CHAPTER 5
FEASIBILITY STUDY FOR THE DEVELOPMENT NEW NAM DONG MICRO-HYDROPOWER PLANT

5.1 Introduction

The small existing Nam Dong small-hydropower plant has an installed capacity of 1 MW. It has been electrified to the central area of Luang Prabang (LPB) district, LPB province. It is a dam and waterway type which is usually applied to obtain the large water storage and higher water head. Beside this, it locates in the mountainous area where the level of intake and tailrace are 603 m.a.s.l. and 486 m.a.s.l. respectively. Base on these conditions, the idea for installation the new micro-hydropower plant (MHP) after the existing plant is more facilitating without the complicated structure and the least of investment cost where the natural source is used with the maximum potential.

The objective of this study is to demonstrate the technical viability and economic feasibility for the new MHP by using the water out flow from the existing Nam Dong hydropower plant in LPB province of Lao PDR.

5.2 General Information of the Project

Nam Dong River is a relatively small river that is tributaries Mekong River. It flows through the south part of LPB city. The New Nam Dong micro-hydropower project is planned to locate in the middle of Nam Dong River after the outlet of the existing Nam Dong hydropower plant. For more information is described in appendix B.

Figure 5.1 Overview of the Nam Dong Hydropower plant.

5.3 Scope of Study

5.3.1 Characteristic of Water Supply

The existing Nam Dong small-hydropower plant can operate throughout the year and has overflow during rainy season. The flow rate of water outflow is approximately 0.88 m^3/s) in case of operation full capacity. The average monthly flow rate shows in figure 5.3 is directly concerned to the discharge of New Nam Dong MHP project and is used to determine the installed capacity of the project. The water detail is shown in figure 5.2.

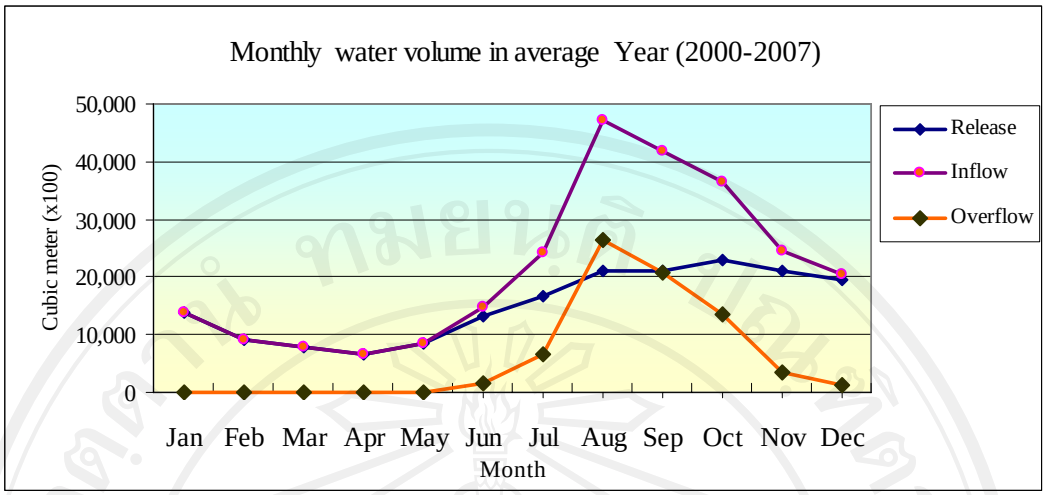

Figure 5.2 The water volume of the existing Nam Dong HHP.

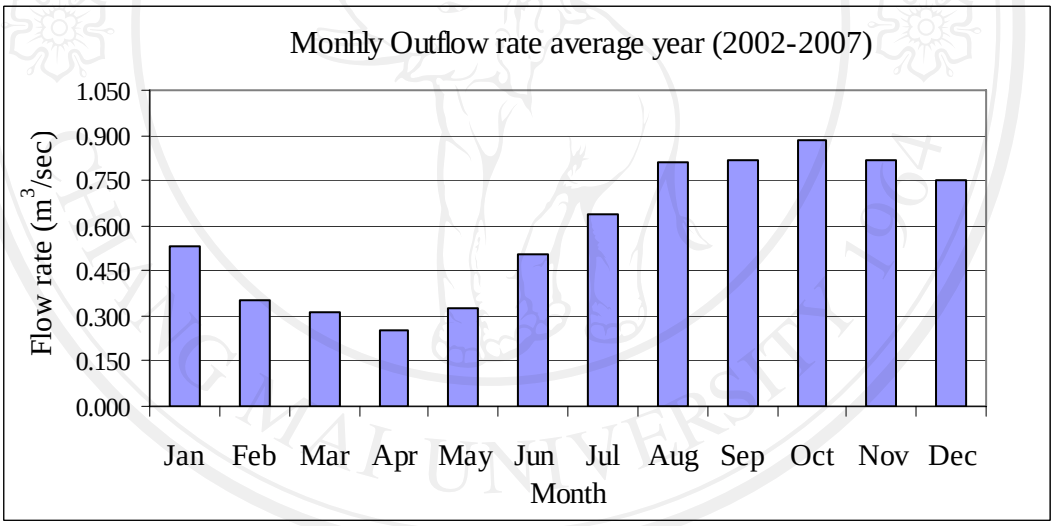

Figure 5.3 Monthly outflow rate average of the existing Nam Dong HPP.

5.3.2 Study Water Flow Rate Capacity

The preliminarily estimated the water flow rate is based on the detail of water outflow volume and operation hours of the existing Nam Dong hydropower plant. Therefore, An average monthly water outflow rate of the existing Nam Dong hydropower plant by the year (2000-2007) which is as the potential flow rate for development New Nam Dong MHP project is shown in the table 5.1.

Table 5.1 An average monthly water outflow rate of small existing Nam Dong hydropower plant.

