Economic Analysis of Small Hydropower Project – A Case Study of Lower Khare Small Hydropower Project

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Abstract: Hydropower projects promoted by government agencies and multi-lateral donor agencies in Nepal such as World Bank, Asian Development Bank etc. take decision to develop the projects on the basis of economic indices which includes the quantified socio-economic cost and benefits. However, by virtue being the nature of private company, the projects being developed by private sectors in Nepal focus mainly on financial indices for the profitability rather than social responsibility. Since, the promulgation of hydropower development policy – 2001, private sectors are allowed to develop hydropower projects on a competitive basis with the Build-Own-Operate-Transfer (BOOT) model in Nepal. The BOOT-administered project may require that the contractor be responsible partially or completely for design and financing, and completely responsible for the construction (the build element), own, operation (operate), and maintenance activities for a specified number of years. This time horizon is 35 years including construction period as per the electricity generation license. After this time period, the owner becomes the government when the ownership is transferred (transfer). Thus, when ultimately the ownership is transferred to government, it seems importance of economic analysis for the small hydropower projects (SHPPs). This article has tried to perform economic analysis of a small hydropower project to be developed in Dolakha district of Nepal.

Keywords: Small hydropower project; Standard Conversion Factor (SCF); Economic analysis; Economic net present value; Economic internal rate of return; Benefit cost ratio; Risk analysis

1. Introduction

Hydropower has been recognized as a sustainable source of energy. Its benefits include it is non-polluting, it has low operating and maintenance cost, its technology offers reliable and flexible operation, and hydropower plants have increased efficiencies along with long life.

Keeping in mind increasing competency, effectiveness, managerial capacity and financial resources of the private sector and the country's urgency to divert financial resources to other noncommercial sectors (e.g. health, education, social security etc.), the Government of Nepal (GoN) has adopted a liberal economic policy. As a consequence, Hydropower Development Policy (HDP), 1992 was approved and accordingly Electricity Act (EA), 1992 and Electricity Regulation (ER), 1993 were enacted to motivate national and foreign private sector investment for the development of hydropower projects. Consequently, the private sector has become interested in the development of small hydropower and the previous active role of the public sector in the construction of small hydropower has been reduced. Presently, 17 small hydropower projects (SHPPs) have signed power purchase agreement (PPA) with a total installed capacity of 70.10 MW, are currently being constructed by private developers (NEA, 2013). Hence, it is an endeavor to perform economic analysis of SHPPs to be constructed by private sectors in Nepal.

2. Literature Review

2.1 SHPPs Definition

Hydropower classification according to size has led to concepts such as 'small hydro' and 'large hydro', based on installed capacity measured in MW as the defining criterion. Small hydropower projects (SHPPs) are more likely to be run-of-river facilities than are larger hydropower projects, but reservoir (storage) hydropower stations of all sizes will utilize the same basic components and technologies.

Nevertheless, there is no worldwide consensus on definitions regarding size categories (Egre and Milewski, 2002). Various countries or groups of countries define 'small hydropower projects' differently. Some examples are given in Table 1.

Table 1: Small hydropower projects by installed capacity (IPCC, 2011)

Country	Installed Capacity (MW)	Reference Declaration
Brazil	≤30	Brazil Government Law (1998)
Canada	<50	Natural Resources Canada (2009)
China	≤50	Jinghe (2005); Wang (2010)
European Union (EU)	≤20	EU Linking Directive (2004)

India	≤25	Ministry of New and Renewable Energy (2010)
Norway	≤10	Norwegian Ministry of Petroleum and Energy (2008)
Sweden	≤1.5	European Small Hydro Association (2010)
USA	5-100	UN National Hydropower Association (2010)

2.2 SHPPs in Nepal

In Nepal, till date, there is no any standard has been set to define SHPPs by any government institution. But, according to Sovacool (2011), Nepal adheres to the generally accepted small hydropower definition of capacity range 1 – 10 MW.

Table 2 shows the status of SHPPs in Nepal under different stages. As shown in table, there are 26 SHPPs in Nepal with an aggregated installed capacity of nearly 101.61 MW. Out of these 26 SHPPs, 19 projects were built on a BOOT (Build-Own-Operate-Transfer) basis and are operated by Independent Power Producers (IPPs).

