380kg/kWh. Assuming that CO_2 reduction is worth US$20/ton-$CO_2$, the external benefit amounts to 0.46P/kWh.

Thus, the product is expected to generate above external benefits, which total 5.55P/kWh and is counted as the saving in foreign currency under the economic analysis.

Other indirect economic benefits

Although not reflected in the economic analysis due to the difficulty in quantification or valuation, the following indirect economic benefits are expected to be generated from the project.

- Economic vitalization and enhancement of well-being of rural villages through creation of employment opportunities.
  As shown in Table 13.1-2 of Chapter 13, 630 persons can get job as the workers for operation units in the village. Also it is expected that many peoples will be engaged in the PV-system installation work Additionally, jobs to sell and maintain electrical appliances will be created in those villages.
  Clearly, the PV rural electrification project, if implemented in full scale, will generate enormous benefits for rural villages, not only economic vitalization but social and cultural enhancement.

(2) Case study

Economic analysis is conducted for the following cases, which assumptions are summarized in Table 13.2-1.

1) Base case

The Base Case for the economic analysis is assumed to consist of the same conditions as those used for the financial analysis in 13.2.2.

2) Other cases

The analysis of other cases is conducted using the same conditions as those used for the financial analysis in 13.2.2.

3) Results and evaluation

The results of the economic analysis using the above cases are summarized in Figures 13.3-1~4. For the Base Case, the EIRR exceeded 15%. In addition, the project is expected to generate significant indirect economic benefits, particularly job creation in rural villages. Thus, the economic analysis justifies implementation of the project.