Month	Outflow (m^3)	Outflow rate (m^3/s)
Jan	1,372,680	0.530
Feb	911,655	0.352
Mar	801,225	0.309
Apr	658,395	0.254
May	849,754	0.328
Jun	1,309,331	0.505
Jul	1,653,634	0.638
Aug	2,096,434	0.809
Sep	2,115,257	0.816
Oct	2,291,451	0.884
Nov	2,122,509	0.819
Dec	1,941,531	0.749
	Minimum	0.254
	Maximum	0.884

Source: Yearly report of Nam Dong Hydropower plant 2000-2007.

5.3.3 System Design for New Nam Dong MHP

The New Nam Dong MHP is planned for simple structure that does not to require large intake weir structure for the water storage. The single diagram of the generation plan is shown in figure 5.4.

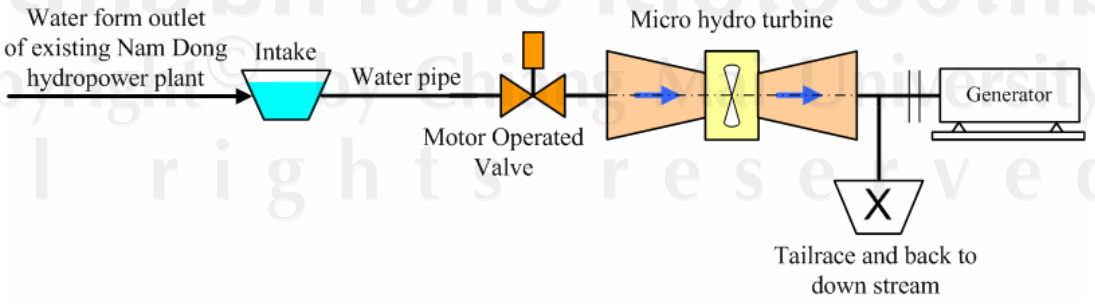

Figure 5.4 Single diagram for development New Nam Dong MHP.

5.3.4 Concept Design of New Nam Dong MHP

The study of New Nam Dong MHP is as a conceptual design. It is based on three main parts, i.e., (1) water flow, (2) power generated, (3) operation and maintenance (O&M). The profile for the concept design of New Nam Dong MHP presents in figure 5.5.

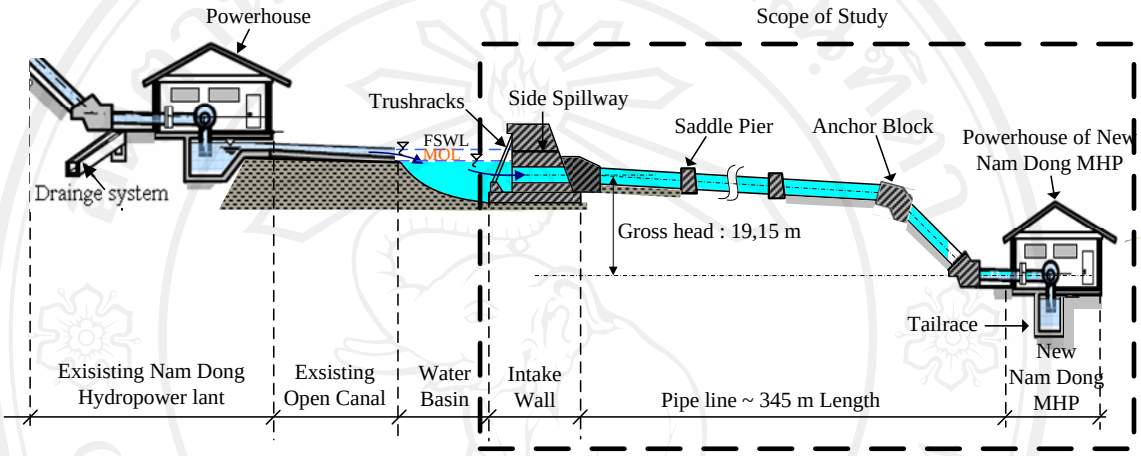

Figure 5.5 The profile of New Nam Dong MHP, (Not to Scale).

5.4 The Work Flow of Development New Nam Dong MHP

The development New Nam Dong MHP is as a conceptual design, and the major works of this project present as follows :

1) Civil work includes the intake wall, powerhouse and the tailrace channel to return the water to the river,

2) Piping work includes layout pipe line laying steel pie above ground and pipe support concrete**,**

3) Mechanical work includes turbine, water inlet control valve, and

4) Electrical work includes control panel and control system main transformer, transmission line for connection the electricity.

5.4.1 Descriptions Civil Work

As seen in the figure 5.5, the particular parts of civil work for development New Nam Dong MHP consist of take wall structure, powerhouse and tailrace (drainage system). The details are shown in appendix B, section B.3.

5.4.2 Descriptions of Piping Work

The considered suitable pipelines for New Nam Dong MHP project, the standard size of steel pipes from manufactures is used [22]. The length of the pipeline is approximately 345 m (See appendix B figure B.16). The steel pipe is used for the design. The determination the diameter of a pipeline is based on the water flow rate (maximum flow rate 0.88 m^3/s, see table 5.1). The determination and selection the suitable pipe for the project are shown in (appendix B, section B.3.2).

1) Summary data of pipe

- Total pipe length	345 m,
- Type of pipe	Wrought Iron or Schedule 40 Steel Pipe,
- Inside Pipe diameter	574 mm or 0.574 m,
- Friction loss	1.54 m at pipe length 345 m
- Minor loss	0.54 m.

5.4.3 Descriptions of Mechanical Work

1) Selection of Turbine

From site investigation and the operation data of the existing Nam Dong small-hydropower plant, the water flow rate of 0.88 m^3/s (See table 5.1) and gross head of 19.15 m (See appendix B, figure B.16) has been used to select the turbine and estimate the power installation of New Nam Dong MHP. Based on the study theoretical and technical approach of hydropower, the reaction turbine type propeller was selected. It is applicable to low head and relative large discharges and it can also maintain the high efficiency against the change of head and discharges.

