Sustainable Management of Small Hydropower for Rural Electrification in Lao PDR by Economic, Social and Environment Blueprint Perspective

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***Abstract*—Electric energy generation mostly from hydroelectric power, thermal power, nuclear power and renewable sources is one of the major key factors for economic and social development in the entire developed and developing nation of the world. The Government of Laos (GoL) has declared that the small hydropower (SHP) with the capacity less than 15 MW is Renewable Energy (RE) and it is playing an important role in the rural development area especially On-grid areas and Off-grid areas. The main challenges for the Government of Laos is how to manage the SHP for the sustainable ways in order to contribute for the GoL's golden target for household to have electricity for 90% in the year 2020 and reduce the poverty in rural. Currently, the government has already approved 35 projects with the capacity less than 5 Mw for the rural development. But the main challenges for the projects are the unreliability supply of electricity to rural areas due to the suitable method for managing and operating of the project has not established. In this study the main purpose is to analyze the 12 existing small hydropower projects in Lao PDR (with the capacity less than 5 MW) that was not sustainable then will propose the recommendation of the suitable management tools for sustainable management of small hydropower in rural area of Lao PDR by using the Economic, Social and Ecological blueprint model (ESE model).**

***Index Terms*—Small Hydro Project (SHP), government of Lao PDR (GoL), economic, social and ecological blueprint model (ESE model).**

I Introduction

Electric power system of Lao PDR is separated into three parts by regions (Northern, Central regions and Southern) because there is no national grid connected from north to south the extensions of electric power grids to remote households are either prohibitively expensive or economically unjustified.

A recent World Bank study estimates that more than 1.8 billion rural people or two thirds of total rural population in developing countries still have not attained any grid-based electricity services [1].

In many Asian and African countries such as Bangladesh, Botswana, Ethiopia, Kenya and Yemen, less than 5 percent of rural villagers have access to grid services [2].

The Government plans to expand electrification in remote areas through two methods. One is to expand the grid to comparatively easily accessible areas. The other is to provide off-grid supplies to remote areas where it is difficult to expand the present grid due to environment or cost reasons [3].

In rural areas, electricity serves many purposes. It can improve business and farm productivity, ease the burden of household tasks, and provide more efficient lighting for rural families. Increased accessibility to electricity in rural areas will improve living standards and help reduce poverty [4]. At present more then 20,000 households have been connected to solar home systems and SHP have been providing electricity to people living in rural and remote area [5]. According to Government's strategy is to raise the national electrification rate to an ambitious target of 90% by the year 2020 [Appendix 1]. Development of off-grid renewable energy sources such as SHP, solar, wind, biomass; increasing energy self-sufficiency and security; and implementation of power projects for maximum long-term sustainability including managing in sustainable ways for renewable energy sources.

In many years ago, electric power generation has been expended from 33 MW in 1975 (independent) to 1,937 MW in 2010 as 99.8% from hydropower generation, 0.07% (1.51MW) from diesel generator and 0.02% (0.47MW) from Solar power and others that shown in Table I. Currently the electrification ratio is approximately 80% and will be 90% in 2020 if the entire SHP plan are implemented and the existing plan are still running in full capacity (80% by grid plus 10% by off-grid) [6]. Therefore, the SHP will contribute for the off-grid supplies to remote areas where it is difficult to expand the present On-grid due to environment or cost reasons.

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II State of Problem

The use of renewable sources is the most valuable solutions to reduce the environmental problems associated with fossil fuels based electric energy generation and achieve clean and sustainable energy development [7].

But the main problems from rural electrification are: high initial investment with the rate of return, no actual tools for management and technical inspection standards. Currently, small hydropower development that provincial is responsible were not sustainable due to natural disaster, lack of management and lack of technical and budget for maintenance.

