Study on Economic Partnership Projects

in Developing Countries in FY2016

Study on Independent Power Producers (IPPs) in Lao People's Democratic Republic

Final Report

February 2017

Prepared for:

Ministry of Economy, Trade and Industry

Prepared by:

Tokyo Electric Power Company Holdings, Inc.
Hokuriku Electric Power Company, Inc.

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Preface

This report puts together the findings and results of Economic Partner Projects for Fiscal Year 2016 undertaken by Tokyo Electric Power Company Holdings Inc., together with Hokuriku Electric Power Co., contracted and funded by the Ministry of Energy, Trade and Industry of Japan.

This study, "Project Identification Study on Independent Power Producers (IPPs) in Lao People's Democratic Republic," aimed to identify several IPP projects for investment targets in the country and survey the maturity, hydrology, socio-environmental conditions, sponsors' requirements, etc. of hydropower projects, in close collaboration with candidate sponsors for investment and with attentive assistance from the Ministry of Energy and Mines, the Ministry of Planning and Investment, and several Prefecture Offices in Lao PDR.

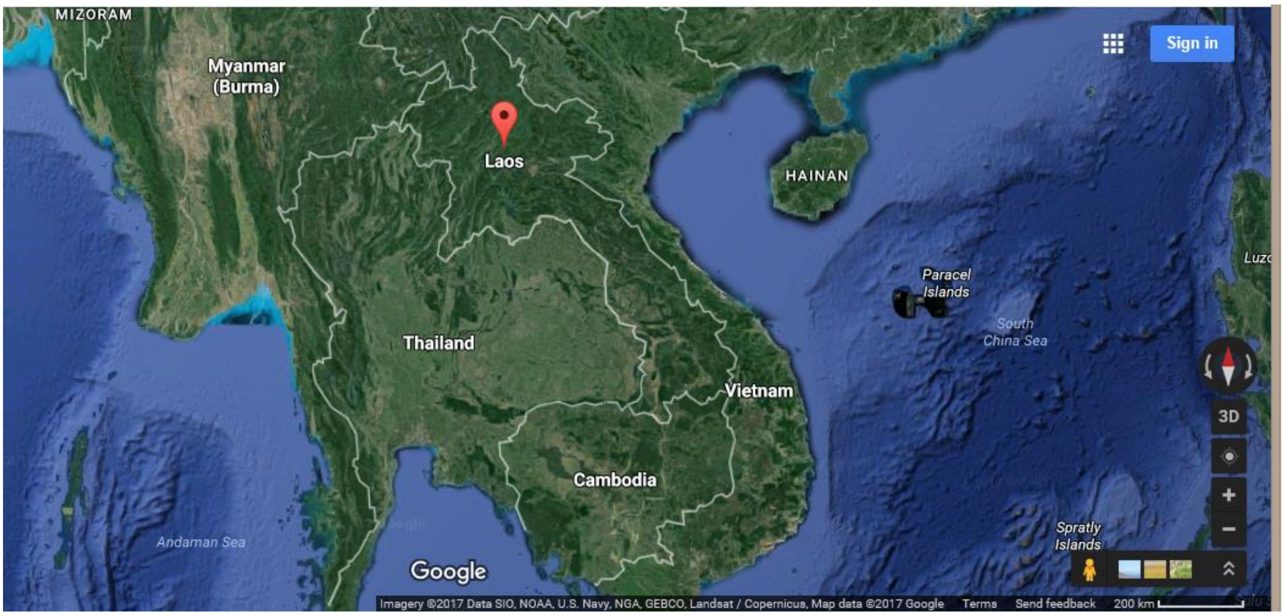
We strongly hope that this report helps to realize these projects and that it will serve as a useful reference for related parties in Japan.

February 2017

Tokyo Electric Power Company Holdings, Incorporated

Hokuriku Electric Power Company, Incorporated

Project map



Source: Study team based on GoogleMap

List of abbreviations

Abbreviation	Definition
ADB	Asian Development Bank
ASEAN	Association of South East Asian Countries
CA	Concession Agreement
COD	Commission of Day
DEB	Department of Energy Business
DEPP	Department of Energy Policy And Planning
DSCR	Debt Service Coverage Ratio
EBRD	European Bank for Reconstruction and Development
EDL	Electricite du Laos
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
F/S	Feasibility Study
GDP	Gross Domestic Product
GIS	Geographic Information System
GW	Giga Watt
GWh	Giga Watt Hour
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IPPs	Independent Power Producers
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
MEM	Ministry of Energy and Mines
METI	Ministry of Economy, Trade and Industry
MOF	Ministry of Finance
MOI	Ministry of Industry
MONRE	Ministry of Natural Resources And Environment
MOU	Memorandum of Understanding
MPI	Ministry of Planning and Investment
MW	Mega Watt
MWh	Mega Watt Hour
NEDO	New Energy and Industrial Technology Development Organization
ODA	Official Development Assistance
PDA	Project Development Agreement
PECC1	Power Engineering Consulting joint stock Company 1
PPA	Power Purchase Agreement
PPP	Public Private Partnership
SIA	Social Impact Assessment

SPC	Super Purpose Company
USD	United States Dollar
UXO	Unexploded Ordnance

Contents

Summary

(1) Background and circumstances of the survey

In Laos, where hydropower resources are abundant, domestic electric power demand is increasing due to steady economic growth, and progress in urban and industrial park development, and many power development projects to be undertaken by independent power generation entities (IPPs) have been planned.

As of the end of 2015, there were over 300 projects such as these that had not yet come to fruition even after obtaining MOUs for development, and numerous projects both good and bad have been presented to foreign investors, including Japan, by the candidate sponsors. Under these circumstances, Japanese electric utility companies have also considered the possibility of conducting multiple hydropower projects in Lao PDR, but they could not ascertain what kind of pros and cons each individual project has compared to the others across more than 300 cases. They also did not know the details of concession contracts and electricity purchase contracts and how they would develop. Therefore, they were interested in business investment but had not yet reached the point of selecting specific projects and proceeding with commercialization.

(2) Identification of promising investment projects

The study team narrowed down potential areas by scale of project (above 15MW or less than 15MW), as well as by status of project (existing, under construction or after MOU signing), based on the latest IPP list as of the end of June 2016. In addition, through a series of consultations with the relevant central and local government offices, the study team confirmed the maturity of projects and long-listed sponsors who have MOUs for one or more projects over 15MW in promising potential areas in the country. Finally, the study team short-listed those sponsors for possible direct contact and made contact with sponsors who own development rights such as MOU, then held discussions with sponsors who were interested in collaborating with Japanese investors.

Ultimately, 4 projects for which we were granted disclosure of technical documents such as the F/S through discussion after the field survey were selected as candidate projects for investment.

(3) Outline of candidate projects

Through the aforementioned identification process in (2), Nam Ngiep 2C, 2B and 2A, undertaken by Nonghai Group, and Nam Ban, undertaken by ECI, were eventually selected as candidate projects.

Nonghai Group has signed MOUs with Xiengkhouan Province for Nam Ngiep 2C, 2B and 2A. The F/S defined the project as cascade projects on the same river. In 2013 the project names changed from Nam Hai 2C, 2B and 2A to Nam Ngiep 2C, 2B and 2A. HEC Engineering (Vietnam) and PECC1 (Vietnam) completed basic designs for the three projects. Contracts for detailed designs and EPCs were conducted separately with other firms.

ECI signed an MOU with Phongsaly Province for Nam Ban and has retained IETL (Thailand) as a contractor for the F/S, which is currently underway. Nam Ban is a reservoir type and expected to have PPA with seasonal and peak/off-peak price differentials.

The study team evaluated the water flow setting, effective height setting and construction costs for these four projects in order to confirm the accuracy and feasibility of their power generation planning from a technical point of view.

（4） Challenges from the Viewpoint of Japanese Companies

(1) Take-or-pay clause

Majority of EDL's PPAs effectively entail the take-and-pay clause, whereby EDL pays only for the volume of electricity generated and bought at the predetermined unit cost. In turn, only a few PPAs, with generation capacity of more than 100MW, have the take-or-pay clause, whereby EDL pays out predetermined amount of fee, regardless of the volume of electricity generated and bought, at least for the period of loan tenure.

When Japanese electric power companies invest in domestic IPP as sponsor, it is inevitable to secure the take-or-pay clause, regardless of the generation capacity, in order for obtaining project financings from Japanese governmental financial institutions and their possible co-lenders.

(2) Settlement currency

The model PPA and MEM's Regulation on Domestic IPPs Purchasing Price (May 2016) use USD as the denomination currency. However, as an example, the model PPA exhibits its settlement currency as follows.

・1 to 12 year USD 70％, LAK 30％

・13 to 27 year USD 20％, LAK 80％

EDL says that the formula, though example, is intended to minimize the currency risk, as the EDL's receivables from distribution business is essentially in LAK. However, as far as the contracted price is denominated or determined (and regulated) in USD, even if settlement currency is LAK, then the currency risk is not alleviated. Rather it is likely that debt financing of IPP project companies are disadvantaged by the portion of LAK, which has virtually no circulation outside the country. When Japanese electric power companies invest in IPP as sponsor, it is inevitable to secure all or almost all settlement in USD, or in another word, minimal to zero settlement in LAK.

（5） Insufficiency under the Current Regulations and Requested Deregulation

(1) Insufficiency

The Law on Electricity gives the approval authority to the central government and provinces or city, respectively, more than 15MW and up to 15MW in generation capacity. Coordination and information sharing between the central government and provinces/city is not necessarily sufficient, and consequently duplicated projects approval takes place in the adjacent areas on the same river flow.

The draft amendment of the Law envisages to limit the approval authority of provinces and city up to 2MW. As there are not so many projects with less than 2MW, the chance of duplicated projects approval shall be significantly decreased, should the draft amendment pass. Nevertheless, the coordination and information sharing between the central government and provinces and city needs to be strengthened anyway.

(2) Requested Deregulations

The Law on Electricity provides for that power development projects with generation capacity of up to 15MW are reserved for Lao citizens (which may implicitly include juristic persons which are majority owned by Lao). Japanese electric power companies may also invest in a project up to 15MW or a set of such projects in the cascaded manner, hence may want to request for deregulation on this nationality limitation.

Capter1 Introduction

(1) Background and circumstances of the survey

Laos is blessed with hydroelectric power resources to the extent that it is called the "ASEAN battery", and it exports electricity to neighboring countries such as Thailand. In addition, due to steady economic growth, and progress in urban and industrial park development, domestic electric power demand is also increasing, and many power development projects for domestic demand are being planned. The electric utilities in Lao PDR have already been separated, and independent power generation entities (IPPs) are responsible for domestic power development. Electricite Du Laos (EDL), which is responsible for transmission and distribution, is the off-taker.

In Lao PDR power development, the Ministry of Energy and Mines (MEM) has the authority to approve projects of over 15 MW, and prefectures can approve projects of over 1 MW. As of the end of 2015, 234 cases (54 in MEM's jurisdiction; 180 in prefectural affairs' jurisdiction) were undergoing Feasibility Study (F/S) preparations, which is the first phase of the approval procedure. There were 27 cases at the second stage of F/S implementation (13 MEM projects, 14 prefectural affairs projects), and 55 projects at the project development stage, which is the third stage (24 in MEM's jurisdiction 24; 31 of prefectural jurisdiction). There are over 300 projects such as these that have not yet come to fruition, and numerous projects both good and bad have been presented to foreign investors, including Japan, by the candidate sponsors.

Meanwhile, purchases by EDL, such as period, contract size, place, price and rated capacity, have not been standardized and institutionalized, but are conducted only by negotiation.

Under these circumstances, Japanese electric utility companies have also considered the possibility of conducting multiple projects with Laos Hydropower, but they could not ascertain what kind of pros and cons each individual project has compared to the other projects in more than 300 cases. They also did not know the details of concession contracts and electricity purchase contracts and how they would develop. Therefore, they were interested in business investment but they have not yet reached the point of selecting specific projects and proceeding with commercialization.

(2) Purpose of survey

The aim of this survey is to discover multiple IPP projects that can become business investment projects, with the cooperation of the Ministry of Energy and Mining (MEM), the Ministry of Planning and Investment, and several prefectures, through consultation with companies that are candidates for joint investment. We will examine matters such as project maturity, water volume, environmental and social conditions, and the appropriateness of sponsor candidates.

(3) Survey method

1) Content of survey

(a) Review of power sector structure, power development plan and power laws and extraction of points for improvement

(b) Review of the IPP business system for domestic and system improvement recommendations

- Purchase fee, concession contract, power purchase agreement, stricter qualification of sponsors etc.

(Including trends and results of technical assistance by World Bank)

- Presentation of directions such as institutional improvement support and institutional transfer by Japan

(c) List and review approved cases

- Listing of cases divided into Ministry of Energy and Mineral Resources (MEM) jurisdiction (over 15 MW) and prefecture office jurisdiction (less than 15 MW)

(d) Collecting information on the sponsors

- Screening of listed projects (prioritization by scale, project maturity, environmental and social constraints, topography, flow rate, etc.)
- Selection of promising areas (water system or prefecture unit) based on the screening results (1 or 2 areas in northern and southern Laos respectively)

(e) Exchanging of views with relevant central and local government agencies, candidate sponsors, etc.

- Explain about Japan's high-quality hydroelectric power generation know-how and JICA's overseas investment and financing

(f) Approach to candidate sponsors and selection of investment candidate projects

- Collecting information by direct contact with development rights owners that have promising projects, confirming issues in project formulation, confirming cooperative intention with Japanese investors
- Scrutinize investment candidate projects (technology/economic finance, commercial review, confirmation of environmental and social considerations matters)
- Gather and pick multiple candidate projects for investment consideration and formulate implementation plan for commercialization
- Calculation of quantitative effects on Japan's stable supply of energy through implementation of candidate projects

2) Survey method / organization

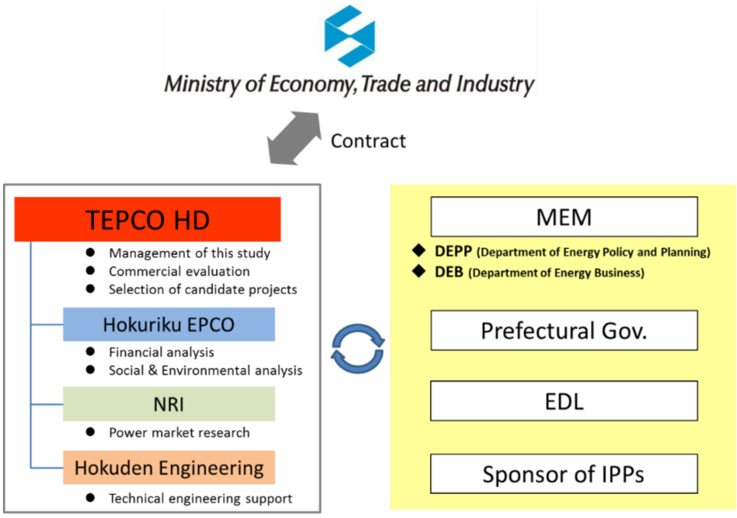
(a) Counterpart

The counterpart on the Laos country side is MEM. For the bureau, the Department of Energy Policy and Planning (DEPP) and Department of Energy Business (DEB) are the counterparts.

The following will be the relevant government agencies/institutions.

- MEM : Ministry of Energy and Mines
- MPI : Ministry of Planning and Investment
- MONRE : Ministry of Natural Resources and Environment
- MOF: Ministry of Finance
- EDL

Figure 1.1 Collaboration with Laos

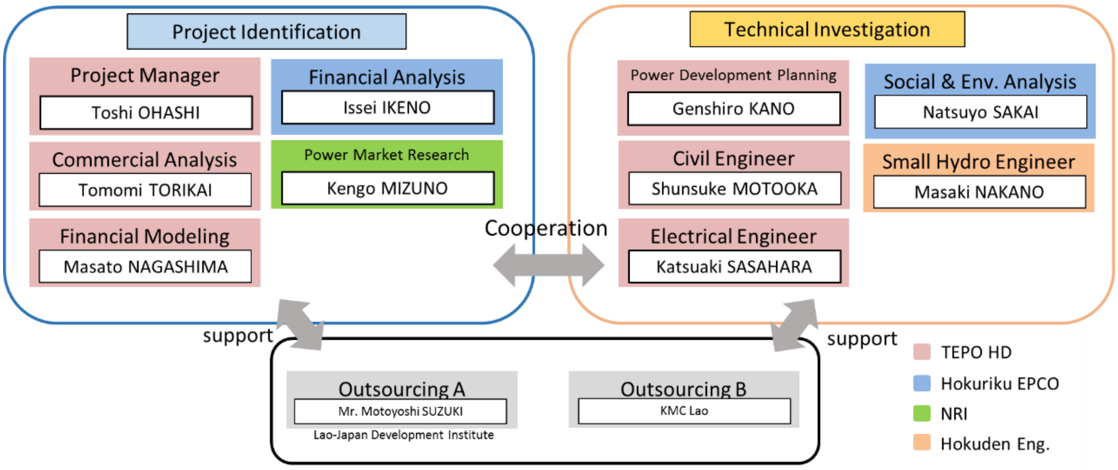


Source: study team-created

(b) Structure and roles of the study team

Figure 1.2 shows the implementation structure for this survey work.

Figure 1.2 Implementation system

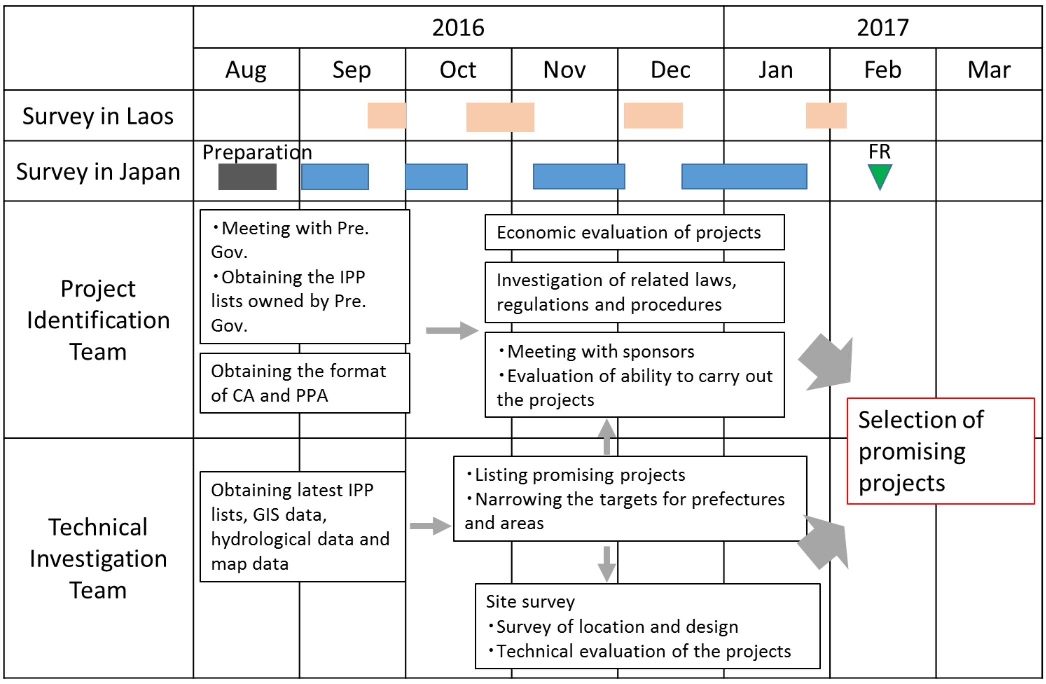


Source: study team-created

3) Survey schedule

The implementation schedule and flow for this survey are shown in Table 1.1.

Table 1.1 Implementation schedule and flow for the entire survey



Source: study team-created

4) Survey results

The study team conducted the first on-site survey in September. We held discussions and exchanged views with DEPP, DEB and related organizations from MEM, which is the counterpart, and gathered the necessary information.

Table 1.2 Main implementation items in field surveys

Survey	Period	Main implementation items
First field survey	20 September 2016 - 29 September 2016	○Meetings with related ministries and agencies, EDL ・Agreement with MEM DEPP and DEB as counterparts ○Meetings with sponsors ・Meetings with three sponsors who have projects of over 15 MW ○Visiting a prefecture office ・Visiting Xiengkhouang prefecture office to discuss the role sharing between the country and the prefecture, the procedure for hydropower IPP development rights, and the problems in development ・Obtain the IPP list that the prefecture office has ○Obtaining necessary information Map, river flow rate, rainfall data etc.
Second field survey	23 October 2016 - 5 November 2016	○Meetings with sponsors ・Meetings with five sponsors, collecting project information and discussing possibility of participation ・Sorting relationships for joint development projects ○Visiting prefecture offices ・Visiting six prefecture offices and hearing about the differences in the procedures for granting development rights and the problems in development ・Acquisition of IPP lists each prefecture office has ○Field surveys ・Implement site surveys at 5 locations and conducted technical evaluations ・Share survey results with wrap-up sponsors in wrap-up meeting ○Obtaining necessary information ・GIS, PPA/CA Format etc.
Third field survey	4 December 2016 - 17 December 2016	○Visiting Government institutions ・Interview EDL on the conditional aspects of PPA contract etc. ・Confirm the laws related to hydraulic investment with MPI ○Meetings with sponsors ・Meetings with 4 sponsors, collecting project information ・Discuss the issues regarding project promotion ○Visiting a prefecture office ・Visiting a prefecture office and discussing the differences in the procedures for granting development rights and the problems in development ○Field surveys ・Implement site surveys at 3 locations and conducted technical evaluations ・Share survey results with sponsors via wrap-up meeting ○Obtaining necessary information ・Environment-related documents

		・Water resource-related materials
Fourth field survey	29 January 2017 - 8 February 2017	○Visiting Government institutions ・Confirming the power laws and government guarantee with MEM ・Confirming the PPA on IPP with EDL ・Share survey results in wrap-up meeting ○Meetings with sponsors ・Meetings with sponsors, collecting project information ・Meetings about PPA conditions and government guarantee

Source: study team-created

Capter2 Overview of the Host Country and Sector

(1) Economy

Lao PDR is a land-locked country in Southeast Asia, neighboring Cambodia, China, Thailand, Vietnam and Thailand. The land area is 236,800 sq. km, approximately 70% of which is mountains and hills, and it is vested with abundant water resources from tributary rivers flowing into the Mekong River. The population is approximately 6.5 million, and it is the third least populated country in the ASEAN after Brunei Darussalam and Singapore. Key economic indicators are as follows.