The diagram for selection of applicable turbine type by given discharge (m^3/s) and Head (meter) is presented by Hydro-eKIDS Toshiba for low head and small scale hydroelectric was used (See figure 5.6).

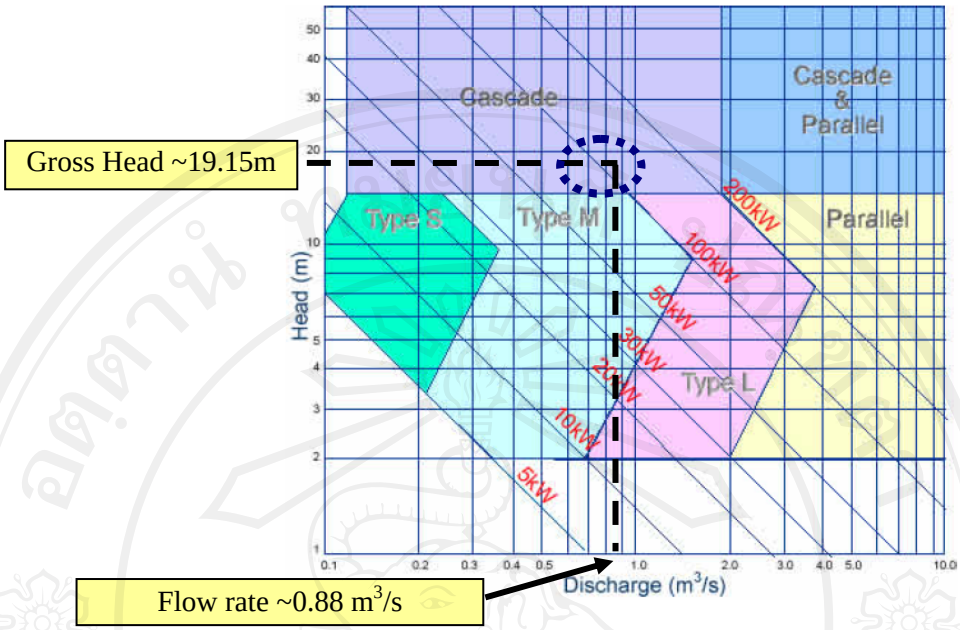

Figure 5.6 Turbine selection diagrams [8].

From the turbine selection diagram, turbine type M is considered for this study and its specific data is shown in figure 5.7.

Figure 5.7 The characteristic and specification of turbine [8].

$$Power\ Equation: \quad P = 9.81 \times Q\ x\ H_e \times 0.7\ \ (kW) \qquad (5.1)$$

The effective head (He) of this project is determined by the gross head (Hg= 19.15 m) and water flow rate (Q= 0.88 m^3/s) by deduction head loss between the intake and the tailrace with 345 meter long (See details in appendix B, section B.3.2). The particular detail is summarized as follows:

Effective Head = Hg - H_{loss} (m)

Where, H_{loss} = Major head Loss - Minor Head Loss = 1.54 m + 0.54 m=2.08 m

Therefore, Effective head= 19.15 m -2.08 m = 17.07 m

2) The technical parameters of New Nam Dong MHP

From the specification data of turbine, water head and flow rate, the main parameters for New Nam Dong MHP can be summarized as flows:

a) Head	17.07 m,
b) Discharge	0.88 m^3/s,
c) Efficiency is not less than	70 %,
d) Turbine output	103.14 kW/at head 17.07 m.

Turbine Output (P) = 9.81 x 0.88 x 17.07 x 0.7 =103.14 kW.

5.4.4 Descriptions of Electrical Work

1) Generator

Asynchronous generator is commonly known as an induction generator used for this project. It must be driven at a constant speed to generated steady power at the frequency of 50 Hz to meet the rated frequency of electricity system of Lao PDR. The selection the size of generator should consider capacity output and specific speed of the turbine.

From recommendation of Mea Ngut MHP project, the induction generator was used in this project. Its specification is shown by the following:

- Type	Induction Motor /and generator
- Power Capacity	100 kW,
- Rated	440V, 50Hz,
- Speed	1000 rpm,
- Power Factor.	0.85.

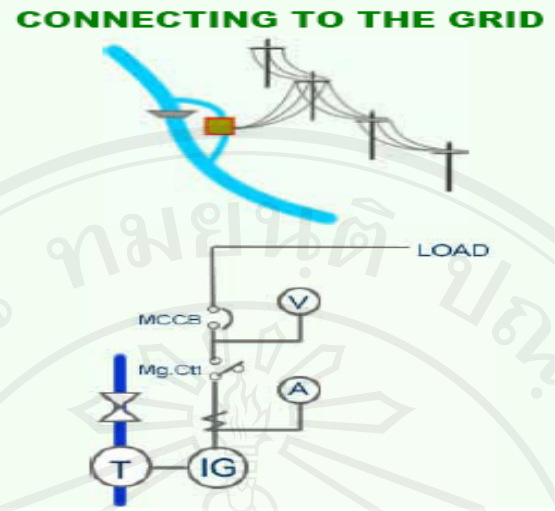

Figure 5.8 A single line diagram aspect for grid connecting [8].