In 2010 with the supported from World Bank and implemented by Nippon Koei and MEM, there were the study on the rural electrification master plan and hydro assessment which include the rehabilitation assessment of existing SHP system in the northern provinces of Phongsaly, Luang Namtha, Luang Prabang, Houaphanh, Xiengkhouang, Xayabuli and Attapeu. The studies mainly focus on the technical area of the project and the problems listed below are the outcomes of the study:

- Plan damaged by flood
- Working and connected to EDL grid but the plant is lacking the water during the dry season and could generate just only 1 unit
- Well working and connect to substation but during the dry season it could generate only one unit
- Some plant is granted aid from the EU and in beginning of 2007 this plant stop generation because of flooded power house but the dam is good condition
- Working but lacking of water because there are many sedimentation in the reservoir and the equipment also in the poor condition
- Working but the power demand is too high
- Working but poor condition
- Stop generating because the equipment are poor, the civil work including powerhouse are in the good condition
- Working but the power demand is too high and there are less of water during the dry season [12]

III Research Objectives

The main purpose of research is to investigate the good management tools for small hydropower in rural area for the sustainable development also to improve the standard of living. This study is using the Economic, Social and Environment blueprint model (ESE model) to identify the factors and creating methodology for trying to solve the problems in case of existing small hydropower that located from northern to southern of Lao PDR (Appendix 3) that provincial is responsible such as:

- To review concept of small hydropower development related to policy and strategy of GOL
- To investigate of the small hydropower management methodology to take into account the new situation of development in rural area
- To identify methodology with the suitable method of SHP management for rural electrification

IV Methodology

In this study the main purpose is to analyze the 12 existing small hydropower projects in Lao PDR (with the capacity less than 5 MW) that was not sustainable

The method are separate into 2 procedures; first is the data collection and analysis of the 12 existing small hydropower projects in Lao PDR (with the capacity less than 5 MW, Appendix 3) that aren't sustainable by using the modified format from Ministry of Energy and Mines, Lao PDR and ASEAN Energy Centre. Secondly, suggestion of the suitable management tools for sustainable and effectiveness management of small hydropower in rural area of Lao PDR by using the Economic, Social and Ecological blueprint model (ESE model).

1.1 Data Collection and Analysis Method

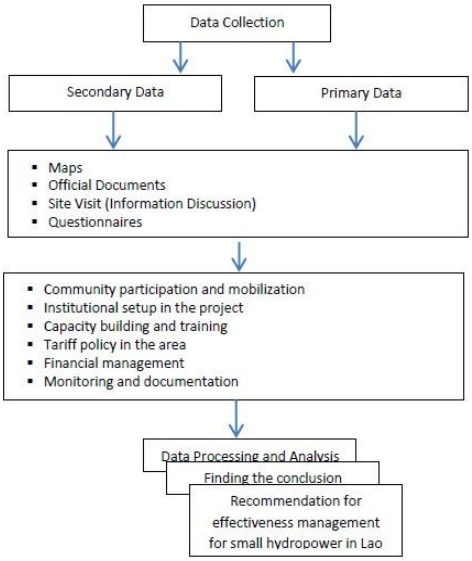


Figure 1. Data collection and analysis method

1.1.1 Outcome of the data analysis

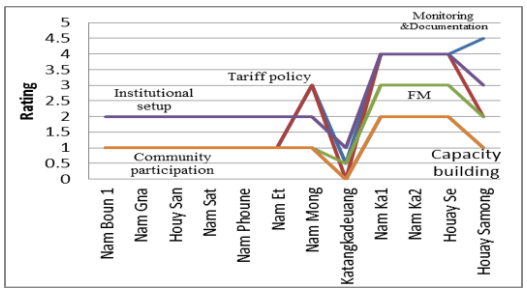


Figure 2. The outcome of the 12 projects analysis

After using the modified format from Department of Policy and Planning, Ministry of Energy and Mines, Lao PDR and ASEAN Energy Centre to the existing 12 sample projects in to this study, we can identifies as the following:

- From the initial phase the participation from the community are very limited.

- Unclear of the responsibility between the local and central government.
- The over/less estimation of the project power generation.
- The unclear of the tariff policy.
- The low quality of the project's electric equipment
- Income can't cover the operation and maintenance
- Drop of power supply in dry season can not meet the power demand
- Lack of financial management mechanism.
- Lack of technical skill and educated staffs, because qualified staff is crucial for a sustainable operation of the plant.