(a) GDP

- Nominal GDP: LAK 98,835 billion, approximately USD 11.7 billion (Bank of Lao PDR, 2014)
- GDP per capita: USD 1,725 (Lao Statistics Bureau, 2014)
- GDP growth rate: 7.56％（Lao Statistics Bureau, 2014）
- GDP composition: Agriculture 26%, Industry 31%, Service 37% (Lao Statistics Bureau, 2012)

(b) FDI

In 2015, the largest FDI was the power generation subsector, comprising 2 projects with USD 568 million investment, while the largest by project number was the mining subsector, comprising 9 projects with USD 184 million investment. This implies how large the power generation projects were. By country, Vietnam was the largest investor origin, comprising 3 projects with USD 466 million investment.

Cumulative investment from 1989 to 2014 by subsector and by country is shown in Tables 2.1 and 2.2. The power generation subsector tops the investment amount (USD 6,671 mil.), while the agriculture subsector tops the number of projects (989 projects). By country, China ranks top, followed by Thailand and Vietnam, whereas Japan ranks 6th.

Table 2.1 Cumulative FDI by Subsector (1989-2014)

No.	Subsector	Projects	Investment（USD mil.）
1	Power generation	47	6,671
2	Mining	303	5,687
3	Agriculture	989	2,770
4	Service	664	2,533
5	Handicraft	926	1,972
6	Hotel and restaurant	429	1,023

Source: Study team based on MPI data

Table 2.2 Cumulative FDI by Country Origin (1989-2014)

No.	Country	Projects	Investment（USD mil.）
1	China	830	5,397
2	Thailand	746	4,455
3	Vietnam	421	3,394
4	South Korea	291	751
5	France	223	491
6	Japan	102	438

Source: Study team based on MPI data

(c) Trade

Trade in goods during 2014/15 is shown in Table 2.3. Lao PDR sells approximately 80% of its power generation to neighboring countries such as Thailand and Vietnam.

Table 2.3 Trade in Goods (2014/15)

	Exports	Imports
Amount	USD 3.4 billion	USD 4.3 billion
Main commodity	Copper and copper products, electricity	Electric devices, machines, fuel
Main counterpart	Thailand, China, Vietnam, etc.	

Source: Study team based on Japan's Ministry of Foreign Affairs website

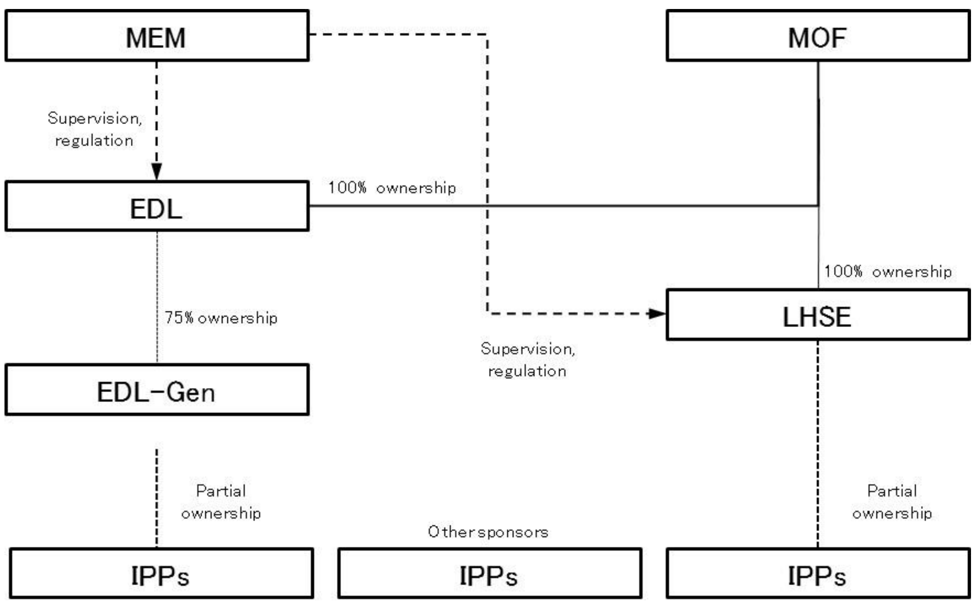
(2) Electricity Sector

1) Outline

Among ministries, MEM is responsible for the electricity sector. EDL is a state owned enterprise, and takes charge of transmission and distribution. While EDL still owns a few generation facilities, the vast majority of generation capacity has been transferred to EDL-Gen, its subsidiary, since December 2010. In addition, a number of IPPs are generating electricity and selling it to domestic and export markets. The main off-taker for exports is EGAT in Thailand, and the main off-taker for the domestic market is EDL.

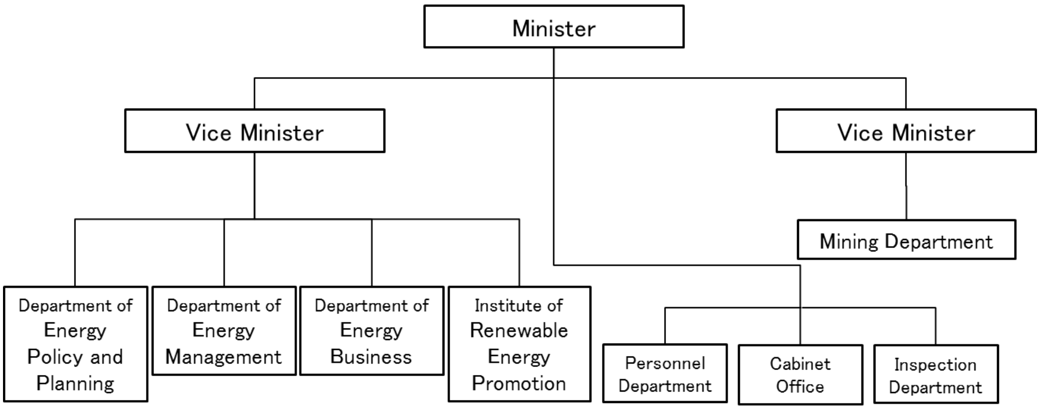
The current structure of the electricity sector is shown in Figure 2.1. DEPP of MEM is responsible for energy and electricity policy, power supply and demand forecast, electricity tariff regulation, etc.

Figure 2.1 Electricity Sector Scheme in Lao PDR



Source: Study team

Figure 2.2 MEM Organizational Figure



Source: Study team based on MEM information

2) Vision

The 10th Party General Assembly in January 2016 adopted "Vision 2030," "Ten-year Socioeconomic Development Strategy 2016-2025"and "8th National Socioeconomic Development Plan 2016-2020." Vision 2030 aims to quadruple GDP per capita by 2030, and lists strategic goals in the electricity sector as follows.

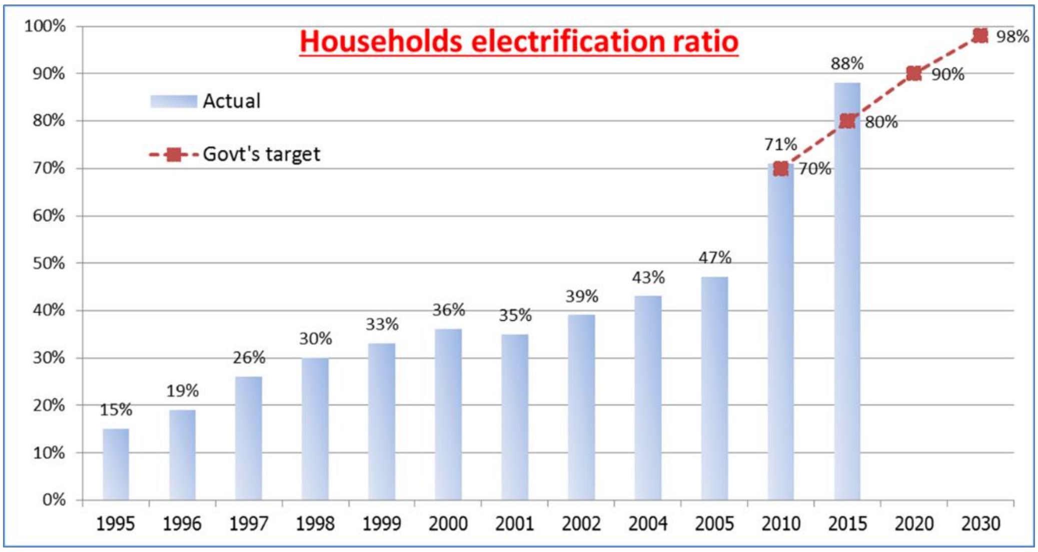
Figure 2.3 Electricity Sector under Vision 2030

- ✓ 98% household electrification ratio at reasonable cost
- ✓ Full usage of all available resources based on competitiveness, sustainability and efficiency
- ✓ Grid connection among ASEAN by strengthening and harmonizing transmission lines
- ✓ Supply of reliable electricity to all sectors based on industrialization and modernization policies

Source: MEM

Household electrification ratio in Lao PDR was 88% in 2015, and the government aims to increase it to 98% by 2030, as shown in Figure 2.4.

Figure 2.4 Households electrification ratio in Lao PDR



Source: MEM

(3) Situation of the target area

The purpose of the survey is to find the IPP project for domestic; therefore, the target area to be surveyed shall be the whole land of Lao PDR. Economic and financial situations of Lao PDR are as described in 2(1) Candidate projects will be selected and evaluated in the subsequent chapters, so the status of individual location areas will be described separately.

Capter3 Identification of promising investment projects

(1) The long list of projects

The hydropower projects listed by status in Laos are shown below.

1) Existing hydropower plants

Table 3.1 shows the hydropower projects that are already operating and are over 15 MW.

There are 18 plants, the total capacity is 1,788 MW, and the total annual energy is 8,064 GWh.

Table 3.1 Existing hydropower plants (over 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual Energy [GWh/y)]	COD	Developer	Off-taker
1	Nam Ngeum 1	Nam Ngeum	Kaeoudom	Vientiane	155	1,160	1971	EDL_GEN	EDL
2	Se Set 1	Se Kong	Laongam, Salavan	Salavan	45	134	1991	EDL_GEN	EDL
3	Nam Loek	Nam Ngeum	Longsan	Saisombun	60	218	2000	EDL_GEN	EDL
4	Nam Mang 3	Nam Loek	Thulakhom	Vientiane	40	150	2009	EDL_GEN	EDL
5	Se Set 2	Se Kong	Laongam	Salavan	76	309	2009	EDL_GEN	EDL
6	Nam Liik 1-2	Nam Ngeum	Feuang	Vientiane	100	435	2010	CWE (China) 80% EDL_GEN 20%	EDL (IPP internal use)
7	Nam Ngeum 5	Nam Ngeum	Phu Kut	Xiengkhwang Luangphabang	120	507	2012	Sinohydro (China) 85% EDL_GEN 15%	EDL (IPP internal use)
8	Nam Nyuwang 8	Nam Theun	Khamkoet	Bolikhamsai	60	316	2013	EDL_GEN 60% GMS Power (Thailand) 20% Statkraf 20%	EDL
9	Nam Ngiap 3A	Nam Ngiap	Khun	Xiengkhwang	44	152	2014	TK construction	EDL (IPP internal use)
10	Huai Lamphan Nyai	Se Kong	Thataeng	Sekong	88	480	2015	EDL_GEN	EDL
11	Nam Ngiap 2	Nam Ngiap	Phasai	Xiengkhwang	180	732	2015	CWE (China) 90% EDL_GEN 10%	EDL (IPP internal use)
12	Nam San 3B	Nam San	Thathom	Saisombun	45	174	2015	Phongsapthawi construntion	EDL (IPP internal use)
13	Nam Khan 2	Nam Khan	Xieng Ngeun	Luangphabang	130	538	2015	EDL_GEN	EDL
14	Nam Baeng	Nam Baeng	Hun	Udomsai	36	145	2015	China National Electrical Equipment Corporation 80% EDL_GEN 20%	EDL (IPP internal use)
15	Nam Ou 2	Nam Ou	Ngoi	Luangphabang	120	548	2016	Sinohydro (China) 90% EDL_GEN 10%	EDL (IPP internal use)
16	Nam Ou 5	Nam Ou	Samphan	Phongsali	240	1,049	2016	Sinohydro (China) 90% EDL_GEN 10%	EDL (IPP internal use)
17	Nam Ou 6	Nam Ou	Phongsali	Phongsali	180	739	2016	Sinohydro (China) 90% EDL_GEN 10%	EDL (IPP internal use)
18	Nam San 3A	Nam San	Khun	Xiengkhwang	69	278	2016	Phongsapthawi construntion	EDL (IPP internal use)
Total					1,788	8,064			

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Table 3.2 shows the hydropower projects that are already operating and are less than 15 MW.

There are 13 plants, the total capacity is 67 MW, and the total annual energy is 342.41 GWh.

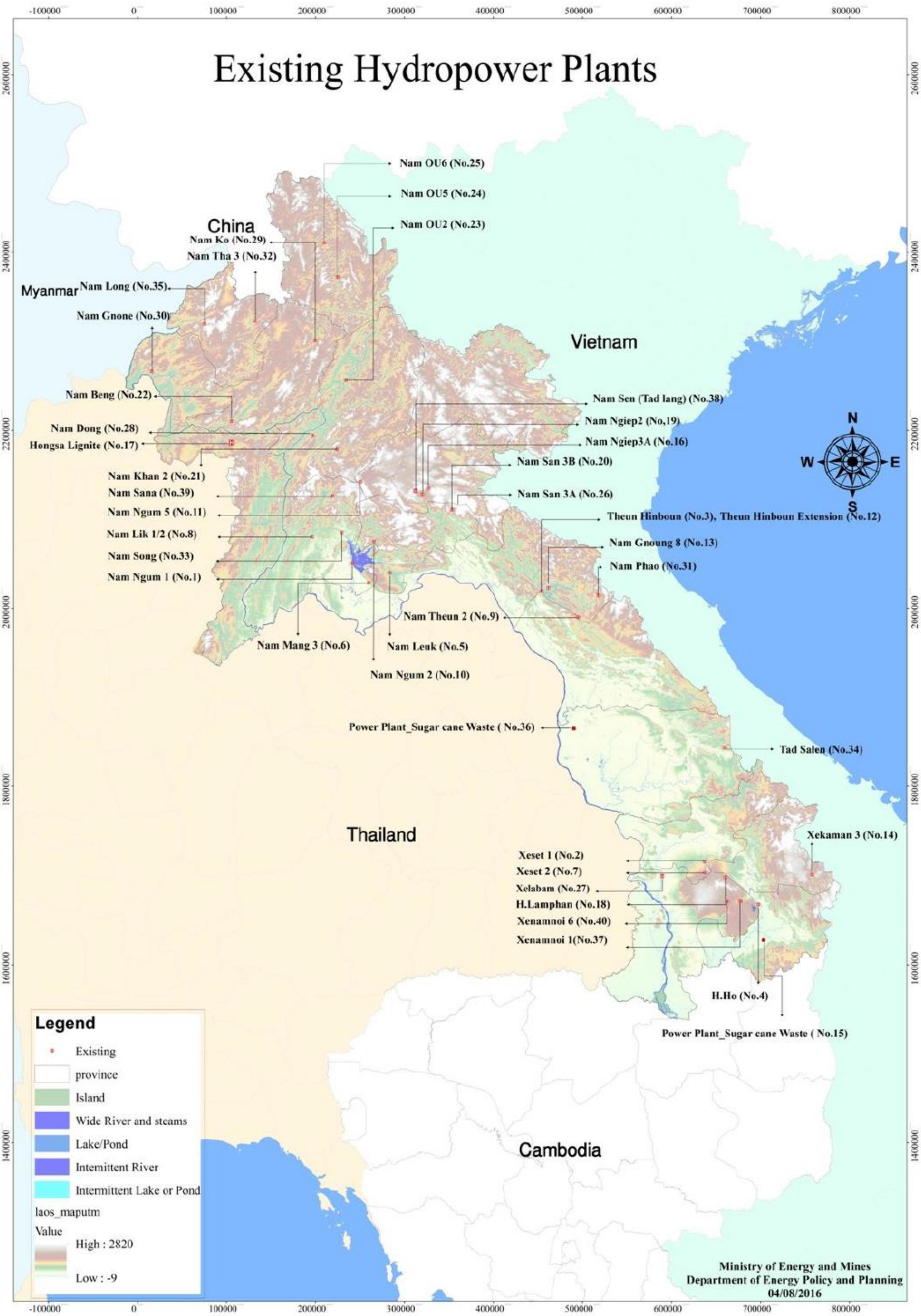
Table 3.2 Existing hydropower plants (less than 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual Energy [GWh/y)]	COD	Developer	Off-taker
19	Se Labam	Se Don	Sanasombun	Champasak	5	21	1970	EDL_GEN	EDL
20	Nam Dong	Nam Khan	Luangphabang	Luangphabang	1	5	1970	EDL	EDL
21	Nam Ko	Nam Ou	Sai, La	Udonsai	2	8	1996	EDL	EDL
22	Nam Nyon	Nam Nyon	Huaisai	Bokaeo	3	12	2011	MK Dynamic Resource Development Co., Ltd 70% CMC Engineering Co., Ltd 20% Giant Billion Overseas Inc 10%	EDL (IPP internal use)
23	Nam Phao	Nam Theun	Khamkoet	Bolikhamsai	2	9	2011	Simuang Group 87% Phathana Khet Phudoi 13	EDL (IPP internal use)
24	Nam Tha 3	Nam Tha	Nam Tha	Luang Namtha	1	6	2011	Huamchai Phathana	EDL (IPP internal use)
25	Nam Song (Expansion)	Nam Ngeum	Vang Viang	Vientiane	6	25	2012	EDL_GEN	EDL
26	Tat Salaen	Se Banghiang	Sepon	Sawannakhet	3	17	2012	SIC Manufacturer (Thailand) 100%	EDL (IPP internal use)
27	Nam Long	Nam Ma	Long	Luang Namtha	6	37	2013	Nam Long Power 80% Lao Government 20%	EDL (IPP internal use)
28	Se Namnoi	Se Kong	Paksong	Attapeu	15	101	2013	TK Construction	EDL (IPP internal use)
29	Nam Saen (Tat Lang)	Nam Ngiap	Phasai	Xiengkhwang	5	25	2014	Bo Thong Inter	EDL (IPP internal use)
30	Nam Sana	Nam Ngeum	Vang Viang	Vientiane	14	50	2014	EDL_GEN	EDL
31	Se Namnoi 6	Se Kong	Paksong	Champasak	5	27	2016	Phongsapthawi Construction	EDL (IPP internal use)
Total					67	342			

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Figure 3.1 shows the locations of existing hydropower plants.

Figure 3.1 Locations of Existing hydropower plants



Source: Updated Hydro Power List - June 2016 (MEM)

2) Hydropower projects under construction

Table 3.3 shows the hydropower projects under construction that are over 15 MW.

There are 21 plants, the total capacity is 2,596 MW, and the total annual energy is 11,677 GWh.

Table 3.3 Hydropower projects under construction (over 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Expected operation year	Developer	Off-taker	Status
1	Nam Kong 2	Se Kong	Phu Wong	Attapeu	66	263	2016	TK Construction	EDL (IPP internal use)	99%
2	Se Set 3	Se Kong	Paksong	Salawan	23	82	2016	EDL	EDL	86.43%
3	Nam Khan 3	Nam Khan	Xieng Ngeun	Luang Phabang	60	240	2016	EDL	EDL	95%
4	Nam Mang 1	Nam Mang	Longsan	Saisombun	64	445	2016	Dongfang 75% A&C 10.75% EDL 10% Saitha 4.25%	EDL (IPP internal use)	87%
5	Nam Hinbun	Nam Hinbun	Hinbun	Khammuan	30	197	2017	EDL	EDL	99%
6	Nam Jae	Nam San	Khun, Thathom	Saisombun	104	448	2017	EDL	EDL	76%
7	Nam Lik 1	Nam Ngeum	Hinhoep	Vientiane	64	256	2017	HEC 40% GPSC 40% EDL 10% POSCO 10%	EDL (IPP internal use)	39.90%
8	Nam Ngeum 1 expansion (Phase 1)	Nam Ngeum	Kaeoudom	Vientiane	80	61	2017	EDL (Loan from China Gov.)	EDL	44.37%
9	Nam Phai	Nam Ngeum	Saisombun	Saisombun	86	420	2017	Norinco International Corporation 85% EDL 15%	EDL (IPP internal use)	80.26%
10	Nam Tha 1	Nam Tha	Pha Udom	Bo Kaeo	168	759	2018	China Southern Grid Co.,Ltd 80% EDL 20%	EDL (IPP internal use)	27%
11	Nam Kong 3	Se Kong	Phu Wong	Attapeu	45	170	2019	Houang Anh Gialai 80% EDL 20%	EDL (IPP internal use)	preparing for const.
12	Don Sahong	Nam Khong	Khong	Champasak	260	2,009	2019	Mega First (Malaysia) 80% GOL 20%	EDL (IPP internal use)	8.80%
13	Nam Ngiap 1(under dam)	Nam Ngiap	Bolikhan	Bolikhamsai	18	105	2019	Kansai Electric (Japan) 45% EGAT Inter 30% LHSE 25%	EDL (IPP internal use)	38%
14	Nam Sam 3	Nam Sam	Samtai	Huaphan	156	626	2019	Phonsapthawi Construction	EDL (IPP internal use)	preparing for const. preparing for CA
15	Nam Mo (Nam Mo 2)	Nam Mo	Mokmai	Xiengkhwang	120	498	2020	Phonsapthawi Construction 37% Duang Chaloen Construction 31% Faifa Nam Mo (Vietnam) 18% Kan Kha Dong Toem (Vietnam) 14%	EDL (IPP internal use)	preparing for CA
16	Nam Ngeum 1 expansion (Phase 2)	Nam Ngeum	Kaeoudom	Vientiane	40	59	2020	EDL (Loan from Japan)	EDL	selecting construction company
17	Nam Ngeum 3	Nam Ngeum	Phun	Saisombun	480	2,146	2020	EDL Sinohydro Corporation Ltd	EDL	15.92%
18	Nam Ou 3	Nam Ou	Ngoi	Luang Phabang	210	826	2020	Sinohydro Corporation Ltd China National	EDL (IPP internal use)	preparing construction
19	Nam Ou 4	Nam Ou	Khwa	Phongsali	132	519	2020	Sinohydro Corporation Ltd China National	EDL (IPP internal use)	preparing construction
20	Nam Ou 7	Nam Ou	Phongsali	Phongsali	210	838	2020	Sinohydro Corporation Ltd China National	EDL (IPP internal use)	preparing construction
21	Nam Ou 1	Nam Ou	Pak Ou	Luang Phabang	180	710	2020	Sinohydro Corporation Ltd China National	EDL (IPP internal use)	preparing construction
	Total				2,596	11,677				

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Table 3.4 shows the hydropower projects under construction that are less than 15 MW. They are expected to start operation up to 2020.