2) DCS System

DCS is as the control system. Its function is to control the electricity generation, and detects all any event during operation of the electricity generation system. Furthermore, it is as a rumored control system using the completed software and it is widely used for the MHP in Thailand. For this study, DSC system is selected and its cost based on the cost recommendation from the Mea Ngut MHP (see appendix D, table D.2)

3) Transmission and Distribution System

The New Nam Dong MHP transmission line is designed to connect to the grid of the EDL's grid with approximately 0.5 km long. The scheme of power transmission of the project is shown in figure 5.9

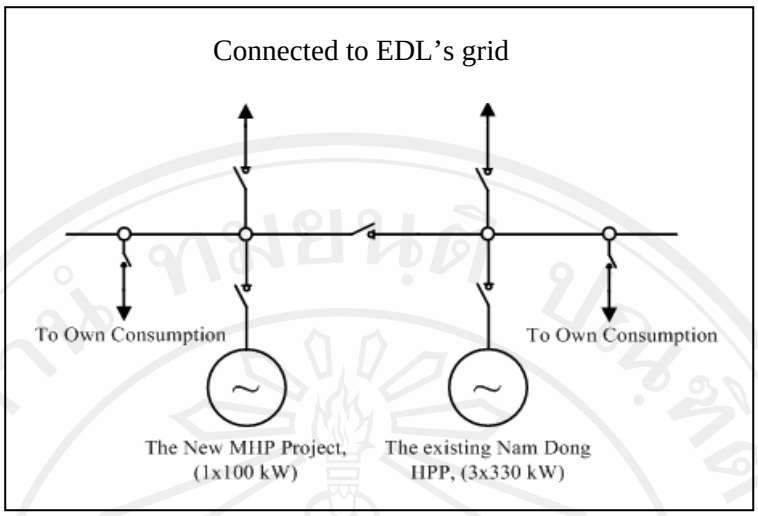

Figure 5.9 The power transmission line scheme for New Nam Dong MHP.

5.5 Estimation Energy Output

The estimated energy output of project is calculated by monthly outflow rate from table 5.1 throughout the year and the power equation 5.1 is used in term of the specific of turbine propeller type M. It is expressed as follows :

$$Energy\ Output = 9.8\ x\ Q\ xH_e\ x\ Running\ hours\ a\ month \quad (kWh)$$

Where, Q: average monthly discharge (m^3/s),

H_e: Effective head (H_e=17.07 m)

Annual energy output potential is integrated by the monthly energy output throughout the year. It is shown in the table 5.2.

Table 5.2 Monthly energy output potential of New Nam Dong MHP project.

Month	Discharge (m^3/s)	Power output (kW)	Energy Output (kWh)
Jan	0.530	62.08	44,696
Feb	0.352	41.23	29,684
Mar	0.309	36.23	26,089
Apr	0.254	29.78	21,438
May	0.328	38.43	27,669
Jun	0.505	59.21	42,633
Jul	0.638	74.78	53,844
Aug	0.809	94.81	68,262
Sep	0.816	95.66	68,875
Oct	0.884	100.00	72,000
Nov	0.819	95.99	69,111
Dec	0.749	87.80	63,218
		Total	587,519

5.5.1 Reality of Electricity Energy Output

The realistic electricity energy output of New Nam Don MHP is the total energy generation throughout the year by deducted by its own energy consumption (power station service) .It is taken 2 % of energy output and expressed as follows[19]:

$$E = E_{output} - E_{own\,consumption}$$

Where, $E_{own\ consumption} = E_{output}$ x 2% = 587,519 x 0.02 = 11,750 kWh/year.

Therefore, E = 578,519 - 11,750 = 575,769 kWh/year

The figure 5.10 shows the monthly duration curve of electricity energy output of the New Nam Dong MHP.

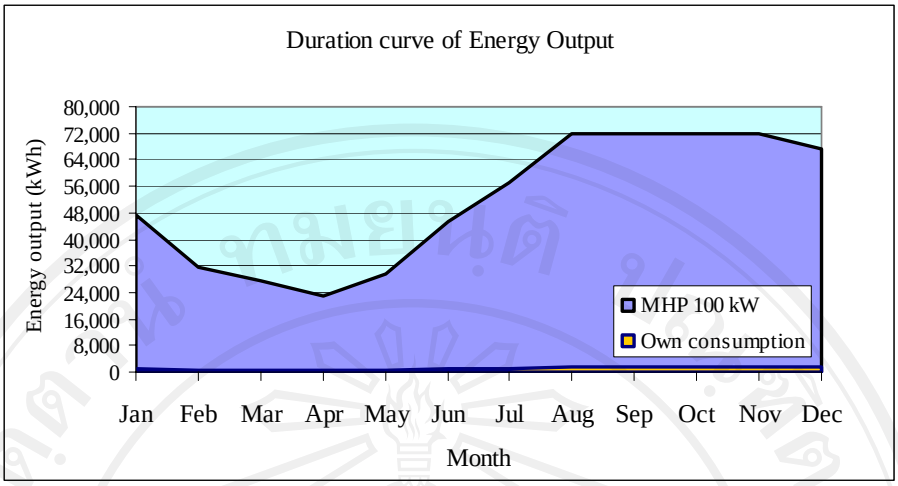

Figure 5.10 The monthly duration curve of electricity energy output of New Nam Dong MHP.

5.5.2 Technical Features

From the results of study the technical data is summarized in table 5.3.

Table 5.3 Summary of Main Technical Data of New Nam Dong MHP.

Data	Indexes
Gross Head	19.15 m
Head Loss	2.08 m
Effective Head	17.07 m
Maximum Water flow rate	0.884 m^3/s
Turbine type	Propeller
Installed Capacity	100 kW
Net Annual Energy Production	575,769 kWh/year

5.6 Estimation Cost of the Project

The estimation costs of New Nam Dong MHP will be base on the data form the study on small hydropower plant in the Northern Laos [10] and cost reference of Mea Ngut MHP, 2007 which have experience with EGAT, and cost of the project are based on 2005 to 2007 price projects . (For details see appendix B, section B.3 and

appendix D). The cost categories of New Nam Dong MHP are shown by the following :

5.6.1 Cost Category

The estimation costs have been broken down in to major items as follows :

1) Mechanical equipment

The cost of mechanical equipment i.e. turbine runner, governor, inlet valve and auxiliaries was generally estimated in term of lump sum cost.