As shown in the graph that all 12 project have difficulty on the community participation and capacity building for the staff in the project. The projects that have more score on the questionnaire are Nam Mong, Nam Ka1&2 and Houay Se due to these projects is already connected to the EDL's grid. Therefore, the monitoring, tariff policy, institutional setup and financial management are already in place.

In conclusion, the project that responsible by provincial are clearly having problem in mentioned areas as indicated in the analysis graph.

1.2 ESE model procedures

In general the Sustainable development of the hydropower sector is founded on 3 important principles namely:

- Economic sustainability relies upon the maintenance of the renewable resource base, and the use of non-renewable resource rents to support the development of other factor of production;
- Social sustainability is based upon the principles of inclusiveness, mutual understanding and consensus; and
- Ecological (Environment) sustainability relies upon the avoidance of irreversible environmental impacts such as the loss of biodiversity, accumulation of persistent pollutants, or disruption of ecological cycles [17]

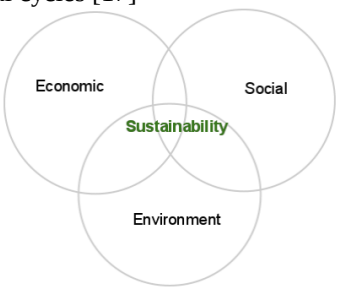
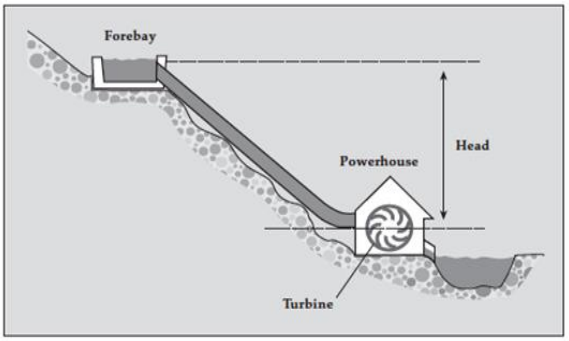


Figure 3. The relationship of ESE

1.2.1 Economic Blueprint

1.2.1.1 General technical aspect



Head is the vertical distance the water falls. Higher heads require less water to produce a given amount of power.

Figure 4. General layout of Small Hydropower project

1.2.1.2 Efficiency of the project itself

As mention the minimum flow and head are the most important information, when is known the theoretical hydro power is calculate as the following:

P[W] = Q[m3/s] x H[m] x 9.81

Where:

P = Power in Watt

Q = Minimum available flow

H = Head, difference in height in meter

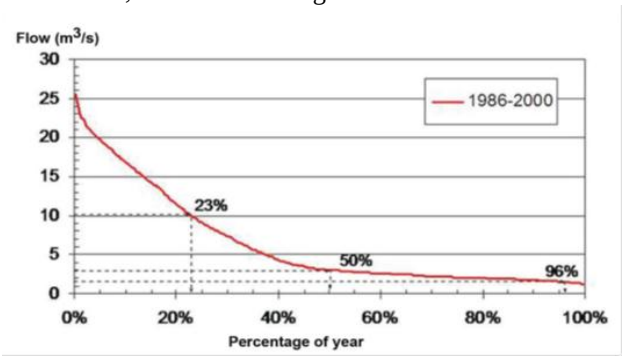


Figure 5. Flow duration curve

4.2.1.3 Monitoring and Documentation

Proper monitoring and goods records make operation and maintenance works easier and enhances customer's trust

- A thorough record of routine O&M and also of any unusual events occurring in the system will facilitate troubleshooting, e.g. when experts from outside the village are consulted for help
- All civil and electro-mechanical parts of an MHP system must be inspected periodically important results of these monitoring activities must be recorded in a log book
- Protocols of community meetings in connection with the MHP system should be recorded in the log book, including any important decisions, agreements and conclusions
- Important actions and occurrences with regard to finances, book keeping and administration should also be recorded in the log book

4.2.1.4 Tariff Policy

TABLE I. SUBSIDY SYSTEM IN JAPAN

Scale	*Subsidy rate*
5MW-30MW	within 1/10
1MW-5MW	within 2/10
-1MW (Local government)	within ½
-1MW (Others)	within 1/3

4.2.2 Social Blueprint

4.2.2.3 Community participation:

Key aspects for community participation

The Community has to be involved from the very beginning of a project, starting from the first site visit; in an ideal case: community itself took the initiative and proposed the construction of a SHP scheme.