There are 23 plants, the total capacity is 258 MW, and the total annual energy is 1,299 GWh.

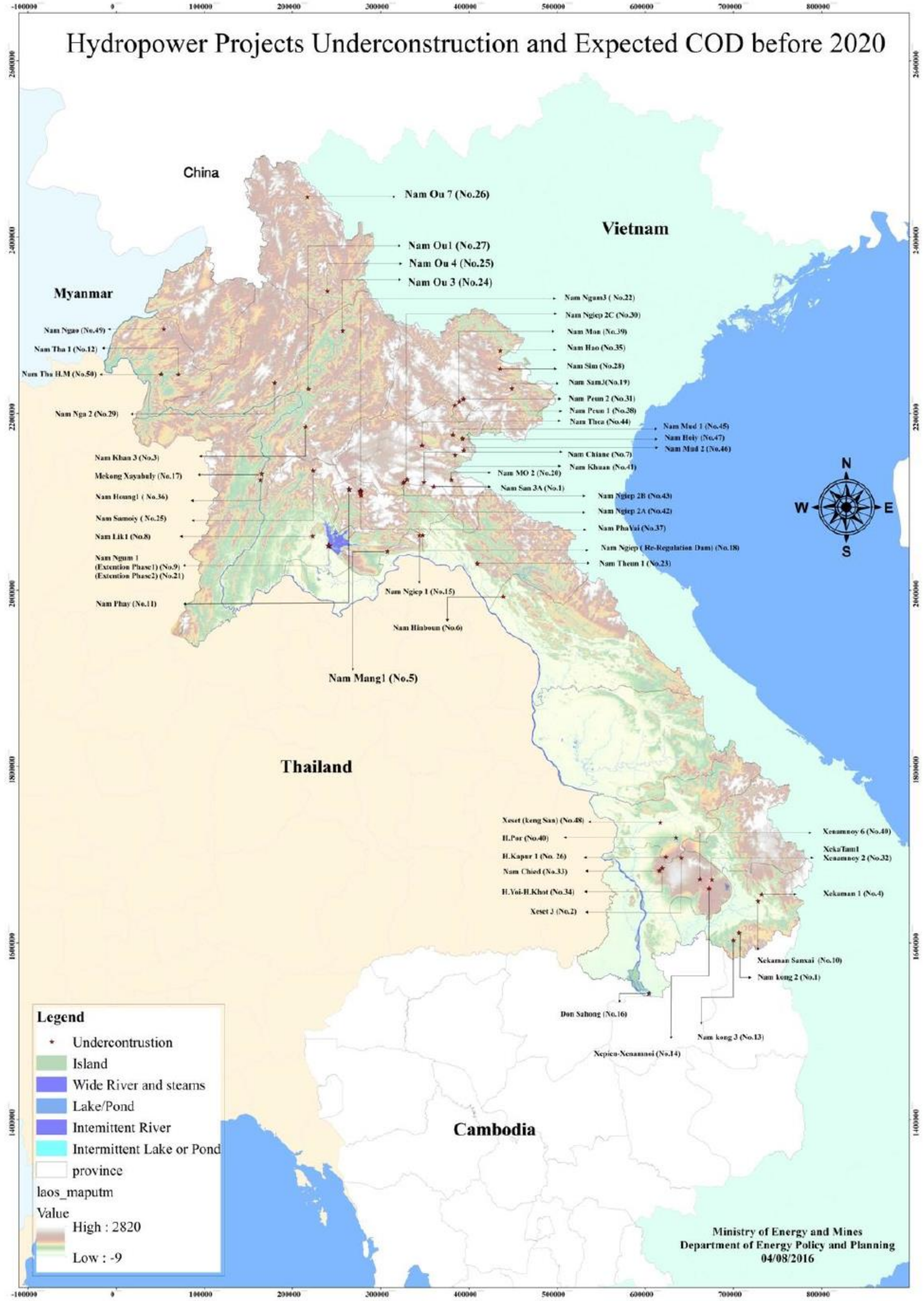
Table 3.4 Hydropower projects under construction (less than 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Expected operation year	Developer	Off-taker	Status
22	Nam Sim	Nam Sim	Viangsai	Huaphan	9	32	2017	MECAMIDI-NORPOWER AS 75% ECI (Laos) 25%	EDL (IPP internal use)	91%
23	Nam Nga 2	Nam Ou	Nga	Udomsai	15	63	2017	Heuangpasoet	EDL (IPP internal use)	66.90%
24	Nam Ngiap 2C	Nam Ngiap	Khun	Xiengkhwang	15	33	2017	Nonghai Construction	EDL (IPP internal use)	79%
25	Nam Poen 2	Nam Noen	Huameuang	Huaphan	12	115	2017	Nyot Chaloen	EDL (IPP internal use)	52%
26	Se Katam 1-Se Namnoi 2	Se Kong	Paksong	Champasak	13	79	2017	Faifa Se Katam 1- Se Namnoi 2	EDL (IPP internal use)	60%
27	Huai Chiat	Se Don	Paksong	Champasak	8	39	2017	Champa	EDL (IPP internal use)	20%
28	Huai Nyoi-Huai Khot	Se Don	Paksong	Champasak	15	78	2018	Faifa Huai Nyoi-Huai Khot	EDL (IPP internal use)	constructing road
29	Nam Hao	Nam Ma	Sopbao	Huaphan	15	173	2018	Duangchaloen	EDL (IPP internal use)	14.40%
30	Nam Hung 1	Nam Hung	Sainyabuli	Sainyabuli	13	50	2018	Simeuang Group	EDL (IPP internal use)	14.40%
31	Nam Phanyai	Nam Ngeum	Long Chaeng	Saisombun	14	48	2018	DSK (Lao)	EDL (IPP internal use)	45%
32	Nam Poen 1	Nam Noen	Huameuang	Huaphan	15	72	2018	Phongsapthawi Construction	EDL (IPP internal use)	70%
33	Nam Mon	Nam Noen	Huameuang	Huaphan	10	74	2018	Phongsapthawi Construction	EDL (IPP internal use)	10%
34	Huai Po	Se Don	Lao Ngam	Salawan	15	60	2018	Huai Por Power Co., Ltd	EDL (IPP internal use)	59%
35	Nam Keun	Nam Ngeum	Paek	Xiengkhwang	1		2018	Somphu Construction	EDL (IPP internal use)	PDA 19/4/2013
36	Nam Ngiap 2A	Nam Ngiap	Khun	Xiengkhwang	13	71	2019	Nonghai Construction	EDL (IPP internal use)	SHOA 23/4/2013
37	Nam Ngiap 2B	Nam Ngiap	Khun	Xiengkhwang	9	32	2019	Nonghai Construction	EDL (IPP internal use)	SHOA 23/4/2014
38	Nam Thae	Nam Maet	Kham	Xiengkhwang	15	50	2019	Nonghai Construction	EDL (IPP internal use)	PDA 30/1/2014 (constructing road)
39	Nam Mat 1	Nam Noen	Nong Haet	Xiengkhwang	15	45	2019	Lao Samphan Phathana	EDL (IPP internal use)	PDA 19/4/2013
40	Nam Mat 2	Nam Noen	Nong Haet	Xiengkhwang	15		2019	Lao Samphan Phathana	EDL (IPP internal use)	PDA 19/4/2013
41	Nam Huai	Nam Mo	Nong Haet	Xiengkhwang	7	30	2019	Lao Samphan Phathana	EDL (IPP internal use)	PDA 19/4/2013
42	Se Set-Kaeng San	Se Set	Salawan	Salawan	13	43	2019	Se Set Huai Tapung Power	EDL (SPP internal use)	PDA 25/2/2013
43	Nam Ngao	Nam Nga	Huaisai	Bo Kaeo	15	58	2020	Heuangpasoet Hydro Power	EDL (SPP internal use)	preparing construction
44	Nam Tha (Ban Hat Muak)	Nam Tha	Phaudom	Bo Kaeo	15	57	2020	Nam Tha-Hat Muak Hydro Power	EDL (SPP internal use)	preparing construction
	Total				258	1,299				

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Figure 3.2 shows the locations of hydropower projects under construction with COD expected by 2020.

Figure 3.2 Locations of hydropower projects under construction with COD expected by 2020.



Source: "Updated Hydro Power List - June 2016 (MEM)"

3) Hydropower projects with COD expected by 2025

Table 3.5 shows the hydropower projects with COD expected by 2025 that are over 15 MW.

There are 18 plants, the total capacity is 2,514 MW, and the total annual energy is 11,435 GWh.

Table 3.4 Hydropower projects with COD expected by 2025 (over 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Developer	Status
1	Nam Phak	Se Bangliang	Paksong	Champasak	150	511	Kobe Green Power Co.,Ltd 40% EDL 20% Investor yet to be found 20%	PDA 6/11/2009
2	Nam Theun Kaeng Seuaten	Nam Theun	Khamkoet	Bolikhamsai	54	200	EDL	preparing for proposal
3	Nam Fa	Nam Fa	Long	Bo Kaeo/Luang Namtha	180	730	Asia Pacific Business Link HND Berhard 80% EDL 20%	preparing for CA
4	Nam Phun	Nam Phun	Pak Lai	Sainyabuli	60	276	Sok Corporation	PDA 18/2/2012 extension 31/3/2016 consulting CA
5	Nam Bi 1	Se Kong	Dak Cheung	Se Kong	50	210	EDL GEN + Chanthawon Construction	preparing for PDA
6	Nam Bi 2	Se Kong	Dak Cheung	Se Kong	68	289	EDL GEN + Chanthawon Construction	preparing for signing
7	Huai Pa Lai	Se Don	Bachian Chaloensuk	Champasak	26	97	EDL + Kwangtung	MOU 16/12/2014
8	Nam Muan	Kading	Viengthong	Bolikhamsai	100	421	Asia Invest and Service	MOU 23/5/2014
9	Nam Kong 1	Se Kong	Phuwong	Attapeu	160	649	China International Water & Electric Corporation 65% EDL 20% Electoric Dam Consultant 15%	
10	Nam Sam 1	Nam Sam	Sam Tai	Huaphan	75	301	Phongsapthawi	PDA 19/9/2011
11	Se Kong Lower A	Se Kong	Sanamsai	Attapeu	76	388	V & H Corporation (Lao) Co., Ltd	PDA 20/3/2015
12	Pak Baeng (Nam Khong)	Nam Khong	Pak Baeng	Udomsai	912	4,765	China Datang Overseas 81% EDL_GEN 19%	PDA 27/12/2010
13	Se Lanong 1	Se Bangliang	Phin	Sawannakhet	70	267	YEIG International Development 70% Daosawan Group 25% Sun Paper Holding 5%	PDA 19/1/2015
14	Se Katam	Se Kong	Paksong	Champasak	81	299	Kansai Electric (Japan)	PDA 5/4/2007 1st extension 20/8/2010 2nd extension 20/8/2011 3rd extension 20/3/2013 4th extension 20/9/2014
15	Tat Sakhoi	Se Kong	Dak Cheung	Attapeu	30	128	Daosawan Group	PDA
16	Se Khaman 4	Se Kong	Dak Cheung	Attapeu	70	289	V & H Corporation (Lao) Co., Ltd	PDA 27/5/2014
17	Se Kong 4A			Se Kong	220	980	Lao Woen Group	MOU 6/11/2015
18	Se Kong 4B			Se Kong	132	636	Lao Woen Group	MOU 6/11/2015
	Total				2,514	11,435		

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Table 3.6 shows the hydropower projects with COD expected by 2025 that are less than 15 MW.

There are 15 plants, the total capacity is 133 MW, and the total annual energy is 517 GWh.

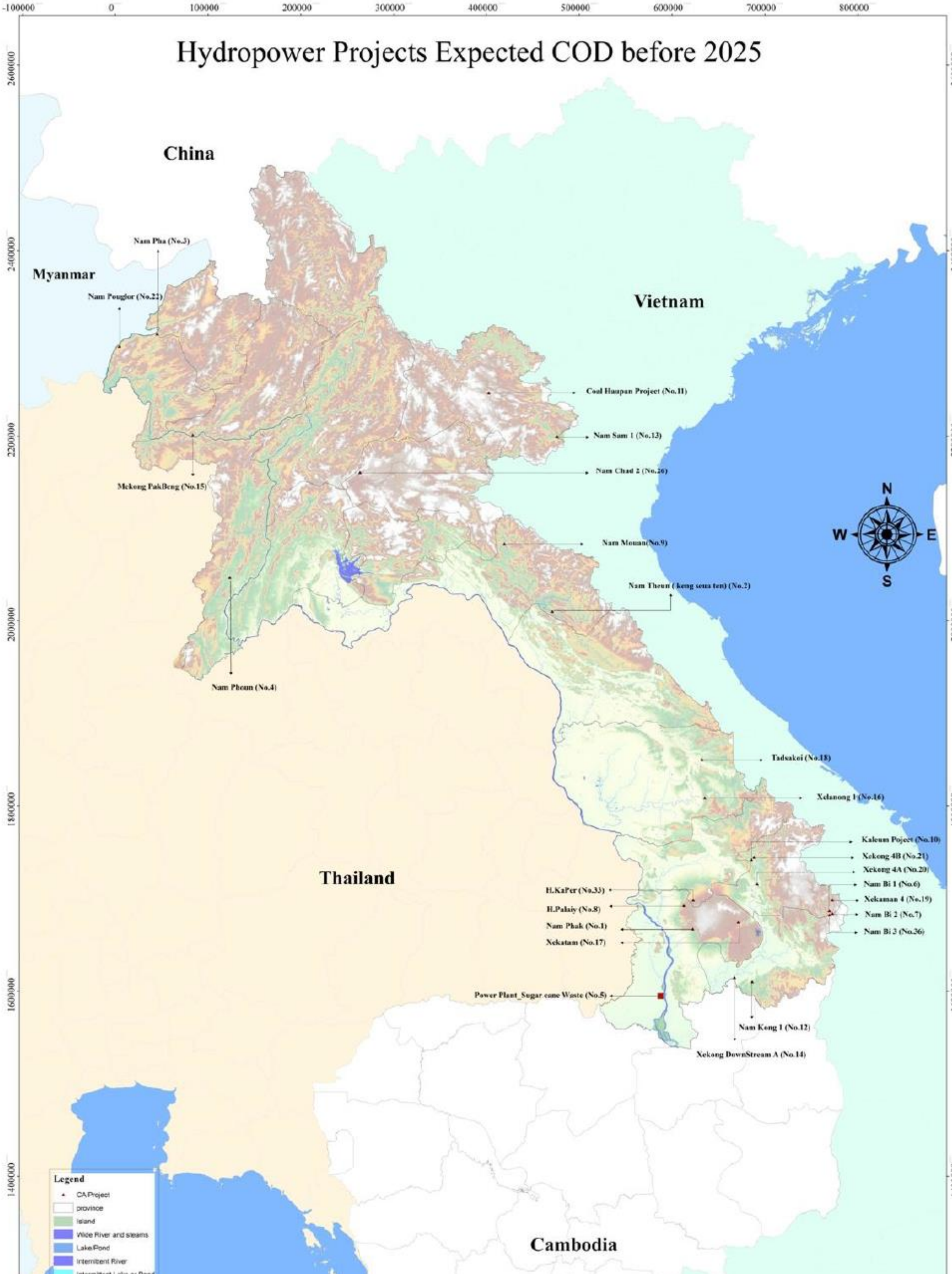
Table 3.6 Hydropower projects with COD expected by 2025 (less than 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Developer	Status
19	Nam Pung Lo	Nam Pung Lo	Meung	Bo Kaeo	5	19	Saiphachan Construction	MOU
20	Nam Dik 1		Samtai	Huaphan	15	79	Nesoenaeu Consulting Group	SHOA 24/2/2015
21	Nam Dik 2		Kuwan	Huaphan	15	78	Nesoenaeu Consulting Group	SHOA 24/2/2015
22	Nam Dik 3		Kuwan	Huaphan	10	56	Nesoenaeu Consulting Group	SHOA 24/2/2015
23	Nam Chat 2	Nam Ngeum	Phukut	Xiengkhwang	8	25	Lao-Asia Consultant Group	PDA 1/4/2014
24	Nam Chae 1	Nam San	Thathom	Saisombun	5	17	Hydro Lao	PDA 1/12/2015
25	Nam Chae 2	Nam San	Thathom	Saisombun	8	26	Hydro Lao	PDA 1/12/2016
26	Nam Samoi	Nam Ngeum	Kasi	Vientiane	5	28	Nam Samoi Hydro Power	SHOA
27	Nam Chat 1		Saichamphon	Bolikhamsai	15	74	Duangchaloen Phathana	SHOA 14/8/2014
28	Huan Palai Lower	Se Don	Bachiangchaloensuk	Champasak	4	16	Palai Dam Electric	MOU 7/1/2011
29	Huai Champi Lak35	Se Don	Paksong	Champasak	5	26	Pasakon Construction	MOU 18/5/2015
30	Huai Kaphoe	Se Don	Lao Ngam	Salavan	5	23	Huai Kaphoe Power	SHOA 30/4/2012
31	Huai Yuang Upper	Huan Yuang	Dak Cheung	Se Kong	6		Hongkham Construction	PDA 29/5/2015 preparing for construction
32	Huan Lamphan Lower	Huan Lamphan	Lamam	Se Kong	15		Vientian Automation	PDA 13/9/2010 preparing for construction
33	Nam Bi 3	Se Kong	Dak Cheung	Se Kong	12	51	EDL_GEN Chanthawon Construction	preparing for PDA
	Total				133	517		

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Figure 3.3 shows the locations of hydropower projects with COD expected by 2025.

Figure 3.3 Locations of hydropower projects with COD expected by 2025



Source: "Hydropower projects with COD expected by 2030"

4) Hydropower projects with COD expected by 2030

Table 3.7 shows the hydropower projects with COD expected by 2030 that are over 15 MW.

There are 23 plants, the total capacity is 3,565 MW, and the total annual energy is 16,311.7 GWh.

Table 3.7 Hydropower projects with COD expected by 2030 (over 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Developer	Status
1	Nam Phuan	Nam Ngiap	Hom	Saisombun	53	203	Velcan Energy (France) ECL	PDA 23/5/2014 preparing for CA
2	Nam Bak 1	Nam Ngeum	Saisombun	Vientiane	160	744	Southeast Asia Energy	PDA 8/8/2013-8/11/2015 MOU 11/4/2007
3	Nam Phak 1	Nam Ou	La	Udomsai	28	107	Sahamit Phathana	PDA 10/9/2015 MOU 23/5/2014
4	Nam Phak 2	Nam Ou	La	Udomsai	29	107	Sahamit Phathana	PDA 10/9/2015 MOU 23/5/2014
5	Nam Phak 3	Nam Ou	La	Udomsai	40	152	Sahamit Phathana	PDA 10/9/2015 MOU 23/5/2014
6	Nam Mo 1	Nam Mo	Mok	Xiengkhwang	60	223	Sahamit Phathana	PDA 10/9/2015 MOU 11/2/2014
7	Nam Laeng	Nam Ou	Phongsali	Phongsali	60	227	Venture Capital and Equipment Inc. (Vietnam)	PDA 24/10/2014 1st extension 18/5/2016
8	Nam Ang-Tabaeng	Se Kong	Sansai	Attapeu	41	183	Velcan Energy (France) ECL	PDA 23/5/2014-23/11/2015
9	Paklai (Nam Khong)	Nam Khong	Paklai	Sainyabuli	770	4,143	CEIEC Sinohydro	MOU 11/6/2007-11/12/2009 1st 12/7/2010 2nd 12/1/2011 3rd 12/1 2012 4th 12/1 2013 5th 1/4/2017
10	Phu Ngoi (Nam Khong)	Nam Khong	Phonthong	Champasak	686	2,751	Charoen Energy and Water Asia Co., Ltd	PDA 7/12/2010-27/12/2012
11	Sanakham (Nam Khong)	Nam Khong	Sanakham	Vientiane	660	3,696	China Datang Overseas 81% Lao Government 19%	PDA 27/12/2010-27/12/2012
12	Nam Noen 1	Nam Ka	Nonghaet	Huaphan	124	576	Vang Sup Development and Investment	PDA 26/8/2014-26/2/2016
13	Nam Noen 2	Nam Ka	Huameuang	Huaphan	60	250	Vang Sup Development and Investment	PDA 26/8/2014-26/2/2017
14	Nam Pui 1	Nam Pui	Phiang	Sainyabuli	60	161	Mudajaya Corporation Berhard (Malaysia) Sukkasoem Construction	PDA 25/4/2016 MOU 6/10/2010-24/3/2012 Last extension 2/3/2014
15	Nam Pot	Nam Ngiap	Phasai	Xiengkhwang	15	71	ACE Consultant	PDA 5/6/2012
16	Nam Imun 3 (Dak Imun)	Se Kong	Lamam	Se Kong	19	171	TK Construction	PDA 22/7/2015 MOU 22/5/2013
17	Nam Imun 4 (Dak Imun)	Se Kong	Lamam	Se Kong	54	226	TK Construction	PDA 22/7/2015 MOU 22/5/2013
18	Nam Imun 5 (Dak Imun)	Se Kong	Lamam	Se Kong	54	226	TK Construction	PDA 22/7/2015 MOU 22/5/2013
19	Nam Seuang 1	Nam Seuang	Luangphabang	Luangphabang	30	114	China Sichuan Gurong Group	PDA 24/4/2016 MOU 9/9/2013
20	Nam Seuang 2	Nam Seuang	Pak Ou	Luangphabang	108	385	China Sichuan Gurong Group	PDA 24/4/2016 MOU 9/9/2013
21	Nam Ngeum 4	Nam Ngeum	Phukut	Xiengkhwang	240	872	EDL	MOU 25/3/2014
22	Se Kaman 2A	Se Kong	Dak Cheung	Attapeu	35	160	EDL China International Water & Electric Corp	F.S
23	Se Kaman 2B	Se Kong	Dak Cheung	Attapeu	180	564	EDL China International Water & Electric Corp	F.S
	Total				3,566	16,311		

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Table 3.8 shows the hydropower projects with COD expected by 2030 that are less than 15 MW.

There are 34 plants, the total capacity is 269 MW, and the total annual energy is 511 GWh.