2) Electrical equipment

The cost of electrical equipment i.e. generator, main transformer, power plant equipment and station auxiliaries was estimated based on lump sum cost.

3) Cost of DCS system is the system for controlling all operation system of hydropower plant. Its cost is based on cost reference of Mea Ngut MHP project, 2008.

4) Transmission Line

The 22kV distribution line is selected for this project, with 0.5 km long from existing Nam Dong hydropower plant distribution line.

5) Civil Work

The civil work includes approach intake, powerhouse and tailrace canal. In general, the design of civil works are based on the topographic map or the location condition. The cost of civil work was estimated based on the information obtained from the previous project in Lao PDR.

6) Piping Work

The cost of piping work includes steel pipe and support. It is estimated based on the quantity of pipe with the total length of pipe from the intake to turbine.

7) Miscellaneous/overhead cost

For estimation of the total project cost, the indirect cost that is the miscellaneous shall be added to estimated direct construction cost. It was estimated by taking 10% of direct cost [10].

5.6.2 Overall Costs Estimation

The cost of each item for development New Nam Dong MHP which is an installed capacity 100 kW is summarized in table 5.4. (See the details in appendix B, section B3.2 and appendix D, table D.2.)

Table 5.4 Costs of equipments for development New Nam Dong MHP.

No.	Items	Unit	Total Amount
I.	Mechanical Work		
1)	100 kW water Turbine (Propeller Type)*	US$	30,000
2)	Inlet valve*	US$	9,000
3)	Relief valve*	US$	9,000
	Sub Total	US$	48,000
II.	Electrical Work		
1)	Induction Generator*	US$	25,000
2)	Turbine and generator control set*	US$	15,000
3)	DCS System*	US$	15,000
4)	Main Transformer (set)*	US$	10,000
5)	Transmission Line (0.5 km)**	US$	5,000
	Sub Total		70,000
III.	Civil Work		
1)	Intake Wall**	US$	5,800
2)	Powerhouse**	US$	16,800
3)	Tailrace (drainage)**	US$	4,200
	Sub total		26,800
IV.	Piping Work		
1)	Water pipe (Type Steel) ***	US$	53,700
2)	Pipe Support	US$	8,000
	Sub Total		61,700
	Total cost of equipments		206,500
V.	Miscellaneous (10%)	US$	20,650
	Grand Total		227,150

Note: * Estimate cost is based on cost reference (Mea Ngut MPH, 2007).

** Estimate cost of work task based on cost reference [10].

*** Estimate cost is from computing by using the pipe diameter standard size [22] (see appendix B, Section B.3.2).

5.7 Economic Analysis

The New Nam Dong MHP could entirely produce the average energy 587,519 kWh/year. The minor extraction due to the maintenance shutdown, station service and other activities was included in further calculation.

The average import tariff of at 22 kV level from PEA that is approved by the government of Lao PDR, is the monetary concerns of project and is used for economic assessment.

5.7.1 Economic Criteria

Discount cash flow technique is adopted, showing the factor i.e. Benefit-Cost ratio (B/C), Net Present Value (NPV) and the Internal Rate of Return (IRR).

The adopted criteria are following:

1) Economic life of hydropower project is 20 years.

2) Station service electricity is 11,750 kWh/year or 2% of total energy generation capacity 587,519 kWh/year.

3) Discount rate 10% recommended by the study on small hydropower plant in Northern Laos [10].

4) The electricity tariff, refer to domestic electricity charge , an import tariff , and EDL internal tariff charge was approved by the Laos government from the year (2006-2001) at level voltage 22kV.

Table 5.5 The electricity tariff at the level voltage 22 kV.

No.	Items	Tariff (US$/kWh)
1)	EDL internal charging	0.0385
2)	An average Domestic charge	0.059
3)	An average Import tariff [1]	**0.563**
4)	An average Import tariff [2]	0.0769

Source : [6].

Note: [1] Import from PEA Thailand,

[2] Imports from China.

5) Operation and Maintenance (O&M) cost only covers cost of maintenance service (annual inspection) and some necessary spare parts. Meanwhile, the operation wage is excluded for the cost of the project due to DCS system which is as a remote control was used to control New Nam Dong MHP. The operation procedure will be controlled small existing Nam Dong hydropower plant. The Estimate cost of annual inspection is based on recommendation Mea Ngut MHP project, 2007 and the micro-hydro power plant work book [12]. The cost of annual inspection for New Nam Dong MHP is expressed in the table 5.6.

Table 5.6 The Estimation costs of annual inspection and Spare parts for Development New Nam Dong MHP Project.

No.	Work Items	Frequency (Year/time)	Cost of Spare part (US$)	Total Amount (US$)
I.	Yearly inspection*	1	-	1,622
1)	0.5 % of Civil work and Piping work	-	-	442
2)	1.0 % of Mechanical and Electrical work			1,180
II.	Spare parts	5		1,770

Source: [16].

Note: * Cost of annual inspection is increased as a shifted gradient at inflation rate 4.5% and applied annually [3].

* * The cost of spare parts is applied in every 5 years. Their cost will be estimated by taken 1.5 % of mechanical and electrical equipment [10].

There fore, the technical and economical criteria of the project are summarized in table 5.7.

Table 5.7 Summary of economic criteria for development New Nam Dong MHP project.

No.	Items	Unit	Indexes
1)	MHP design Capacity	kW	100
2)	Total of energy generation potential	kWh/year	587,519
3)	Station service	kWh/year	11,750
4)	Net Annual Energy Generation	kWh/year	575,769
5)	Project life	Year (s)	20
6)	Electricity tariff	US$/kWh	0.0563
7)	Inflation Rate**	%	4.5
8)	Discount rate	%	10%

Note: ** Inflation rate: 4.5% is the average rate for the last 3 years reported by Bank of Lao, 2007 [3].