Organize regular meetings between community and consultant during the planning stage and between community, consultant and contractor during construction stage in weekly intervals, to inform and coordinate all activities.

Make clear that villagers' contribution to construction work, either in cash or labor is a condition to implement the project. Villagers' contribution significantly boosts their feeling of ownership of the plant. However, make sure that contribution is reasonable and within their ability (e.g. labor contribution by the community during harvest periods will be very limited)

Don't raise wrong expectations in the community about the SHP project (e.g. community has to understand and be aware of power supply limits during the dry season) transparency

Involvement of Women

Women are very often more trustworthy and experienced in managing the household finances and thus more qualified as book keepers of the MHP finances during the operation stage

Usually women tend to have a deeper understanding of the importance of the implementation and sustainable operation of the SHP and the resulting improvement to their and their children's' livelihood. Women therefore usually have a much greater interest to see the project implemented and well maintained, making them the priority group to address for community mobilization

Some of the key Questions in Community Participation

What is important for whom and when? Consider if for certain issues separate meetings with men and women are useful (also depending on total number of people and available facilities)

How much time is needed for which kind of meeting? Take your time for community meetings SHP might be a very new concept for the community, resulting in lengthy discussions

Which decisions have to be taken at what stage of the project? Mention important deadlines (planned project schedule, start of operation, opening of bank account, etc.). Establish a plan of action for the activities required from the community (legal registration process, definition of land use rights, compensation, labor input)

Use videos, pictures etc to make people easily understand! If Power Point presentations are used, present short and concise text only, with many

Limit presentations to the essential and leave enough time for discussions, questions, input from villagers

4.2.2.4 Institutional Setup of the project:

When a community-based organization is needed to take over ownership of the system and thus also responsibility for its operation, preferably an already existing organization should be used (e.g. cooperative managing the irrigation system in the village). If no such organization exists, identify a suitable institutional and organizational setup for the SHP project under consideration of the local conditions

Within the organization individual staff must be assigned for specific tasks of operation and management (OM). A typical staffing looks like this:

- 2 operators (mandatory)
- 1 book keeper (mandatory)
- 1 head of management (optional)
- 1 secretary (optional)

Selection of Staff for Management & Operation

Staff should be selected under consideration of the following:

- Technical skills and education,
- Know-how on book keeping, etc.
- Relevant, long and varied experience in the field
- Tendency to stay in the village over the long term.
- Don't choose candidates who plan to move away in the future (e.g. unmarried young men are more likely to move away)
- Involve women as much as possible

Clarify legal and regulatory issues regarding a formal registration of the community as owner, operator and beneficiary of the project. For each staff position a detailed task description should be written up and made accessible for the customers

Depending on the size of the system, staff may have to be employed part-time or full time. The operators should earn more since their tasks are heavy, and also more difficult and time-consuming

If salaries are set too low, they do not attract and/or motivate the people with required skills to do a good job.

But if salaries are too high, they are difficult to be covered by tariff payments Salary has to be competitive to avoid migration of trained staff

4.2.2.5 Capacity Building and training:

Aspects for efficient capacity building and training

Conduct training and capacity building measures separate from village meetings in small groups in an interactive and participatory way. In case of several villages in one area, get operators, book keepers and secretaries together for a common training workshop

For training in small groups as well as workshop training use demonstration material / visual aids, like log-books, book-keeping folders, etc

If possible invite an operator / secretary from an existing SHP system or organize a visit to an SHP system in operation, with some village representatives (preferably the selected OM staff) this would facilitate a direct exchange

Award certificates to those attended a training successfully in order to raise their social standing and thereby the qualified influence on the MHP

4.2.3 Environment Blueprint

4.2.3.3 Implementation of the Initial Environmental Examination (IEE)

To enable environmental management to be integrated into electricity projects and to ensure sustainability, it is essential that an appropriate environmental assessment process is developed and implemented. An Initial Environmental Examination (IEE) is an integral part of an Environmental Assessment process.