Table 3.8 Hydropower projects with COD expected by 2030 (less than 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Developer	Status
24	Nam Hun 1	Nam Ou	Samphan	Phongsali	15		Duangchaloen Phathana	MOU 20/8/2013 FS completed
25	Nam Long 2	Nam Ma	Long	Luang Namtha	11	92	Nam Long Power	MOU 4/11/2011
26	Nam Talan		Luang Namtha	Luang Namtha	5	30	Saiphachan	MOU 28/8/2013
27	Nam Long	Nam Ma	Sopbao	Huaphan	13		Bukthalu	MOU 9/11/2012
28	Nam Ham 2	Nam Heuang	Botaen	Sainyabuli	5	16	PEA Encom 67% EDL 30% Cobrie 3%	MOU 6/5/2005 FS, EIAcompleted
29	Nam Hung 2	Nam Hung	Sainyabuli	Sainyabuli	5	23	Phanthamit Phathana	MOU 27/4/2012 FS, EIAcompleted
30	Nam Maet 1	Nam Hung	Sainyabuli	Sainyabuli	3	13	Phanthamit Phathana	MOU 21/9/2012 FS, EIA completed
31	Nam Sing	Nam Phun	Hongsa	Sainyabuli	5	31	Ketmani	MOU 6/9/2013 FS, EIA completed
32	Nam Ao	Nam Maet	Kham	Xiengkhwang	15		Bothong Inter	PDA 19/10 2015
33	Nam Khao 1	Nam Maet	Kham	Xiengkhwang	5		SV Group	PDA 12/11/2015
34	Nam Khao 2	Nam Maet	Kham	Xiengkhwang	5		SV Group	PDA 12/11/2015
35	Nam Khao 3	Nam Maet	Kham	Xiengkhwang	5		SV Group	PDA 12/11/2015
36	Nam Khao 4	Nam Maet	Kham	Xiengkhwang	5		SV Group	PDA 12/11/2015
37	Nam Khao 5	Nam Maet	Kham	Xiengkhwang	5		SV Group	PDA 12/11/2015
38	Nam Hong	Nam Mo	Mok	Xiengkhwang	5	7	Huaisuwan Lao	PDA 25/5/2016
39	Nam So	Nam Kading	Wiangthong	Bolikhamsai	4	19	Vientiane Techno	preparing SHOA
40	Small Dam & Irrigation (Lower)	Nam Hinbun	Hinbun	Khammuan	5		Phalangngan Lasita	PDA 1/6/2016
41	Kaeng Soi	Se Bangfai	Khammuan	Khammuan	15		Phosi Construction	PDA 12/2/2016
42	Huai Bangliang Lower	Bangliang	Paksong	Champasak	11	45	Mae Khong Concrit	IPP internal use
43	Huai Champi Khamnosaeb	Se Don	Bachiang Chaloensuk	Champasak	5	23	STL	IPP internal use
44	Huai Champi Udomsuk	Se Don	Bachiang Chaloensuk	Champasak	5	28	Daoheuangsong	IPP internal use SHOA 6/7/2009
45	Huai Namphak Lower	Bangliang	Pathunphon	Champasak	9	39	Daoheuangsong	IPP internal use SHOA 23/11/2012
46	Se Namnoi 5	Se Kong	Paksong	Champasak	5	23	KTX Phathana Phalangngan	IPP internal use (less than 1% constructed) SHOA 30/11/2009
47	Se Set 4	Se Kong	Paksong	Champasak	10	110	EDL	
48	Huai Namsai 1 (Tat Kaloei)	Se Don	Salawan	Salawan	6		PCC Construction	PDA 6/3/2013
49	Huai Lai	Se Banghiang	Taoi	Salawan	3	12	P & P Construction	PDA 23/5/2014
50	Huai Phok	Se Kong	Samakhisai	Attapeu	12		Hydro Lao	
51	Huai Sanong		Sanamsai	Attapeu	1		Satsada	
52	Nam Su		Sansai	Attapeu	7		Maek Electric Lao	
53	Se Su 4		Sanamsai, Phuwong	Attapeu	13		Maek Electric Lao	
54	Huai Chaliu 1	Huai Chaliu	Dak Cheung	Se Kong	11		Vientiane Automation	PDA 24/6/2012
55	Huai Chaliu 2	Huai Chaliu	Dak Cheung	Se Kong	13		Vientiane Automation	PDA 24/6/2012
56	Huai Panyu Lower	Nam Panyu	Dak Cheung	Se Kong	15		Vientiane Automation	PDA 17/5/2012
57	Huai Pet	Huai Pet	Lamam	Se Kong	13		DMD Phathana	MOU 17/6/2015 MOU being negotiated again
Total					269	511		

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

5) Hydropower projects with signed MOU

Table 3.9 shows the hydropower projects for which an MOU has already been acquired but COD is undetermined, and which have a capacity of over 15 MW.

There are 40 plants, the total capacity is 5,383 MW, and the total annual energy is 23,898 GWh.

Table 3.9 Hydropower projects with signed MOU (over 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Developer	Status
1	Se Pian-Huai Chot	Se Kong	Paksong	Champasak	21	100	CLM & LEADER infrastructure	MOU 20/12/2012
2	Se Pon 3	Se Banghiang	Samuai	Salawan	47	167	EDL Korea Water Resource Corporation	MOU 21/5/2015
3	Se Don	Se Don	Wapi	Salawan	20	80	EDL	
4	Nam Nga 1	Nam Ou	Nam Bak	Luangphabang	62	266	Duangchaloen	MOU 11/4/2012 1st extension 10/10/2013 2nd extension 18/11/2016
5	Se Neua	Se Bangfai	Bualapha	Khammuan	53	209	Phonsak Group	MOU 16/5/2006 1st extension 16/1/2010
6	Nam Theun 4	Kading	Khamkoet	Bolikhamsai	80	300	SSPT	MOU 26/6/2013-12/5/2014
7	Se Lanong 2	Se Banghiang	Taoi	Salawan	35	143	China Gezhouba Groip	MOU 11/7/2012
8	Se Pian-Huai Soi	Se Kong	Sanamsai	Attapeu	60	229	DMD	MOU 31/1/2014 1st extension 21/9/2015
9	Ban Wangdeua-Nam Muan	Kading	Wiangthong	Bolikhamsai	66	140	Phonsak Group	MOU 22/5/2013-21/11/2014
10	Nam Seuang 4	Nam Seuang	Pak Saeng	Luangphabang	42	147	China Sichuan Gurong Group	MOU 9/9/2013
11	Nam Seuang 5	Nam Seuang	Wiangkham	Luangphabang	47	156	China Sichuan Gurong Group	MOU 9/9/2013
12	Nam Seuang 6	Nam Seuang	Pak Saeng	Luangphabang	72	242	China Sichuan Gurong Group	MOU 9/9/2013
13	Se Kong 3A	Se Kong	Lamam	Attapeu	105	411	Asia Longtheun Development	MOU 31/3/2015
14	Se Kong 3B	Se Kong	Saisetha	Attapeu	100	394	Asia Longtheun Development	MOU 31/3/2015
15	Se Kong Lower B	Se Kong	Samakhisai	Attapeu	50	206	V & H Corporation	MOU 29/11/2011
16	Huai Langae	Se Kong	Kaleum	Se Kong	60	294	Chiantho	MOU 21/7/2015
17	Nam Ngiap-Meuang Mai	Nam Ngiap	Bolikhan	Bolikhamsai	25	60	Phongsapthawi	MOU 25/2/2010-24/8/2011 1st extension 25/2/2012
18	Nam Sam 4	Nam Sam	Sam Neua	Huaphan	150	343	Simon Consulting	MOU 21/3/2013
19	Se Su	Se Kong	Saisetha	Attapeu	30	126	Hoang Anh Gia Lai Mineral Joint Stock Company	MOU 10/9/2011 Last extension -10/3/2013
20	Se Tanuan	Se Banghiang	Phin	Sawannakhet	35	143	China Gezhouba Groip	MOU 11/7/2012-10/1/2014
21	Nam Feuang	Nam Feuang	Maet	Vientiane	51	242	Syntec Construction Public Company	MOU 14/8/2013
22	Se lanong 3 Ban Tang Oen	Se Banghiang	Nong	Sawannakhet	80	400	Simeuang Group	MOU 1/7/2013-2/4/2015 1st extension -8/1/2016
23	Se Kong 5	Se Kong	Kaleum	Se Kong	330	1,613	Inter RAO-Engineering (Russia)	MOU 5/2/2014-5/8/2015
24	Nam Khan 4	Nam Khan	Phukhun	Luangphabang	64	258	Duangpasoet	MOU 2/9/2013
25	Nam Ngeum	Nam Ngeum	Ngoen, Hongsa	Sainyabuli	44	296	Sinwoesaen Group Saiphon Electric	MOU 20/6/2013
26	Nam Ma 1	Nam Ma	Siengkho	Huaphan	44	200	Guangdong Electric Company	MOU 10/6/2014-10/12/2015
27	Nam Ma 1A	Nam Ma	Siengkho	Huaphan	39	156	Guangdong Electric Company	MOU 10/6/2014-10/12/2015
28	Nam Ma 2	Nam Ma	Siengkho	Huaphan	30	118	Guangdong Electric Company	MOU 10/6/2014-10/12/2016
29	Nam Ma 2A	Nam Ma	Siengkho	Huaphan	18	74	Guangdong Electric Company	MOU 10/6/2014-10/12/2017
30	Nam Ma 3	Nam Ma	Siengkho	Huaphan	18	76	Guangdong Electric Company	MOU 10/6/2014-10/12/2018
31	Ban Kum (Nam Khong)	Nam Khong	Phonthong	Champasak	1,872	8,433	Italian Thai Asia Corp Holdings Limited	MOU 25/3/2008-25/9/2010 1st extension -25/9/2011
32	Luangphabang (Nam Khong)	Nam Khong	Chomphet	Luangphabang	1,200	6,500	Petro Vietnam Power Corporation	MOU 13/10/2007-10/4/2010 1st extension 13/10/2010 2nd extension 13/10/2011
33	Pak Ngeum	Nam Ngeum	Pak Ngeum	Nakhonluang Vientiane	110	463	Vientiane Automation	MOU 1/9/2015
34	Nam Tha 2	Nam Tha	Luang Namtha	Luang Namtha	25	149	Huamchai Phathana	MOU 9/7/2015
35	Nam Cha 2	Nam Ngeum	Saisombun	Saisombun	40	205	Namtha Construction	MOU 4/9/2015
36	Nam Mang (upper)			Saisombun	50		Venture Capital and Equipment Inc. (Vietnam)	MOU 27/5/2015
37	Se Bangnuan 2			Salawan	80	290		
38	Se Banfai Kaeng Kaeo		Saibuli	Sawannakhet	63	271	Laosamai Group	MOU 13/11/2015
39	Nam Ngorn 1,2			Se Kong	30		Phongsapthawi	MOU 30/3/2016
40	Nam Hong			Bolikhamsai	35		Nalinni Thachaloensai	MOU 19/5/2016
	Total				5,383	23,898		

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Table 3.10 shows the hydropower projects for which an MOU has already been acquired but COD is undetermined, and which have a capacity of less than 15 MW.

There are 193 plants, the total capacity is 1,823 MW, and the total annual energy is 3,777 GWh.

Table 3.10 Hydropower projects with signed MOU (less than 15 MW)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Developer	Status
41	Nam Ou 8	Nam Ou	Nyot Ou	Phongsali	15	60	Heuangpasoet	MOU 5/7/2012
42	Nam Nua	Nam Ma	Mai	Phongsali	15		Heuangpasoet	MOU 8/5/2013
43	Nam Hun 2	Nam Ou	Samphan	Phongsali	15	55	Duangchaloen Phathana	MOU 20/8/2013
44	Nam Hun 3	Nam Ou	Samphan	Phongsali	15	60	Duangchaloen Phathana	MOU 20/8/2013
45	Nam Bun 2	Nam Ou	Bun Neua	Phongsali	15		Lai Engineering	MOU 16/9/2013
46	Nam Phae	Nam Ou	Phongsali	Phongsali	13	45	Phosi Construction	MOU 17/9/2013
47	Nam Ban	Nam Ou	Mai	Phongsali	12	45	Lat Wisahakit (ECI)	MOU 29/4/2014
48	Nam Moek	Nam Ou	Mai	Phongsali	10	35	Lat Wisahakit (ECI)	MOU 29/4/2014
49	Nam Talan	Nam Tha	Luang Namtha	Luang Namtha	15	80	Saiphachan	MOU 28/8/2013
50	Nam Fa 2	Nam Fa	Wiangphukha	Luang Namtha	180	424	Huamchai Phathana	MOU 5/8/2014
51	Nam Ngao	Nam Ngao	Huaisai	Bokaeo	15	85	Saisombun Construction	MOU 10/12/2014
52	Nam Ngao 2	Nam Ngao	La	Udomsai	8		DPS	MOU 25/3/2011
53	Nam Ko lower (Ban Phonsawang)	Nam Ou	La	Udomsai	10	50	MP	MOU 16/8/2013
54	Nam Ko lower (Ban Huaisang)	Nam Ou	La	Udomsai	10	50	Wiang Electronic	MOU 4/2/2013
55	Nam Ngao 1	Nam Ou	Nga	Udomsai	12	53	M Consulting	MOU 25/4/2014
56	Huai Prong	Nam Ou	Nga	Udomsai	2		Phisitsaisombat	MOU 23/2/2016
57	Nam Ma	Nam Noen	Kham	Xiengkhwang	5		Sonsana Construction	MOU 28/7/2011
58	Nam Khan 4	Nam Ngeum	Phukut	Xiengkhwang	15		Bosaikham Phathana	MOU 1/11/2013
59	Nam Phang 1	Nam Ngiap	Khun	Xiengkhwang	3		Bosaikham Phathana	MOU 12/5/2013
60	Nam Ngan	Nam Ngiap	Khun	Xiengkhwang	5	15	Bosaikham Phathana	MOU 12/5/2013
61	Tat Kha	Nam Mo	Nonghaet	Xiengkhwang	5		Bosaikham Phathana	MOU 12/5/2013
62	Nam Khan 3A	Nam Ngeum	Phukut	Xiengkhwang	15		Bosaikham Phathana	MOU 4/7/2014
63	Nam Khan 3B	Nam Ngeum	Phukut	Xiengkhwang	15		Bosaikham Phathana	MOU 14/1/2014
64	Nam Hang	Nam Ngeum	Phukut	Xiengkhwang	5		Suksomwang	MOU 17/12/2014
65	Nam Sannoi	Nam Ngiap	Khun	Xiengkhwang	5		Suksomwang	MOU 17/12/2014
66	Nam Noen (lower)	Nam Mo	Nonghaet	Xiengkhwang	15	70	Songhua FIM	MOU 10/3/2014
67	Nam Lan 1	Nam Mo	Nonghaet	Xiengkhwang	5		SN Energy	MOU 21/9/2015
68	Nam Lan 2	Nam Mo	Nonghaet	Xiengkhwang	5		SN Energy	MOU 21/9/2015
69	Nam Lan 3	Nam Mo	Nonghaet	Xiengkhwang	5		SN Energy	MOU 21/9/2015
70	Nam Chat 1	Nam Ngeum	Phukut	Xiengkhwang	15		Wisawakam Construction	MOU 25/5/2015
71	Nam Sui	Nam Ngeum	Phukut	Xiengkhwang	4		Somphu Construction	MOU 21/8/2015
72	Nam Khao Ban Tha	Nam Noen	Kham	Xiengkhwang	5		Phanthawong	MOU 7/1/2015
73	Nam Siam	Nam Ngiap	Phasai	Xiengkhwang	5	65	Lansang	MOU 20/1/2015
74	Nam Khao Ban Sop O	Nam Maet	Kham	Xiengkhwang	5		Phanthawong	MOU 7/1/2015
75	Nam Wang Ban Na Luang	Nam Maet	Kham	Xiengkhwang	12	44	Phanthawong	MOU 7/1/2015
76	Nam Keun	Nam Khan	Phukut	Xiengkhwang	9		Phanthawong	MOU 7/1/2015
77	Nam Khian	Nam Mo	Nonghaet	Xiengkhwang	9	30	Phanthawong	MOU 7/1/2015
78	Nam Khian	Nam Mo	Nonghaet	Xiengkhwang	15		SDS Group	MOU 25/5/2015
79	Nam Keua	Nam Maet	Kham	Xiengkhwang	12		Phanthawong	MOU 7/1/2015
80	Nam Siam (lower)	Nam Khan	Phukut	Xiengkhwang	5		Wisawakam Construction	MOU 20/1/2015
81	Nam Chat	Nam Mo	Mok	Xiengkhwang	1		Ongkham Gold Mining	
82	Nam Siam (upper)	Nam Ngiap	Phasai	Xiengkhwang	4		DMD	MOU 17/3/2015
83	Nam Sao 1	Nam Mo	Mok	Xiengkhwang	3		Phongsapthawi	13/7/2015
84	Nam Sao 2	Nam Mo	Mok	Xiengkhwang	3		Phongsapthawi	13/7/2015
85	Nam Sao 3	Nam Mo	Mok	Xiengkhwang	3		Phongsapthawi	13/7/2015
86	Nam Sao 4	Nam Mo	Mok	Xiengkhwang	3		Phongsapthawi	13/7/2015
87	Nam Sao 5	Nam Mo	Mok	Xiengkhwang	3		Phongsapthawi	13/7/2015
88	Nam Ao	Nam Ngiap	Phasai	Xiengkhwang	15		Bothong Inter	9/4/2015
89	Nam Keun	Nam Mo	Nonghaet	Xiengkhwang	8	34	Bosaikham Phathana	10/4/2015
90	Nam Ngeum	Nam Khan	Phukut	Xiengkhwang	4		Thinthong Phathana	MOU 12/1/2016
91	Nam Mang	Nam Mo	Mok	Xiengkhwang	5		Sipannya Construction	MOU 19/2/2016
92	Nam Hok	Nam Mo	Mok	Xiengkhwang	5		Sipannya Construction	MOU 19/2/2016
93	Nam Iyam	Nam Mo	Mok	Xiengkhwang	5		Sipannya Construction	MOU 19/2/2016
94	Nam Kam	Nam Ngiap	Phasai	Xiengkhwang	5		Khamson Phathana	MOU 19/2/2016
95	Nam Thong	Nam Ngiap	Phasai	Xiengkhwang	5		Khamson Phathana	MOU 19/2/2016
96	Nam Poe	Nam Mo	Mok	Xiengkhwang	5		Thewan Construction	MOU 25/5/2016
97	Nam Tak	Nam Mo	Mok	Xiengkhwang	5		Thewan Construction	MOU 25/5/2016
98	Nam Khom	Nam Mo	paek	Xiengkhwang	5		Somphu Construction	
99	Nam Sam	Nam Maet	Kham	Xiengkhwang	5		Somphu Construction	
100	Nam Ngeum Kaeng Khwan	Nam Maet	Paek	Xiengkhwang	1	6	Somphu Construction	
101	Nam Chao	Nam Mo	Mok	Xiengkhwang	5		Phongsapthawi	
102	Nam Chiat	Nam Mo	Mok	Xiengkhwang	5		Phongsapthawi	
103	Nam Liang	Nam Mo	Khun	Xiengkhwang	5		Phongsapthawi	
104	Nam Aet 4		Son	Huaphan	19	76	EDL	MOU 30/11/2012
105	Nam Aet 5		Son	Huaphan	8	30	EDL	MOU 30/11/2012
106	Nam Aet 6		Son	Huaphan	2	7	EDL	MOU 30/11/2012
107	Nam Pong	Nam Khan	Samneua	Huaphan	9		Nak Kham 2010	MOU 31/10/2013
108	Nam Wang	Nam Khan	Hiam	Huaphan	1		Saichaloen	MOU 9/9/2014
109	Nma Khan	Nam Khan	Hiam	Huaphan	15		Saichaloen	MOU 9/9/2014
110	Nam Hang	Nam Khan	Hiam	Huaphan	5		Saichaloen	MOU 9/9/2014
111	Nam Noen 2	Nam Noen	Huameuang	Huaphan	5		Saichaloen	MOU 9/9/2014
112	Nam Noen 4	Nam Noen	Huameuang	Huaphan	5		Saichaloen	MOU 9/9/2014
113	Nam Poen 3	Nam Noen	Huameuang	Huaphan	5		Nyotchaloen	MOU 20/10/2014
114	Nam Dang	Nam Noen	Huameuang	Huaphan	5		Nyotchaloen	MOU 20/10/2014
115	Nam Yeuang 1			Huaphan	15	250	SV Group	MOU 21/9/2015
116	Nam Yeuang 2			Huaphan	15	110	SV Group	MOU 21/9/2015
117	Nam Yeuang 3			Huaphan	15	150	SV Group	MOU 21/9/2015

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Table 3.10 Hydropower projects with signed MOU (less than 15 MW) (cont.)