5.7.2 Economic Cash Flow

The economic cash flow of the project is summarized by the overall cost estimate and economic criteria (See table 5.6 and 5.7). It is shown in table 5.8.

Table 5.8 The economic cash flow for Development New Nam Dong MHP Project.

Year	Cost of Project (C)			Benefit			Net Cash Flow (B+C) (US$)	Discount factor at discount rate 10%	NPV of Net Cash Flow (US$)
	Capital Cost (US$)	Cost of O&M		Energy generation potential					
		Yearly Inspection (US$)	Spare Parts (US$)	(kWh/year)	Electricity tariff (US$/kWh)	Amount (US$)			
0	(227,150)						(227,150)		(227,150)
1	-	(1,622)		575,769	0.0563	32,416	30,794	0.9091	27,994
2	-	(1,695)		575,769	0.0563	32,416	30,721	0.8264	25,389
3	-	(1,771)		575,769	0.0563	32,416	30,645	0.7513	23,024
4	-	(1,851)		575,769	0.0563	32,416	30,565	0.6830	20,876
5		(1,934)	(1,770)	575,769	0.0563	32,416	28,712	0.6209	17,828
6	-	(2,021)		575,769	0.0563	32,416	30,394	0.5645	17,157
7	-	(2,112)		575,769	0.0563	32,416	30,304	0.5132	15,551
8	-	(2,207)		575,769	0.0563	32,416	30,208	0.4665	14,092
9	-	(2,307)		575,769	0.0563	32,416	30,109	0.4241	12,769
10		(2,410)	(1,770)	575,769	0.0563	32,416	28,235	0.3855	10,886
11	-	(2,519)		575,769	0.0563	32,416	29,897	0.3505	10,479
12	-	(2,632)		575,769	0.0563	32,416	29,784	0.3186	9,490
13	-	(2,751)		575,769	0.0563	32,416	29,665	0.2897	8,593
14	-	(2,875)		575,769	0.0563	32,416	29,541	0.2633	7,779
15		(3,004)	(1,770)	575,769	0.0563	32,416	27,642	0.2394	6,617
16	-	(3,139)		575,769	0.0563	32,416	29,277	0.2176	6,371
17	-	(3,280)		575,769	0.0563	32,416	29,136	0.1978	5,764
18	-	(3,428)		575,769	0.0563	32,416	28,988	0.1799	5,214
19	-	(3,582)		575,769	0.0563	32,416	28,834	0.1635	4,715
20	-	(3,743)		575,769	0.0563	32,416	28,672	0.1486	4,262
								Total	27,700

Results:

Discount Rate	10	%	NPV:	27,700	US$
Electricity tariff	0.0563	US$/kWh	IRR :	12	%
Energy generation	575,769	kWh/year	B/C Ratio :	1.12	
	32,416	US$/year	Payback Period :	14.79	Year(s)
Initial Investment	227,150	US$	Unit Energy Cost :	0.0502	US$/kWh

5.8 Results and Discussion

The feasibility study of the project was based on the assumption such as the discount rate was 10%, electricity tariff was 0.0563 US$/kWh and the potential energy generation of the new Nam Dong MHP was 575,769 kWh/year .The economic project life was 20 years period, the results of this project is summarized in the table 5.9.

Table 5.9 The economic analysis results

No.	Descriptions	Result	Unit
1)	Project cost	227,150	US$
2)	Net Annual Energy Production Potential	575,769	kWh/year
3)	Annual receipts	32,416	US$
4)	Net Present Value (NPV)	27,700	US$
5)	Benefit-Cost ratio (B/C)	1.12	
6)	Payback Period	14.79	Year (s)
7)	Internal Rate of Return (IRR)	12	%
8)	Unit Energy Cost	0.0502	US$/kWh

The economic key indicators indicated that the Benefit-Cost ratio was greater than 1. The project could earn more than an investment while the Unit Energy Cost was lower than the import tariff form PEA Thailand. The IRR was greater than discount rate of 10%, and obviously would be considered as “bank able” if founding to be sought from ADB bank for evaluation of economic viability of the project in Lao PDR [10]. Further more, when the New Nam Dong MHP has been planned to develop, it could promote the existing Nam Dong hydropower plant for producing more electrical energy and could manage the water supply for improving its plant factor.

5.8.1 Economic Evaluation

The evaluation of the project viability is defined in variation by the following parameters :

1) Variation of Discount Rate

The discount rate at 8%, 10%, 12% and are examined. The results of this study was demonstrated in table 5.10 (the details see appendix B, table B.5).

Table 5.10 Results of economic evaluation in variation discount rate.

Discount rate	Unit Energy Cost	NPV (US$)	B/C Ratio	IRR (%)
8%	0.0441	66,167	1.28	12%
10%	**0.0502**	**27,700**	**1.12**	**12%**
12%	0.0566	(3,139)	0.99	12%
15%	0.0667	(38,955)	0.84	12%

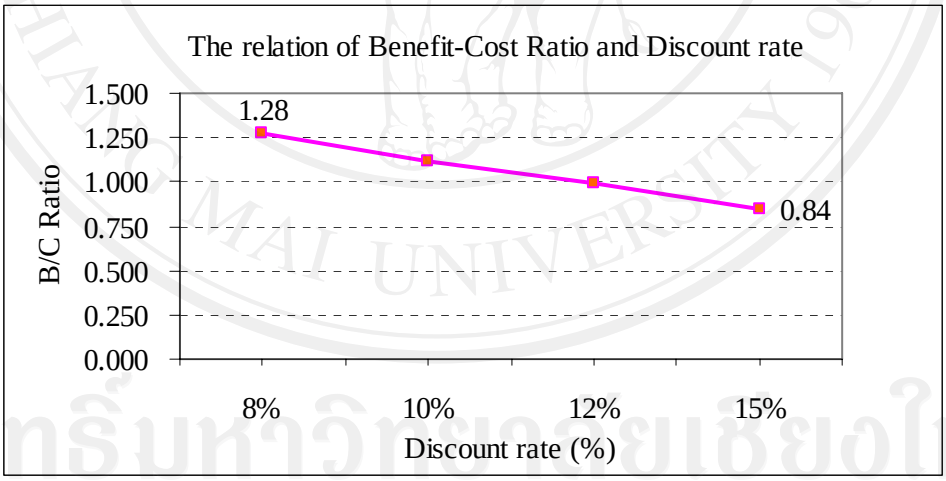

Figure 5.11 The of Benefit-Cost ratio in variation Discount rate

As seen in the table 5.10 and figure 5.11, base on the economic assumption the electricity tariff was 0.0563 US$/kWh. It was found that the B/C ratio was greater than 1 by the discount rate in range (6% to 10%). However, the B/C ratio was lower than 1 in case of the discount rate is greater than 10%.