Table 2: Small hydropower projects in Nepal – Under Different Stages

SHPPs	No. of Projects	Capacity (MW)	Reference
Installed by private sector on BOOT basis	19	84.29	NEA (2013)
Installed by public sector	7	17.32	NEA (2013)
PPA concluded and projects under construction	17	70.10	NEA (2013)
Issued survey license	65	300.23	DoED (2014)
Issued generation license	52	262.54	DoED (2014)

2.3 Earlier works performed for SHPPs' economic analysis

There are some organizations that have performed economic analysis of micro-hydropower (MHP) projects (capacity less than 100 kW, SREP, 2011). Practical Action Nepal, Water and Energy Commission Secretariat (WECS), Asian Development Bank (ADB) and Department of International Development (DFID, UK) are some organizations who have tried to perform financial and economic analysis of MHP projects. In most of the reports, financial analysis is only focused. Similarly, "Economic evaluation of micro hydro power project with special reference to Agretar MHP Kavre district, Nepal" has been conducted by Singh (2004). This report has tried to incorporate some parameters to quantify economic cost and benefit for MHP plants. All these works are focused in MHP areas only.

In Nepal, we rarely observe the economic analysis performed for SHPPs. Thus, it as an endeavor of this research work to perform an economic analysis of Lower Khare Small Hydropower Project (8.26 MW) considering social costs and benefits and its quantification in accordance with ADB and World Bank (WB) guidelines to be constructed in Dolakha district of Nepal.

3. Methodology

Calculation of economic indices of the selected small hydropower project considering both tangible & intangible benefits and costs is based on data collected from the detailed project report (DPR) and initial environment examination (IEE) report. Similarly, other necessary relevant data have been collected from public relation officer employed in the project site.

The tangible benefit is the sale of electrical energy, based on approval by country regulators, Nepal Electricity Authority (NEA) in Nepal. The tangible costs are – investment cost (civil construction costs, electromechanical equipment costs, power transmission line costs, engineering and design (E&D) cost, supervision and administration (S&A) cost, inflation cost during construction); annual costs (viz. operation & maintenance (O & M) cost, replacement & renovation cost) etc.

Similarly, the intangible benefits cover the increase in agriculture production, local employment generation, saving in fuel wood, reduction in fossil fuel consumption for lighting & cooking, saving from extended time for work, saving from battery use etc. The intangible costs are – forest destruction, fish collection loss, accidental expenses etc.

The financial costs and benefits obtained from DPR have been converted to economic costs and benefits by Standard Conversion Factor (SCF) approach using foreign exchange rate numeraire used by ADB and WB.

After collecting the required data and arranging in spreadsheet, the project's economic results are find out. These results are – discounted payback period, ENPV, EIRR and B/C ratio etc. Further, risk analysis and scenario analysis is performed with the help of Crystal Ball using Monte Carlo Simulation.

3.1 *Assumptions for economic analysis*

- The construction period is approximated as 3 years (DPR,2013)
- Capital investment in different time line of project (Hosseini et. al., 2003, 2005)
  - 37% in Year 1
  - 56% in Year 2
  - 7% in Year 3 .
- The economic life of the project is assumed as 35 years including construction period (DoED, Generation License, 2012).
- Normal outages, self consumption, forced outages; line loss, interconnection loss etc. are considered for saleable energy from gross energy generation (NEA, 2013).
- Discount Rate or opportunity cost of capital is taken 10 % (ADB, 1997).
- Rate of sale of energy is considered as NRs 4.80 per unit in wet months and NRs 8.40 per unit for the dry months as per present posted rate of NEA (NEA, 2013).
- 3% tariff escalation is considered in present posted rate for 5 years after commercial operation date (NEA, 2013).
- The royalty is calculated as applicable to SHPPs (GoN, Electricity Act, 1992).
- Interest payment and repayment of principle for the loan amount are not considered in the analysis (WB, 2001).
- Interest during construction (IDC) is not considered (WB, 2001).
- Transfer payments such as taxes and subsidies are not considered (ADB, 1997).
- Physical contingencies represent expected real costs and, unlike price contingencies, they are included in project economic costs in the analysis (ADB, 1997).
- Financial prices are converted to economic prices by using Standard Conversion Factor (SCF) approach (ADB, 1997)

  i.e. Economic Cost = SCF × Financial Cost
- The financial cost is the market value of the various components and SCF varies from 70% to 90% (ADB, 1997).