118	Nam Sam 2		Samtai	Huaphan	15		Phongsapthawi	MOU 14/12/2015
119	Nam Taep	Nam Khan	Samtai	Huaphan	5		Longchaeng Phathana	MOU 31/3/2016
120	Nam Bak	Nam Ou	Nam Bak	Luang Phabang	15		DSK	MOU 8/4/2010
121	Nam Mat	Nam Khan	Phonthong	Luang Phabang	15		Siluangphabang	MOU 10/1/2013
122	Nam Saeng	Nam Khan	Paksaeng	Luang Phabang	15		Phusi Luangphabang Construction	MOU 10/1/2013
123	Nam Mi	Nam Seuang	Wiangkham	Luang Phabang	15		Phusi Luangphabang Construction	MOU 10/1/2013
124	Nam Saeng	Nam Feuang	Nan	Luang Phabang	15		EDL	MOU 17/11/2014
125	Nam Sanan	Nam Khan	Sieng Ngeun	Luang Phabang	15		Phusi Luangphabang Construction	MOU 23/2/2015
126	Nam Ming 1	Nam Ming	Sieng Ngeun	Luang Phabang	15		EDL	MOU 30/11/2015
127	Nam Ming 2	Nam Ming	Sieng Ngeun	Luang Phabang	15		EDL	MOU 9/2/2016
128	Nam Pui (Ban Paksong)	Nam Pui	Phiang	Sainyabuli	5		Kaeochaloen Construction	MOU 31/7/2012
129	Nam Ngeum 2	Nam Ngeum	Ngoen-Sienghon	Sainyabuli	5		Hai Engineering	MOU 28/6/2012
130	Nam Nyang	Nam Khan	Ngoen	Sainyabuli	5		DM	MOU 12/9/2012
131	Nam Hung 3 (Kaeng Phoeng)	Nam Hung	Sainyabuli	Sainyabuli	10		DM	MOU 14/5/2015
132	Nam Sa Nyai	Nam Ngeum	Kasi	Vientiane	3	14	Phathana Long Ngeum	MOU 21/1/2011
133	Nam Kai	Nam Ngeum	Kasi	Vientiane	3	8	Phadaeng Construction	MOU 28/3/2011
134	Nam Ngeum Na Nin	Nam Ngeum	Wiangkham	Vientiane	15	99	Vientiane Automation	MOU 21/10/2011
135	Nam Lik (Kaeng Luang) 1/2A	Nam Ngeum	Kasi	Vientiane	15	99	DMD	MOU 6/11/2012
136	Nam Sanaen	Nam Ngeum	Wangwiang	Vientiane	7	20	Phetthongkham	MOU 16/11/2012
137	Nam Mon	Nam Ngeum	Wiangkham	Vientiane	6	29	BML Construction	MOU 22/3/2013
138	Nam Thaem	Nam Ngeum	Wangwiang	Vientiane	4	20	Vientiane WERC	MOU 2/7/2013
139	Nam Sana upper	Nam Ngeum	Kasi	Vientiane	10	39	Nam Sanoi Hydro Power	MOU 13/2/2013
140	Nam Sana under	Nam Ngeum	Kasi	Vientiane	3	15	Kasi Hungheuangsap	MOU 24/5/2013
141	Nam Feuang lower	Nam Feuang	Maet	Vientiane	15	99	Buathip Lao	MOU 16/9/2014
142	Nam Kaen upper	Nam Ngoen	Kasi	Vientiane	2		Intracorporation	MOU 29/1/2014
143	Nam Kaen lower	Nam Ngoen	Kasi	Vientiane	3		Maisak Luangphabang	MOU 13/12/2014
144	Nam Feuang Neua Khet Tham Thoep	Nam Feuang	Kasi	Vientiane	15		Thongkhunsap Mining Service	MOU 30/12/2014
145	Nam Po	Nam Ngeum	Wangwiang	Vientiane	1		PCC Construction	MOU 27/8/2015
146	Nam Kap	Nam San	Longchaeng	Saisombun	12	55	Phongsapthawi	MOU 5/2/2012
147	Nam Chae lower	Nam San	Thathom	Saisombun	10	47	Thawisai Construction	MOU 8/11/2012
148	Nam Tai	Nam San	Thathom	Saisombun	5	19	Phongsapthawi	MOU 23/10/2012
149	Nam Nyam	Nam San	Thathom	Saisombun	8	17	DMD	MOU 12/12/2012
150	Nam Pheuak			Saisombun	10	32	NCG	MOU 6/9/2013
151	Nam San	Nam San	Thathom	Saisombun	5	17	Phongsapthawi	MOU 23/10/2014
152	Nam Thong 1	Nam Ngiap	Anuwong	Saisombun	10	83	Wansana Songsoem Kasikam	MOU 18/4/2014
153	Nam Thong 2	Nam Ngiap	Anuwong	Saisombun	5	44	Wansana Songsoem Kasikam	MOU 18/4/2014
154	Nam Thaeng	Nam Ngiap	Anuwong	Saisombun	5	17	Sisaket Construction	MOU 6/5/2014
155	Nam Chang 4	Nam Ngiap	Anuwong	Saisombun	15	72	Asia Pacific	MOU 5/8/2015
156	Nam Chang 5	Nam Ngiap	Anuwong	Saisombun	5	39	Asia Pacific	MOU 5/8/2015
157	Nam Song	Nam San	Thathom	Saisombun	7	27	Phongsapthawi	MOU 23/1/2015
158	Nam San (Hat To)	Nam San	Bolikhan	Bolikhamsai	15	90	Nalinnitha Chaloensai	MOU 26/10/2012
159	Nam Hoeng	Kading	Saichamphon	Bolikhamsai	13	50	VSK	MOU 18/3/2013
160	Nam Hong	Kading	Wiangthong	Bolikhamsai	14	60	Nalinnitha Chaloensai	MOU 1/2/2013
161	Nam Chat 2	Kading	Saichamphon	Bolikhamsai	15	68	Kaeodawon	MOU 9/9/2013
162	Nam San 1	Nam San	Bolikhan	Bolikhamsai	7		Intra Corp	MOU 28/1/2013
163	Nam San 2	Nam San	Bolikhan	Bolikhamsai	7	62	SPS	MOU 15/5/2014
164	Nam Hong upper	Kading	Wiangthong	Bolikhamsai	12		LBSS	MOU 4/9/2014
165	Nam Sang	Kading	Wiangthong	Bolikhamsai	15	62	Chaloensap Khopwongchon	MOU 31/12/2014
166	Nam Toeng	Kading	Saichamphon	Bolikhamsai	13	42	Chaloensap Khopwongchon	MOU 31/12/2014
167	Huai Sai Nam Khong	Kading	Saichamphon	Bolikhamsai	14	48	Chaloensap Khopwongchon	MOU 31/12/2014
168	Nam Nyong	Kading	Thaphabat	Bolikhamsai	14		Sukkhasoem Construction	MOU 12/1/2015
169	Nam Kang	Kading	Wiangthong	Bolikhamsai	5		Khamkhun Group	MOU 3/3/2015
170	Nam Lo	Kading	Thaphabat	Bolikhamsai	5		Phetbangdit Group	MOU 28/1/2015
171	Nam Nyala	Kading	Saichamphon	Bolikhamsai	5		Chaloensap Khopwongchon	MOU 4/4/2016
172	Nam Mang	Nam san	Bolikhan	Bolikhamsai	4		Chaloensap Khopwongchon	MOU 2/3/2016
173	Huai Nam Thwai	Kading	Thaphabat	Bolikhamsai	4		Chaloensap Khopwongchon	MOU 4/4/2016
174	Huai Nam Cham	Kading	Saichamphon	Bolikhamsai	2		Chaloensap Khopwongchon	MOU 4/4/2016
175	Huai Nam Chuwan	Kading	Wiangthong	Bolikhamsai	15		Chaloensap Khopwongchon	MOU 4/4/2016
176	Huai Nam Pan	Kading	Saichamphon	Bolikhamsai	15		Chaloensap Khopwongchon	MOU 4/4/2016
177	Nam Senoi	Se Bangfai	Se Bangfai	Khammuan	5		Namsok Samluat Seni Dam	MOU 13/5/2011
178	Ban Kaeng Yaluwan (Se Bangfai)	Se Bangfai	Bualapha	Khammuan	15		SKSK	MOU 14/1/2012
179	Nam Kwang	Nam Thoen	Nakai	Khammuan	8	24	Heuangsi Construction Hungheuang Chaloensap	MOU 27/5/2015
180	Sai Nam Hai	Se Bangfai	Khunkham	Khammuan	15		Atlantic International	MOU 7/4/2016
181	Se Kok 1	Se Banghiang	Se Pon	Sawannakhet	6		Khunsai Phathana	MOU 9/1/2014
182	Se Kok 2	Se Banghiang	Se Pon	Sawannakhet	5		Khunsai Phathana	MOU 9/1/2014
183	Se Sangi 1	Se Banghiang	Se Pon	Sawannakhet	3		Khunsai Phathana	MOU 9/1/2014
184	Se Sangi 2	Se Banghiang	Se Pon	Sawannakhet	2		Khunsai Phathana	MOU 9/1/2014
185	Se Sangi 3	Se Banghiang	Se Pon	Sawannakhet	13		Khunsai Phathana	MOU 9/1/2014
186	Se Banghiang upper	Se Banghiang	Se Pon	Sawannakhet	10	64	Khunsai Phathana	MOU 9/1/2014
187	Se Lanong Kaeng Asing	Se Banghiang	Nong	Sawannakhet	15		SV Group	MOU 11/1/2014
188	Nam Se Pon (Ban Kaengluang)	Se Banghiang	Se Pon	Sawannakhet	15		Kham Wiang Ngam	MOU 29/1/2014
189	Huai Champi Nong Kang	Se Don	Paksong	Champasak	8	46	Bolihan Phalangngan Pen Loet	MOU 18/10/2013
190	Huai Kaphoe 2	Se Don	Bachiangchaloensuk	Champasak	6	39	LTV Construction	MOU 15/5/2015
191	Se Namnoi 4	Se Kong	Paksong	Champasak	5	28	LTV Construction	MOU 3/7/2015
192	Huai Salai	Se Banghiang	Taoi	Salawan	5	22	P & P Construction	MOU 11/6/2013
193	Huai Nam Sai 2 (Kaeng Tung)	Se Don	Salawan	Salawan	5	25	SDS Coffee	MOU 7/1/2013

Source: Made by the study team based on "Updated Hydro Power List - June 2016 (MEM)"

Table 3.10 Hydropower projects with signed MOU (less than 15 MW) (cont.)

No.	Project	Basin	District	Province	Capacity [MW]	Annual energy [GWh/y]	Developer	Status
194	Huai Awian	Se Banghiang	Samuai	Salawan	5	25	Chanthasen Construction	MOU 13/3/2014
195	Huai Kantrong	Se Banghiang	Samuai	Salawan	5	25	SPS Coffee	MOU 12/12/2014
196	Se Lanong 3	Se Banghiang	Taoi	Salawan	12	53	Phathana Sakon Huisuwan Lao	MOU 21/6/2013
197	Nam Thwai	Se Kong	Sansai	Attapeu	2		Satsada Electric	MOU 30/3/2013
198	Nam Pa upper	Se Kong	Sansai	Attapeu	3		Satsada Electric	MOU 30/3/2013
199	Nam Pa lower	Se Kong	Sansai	Attapeu	4		Satsada Electric	MOU 30/3/2013
200	Huai Toklok	Se Kong	Sanamsai	Attapeu	5		Pasansok	MOU 21/7/2010
201	Nam Ka Uwan	Se Kong	Phuwong	Attapeu	15		Phongsapthawi	MOU 13/5/2011
202	Se Pian lower	Se Kong	Samakhisai	Attapeu	15		Samliam Sethakit	MOU 29/9/2011
203	Huai Paluat 1	Se Kong	Sansai	Attapeu	12	50	Samliam Sethakit	MOU 22/12/2012
204	Huai Paluat 2	Se Kong	Sansai	Attapeu	12	55	Samliam Sethakit	MOU 22/12/2012
205	Nam Pin	Se Kong	Sanamsai	Attapeu	12		Asian Power Grit	MOU 9/4/2014
206	Huai Toklok	Se Kong	Sanamsai	Attapeu	5		Pasansok	MOU 21/7/2010
207	Se Su upper	Se Kong	Phuwong	Attapeu	15		Inpaeng	MOU 30/3/2013
208	Se Su middle	Se Kong	Phuwong	Attapeu	15		Sawan construction	MOU 9/8/2013
209	Se Su lower	Se Kong	Saisetha	Attapeu	15		Phosi Construction	MOU 5/8/2014
210	Huai Puang	Se Kong	Dak Cheung	Se Kong	6		Hongkham Construction	MOU 27/6/2012 preparing for 2nd extension
211	Nam Nyoeng 5	Se Kong	Dak Cheung	Se Kong	12		MP	MOU 2/5/2014
212	Nam Nyoeng 7	Se Kong	Dak Cheung	Se Kong	15		MP	MOU 16/7/2014
213	Huai Puang lower	Se Kong	Dak Cheung	Se Kong	5		Wisawakam Energy	MOU 13/8/2014
214	Huai Kalabai 2	Se Kong	Dak Cheung	Se Kong	9		KSC	MOU 30/11/2015
215	Huai Kalabai 3	Se Kong	Dak Cheung	Se Kong	8		KSC	MOU 30/11/2015
216	Huai Pa Ae	Se Kong	Kaleum	Se Kong	15		Chaloen Construction	MOU 10/2/2015
217	Nam Nyoeng	Se Kong	Dak Cheung	Se Kong	5		Khamkhun	MOU 27/6/2012
218	Huai Imoen 1	Se Kong	Kaleum	Se Kong	15		Thanchai Construction	MOU 13/11/2015
219	Huai Imoen 2	Se Kong	Kaleum	Se Kong	10		Thanchai Construction	MOU 13/11/2015
220	Huai Tro	Se Kong	Kaleum	Se Kong	5		Hongkham Construction	MOU 8/10/2015
221	Huai Lasam	Se Kong	Kaleum	Se Kong	5		Lao Economic	MOU 15/10/2015
222	Huai Pa Yu upper	Se Kong	Dak Cheung	Se Kong	15		Vientiane Automation	MOU 19/6/2015
223	Se Loen 1	Se Kong	Kaleum	Se Kong	5		Phongsapthawi	MOU 16/10/2015
224	Se Loen 2	Se Kong	Kaleum	Se Kong	5		Phongsapthawi	MOU 16/10/2015
225	Nam Nyoeng 2	Se Kaman	Dak Cheung	Se Kong	6		Phongsapthawi	MOU 16/10/2015
226	Nam Nyoeng 4	Se Kaman	Dak Cheung	Se Kong	8		Phongsapthawi	MOU 16/10/2015
227	Nam Nyoeng 6	Se Kaman	Dak Cheung	Se Kong	4		Phongsapthawi	MOU 16/10/2015
228	Nam Nyoeng 8	Se Kaman	Dak Cheung	Se Kong	5		Phongsapthawi	MOU 16/10/2015
229	Huai Wi 1	Se Kong	Lamam	Se Kong	5		Phongsapthawi	MOU 16/10/2015
230	Huai Wi 2	Se Kong	Lamam	Se Kong	5		Phongsapthawi	MOU 16/10/2015
231	Huai Cha Okhe 1	Se Kaman	Dak Cheung	Se Kong	6		Phongsapthawi	MOU 16/10/2015
232	Huai Cha Okhe 2	Se Kaman	Dak Cheung	Se Kong	8		Phongsapthawi	MOU 16/10/2015
233	Huai Konglai	Se Kaman	Dak Cheung	Se Kong	3		Phongsapthawi	MOU 16/10/2015
Total					1,823	3,777		

Source: Made by the study team based on “Updated Hydro Power List - June 2016 (MEM)”

(2) Screening and evaluation criteria for prioritization

1) Screening policy

As shown in 3.1, the project lists were organized by MEM on June 30th, 2016.

At an early stage of this survey, the screening policy is determined based on the lists made by MEM.

Figure 3.4 shows the screening flow for the candidate projects.

Figure 3.4 Screening flow for candidate projects

Listing the projects under development (Divided into less/more than 15MW)

↓

Selection of the promising areas by prefecture according to number of projects under development with reference to river flow

↓

Collection of information such as project maturity by interviews with MEM and prefecture offices

↓

Listing candidate qualified sponsors based on selection criteria: owning "multiple projects" and "projects whose output is more than 15MW"

↓

- Contacting qualified sponsors
- Checking the details (F/S) of projects, Confirmation of willingness to jointly develop with Japanese investors

↓

Narrowing down the promising candidate projects

Source: Study team

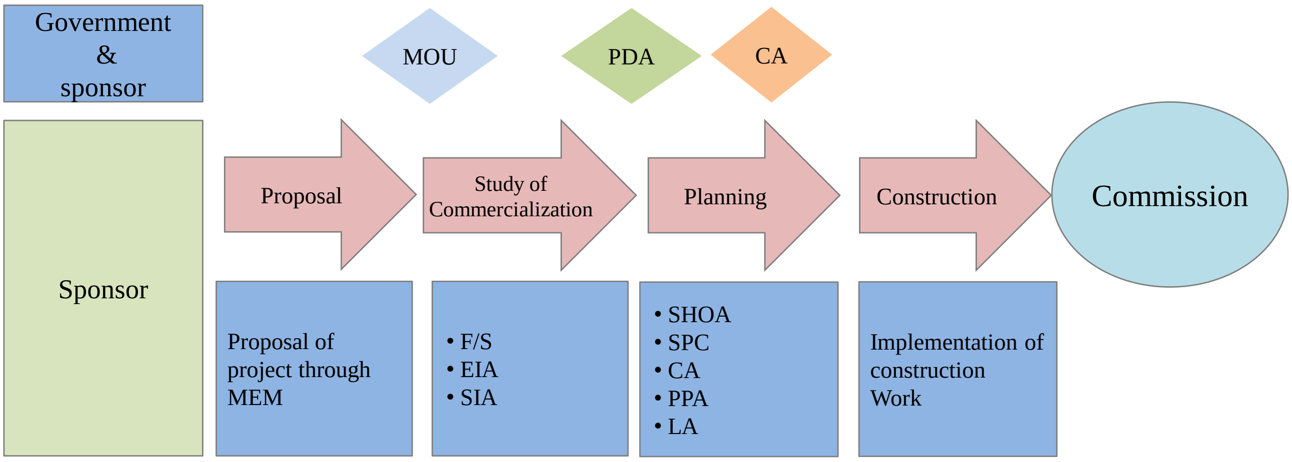
The study team listed the hydropower projects under development, dividing them into less/than 15MW, because projects of more than 15 MW are licensed by the government, and projects of less than 15 MW are approved by prefectures. There is also a purpose for investigating the actual situation with regard to divisional development at the boundary of 15 MW.

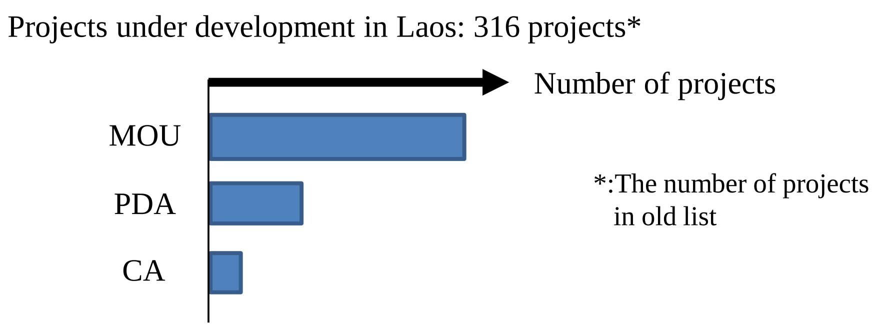
First, the study team conducted the first screening based on the scale of the project (number of projects, capacity), then narrowed down promising areas by evaluating the river flow rate. Regarding maturity of individual projects, we surveyed this through interviews with MEM and prefecture offices in promising areas.

Subsequently, the study team listed sponsors who own multiple development rights within a selected promising area and have at least 1 project more than 15 MW (as it is desirable to have mid-large capacity sufficient to obtain loans). Regarding evaluation of the social environment, for example, protected forests are distributed in all prefectures, and since it is difficult to judge the superiority of each region, this is evaluated individually.

An outline of the development procedure for hydropower in Laos is shown in Figure 3.5.

Figure 3.5 Outline of development procedure for hydropower





Source: Study team

2) Sorting lists by number of projects in old list

The list sorted based on the hydropower projects obtained from MEM in February 2016. In terms of the old list, Figure 3.6 shows the list sorted under the following policy. The number of projects for each prefecture is arranged according to the project status.

- Policy 1: Project status limited to MOU and PDA

  It is difficult for Japanese investors to participate in projects under way with an already signed CA.

- Policy 2: Selection of prefecture with many projects (10 to 15 MW)

  The study team should focus on investigation for divisional development.

- Policy 3: Selection of prefectures with many projects (over 15 MW)

  Priority was given to projects over 15 MW, because for less than 10 MW projects the investment advantage is small in terms of scale.

Figure 3.6 The list sorted by number of projects (made with old list from Feb. 2016)

Policy 3 Policy 1 Policy 1 Policy 2

Province	over 15MW						less than 15MW								Total (MOU+PDA)	Total
	Existing	Under Const.	MOU	PDA	MOU+PDA	Total	Existing	Under Const.	MOU	PDA	MOU+PDA	10～15MW※ MOU	10～15MW※ PDA	Total		
Attapeu	3	3	7	3	10	16	1				0			1	10	17
Bokeo	1			1	1	2	1	1	1		1	1	1	3	2	5
Bolikhamxay	4	1	5	1	6	11	1		7	1	8	5		9	14	20
Champasak		4	1	2	3	7	1	4	7	4	11	1	1	16	14	23
Houaphanh		1	9	3	12	13	4	3	6		6	1		13	18	26
Khammouan	1	2	2		2	5			2		2			2	4	7
Luangnamtha		1	1		1	2	2		1		1	1		3	2	5
Luangprabang	1	4	8		8	13	2		4		4			6	12	19
Oudomxay		1	1	1	2	3	2	1	2	2	4			7	6	10
Phongsaly	2	2	5	2	7	11	3		3	3	6	7	1	9	13	20
Salavan	2	1	3		3	6			9	4	13	2		13	16	19
Savannakhet			3	1	4	4	2		2		2	2		4	6	8
Vientiane	3	3	1	1	2	8					0			0	2	8
Vientiane Cap.			1		1	1					0			0	1	1
Vientiane Pro.	2	1	1	1	2	5	2	1	3	1	4	1		7	6	12
Vientiane-XYBL				1	1	1					0			0	1	1
Xayabouly	3		3	1	4	7			10		10			10	14	17
Xaysomboun		1	2	1	3	4			1		1	1		1	4	5
Xekong(Sekong)	2		7	2	9	11			7		7	1		7	16	18
Xiengkhuang	1	3	2	5	7	11	1			3	3		4	4	10	15
Total	25	28	62	26	88	141	22	10	65	18	83	23	7	115	171	256

Source: Study team

The prefectures selected according to the screening policy (3 (2) 2)) from the old list are shown as follows.

- Policy 2: Selection of prefectures with many projects (10 to 15 MW)

  3 prefectures: Bolikhamxay, Phongsaly, Xiengkhouang

- Policy 3: Selection of prefectures with many projects (over 15 MW)

  3 prefectures: Attapeu, Houapanh, Xekong

Since the latest list had not been obtained at the time of the first survey (September 2016), the study team made a speculative visit to Xiengkhouang province, where there were many PDA projects (10 to 15 MW) in the area selected via policy 2 above, and where the projects have an already completed F/S. Through a meeting with the prefecture office, the study team discussed the progress of matters and information on sponsors, and reviewed the planned screening policy.

3) Sorting lists by number of projects in new list

The prefectures selected according to the screening policy (3 (2) 2)) from the latest list are shown below.

Table 3.11 shows the list of projects based on the output scale (over 15 MW and less than 15 MW) and the number of projects by each prefecture.