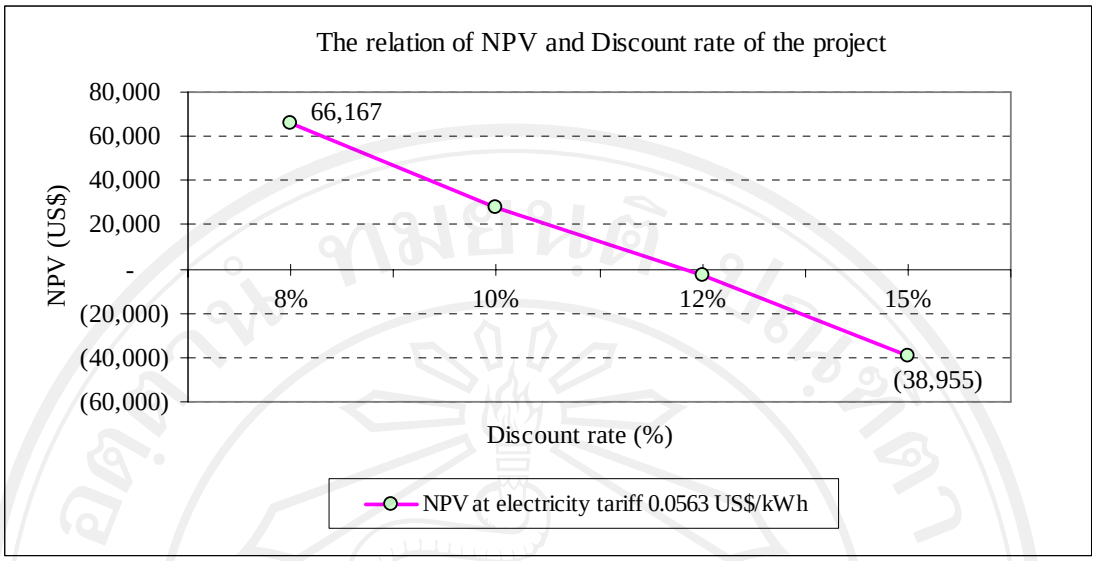

Figure 5.12 The NPV in variation Discount rate.

The similar result shown in figure 5.12, the NPV was lower than zero when the discount rate was greater than 10%. Therefore, the project would be infeasible incase of electricity tariff was 0.0563 US$/kWh and discount was grater than 10% with the project cost 227,150 US$.

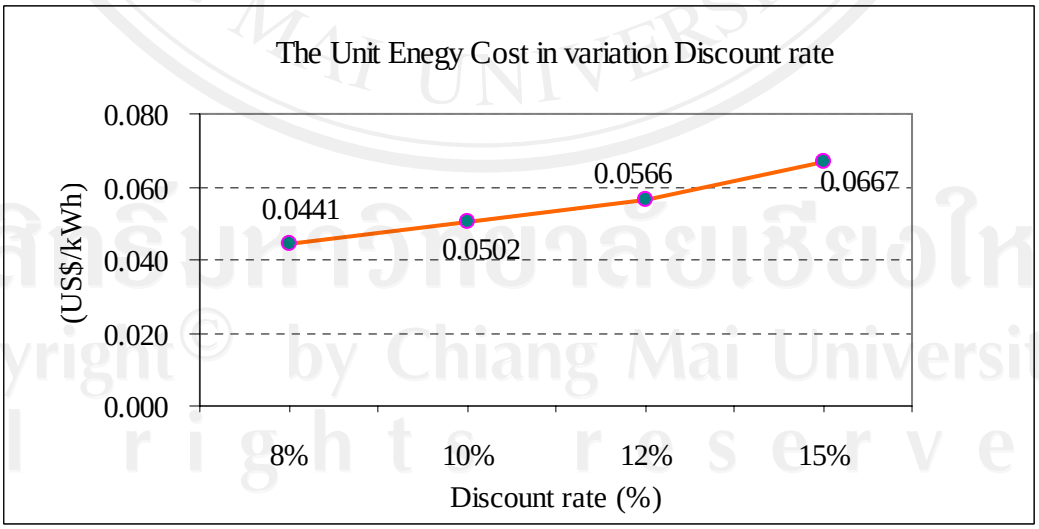

Figure 5.13 The Unit Energy Cost incase of variation discount rate

As seen in figure 5.13, the Unit Energy Cost of the project in varies discount rates. It was a proportion to the discount rate. It was lower than the import tariff from PEA Thailand of 0.0563 US$/kWh at discount rate was greater than 10%. Therefore, when the discount rate is increased, it will be increased too.

2) Evaluate the project by increasing the project Cost

The study was considered cost of the project by the year 2008. The project might be implemented in the future; the cost of the project will be increased in term of the growth of inflation rate. It was therefore, the evaluation of the project viability considering to percentage of the increment of costs of the project based on the following assumption

Assumption at Base case

Project cost	227,150 US$,
Discount rate	10%,
Electricity tariff	0.0563 US$/kWh.