4. Lower Khare Small Hydropower Project

4.1 *Introduction*

Lower Khare Small Hydropower Project is located in Chankhu, Khare and Suri village development committees of Dolakha district in central development region of Nepal. Geographically, the project area is located between latitudes of 26º 45’ 53” N to 26º 45’ 00” N and longitudes of 86º 13' 52" E to 86º 11’ 30” E as per the issued survey license (2009).

4.2 *Salient features of project*

The salient features of the project have been presented in Table 3.

Table 3: Salient feature of project

Particulars	**Features**
Project Capacity	8,260 kW
Catchment Area	180 sq. km.
Design Discharge	9.40 m^3/sec (at Q 42%)
Net Turbine Head	104.73 m
Penstock Pipe	2,887 m; 2 m diameter; 22 mm thick
Turbine	Francis, 2 units
Generator	Synchronous brushless, 2 units; 3 phase AC
Transmission Line	Single circuit, 132 kV
Saleable Energy	48.34 GWh

5. Calculation and Results

5.1 *Economic cost of project*

The total project’s economic cost has been presented in Table 4 by adjusting financial values to reflect economic costs.

Table 4: Economic cost of project

S. No.	**Particulars**	**Amount, (NRs, 000)**
1	Civil Construction	428,023
2	Metal Works	414,594
3	Plant and Machinery	306,249
4	Transmission Line & Switchyard	76,366
5	Land Purchased & Development	3,679
6	Environment Mitigation	13,250
7	Logistics & Office equipments	2,100
8	Project Supervision, Engineering & Management	62,213
9	Project Insurance	12,443
	Total Economic Cost of Project	1,318,917

5.2 Results

Case – I: When the energy reduction is 20%

A. Discounted payback period

In this case, there is 90% certainty that the discounted payback period will be 6.07 years. The risk analysis shows that the project discounted payback is ranging from 5.66 to 7.66 years. The most probable region of discounted payback period is around 6.56 years according to the result shown.

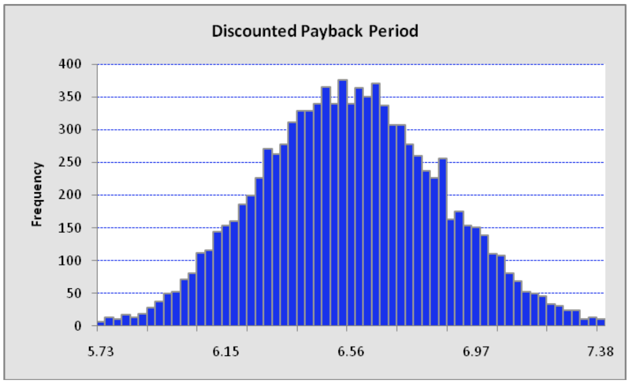

Figure 1: Risk analysis for discounted payback period

B. Economic net present value (ENPV)

In this case, there is 90% certainty that the ENPV will be NRs. 707 million. The risk analysis shows that the project ENPV is ranging from NRs. 632 million to NRs. 860 million. The most probable region of ENPV is around NRs. 752 million according to the result shown.

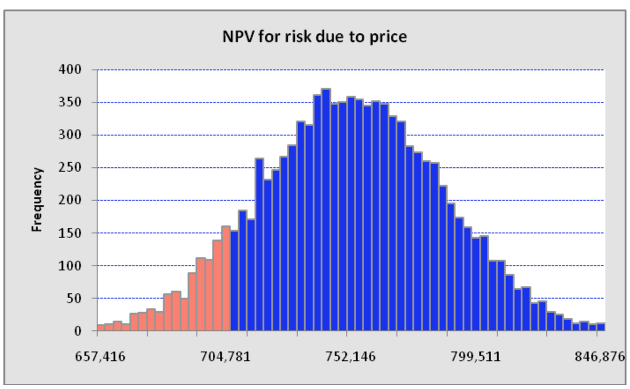

Figure 2: Risk analysis for NPV

C. Economic internal rate of return (EIRR)

In this case, there is 90% certainty that the EIRR will be 15.99%. The risk analysis shows that the project EIRR is ranging from 15.42% to 17.14%. The most probable region of EIRR is around 16.33% according to the result shown.