Table 3.11 The list sorted by the number of projects (made with latest list from June 2016)

Province	over 15MW						less than 15MW								Total (MOU+ PDA)	Total	Number of projects being just/nearly 15MW
	Existing	Under Const.	MOU	PDA	MOU+ PDA	Total	Existing	Under Const.	MOU	PDA	MOU+ PDA	10～15MW※ MOU	10～15MW※ PDA	Total			
Attapeu	3	3	7	3	10	16	1				0			1	10	17	
Bokeo	1			1	1	2	1	1	1		1	1	1	3	2	5	15MW: 1 project
Bolikhamxay	4	1	5	1	6	11	1		7	1	8	5		9	14	20	15MW: 2 projects
Champasak		4	1	2	3	7	1	4	7	4	11	1	1	16	14	23	
Houaphanh		1	9	3	12	13	4	3	6		6	1		13	18	26	
Khammouan	1	2	2		2	5			2		2			2	4	7	
Luangnamtha		1	1		1	2	2		1		1	1		3	2	5	
Luangprabang	1	4	8		8	13	2		4		4			6	12	19	
Oudomxay		1	1	1	2	3	2	1	2	2	4			7	6	10	
Phongsaly	2	2	5	2	7	11	3		3	3	6	7	1	9	13	20	15MW: 6 projects
Salavan	2	1	3		3	6			9	4	13	2		13	16	19	
Savannakhet			3	1	4	4	2		2		2	2		4	6	8	
Vientiane	3	3	1	1	2	8					0			0	2	8	
Vientiane Cap.			1		1	1					0			0	1	1	
Vientiane Pro.	2	1	1	1	2	5	2	1	3	1	4	1		7	6	12	15MW: 1 project
Vientiane-XYBL				1	1	1					0			0	1	1	
Xayabouly	3		3	1	4	7			10		10			10	14	17	
Xaysomboun		1	2	1	3	4			1		1	1		1	4	5	15MW: 1 project
Xekong(Sekong)	2		7	2	9	11			7		7	1		7	16	18	
Xiengkhuang	1	3	2	5	7	11	1			3	3		4	4	10	15	15MW: 2 projects
Total	25	28	62	26	88	141	22	10	65	18	83	23	7	115	171	256	

Source: Study team

As a result of organizing the latest list according to the number of projects, it is found that the prefectures with many projects whose capacity is 10 to 15 MW and the prefectures with many projects whose capacity is over 15 MW are almost the same. In addition, considering the number of projects of exactly 15 MW, the 10 prefectures of Attapeu, Bolikhamxay, Champasak, Huaphanh, Luang Prabang, Phongsaly, Vientiane province, Xaysomboun, Xekong and Xiengkhouang were selected as promising areas.

4) Sorting lists by capacity potential

The capacity potential for each prefecture in hydropower development projects is as shown in Table 3.12 below.

As a result of organizing the latest list by capacity, Attapeu, Bolikhamxay, Champasak, Luang Prabang, Vientiane province, and Xekong prefectures, with large capacity potential, are selected as attractive prefectures.

Table 3.12 List sorted by capacity

Province	Under development (MOU, PDA) [MW]	Total capacity [MW]	Undeveloped rate [%]
Attapeu	1144	1718	66.5
Bokeo	230	401	57.3
Bolikhamxay	1492	1794	83.2
Champasak	2924	3625	80.7
Houaphanh	910	971	93.7
Khammouan	116	1441	8.0
Luangnamtha	236	243	97.2
Luang Prabang	2135	2446	87.3
Oudomxay	1051	1103	95.3
Phongsaly	527	947	55.6
Salavan	241	400	60.3
Savannakhet	317	320	99.0
Vientiane	1127	1586	71.1
Xayabouly	977	2275	43.0
Xaysomboun	253	1721	14.7
Xekong (Sekong)	1285	1623	79.2
Xiengkhouang	869	1182	73.5
Total	15833	23795	66.5

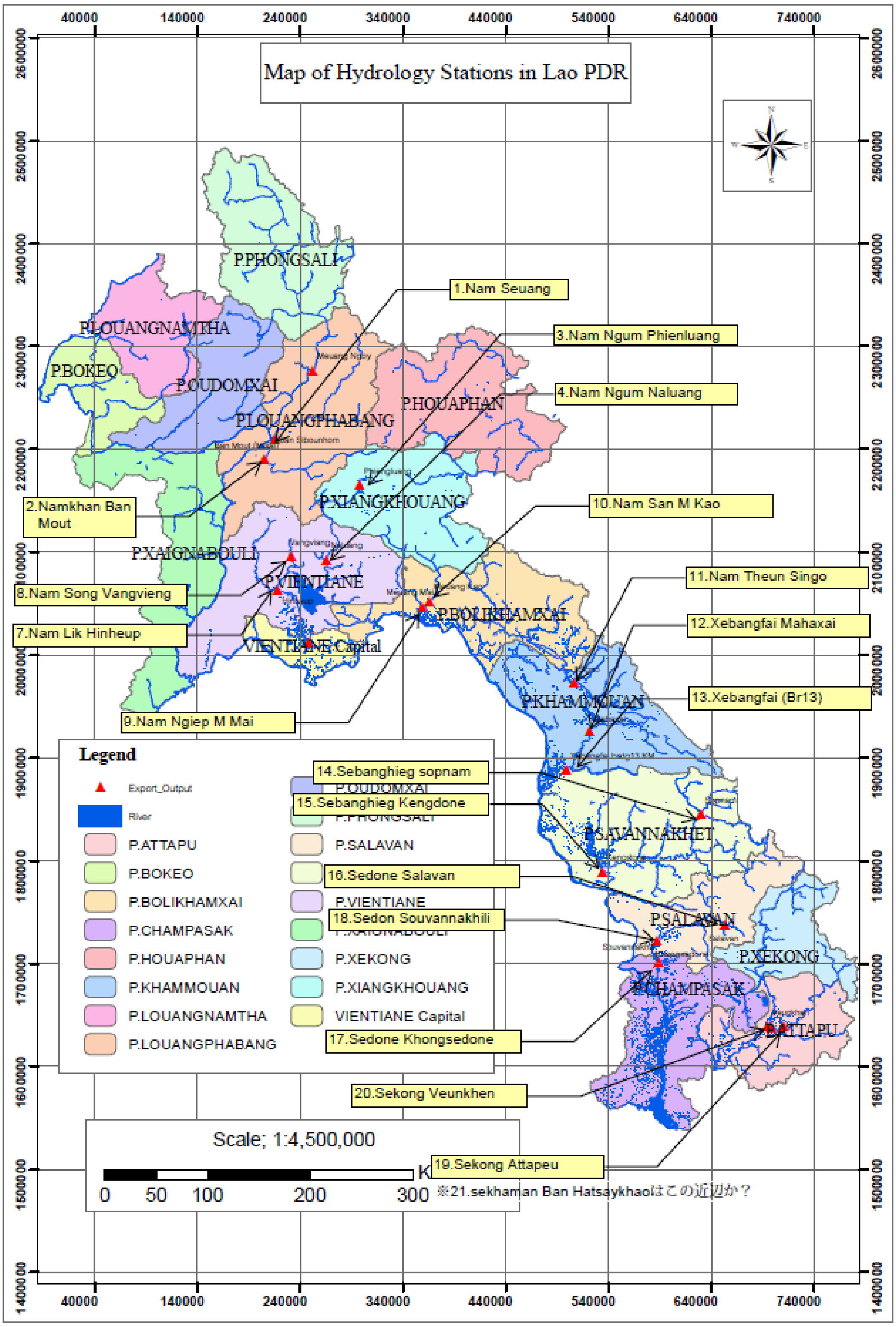
Source: Study team

5) List sorted by river flow

Table 3.13 shows flow data statistically calculated by the MONRE Meteorological Agency. This data is converted into the flow rate from the river water level data by H-Q curve. There are 53 river water level measurement points all over the country in Laos, but the points statistically calculated are only from about 21 places (Fig. 3.7). Therefore, it is difficult to select promising areas by flow rate, which is provided for reference here.

At each measurement point, the local staff visually check the water level of the river twice a day (morning and evening) and record it by hand. The data for 3 to 6 months are sent from each prefecture to the Meteorological Agency and also digitized and converted into flow data at the data input center in the Meteorological Agency.

Figure 3.7 Measurement points for river water levels



Source: Made by study team based on document provided by meteorological agency

Table 3.13 River flow data

	Measurement point	Province	River	Catchment area [km2]	Average discharge[m3/s]			Measurement period	Remarks (Missing period)
					May to Oct.	Nov. to Apr.	Yearly average		
1	Ban Sibounhom	Luangprabang	Seuang	-	149.14	40.61	94.87	1994-2014	
2	Ban Mout	Luangprabang	Khan	6,100	155.70	32.94	98.85	1995-2014	
3	Ban Phiengluang	Xiengkhouang	Nam Ngum	715	31.08	4.24	17.59	1996-2015	2012.8 to 2012.9
4	Ban Naluang	Saysomboun	Nam Ngum	5,220	231.88	54.50	143.19	1989-2008	
5	Ban Pakkagnoung	Vientiane	Nam Ngum	14,300	817.87	357.50	587.69	1995-2014	
6	Venkham	Vientiane Capital	Nam Ngum	-	963.68	420.02	691.85	1996-2015	
7	Ban Hin Heup	Vientiane	Nam Lik	5,115	364.88	106.06	235.47	2005-2014	
8	Vangvieng	Vientiane	Nam Xong	864	118.31	41.11	79.71	1994-2014	1996.1 to 1996.12
9	Meuang Mai	Borikhamxay	Nam Ngiep	4,270	277.53	61.03	169.28	1996-2015	
10	Meuang Kao	Borikhamxay	Sane	2,230	254.10	43.46	148.78	1996-2015	2011.9 to 2011.12, 2012.1 to 2012.4
11	Signo	Khammouan	singo	3,370	405.12	54.73	229.93	1987-2007	
12	Mahaxai	Khammouan	Xe Bangfai	4,520	483.68	79.42	281.55	1996-2015	1998.1 to 1198.4
13	Xe Bangfai (Br-13)	Khammouan	Xe Bangfai	8,560	978.41	64.91	521.66	1996-2015	2009.4
14	Sopnam	Savannakhet	Se Banghiang	3,990	340.55	94.82	220.12	1996-2015	1998.1 to 1998.3, 1999.1 to 1999.4, 2007.11 to 2007.12, 2008.5, 2008.10, 2008.12, 2010.11, 2010.12, 2011.1 to 2011.7, 2014.12
15	Kengdone	Savannakhet	Xe Banghiang	-	899.89	127.38	513.64	1994-2015	2010.3 to 2010.5
16	Salavan	Salavan	Sedone	-	72.42	4.65	38.53	2000-2015	
17	Khongsedone	Salavan	Sedone	-	303.26	21.55	162.40	1993-2015	2000.10 to 2000.11
18	Souvannakhili	Champasak	Sedone	5,760	331.25	33.30	182.28	1995-2004	
19	Attapeu	Attapeu	Sekong	10,500	603.17	216.19	409.68	1995-2014	2014.9 to 2014.12
20	Ban Veunkhen	Attapeu	Xekong	-	1,036.94	336.54	686.74	1997-2015	1997.1
21	Ban Hatsaikhao	Attapeu	Xe Khaman	4,400	400.00	112.79	256.40	1995-2014	

Source: Made by study team based on document provided by meteorological agency

6) Listing sponsors

Table 3.14 shows sponsors with multiple projects in promising areas (indicated in 3.2.3 and 3.2.4) and with projects of more than 15 MW.

Table 3.14 Sponsors with multiple projects in promising areas

No.	Sponsor	Number of projects owned	Number of projects of more than 15 MW owned
1	Asia Longtheun Development	2	1
2	Asia Pacific	2	1
3	AIDC*	2	2
4	Bosaikham Phathana	6	2
5	Chaloensap Khopwongchon	9	2
6	China Sichuan Gurong Group	5	5
7	Daoheuangsong	2	2
8	DMD	5	3
9	DSK Group	2	1
10	Duangchaloen	6	6
11	ECI*	2	2
12	EDL	11	8
13	EDL-Gen*	6	5
14	Guangdong Electric Company	5	5
15	Heuangpasoet	2	2
16	Hoang Anh Gia Lai	2	2
17	Lao Samphan Phathana	3	2
18	Lao Woen Group	2	2
19	MP	2	1
20	Nalinnitha Chaloensai	3	2
21	Namtha Road Bridge	2	1
22	Nesoenaeu Consulting Group	3	2
23	Nonghai Group	4	2
24	Phongsapthawi*	34	8
25	Phonsak Group*	3	3
26	PT company	5	4
26	Saichaloen	5	1
27	Sahamit Phattana	2	1
28	Sinohydro Corporation Ltd	4	4
29	SV Group	8	3
30	Thanchai Construction	3	1
31	TK Group (T&C power HD)	4	4

32	V & H Corporation	3	3
33	Vang Sup Development and Investment	2	2
34	ECI	2	2
35	Venture Capital and Equipment Inc., (Vietnam)	2	2
36	Vientian Automation (VASE)	6	4
37	Wisawakam Construction	3	1

*Including co-development with other sponsor

Source: Study team

(3) Long list of promising projects narrowed down

The study team narrowed down the number of sponsors that we could actually discuss from the selected sponsors (Table 3.14), and listed the projects that the sponsor owns in the promising areas.

(4) Candidate projects for investment

Based on the long list, the study team made contact with sponsors who own development rights such as MOU and held discussions with sponsors who were interested in collaborating with Japanese investors. Field surveys have been carried out jointly to obtain their consent.

Ultimately, 4 projects for which we were granted disclosure of technical documents such as the F/S through discussion after the field survey were selected as candidate projects for investment.

Table 3.15 List of candidate projects for investment

	Project	Capacity	Sponsor
1	Nam Ngiep 2C	14.5 MW	Nonghai Group
2	Nam Ngiep 2B	18.0 MW	Nonghai Group
3	Nam Ngiep 2A	10.0 MW	Nonghai Group
4	Nam Ban	14.0 MW	ECI

Source: Study team

Capter4 Justification, Objectives and Technical Feasibility of the Projects

(1) Background to Technical Feasibility of the Projects

1) Projects by Nonghai Group

The Nonghai Group was originally a construction company that undertook civil engineering work such as military-related roads, bridges, runways, etc. Later, in order to diversify the business, they started hydropower IPP projects. They have been developing five self-funded projects while obtaining financial support from the government, and some projects are under construction. However, self-funded development has limitations, and they are looking for a strategic partner to work with jointly.

2) Projects by Electrical Construction and Installation, State Enterprise

ECI's predecessor is implementing electricity development projects in rural areas of Laos under EDL, formally established as ECI in 1986. They mainly conduct surveys for power generation, planning, design, etc. They own power transmission and distribution substations, and have concrete pillar factories in Vientiane and Pakse. There are branch offices in each prefecture in the south, and 3 branches in Vientiane. There is only one branch office in Luang Prabang in the north. It was integrated into EDL in 1996, and it also became independent again in 2006. It will be integrated into EDL again at the beginning of next year, repeating the pattern of independence and integration. They are government-owned companies and have four development rights, one of which is already in operation. Although they have power-related technical capabilities, they are definitely short of funds and they are looking for partners.

(2) Basic policies and decisions on the content of the Technical Feasibility of the Projects

This survey, in order to encourage investment promotion for hydropower IPP projects that can become business investments for Japanese companies, selects projects where multiple developments are planned and sponsors are seeking funds and technical partners in Japan. In this survey, field surveys are conducted on selected projects, and a brief review from a technical point of view is conducted to narrow down the number of projects. In addition, this survey will conduct the necessary investigations to determine the purpose and effects of the projects, and opportunities for investment and financing. After determining promising projects, investigations will be conducted with a focus on project outline, project cost, process, project implementation system, operation and maintenance system, and environmental and social aspects. To start a hydro power project, first one must search for a candidate point for it. In addition to the method of installing a weir in a mountain stream to take in water, small and medium-sized hydro power projects often use existing facilities in the vicinity, and there are various kinds of usage forms, such as utilization of a sand control dam, utilization of river maintenance flow, agricultural water use, and water supply facility use. After determining the candidate point for the hydro power project, considering whether it is possible to install hydroelectric power generation facilities, performing a desk-based study with existing data to determine how much power generation is possible, and carrying out an on-site investigation as necessary are the main considerations. In doing this, one should effectively utilize existing materials as much as possible to reduce expense, and perform a comprehensive evaluation from the following viewpoints to select promising sites.

① Hydro Power scale (discharge available for power generation, head drop etc.)
② Relationship with demand (facilities at demand destination, capacity of equipment, usage form of electric power, etc.)
③ Environment of surrounding site
④ Presence/absence of transmission/distribution cables of power company

In choosing a promising site, discharge and heading are important considerations. Generally, in order to ascertain the discharge, one must first check for existing material. When it is difficult to obtain flow data for the promising site, it is necessary to investigate the correlation with the discharge data of a neighboring place and to prepare discharge data for the promising site. Based on these materials, we ascertain the flow data that can be used for power generation at the relevant point, and gross head (the difference in elevation between the intake level and the discharge point; an approximate value is calculated using a topographic map etc.). We perform a desk study on the scale and select some power station installation candidate points. We also need to carry out a field survey to complement the desk review and improve the accuracy of the plan. When carrying out the field survey, it is necessary to pay attention to the following items and to feed the results of the survey back into the plan.

① Status of existing roads and land owner classification
② Status of existing electric power system (presence/absence of existing system, voltage /capacity, distance from power plant, etc.)
③ Utilization situation of river water (already-acquired water rights, presence of recreational facilities etc. using rivers)
④ Laws and regulations (rivers, natural parks, natural environment preservation, national forest, forest, etc.)
⑤ Other development plans (existence of residential land development, road plans, tourism development etc.)

In addition, in the case of the water supply and sewage system, the generation method using water in factories is often a power generation plan within existing facilities, and not all of these field survey items are necessarily required. The investigation based on the above is carried out in the F/S and the target point discharge is set. In this project, it is necessary to confirm the implementation status of the F/S for promising projects and to verify their accuracy.

(3) Outline of Technical Feasibility of the Projects

Nonghai Group signed an MOU with Xiengkhouang Province for an F/S for the Nam Hai 1, 2, and 3 hydraulic projects on February 29, 2012. F/S were implemented as for a cascade type hydropower project, and in 2013 the project was renamed Nam Ngiep 2A, 2B and 2C. Investigations for project development were entrusted to various consulting companies and experts. In October 2012, Hydraulic Engineering Consultants Corporation, civil engineering consultants in Vietnam, conducted a field survey including geology, terrain, mapping, and an F/S report. Hydrologic surveys and data modifications were made by SSN Consultant Co. Ltd, and HEC Engineering used this field data for the evaluation and calculation of F/S reports in October 2012. The hydrological survey was reviewed by experts in meteorology and hydrology, and the latest edition of the hydrological survey for Nam Ngiep 2A in June 2014 was reviewed by Scottish hydrologists. The site survey and F/S report by HEC target Nam Ngiep 2A, 2B and 2C. PECC 1 from Vietnam conducted the basic design at the three sites, and the detailed design and EPC contract were carried out separately. In the case of Nam Ngiep 2C, the Nonghai Group is the developer, but as a subcontractor of Chinese enterprises, it is in charge of electromechanical construction, steel construction, tunnel construction etc. The design for this project was reviewed by Kunming Engineering Corporation in China. ECI concluded an MOU with Phongsaly province on April 29, 2014, concluded an MOU on IETL implementation for the F/S, and is currently implementing the F/S. The Nam Ban project is a coordination pond type, assuming PPA with peak/off peak and seasonal change in unit price, and is expected to be a model project for adjusted pond type among Lao domestic IPPs. Information on the two projects is shown in Table 4.1.

Table 4.1 Outline of Projects

Item		Nam Ngiep 2A/2B/2C	Nam Ban
Basic Information	Province	Xiengkhouang	Phongsaly
	River	Nam Ngiep	Nam Ou
	Annual Precipitation	1,372 mm	1,450 mm (F/S)
	Mean Flow (meteorological station)	3.35 m^3/s/9.40 m^3/s/12.90 m^3/s	19.2 m3/s
	Topographic Features	Bedrock widely outcrops Steep slope of river bank	River meanders with good rock The right bank side is a gentle slope
Planning specifications	Sponsor	Nonghai Group	ECI
	F/S	Final (Construction in progress)	Draft Final
	Origin (confluence river)	Nam Hai, Nam Song Sieng	Nam Ban
	Install Capacity	14.5 MW/18.00 MW/10.18 MW	14.0 MW
	Rate Head	356.0m/133.05m/65.0m	51.1m
	Design Flow	4.86 m^3/s/16.0 m^3/s/18.0 m^3/s	31.8m3/s
	Plant Factor	62.50%/58.67%/58.74%	52.63%
Local situation	Access Road Extension	14 km/7.9km/3.0km	4 km (from Nam Ou junction)
	Local Villages	None	Flooded Area: 2 villages (80 houses) (One in village, 37 houses and 180 people agreed to transfer)
	Others	・2A/2B/2C chooses the best location for each ・Suitable water collection/power generation system with multiple dams	・Under construction Nam Ou 4 ・Existing roads along Nam Ou
Summary		・Good access from national highway ・Secure total electricity at 2A/2B/2C	・Reliable in ECI investment project ・The output is relatively small at the point alone

Source: study team

(4) Necessary Study Items

1) Extraction of Items for Consideration regarding Technical Aspects of Promising Project

For each promising project, we examine the accuracy and feasibility of the content of the power generation plan from a technical aspect. During this, the following items are particularly verified. The verification will be conducted as per the content shown in the F/S of each candidate project.

Table 4.2 F/S Formulation Month of Each Candidate Project

Project Title		Install capacity	Sponsor	F/S formulator	Formulation
1	Nam Ngiep 2C	14.5 MW	Nonghai Group	Kunming Engineering Corporation	2014.06
2	Nam Ngiep 2B	18.0 MW	Nonghai Group	Kunming Engineering Corporation	2014.06
3	Nam Ngiep 2A	10.0 MW	Nonghai Group	Nor Consult Laos Ltd	2015.07
4	Nam Ban	14.0 MW	ECI	MAX proof Co. Ltd	2015.12

Source: study team

Table 4.3 Study Items and Purpose, Main Method of Study

Study items	Purpose	Method of study
Flow setting	Verify the validity of the setting condition for the discharge at the planning point and confirm whether the planned power generation output can be secured steadily.	Based on flow data and map data separately obtained in this survey, we summarize the drainage basin areas and flow conditions and check the divergence from F/S flow setting.
Rate head	Confirm the content for loss calculation on each structure, including penstock, and confirm whether it can be secured steadily.	Calculate the head loss from F/S and drawing data obtained in this survey and check the difference from rate head in F/S.
Construction cost	Confirm the estimation content of the construction costs for new temporary roads and transmission lines and verify the validity of the construction cost calculation.	Calculate the approximate cost based on the standards in Japan and confirm the divergence from the construction cost in F/S.