As mentioned in the decree on environmental impact assessment for electricity projects due to size and location of the project which it has an installed capacity of less than 15 MW, water volume less than 200 million m3, reservoir area less than 1500 Ha need to do the IEE and result of site investigation and analysis of all potential impacts by project.

The main objectives of IEE are to:

- Examine the available environmental information as well as baseline investigation on existing environmental situation in the project area and identification of proposed effected areas in which the project construction and operation will cause noticeable impacts of any kind to environment;
- Report the all potential significant environmental issues with regards to the project impact upon environmental resources and screening out the insignificant impact of the project including proposed mitigation measures;
- Identify expected or potentially direct or indirect impacts caused by the project and adequate mitigation measures; and
- Prepare the environmental management and budget plan

The main IEE's report of the project should include as follow:

- Introduction and background such as general situation of Lao PDR, the importance of the project
- Institutional and legal framework
- Approach and methodology for conducting the IEE should includes ground survey, village profile and household survey with use of questionnaire and interview and discussion with community leaders
- Initial social impact assessment such as existing socio-economic, project's area socio-economic perspective, compensation issue in the reservoir areas, employment opportunity, commercial opportunity increase in affluent/poor income group

V. Conclusions

This paper study is using only the Social and Environment blueprint perspective from the ESE model (Economic, Social and Ecological) to solve the problems in the case of the existing small hydropower that located from northern to southern of Lao PDR.

As we have been discussed that the Economic blueprint the general technical aspect such as measure, collect river flow (flow duration curve) and head data is the must component for the planner to do in order to calculate the final electrical power with the losses of 20-30% (P[W] = Q[m3/s] x H[m] x 9.81), Also the tariff policy because for the project to cover the operation and maintaining cost the income form the electricity charges is the most important, and the tariff policy should include the setting up the ability to pay (ATP) for electricity and the study shown that the ability to pay for electricity is assumed to be 5%-10% of household expenditure.

For the Social blueprint the community participation including the key aspects for community participation, Involvement of Women is very important factor. Also the institutional Setup including the selection of Staff for Management & Operation for the project need to be considers and also the capacity building is the most important part in order to make the project sustainable.

For the Environment blueprint is to ensure sustainability, it is essential that an appropriate environmental assessment process is developed and implemented. An Initial Environmental Examination (IEE) is an integral part of an Environmental Assessment process

Finally this study will contribute to the new small hydropower in the future in term of sustainable management.

Acknowledgement

I would like to take this opportunity to thanks the Hydropower and Mining Technical Assistance's Project that funded by World Bank and AusAid for the supported of my research, and hopefully my research can contributed to the development of the small hydropower for rural electrification in Lao PDR in the future.

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APPENDIXS

Appendix 1: The forecast ratio of electrify up to 2020

Description/Year	2005	2010	2020
Households	874,476	1,034,623	1,231,454
Households to be electrifies	508,799	749,953	1,108,309
In Percentage	58.2%	72.5%	90%
Population	5,900,000	6,256,197	7,261,600

Appendix 2: List of Existing SHP that responsible by Provincial

No	Plants Name	Province Location	Install capacity (kW)	COD
1	Nam Boun 1	Phongsaly	110.0	1996
2	Nam Gna	Phongsaly	110.0	2010
3	Houy San	Huaphanh	110.0	1995
4	Nam Sat	Huaphanh	250.0	1999
5	Nam Phoune	Huaphanh	60	1995
6	Nam Et	Huaphanh	60	1995
7	Nam Mong	Luangprabang	70	1996
8	Katangkadeuang	Luangprabang	3	N.A
9	Nam Ka1	Xiengkhuang	24	1999
10	Nam Ka2	Xiengkhuang	75	2002
11	Houay Se	Oudomxay	80	2003
12	Houay Samong	Attapeu	113.0	2003
Total			**1,065.0**	

Appendix 3: 12 existing small hydropower project with the capacity less than 5 Mw in Lao PDR