Variation of cost of the project at increment rate 10%, 20%, 30% and 40% and the results of the evaluation of the project was shown in table 5.11, figure 5.14 and 5.15 (See the details in appendix B, table B.5).

Table 5.11 Results of economic evaluation in case of increment project.

Cases	Project cost (US$)	NPV (US$)	B/C	IRR (%)	Unit Energy Cost (US$/kWh)	Payback period (years)
Base case	**227,150**	**27,700**	**1.12**	**12%**	**0.0502**	**14.79**
10%	249,865	4,985	1.03	10%	0.0548	18.85
20%	272,580	(17,730)	0.95	9%	0.0595	-
30%	295,295	(40,445)	0.88	8%	0.0641	-
40%	318,010	(63,160)	0.82	7%	0.0687	-

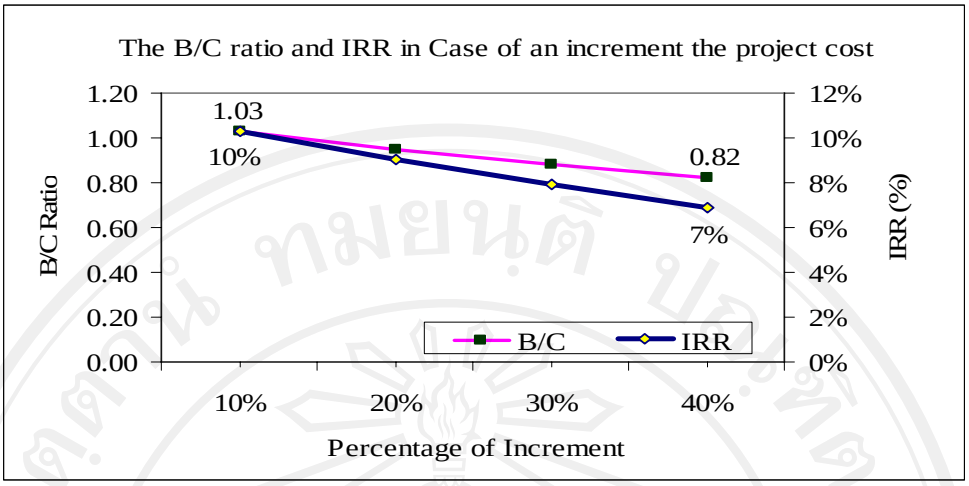

Figure 5.14 The B/C ratio and IRR by increasing cost of the project.

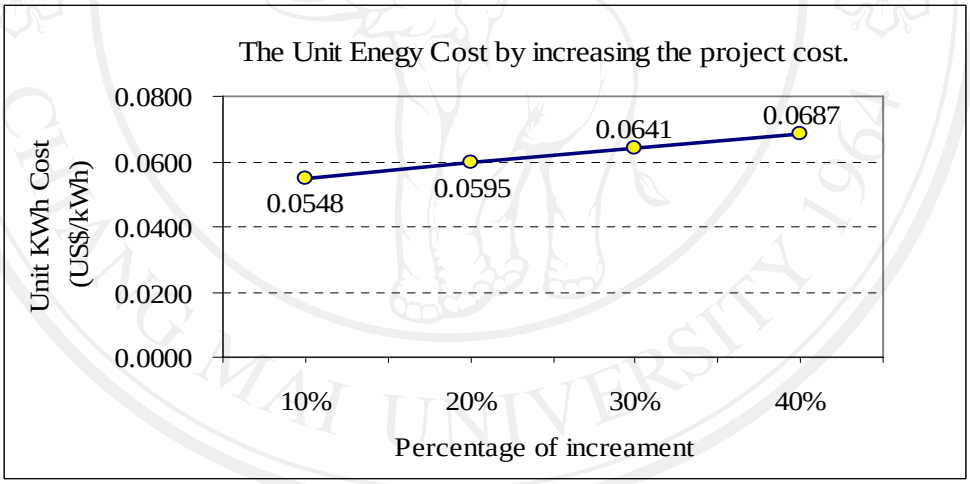

Figure 5.15 The Unit Energy Cost by increasing cost of the project

As seen in figure 5.14 and 5.15, it was indicated that when the project cost was increased 10% of an initial investment cost of 227,150 US$. The project is feasible at the base case of the discount rate is 10% and the electricity tariff was 0.0563 US$/kWh. However, when project cost is increased more than 20% of initial investment cost, the B/C ration was lower than 1. The Unit Energy Cost is greater than an average the import tariff 0.0563 US$/kWh, the project would be infeasible. Therefore, the development for New Nam Dong MHP should be carefully considered for an increment cost during the implemented of the project.

5.9 Conclusion

The results of the feasibility study for New Nam Dong MHP can be concluded as follows :

1) Incorporation of the plant structure connects at the tailrace existing Nam Dong hydropower plant. The project is technically and economically feasible.

2) The steel pipe with the inside pipe diameter 0.574 m and the total pipe length 345 m and completed with the standard support is designed for the New Nam Dong MHP Project.

3) The powerhouse is planned to construction near the Nam Dong river bank. It is an indoor type and designed as concrete structure for 1 propeller turbine and generation facilities,

4) The suitable installed capacity is 100 kW. The annual energy generation potential from the New Nam Dong MHP project is approximately 587,519 kWh/year,

5) The 22kV distribution line from New Nam Dong MHP from the powerhouse to the EDL existing distribution line is about 0.5 km long,

6) The total project cost 227,150 US$/100 kW,

7) The results of economic analysis based on an average import rate form PEA Thailand electricity tariff of 0.0563 US$/kWh and discount rate 10%. It was indicated that the project is economically acceptable. The results are summarized as follows :

Internal Rate of Return (IRR)	12%
Benefit-Cost ratio (B/C)	1.12
Net Present Value (NPV)	27,700 US$
Payback period	14.79 years
Unit Energy Cost	0.0502 US$/kWh.