Source: study team

2) Outline and Verification of Flow Setting in Candidate Project

In planning the hydro power plan, the discharge data is necessary for calculation of power generation scale, design flow, and annual energy production, and it is an important factor for formulating various elements of the power generation plan.

(a) Main Flow of Flow Setting in Candidate Project F/S

In the F/S of the candidate project, the main flow in setting the river discharge is as follows. The table below summarizes up to the discharge setting in the candidate project

Table 4.4 The Discharge Setting

① Organization of dam and weir points

② Calculation of catchment area

③ Observation points such as discharge; data collection confirmation

④ Confirmation of correlation between collected data and discharge

⑤ Completion of missing data; setting long term mean flow

Source: Study Team

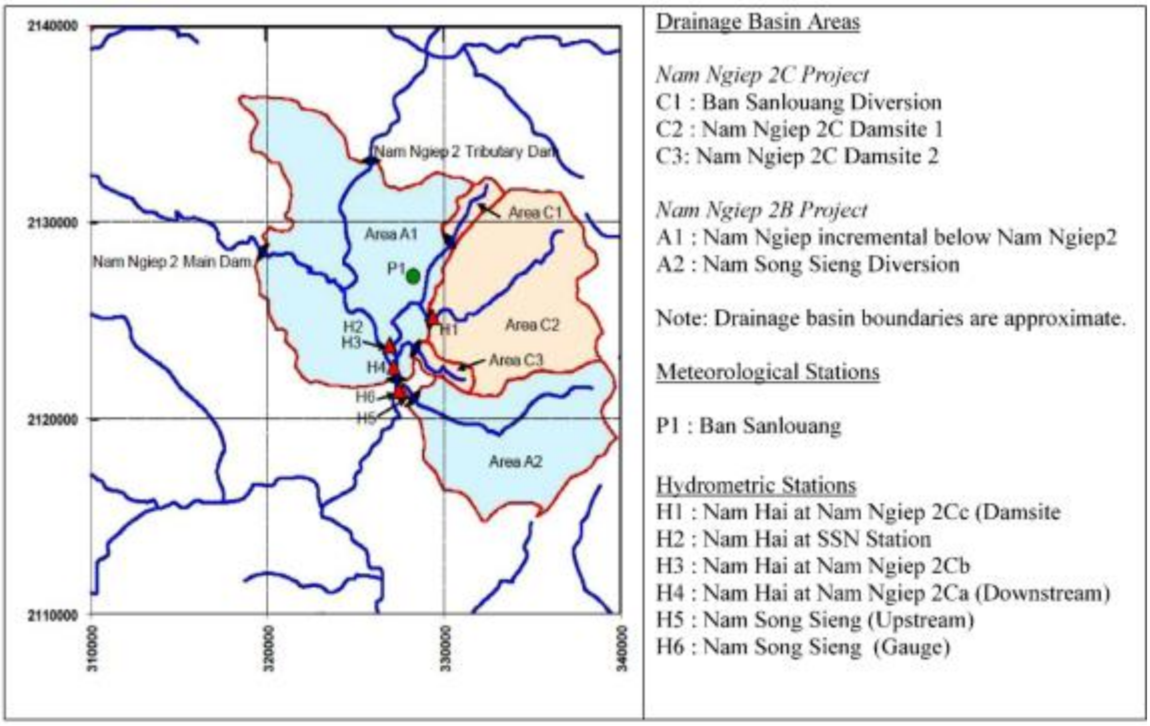
(b) Outline of set discharge by candidate project

(i) Nam Ngiep 2A, 2B, 2C

① Organization of Dam and Weir Points

Nam Ngiep 2A, 2B, and 2C are hydroelectric power generation projects in the same basin, and the method of discharge setting is the same as in the F/S at these 3 sites. The F/S show the position and altitude of each dam site etc. They use information from Google Earth etc.

Figure 4.1 The Positions and Coordinates of the Dams of Nam Ngiep 2A, 2B, and 2C



No.	Structure	Location[1]				Elevation[2] (m.asl)
		Coordinates (UTM WGS 84) E	Coordinates (UTM WGS 84) N	Latitude N	Longitude E	
Nam Ngiep 2						
1	Nam Ngiep 2 Tributary Dam	325,815	2,133,477	19°17'15.19"	103°20'32.44"	911
2	Nam Ngiep 2 Main Dam	319,613	2,128,640	19°14'35.90"	103°17'01.67"	865
Nam Ngiep 2C						
3	Nam Ngiep 2C san Luang diversion	330,344	2,128,940	19°14'49"	103°23'09"	1340
4	Nam Ngiep 2C dam site 1 (D3)	329,169	2,125,138	19°12'45"	103°22'30"	994
5	Nam Ngiep 2C dam site 2 (D3A)	328,221	2,123,732	19°11'59"	103°21'58"	961
Nam Ngiep 2B						
6	Nam Ngiep 2B Song Sieng diversion	328,312	2,120,902	19°10'27"	103°22'02"	600
7	Nam Ngiep 2B dam site	327,208	2,122,185	19°11'08.39"	103°21'23.80"	584
Nam Ngiep 2A						
8	Nam Ngiep 2A dam site	325,935	2,118,640	19° 9'12.69"	103°20'41.41"	445

Source: Quoted from F/S

② Calculation of Catchment Area at Dam and Weir Points

A meteorological station shows information about the catchment area from each observation point. The catchment area from the dam/weir point from F/S-recorded areas are based on Google Earth and a 1/100,000 topographical map. Therefore, it cannot be said that the calculation precision for the catchment area is very high; verification with an improvement in catchment area accuracy is required. However, there is a lack of effective drawing data for area calculation of the area concerned, so area calculation in a 1/10,000 topographic map is the most accurate method at the present time.

Figure4.2 Drainage Basin Area List at Each Location of Nam Ngiep

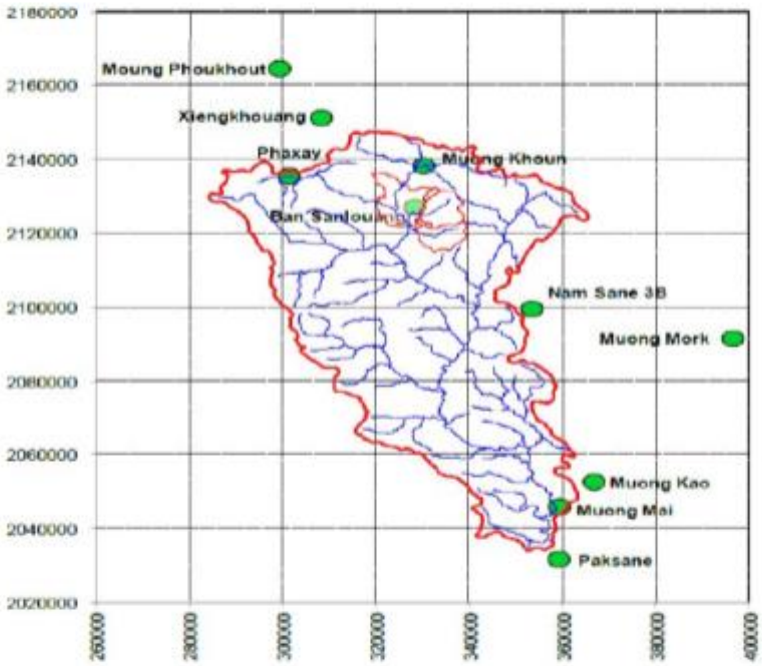
No.	Structure	Drainage Basin Area (Km^2)
Nam Ngiep 2		
1	Nam Ngiep 2 Tributary Dam	344
2	Nam Ngiep 2 Main Dam	349
Nam Ngiep 2C		
3	Nam Ngiep 2C san Luang diversion dam	6.8
4	Nam Ngiep 2C dam site 1 (D3)	61.7
5	Nam Ngiep 2C dam site 2 (D3A)	4.5
Nam Ngiep 2B		
6	Nam Ngiep 2B Song Sieng diversion dam	59
7	Nam Ngiep 2B dam site	184
Nam Ngiep 2A		
8	Nam Ngiep 2A dam site	281

Source: Quoted from F/S

③ Observation Points such as Discharge; Data Collection confirmation

In the F/S, they collect flow data from meteorological stations, organize the flow data separately observed by the Nonghai Group, and try to use actual data.

Figure 4.3 Locations of Meteorological Stations



Source: Quoted from F/S

Table 4.5 Observed Mean Annual Precipitation at Meteorological Stations

No.	Station	Period of available data (record not complete for some stations)	Observed No. of complete years[3/] (-)	Mean annual precipitation (mm)
In Nam Ngiep Basin				
1	Muong Khoun	1996 - 2009	14	1599
2	Phaxay	1996 - 2008	12	1542
3	Ban Sanlouang	Mar 2012 - Feb 2014	1	1632
4	Muong Mai	1978 - 2013	30	3634
In Neighbouring Basins				
5	Moung Phoukhout	1996 - 2009	12	1487
6	Xiengkhouang	1929-1941, 1982-2013	56	1501
7	Nam Sane 3B	2011 - 2012	1	2732
8	Muong Mork	1996 - 2009	14	1798
9	Muong Kao	1988 - 2013	30	2999
10	Paksane	1965 - 2013	50	3160

No.	Station	Location[1/] Coordinates (WGS84 UTM 48N) E	N	Latitude N	Longitude E	Elevation[2/] (m.asl)
In Nam Ngiep Basin						
1	Moung Khoun	330.170	2,138.504	19°20'00	103°23'00''	-
2	Phaxay	301.240	2,135.722	19°18'20''	103°06'30''	1,511
3	Ban San Luang	328.211	2,127.271	19°13'54.097''	103°21'56.523	1,015
4	Muong Mai	359.243	2,046.025	18°30'00''	103°40'00''	163
In Neigbouring Basin						
5	Muong Phoukout	299.256	2,164.776	19°34'04''	103°05'11''	-
6	Xieng Khouang	308.180	2,151.454	19°26'54''	103°10'22''	1097
7	Nam Sane 3B	353.328	2,099.902	18°59'11''	103°36'24''	-
8	Muong Mork	396.449	2,091.895	18°55'00''	104°01'00''	-
9	Muong Kao	366.681	2,052.796	18°33'42''	103°44'12''	159
10	Paksane	359.138	2,031.823	18°22'18''	103°40'00''	163

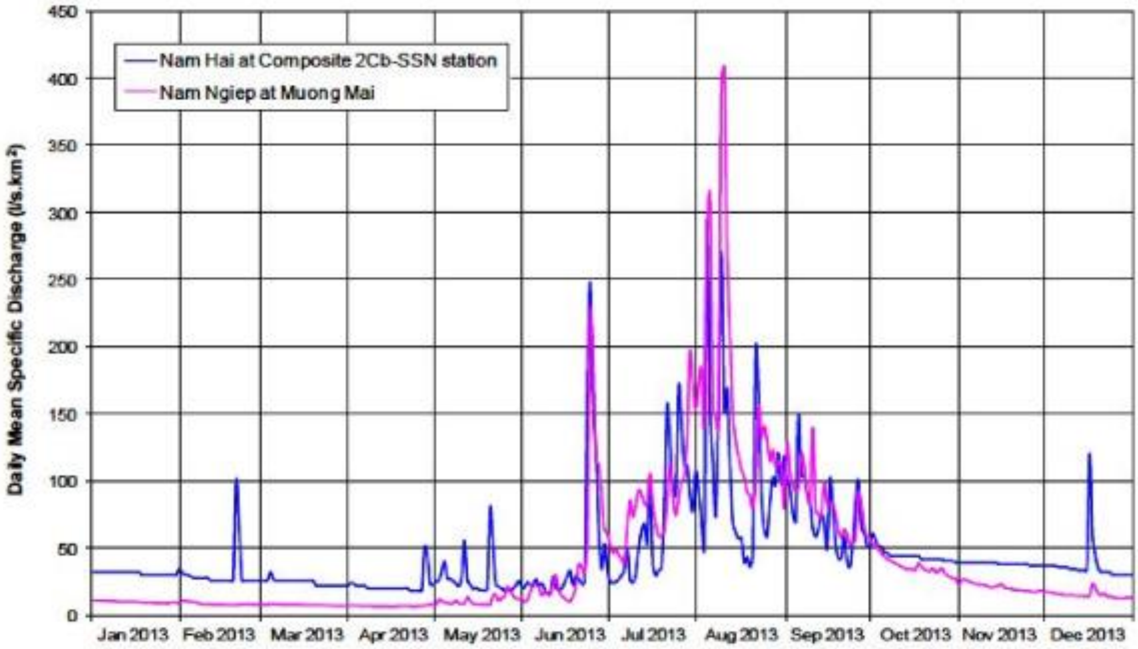
Source: Quoted from F/S

④ Confirmation of Correlation Between Collected Data and Discharge

Based on the proximity of Nam Hai and Nam Ngiep 2 Cb point, synchronization with observation point data and observation accuracy by data acquisition method etc., the point discharge is formed by combining these records. In addition, paying attention to the fact that the correlation between the Nam Hai/Nam Ngiep 2 Cb composite data and the flow data at the Muong Mai point is the highest, long-term discharge is set based on these data. In addition, differences in discharge conditions in the dry season are observed when flow data at both sites are overlapped. Since the granite found in the Nam Ngiep area is a less permeable geologic area than the limestone in the surrounding area, it is analyzed as an increase in discharge due to permeation.

Figure 4.4 Hydrographs of Specific Daily Mean Discharge at the Nam Hai/Composite 2Cb-SSN and Nam Ngiep/Muong Mai Stations

b) Year 2013



Source: Quoted from F/S

⑤ Completion of Missing Data; Setting Long Term Mean Flow

In the F/S, it is confirmed that there is a high correlation (R2 = 0.845) in the composite data (Nam Hai/Nam Ngiep 2 Cb) observed by the Nonghai Group and the point of the Muong Mai by the meteorological station.

Figure 4.5 Composite 2Cb-SSN and Muong Mai Hydrometric Stations

– Correlation of Monthly Mean Discharge –

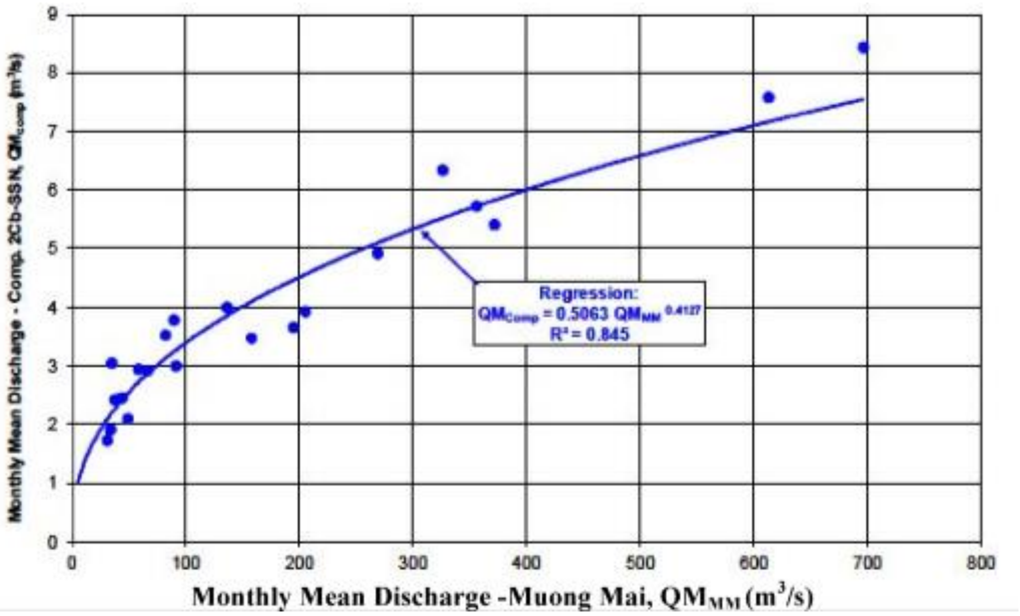


Table3-10: Long-Term Duration Curves of Daily Mean Discharge at Project Sites (1987-2013)

Exceedence Probability (%)	Nam Ngiep 2C Sanluang	Nam Ngiep 2C Dam D3	Nam Ngiep 2C Dam D3A	Nam Song Sieng Diversion dam	Nam Ngiep 2B Dam	Nam Ngiep 2A dam
0.00%	2.18	19.76	1.44	18.89	58.93	89.99
1.00%	1.25	11.36	0.83	10.87	33.89	51.75
2.00%	1.13	10.25	0.75	9.80	30.56	46.68
3.00%	0.92	8.39	0.61	8.02	25.02	38.22
4.00%	0.81	7.35	0.54	7.03	21.91	33.47
5.00%	0.76	6.88	0.50	6.58	20.52	31.34
6.00%	0.71	6.44	0.47	6.16	19.22	29.35
7.00%	0.69	6.26	0.46	5.98	18.65	28.49
8.00%	0.64	5.79	0.42	5.54	17.27	26.37
9.00%	0.63	5.75	0.42	5.49	17.13	26.17
10.00%	0.60	5.47	0.40	5.23	16.31	24.90
11.00%	0.60	5.47	0.40	5.23	16.31	24.90
12.00%	0.60	5.47	0.40	5.23	16.31	24.90
13.00%	0.56	5.05	0.37	4.83	15.06	23.00
14.00%	0.53	4.85	0.35	4.63	14.45	22.07
15.00%	0.51	4.66	0.34	4.45	13.88	21.20
16.00%	0.47	4.26	0.31	4.07	12.70	19.39
17.00%	0.47	4.26	0.31	4.07	12.70	19.39
18.00%	0.44	4.01	0.29	3.83	11.96	18.26

Source: Quoted from F/S

(ii) Nam Ban

① Organization of Dam and Weir Points

According to the F/S for Nam Ban, coordinates and elevations of dam points are determined by GPS during field survey.

② Calculation of Catchment Area at Dam and Weir Points

Based on the 1/50,000 topographic map, the catchment area of the dam site is calculated as 708.6 km 2. The catchment area of M.Ngoy (Meteorological station), which is the observation point to be correlated, is shown.

Figure 4.6 Catchment Areas of Dam Site and Meteorological Station (M.Ngoy)

Figure 4.1-1: Nam Ban HPP on Combined Topographic Map 1:50000 Scale

Table 2.2.2-1: Streamflow Gauging Station around the Project Area

No.	Station Name	Stream	Drainage Area (km^2)	Period of Record	No. of Year	Mean Annual Discharge (MCM)	Yield (lite/sec/km^2)
1	M.Ngoy	Nam Ou	19,698	1994-2003, 2006-2013	18	14,274.16	22.82

Source: Quoted from F/S

③ Observation Points such as Discharge; Data Collection confirmation

In the F/S, flow analysis at the relevant point needs to be collected and public flow data, analyzed. The consultant who created the F/S is conducting the flow observation at the relevant point, but the observation period is only about 5 months, from 2015.3.22 to 2015.8.17.

Figure 4.7 Locations of Meteorological Stations 0

Figure 2.2-1: Location Map of the Hydrological Station in the Surrounding Project Area

Source: Quoted from F/S

Table 4.6 List of Rainfall Stations Scattered in the Surrounding Project Area

Table 2.2.1-1: List of Rainfall Station Scattered in the Surrounding Project Area

No	Station Name	Country	Period of Record	No. of Year	Mean Annual Rainfall (mm)
1	Gnot-Ou	Lao	2003-2010	8	1,029.80
2	Phongsaly	Lao	1988-2014	27	1,614.29
3	Boun Neua	Lao	2003-2010	8	2,077.60
4	Muang Khoua	Lao	1930-1935, 1938, 2003-2007, 2009-2010	13	1,248.90
5	M. Ngoy	Lao	1992-2009, 2011-2012	19	1,193.95
6	Dien Bien Phu	Vietnam	1994-2013	20	1,593.50
7	Louangnamtha	Lao	1993-2014	22	1,550.17
8	M. Sing	Lao	1929-1930, 1934-1935,1938-1939, 2003-2014	18	1,438.86
9	Oudomxay	Lao	1991-2014	24	1,468.35

Source: Quoted from F/S

④ Confirmation of Correlation Between Collected Data and Discharge

In the F/S, it is examined whether there is a big difference in the trend of the long-term discharge of the collected rainfall stations. At the planning site, there is no meteorological station in Nam Bang. For this reason, they use the meteorological station at M.Ngoy.

⑤ Completion of Missing Data; Setting Long Term Mean Flow

In the F/S, the long-term discharge at the planning site is calculated from the meteorological station of M.Ngoy and the catchment area at the dam site.

However, the F/S does not indicate why they chose the meteorological station of M.Ngoy, or that the correlation between the dam site and the meteorological station of M.Ngoy is high.

Calculation Formula for Mean Discharge

$$Q_2 = Q_1 \times \left(\frac{A_2 \times I_2}{A_1 \times I_1} \right)$$

Where:

Q_1 = runoff at the index station, m^3/s;

Q_2 = runoff at the proposed dam site, m^3/s;

A_1 = catchment area at the index station, km^2;

A_2 = catchment area at the proposed site, km^2;

I_1 = mean annual basin rainfall at the index station, mm; and

I_2 = mean annual basin rainfall at the proposed site, mm.