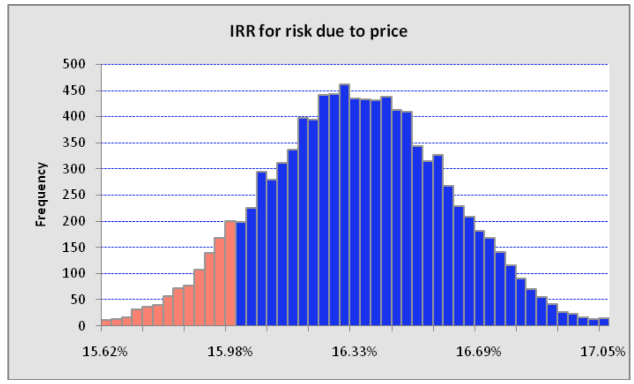

Figure 3: Risk analysis for EIRR

D. Benefit cost (B/C) ratio

In this case, there is 90% certainty that the B/C ratio will be 1.73. The risk analysis shows that the project B/C ratio is ranging from 1.57 to 1.78. The most probable region of B/C ratio is around 1.68 according to the result shown.

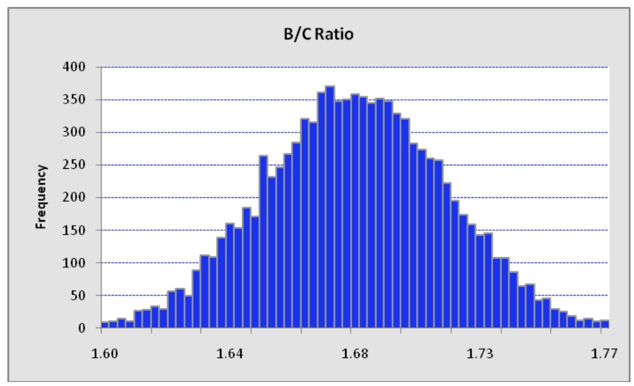

Figure 4: Risk analysis for B/C ratio

Similar analysis is performed for case-II viz. project cost increased by 20% and case-III viz. combined scenario for energy reduction by 20% and project cost increased by 20%. The summary is presented in Table 5.

Table 5: Results of risk analysis

Conditions	**PBP (Year)**	**ENPV (Mill NRs)**	**EIRR (%)**	**B/C**
Base Case	4.84	972	17.96	1.88
Case-I: Energy reduction by 20%	6.07	707	15.99	1.73
Case-II: Project cost increased by 20%	5.52	781	15.75	1.60
Case-III: Combined of Case-I & Case-II	7.05	567	14.31	1.43

6. Conclusion & Recommendation

The economic analysis of a Lower Khare Small Hydropower Project to be developed in Dolakha district of Nepal shows the following results:

- EIRR, NPV, B/C ratio and payback period are found positive in economic analysis.
- The project is economically acceptable even at 90% certainty level when there is reduction in energy generation by 20%; increase in project cost by 20% or in both combinations.
- In the combined scenario, the EIRR, ENPV & B/C ratio is marginally convincing at 90% certainty, but the project is feasible.

Thus, economic analysis helps analysts and decision makers to look at hydropower projects from the country's viewpoint (to ensure that projects contribute more resources to the economy than they use), from the financial and fiscal viewpoint (to ensure that the implementing agencies will have the resources to implement projects as designed) and from the viewpoint of the people who are most affected by projects (to ensure that the distribution of costs and benefits is acceptable to society). It is equally important to perform economic analysis for the hydropower projects being developed by public sector and private sector. Therefore, government should enforce in hydropower development policy to perform economic analysis while issuing electricity generation license, transmission license and power purchase agreement for sustainable development of hydropower projects in Nepal.

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