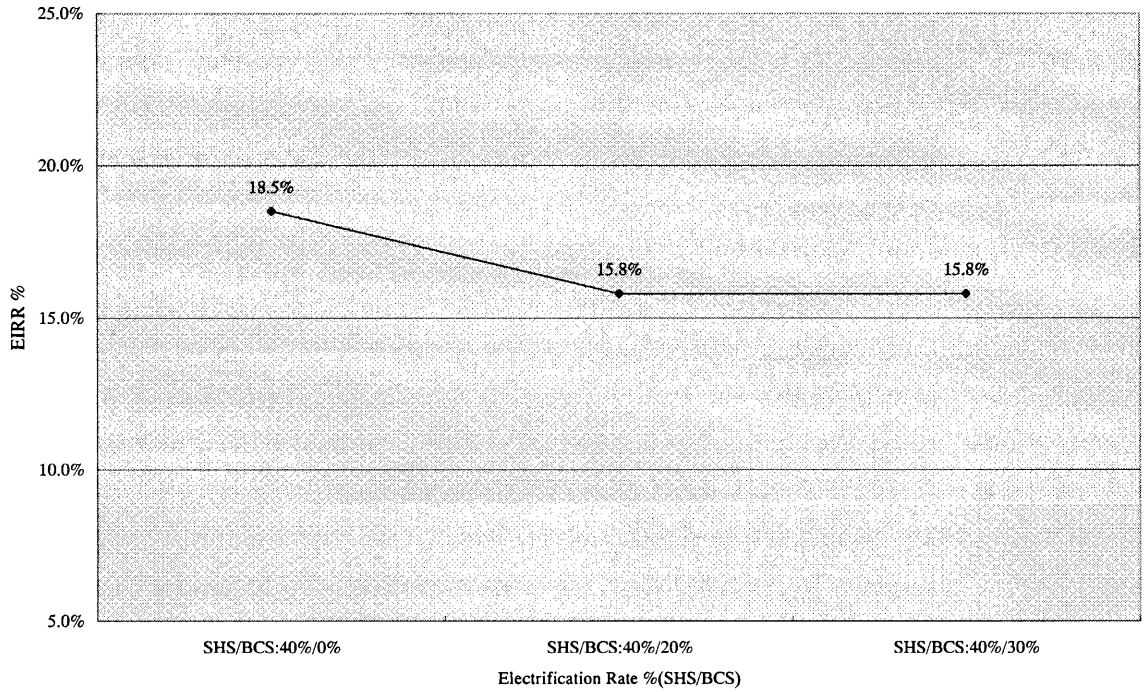

Figure 13.3-1 EIRR per SHS/BCS Electrification Rate

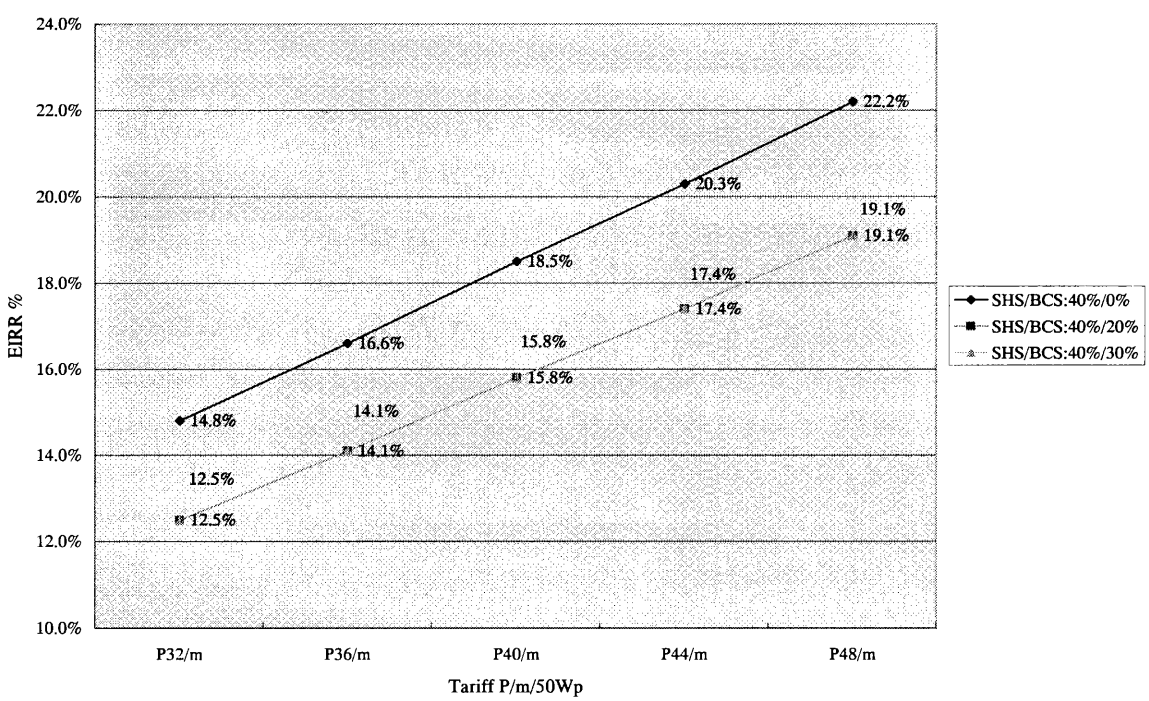

Figure 13.3-2 EIRR per Tariff Variation

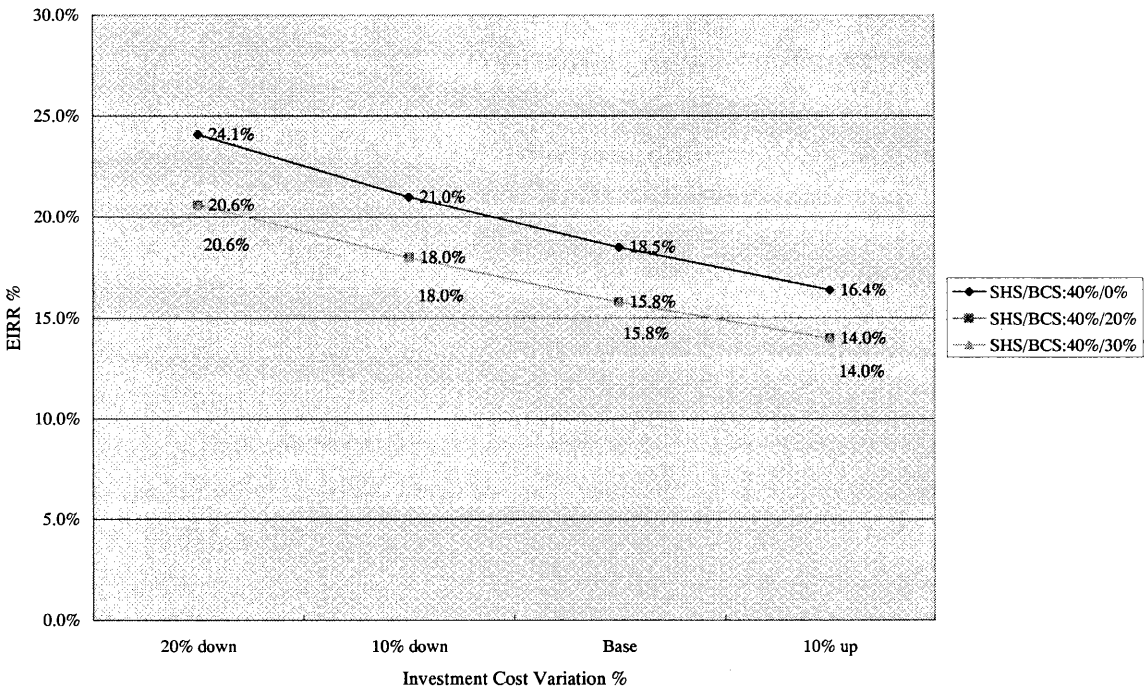

Figure 13.3-3 EIRR per Investment Cost Variation

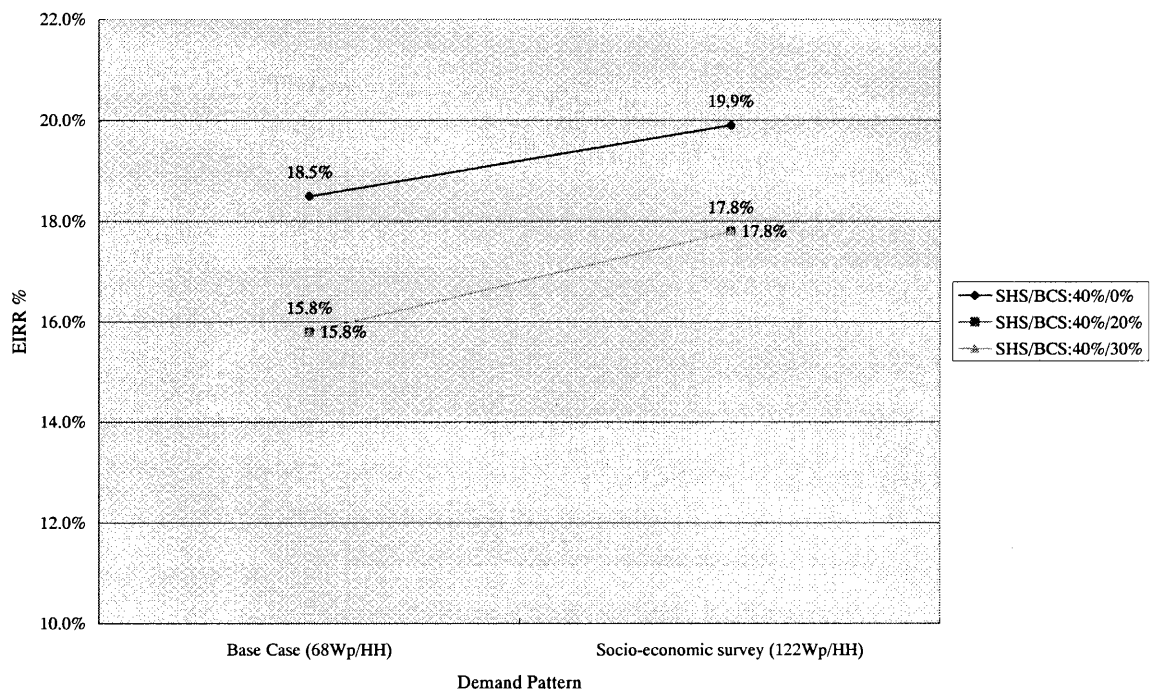

Figure 13.3-4 EIRR Per Demand Pattern

13.4 Recommendations

Based on the results of evaluation and analysis, the following recommendations are made for the formulation and implementation of the PV rural electrification project plan.

1) Base Case A-1 "SHS/BCS (SHS electrification rate of 40%/BCS 20%)" should form the basis of the project. This is expected to achieve the electrification rate of 47.3% for all households in the target villages and localities.
2) To ensure sustainable operation of the project (Base Case A-1), the government should provide the subsidy outlined in Figure 13.2-8 for the first 12 years, while the Implementation Body will be able to meet the rest of financial requirements by itself. Under this financial plan, the IRROI is estimated at 18.0%.
3) Appropriate pricing holds the key to the achievement of a desired electrification rate and project profitability. In particular, it is important to:
   a) Maintain a sufficiently high rate of user charge collection; and
   b) Have the user charge exempted from the VAT, which would otherwise discourage low income households from use of the PV system. If VAT cannot be exempted, the same amount of operation subsidy as VAT should be allocated during the entire business period.
4) As the operating cost of the Implementation Body (salary, etc.) accounts for significant portions of the project cost, its reduction will contribute greatly to the improvement of project profitability. Efforts should be made to use local workforce as far as possible.
5) The PV system for public facilities in villages should be incorporated into the scope of the project.
6) Efforts should be made to minimize the equipment cost, especially the BCS.
7) There are significant differences between the results obtained in the socio-economic survey and Dissemination Project. The differences affect the project feasibility. It is, therefore, recommended to conduct detailed socioeconomic survey for the formulation of the business plan of PV rural electrification.

Refer to Appendix 13 on the calculation results of various case studies.