Source: Quoted from F/S

Table 4.7 Generated Monthly Runoff of Nam Ban Basin at Dam Site

Unit : m^3/s

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
1994	4.4	3.9	4.1	4.1	5.3	19.6	96.7	69.0	32.8	28.8	15.2	9.9	24.5
1995	***6.0***	***5.0***	***4.7***	***5.4***	4.8	33.8	41.8	75.9	31.2	19.6	9.5	6.5	20.4
1996	5.4	5.0	4.7	4.8	6.4	11.0	50.2	100.1	44.8	21.3	11.6	8.6	22.8
1997	6.4	5.3	5.3	6.7	4.8	7.2	52.5	51.0	54.6	27.5	11.4	7.8	20.0
1998	6.0	5.1	4.3	6.0	6.5	18.5	42.7	32.6	31.7	9.7	7.6	5.7	14.7
1999	5.3	4.5	4.1	4.7	8.7	19.4	39.4	63.2	57.5	19.1	13.9	7.2	20.6
2000	5.8	4.8	4.3	6.3	8.5	14.3	68.1	38.5	39.1	13.9	9.2	6.6	18.3
2001	5.3	4.8	4.9	4.8	14.3	31.9	70.0	50.4	32.9	20.8	17.5	7.8	22.1
2002	6.0	5.3	4.9	4.6	12.3	23.7	100.2	90.2	14.0	17.7	10.4	8.7	24.8
2003	12.8	6.7	5.8	5.3	4.8	9.0	13.0	40.9	34.4	9.6	11.7	9.7	13.7
2006	***6.0***	***5.0***	***4.7***	***5.4***	***7.4***	***16.6***	41.3	63.0	28.7	24.8	8.4	6.0	18.1
2007	4.8	4.6	4.1	5.7	8.0	10.6	25.9	47.4	34.7	12.7	6.5	5.5	14.2
2008	5.2	5.5	5.0	3.8	5.2	25.6	65.7	79.1	67.6	***17.7***	29.1	7.7	26.4
2009	6.8	5.4	4.7	6.8	8.0	11.6	51.9	47.5	32.0	14.1	7.9	5.9	16.9
2010	5.1	4.3	4.6	7.8	7.6	8.3	16.2	35.0	28.4	14.5	6.9	5.4	12.0
2011	4.9	4.3	5.0	4.6	8.2	13.3	46.0	38.6	46.8	16.9	10.6	6.6	17.1
2012	6.5	5.3	4.7	4.7	5.9	14.9	45.6	70.0	31.8	12.8	8.8	7.8	18.3
2013	5.9	5.6	4.9	5.2	7.3	9.2	42.6	65.7	54.2	16.3	7.8	16.3	20.1
Average	**6.0**	**5.0**	**4.7**	**5.4**	**7.4**	**16.6**	**50.6**	**58.8**	**38.7**	**17.7**	**11.3**	**7.8**	**19.2**
Max	**12.8**	**6.7**	**5.8**	**7.8**	**14.3**	**33.8**	**100.2**	**100.1**	**67.6**	**28.8**	**29.1**	**16.3**	**26.4**
Min	**4.4**	**3.9**	**4.1**	**3.8**	**4.8**	**7.2**	**13.0**	**32.6**	**14.0**	**9.6**	**6.5**	**5.4**	**12.0**

Note: 1. The value written in italic and bold format is filled by average values.

2. Data is missing in year 2004-2005.

Source: Quoted from F/S

(a) Validation and Issues Concerning Discharge Setting

(ⅰ) Considerations in Selection of Flow Observation Points to be Correlated

With regard to the F/S for the candidate project, the main flow in the setting of the mean flow and the corresponding situation are summarized in the previous section. Investigation of river discharge over a long period is necessary to study the discharge in a plan for hydro power generation. In the absence of observation discharge data, it is necessary to consider the discharge at the planning point using the discharge data from a highly correlated water measurement station, which is close to the planning site. The discharge at the planning point is obtained by calculating the correlation coefficient between these points. When planning hydro power generation in Japan, the method of calculating the discharge is provided by the "Small Hydroelectric Power Guide, New Energy Foundation" (p 54) and "Hydropower Planning Point Flow Calculation Manual, New Energy Foundation" (p 33).

According to these documents, conditions for discharge considerations are as follows.

・The geological conditions of the planning site and the neighboring water measuring station are similar
・The characteristics of rainfall are similar
・Ratio of catchment area is in the range of 0.5 to 2.0
・Flowing rivers are in parallel
・Observation data for the planning point discharge is for one year or more

According to the above conditions, the F/S for the candidate project are as follows. At the candidate project sites, since there are few meteorological stations the dam site and the river at the meteorological station are not parallel. In addition, the catchment area ratio does not satisfy the conditions. However, for the Nam Ngiep site the discharge has been observed for about two years at the planning site with information collected to verify the correlation. The point observation discharge data for the Nam Ban point has only been accumulated for about 5 months. Therefore, it is necessary to verify the accuracy for the accumulation of observation data and discharge setting.

Table 4.8 Match With Discharge Setting Conditions

Condition	Nam Ngiep 2A, 2B, 2C		Nam Ban	
Geological similarity	Between granite and limestone Consideration of difference	△	Wide geological map	△
Similarity of rainfall characteristics	There is verification of similarity	○	There is verification of similarity	○
Ratio of catchment area is 0.5 - 2.0	Dam Site : 74.2 km^2 Muong Mai : 4,305 km^2 Ratio : 0.017	×	Dam Site : 708.6 km^2 M.Ngoy : 19,698 km^2 Ratio : 0.036	×
The target river is parallel	Not parallel	×	Not parallel	×
Discharge observation period is 1 year or more	2012.3.16 to 2014.1.31 For about two years	○	2015.3.22 to 2015.8.17 For about 5 months	×

Source: study team

(ii) Considerations in Calculation of River Basin Area at Dam Site

① Nam Ngiep 2A, 2B, 2C

According to the F/S, the catchment area of the dam site shown is from Google Earth and 1/100,000 topographic maps. We calculated the catchment area at the dam site based on a topographic map (1:150,000), then collected and compared it with the catchment area shown in the F/S. In addition, we used AutoCAD to calculate the catchment area with the collected topographic map (1:150,000). As a result of calculating the catchment area, we did not see much difference from the catchment area shown in the F/S.

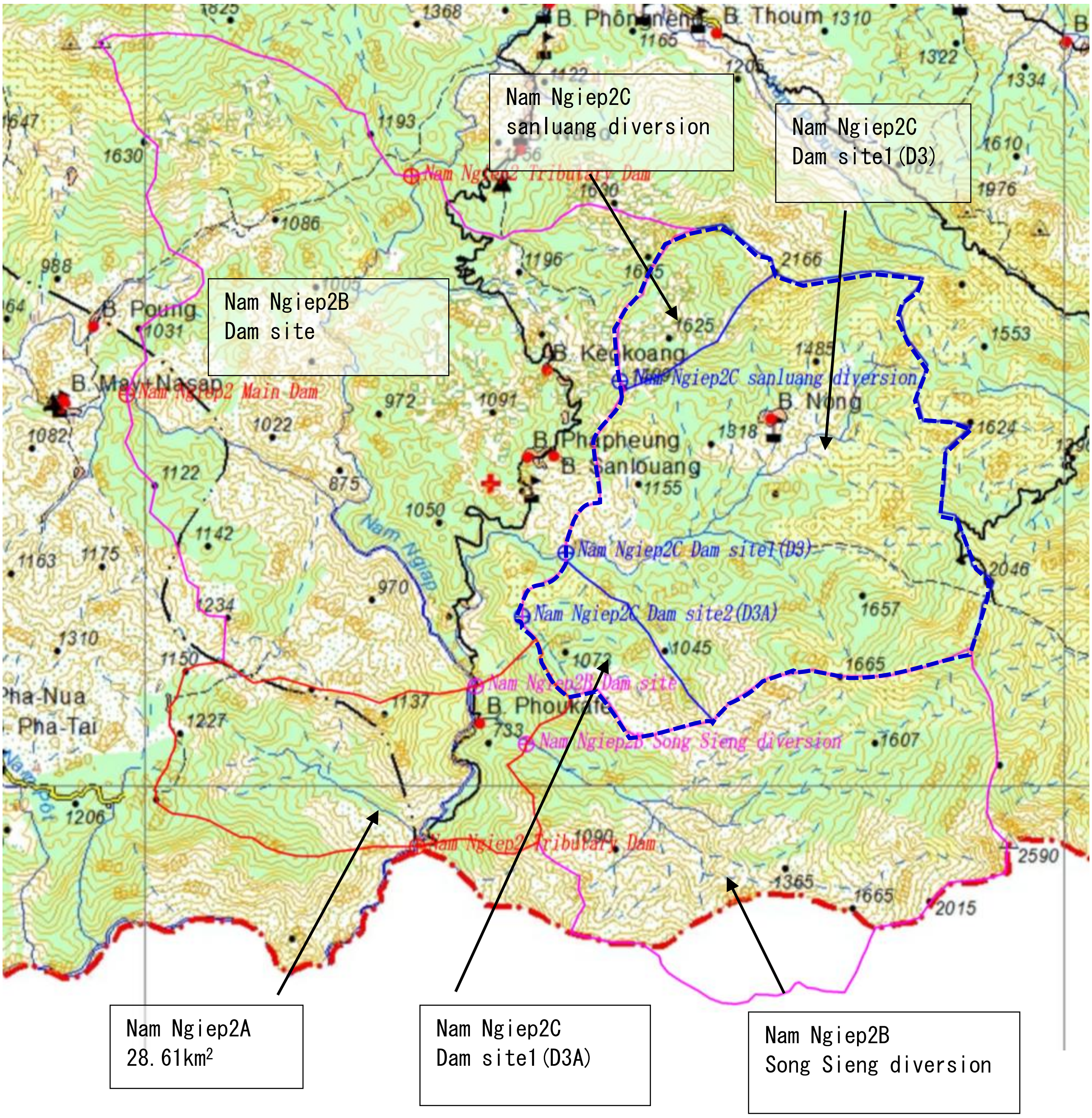
Table 4.9 Comparison of Catchment Area at Nam Ngiep Site

unit: km^2

	F/S ①	Measure on map ②	difference ①−②
Nam Ngiep2C			
1 Sanluang diversion	6.80	6.87	-0.07
2 Dam site 1 (D3)	61.70	59.84	1.86
3 Dam site 1 (D3A)	4.53	7.67	-3.14
Nam Ngiep2B			
4 Song Sieng diversion	59.20	56.06	3.14
5 Dam site	184.03	188.64	-4.61
Nam Ngiep2A			
6 Dam site	281.23	273.31	7.92
Total area			
Nam Ngiep 2C	73.03	74.38	-1.35
Nam Ngiep 2B	243.23	244.70	-1.47
Nam Ngiep 2A	281.23	273.31	7.92

Source: study team

Figure 4.8 Catchment Area of Nam Ngiep Site Measurement Chart with 1/150,000 Topographic Map



Source: study team

Photo 4.1 Intake Point for Nam Ngiep 2A

Source : study team

Photo 4.2 Dam Site for Nam Ngiep 2C

Source : study team

② Nam Ban

According to the F/S, it can be assumed that the catchment area of the dam site is calculated based on a 1/50,000 topographic map. We calculated the catchment area at the dam site based on a topographic map (1:150,000), then collected and compared it with the catchment area shown in the F/S. In addition, we used AutoCad to calculate the catchment area with the collected topographic map (1:150,000). As a result of calculating the catchment area, we did not see much difference from the catchment area shown in the F/S.

Table 4.10 Comparison of Catchment Area at Nam Ban Site

Site	Catchment Area		Difference ①−②
	F/S ①	Calculated based on the Topographic map ②	
Nam Ban Dam Site	708.6 km^2	700.4 km^2	8.20 km^2 (1.2%)

Source: study team

Figure 4.9 Catchment Area of Nam Ban Site Measurement Chart with 1/150,000 Topographic Map

Source: study team

(iii) Considerations in Setting of Long-term Discharge

If the discharge data at the watering station at the planning point does not cover 10 years, it is necessary to complement the flow rate data for the years that are insufficient. According to "Hydroelectric planning point flow rate calculation manual, New Energy Foundation", the complementary method is as follows.

- Select a water measurement station to use for the complement
- Analyze the correlation for the same year's discharge data from the water measurement station at the planning site and the water measurement station used for supplementation
- Estimate the regression equation for the discharge data
- Complement the discharge for the insufficient years from the discharge data of the measuring station by using the estimated regression equation

The selection method and considerations concerning the measuring station used for supplementation are shown in the previous section. Below, we consider the supplementary concept of discharge and the calculation method for long-term discharge.

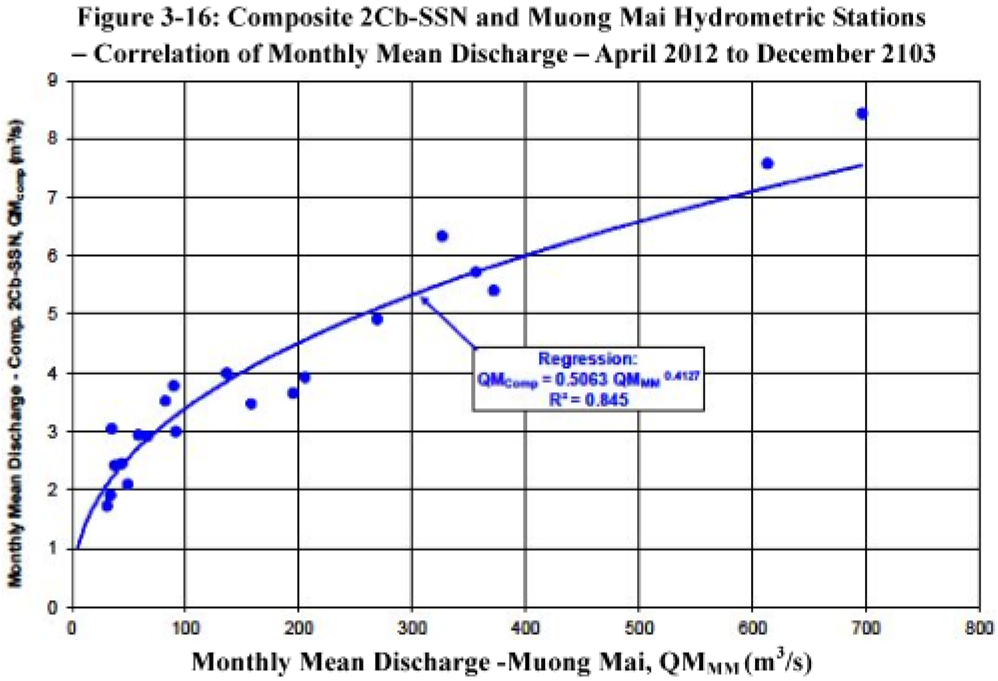
① Nam Ngiep 2A, 2B, 2C

In order to estimate the regression equation from the correlation of the discharge data, it is standard to make it a linear regression equation. However, the F/S calculates a quadratic regression equation. Ideally, 0.9 or more is the coefficient of correlation, but this is only 0.845 in the F/S. For this reason, it is better to re-examine the reliability of the set discharge. Specifically, it is better to accumulate data on the discharge observation at the planning site that is still in progress and improve the accuracy. Looking at the Duration Curve set by the F/S, it is larger than the value of the Muong Mai point after the 110th day. In general, as the catchment area becomes larger, the ratio of the discharge becomes smaller, so at the Muong Mai point (4,305 km 2) and the Nam Ngiep 2A dam site (281 km 2), the possibility that the Nam Ngiep 2A dam site may increase the discharge is high. Therefore, this result seen in the duration curve can be considered as representing no particular problem. For this reason, although there are some problems such as low correlation coefficient and secondary regression formula, it is considered that there is no big difference in the discharge setting at the point as a whole.

② Nam Ban

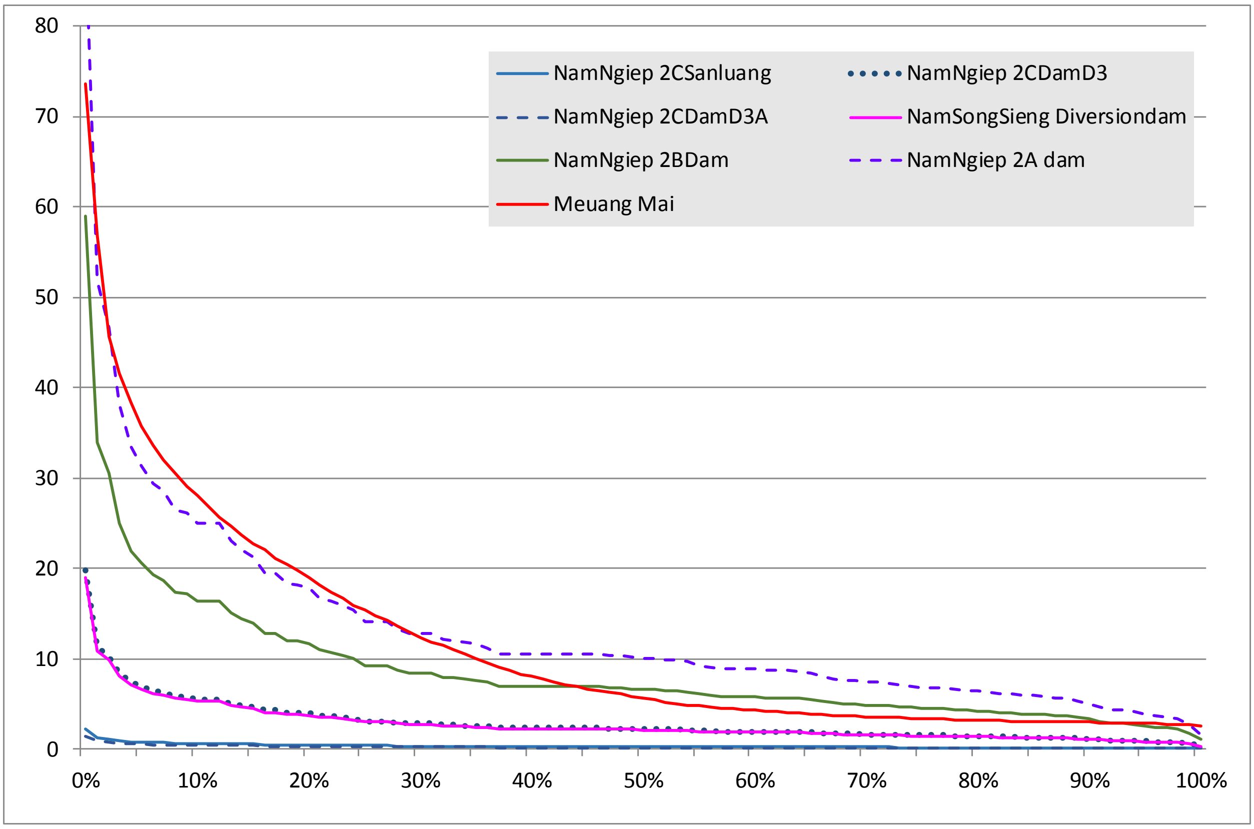
In the F/S for Nam Ban, we do not clarify the high correlation between the dam site discharge and the meteorological station M.Ngoy. It is considered that the discharge at the planning point is calculated based on the ratio of the catchment area at the two points. As mentioned earlier, observation data at the planning point is only for about 5 months. Moreover, since the M.Ngoy point to be supplemented is far from the planning site and the area of the catchment basically differs between them, the discharge at the planning point may be different from the discharge in the F/S. Therefore, it is better to accumulate observation data and improve the accuracy of the discharge setting.

Figure 4.10 Composite 2Cb-SSN and Muong Mai Hydrometric Stations
– Correlation of Monthly Mean Discharge – (Repeated)



Source: Quoted from F/S

Figure 4.11 Mean Discharge of Nam Ngiep Area



Source: study team

Table 4.11 Long Term Discharge table in Each Area of Nam Ngiep

	NamNgiep 2C Sanluang	NamNgiep 2C DamD3	NamNgiep 2C DamD3A	NamSongSieng Diversiondam	NamNgiep 2B Dam	NamNgiep 2A Dam	Meuang Mai
0.00%	2.18	19.76	1.44	18.89	58.93	89.99	73.56
1.00%	1.25	11.36	0.83	10.87	33.89	51.75	56.80
2.00%	1.13	10.25	0.75	9.80	30.56	46.68	45.69
3.00%	0.92	8.39	0.61	8.02	25.02	38.22	41.55
4.00%	0.81	7.35	0.54	7.03	21.91	33.47	38.29
5.00%	0.76	6.88	0.50	6.58	20.52	31.34	35.71
6.00%	0.71	6.44	0.47	6.16	19.22	29.35	33.56
7.00%	0.69	6.26	0.46	5.98	18.65	28.49	32.02
8.00%	0.64	5.79	0.42	5.54	17.27	26.37	30.46
9.00%	0.63	5.75	0.42	5.49	17.13	26.17	29.07
10.00%	0.60	5.47	0.40	5.23	16.31	24.90	28.03
11.00%	0.60	5.47	0.40	5.23	16.31	24.90	26.70
12.00%	0.60	5.47	0.40	5.23	16.31	24.90	25.64
13.00%	0.56	5.05	0.37	4.83	15.06	23.00	24.62
14.00%	0.53	4.85	0.35	4.63	14.45	22.07	23.65
15.00%	0.51	4.66	0.34	4.45	13.88	21.20	22.77
16.00%	0.47	4.26	0.31	4.07	12.70	19.39	22.03
17.00%	0.47	4.26	0.31	4.07	12.70	19.39	21.10
18.00%	0.44	4.01	0.29	3.83	11.96	18.26	20.50
19.00%	0.44	3.99	0.29	3.82	11.90	18.17	19.84
20.00%	0.43	3.92	0.29	3.75	11.69	17.86	18.99
21.00%	0.40	3.66	0.27	3.50	10.91	16.67	18.13
22.00%	0.40	3.60	0.26	3.44	10.74	16.40	17.34
23.00%	0.38	3.49	0.25	3.34	10.41	15.90	16.63
24.00%	0.37	3.37	0.25	3.22	10.05	15.35	15.93
25.00%	0.34	3.10	0.23	2.96	9.24	14.11	15.36

	NamNgiep 2C Sanluang	NamNgiep 2C DamD3	NamNgiep 2C DamD3A	NamSongSieng Diversiondam	NamNgiep 2B Dam	NamNgiep 2A Dam	Meuang Mai
26.00%	0.34	3.10	0.23	2.96	9.24	14.11	14.78
27.00%	0.34	3.10	0.23	2.96	9.24	14.11	14.22
28.00%	0.32	2.91	0.21	2.79	8.69	13.27	13.61
29.00%	0.31	2.81	0.21	2.69	8.39	12.81	12.96
30.00%	0.31	2.81	0.21	2.69	8.39	12.81	12.34
31.00%	0.31	2.81	0.21	2.69	8.39	12.81	11.86
32.00%	0.29	2.66	0.19	2.55	7.94	12.13	11.46
33.00%	0.29	2.63	0.19	2.51	7.83	11.96	11.00
34.00%	0.28	2.58	0.19	2.46	7.68	11.73	10.52
35.00%	0.28	2.55	0.19	2.44	7.60	11.61	10.05
36.00%	0.27	2.47	0.18	2.36	7.35	11.23	9.47
37.00%	0.25	2.30	0.17	2.20	6.87	10.50	9.05
38.00%	0.25	2.30	0.17	2.20	6.87	10.50	8.67
39.00%	0.25	2.30	0.17	2.20	6.87	10.50	8.29
40.00%	0.25	2.30	0.17	2.20	6.87	10.50	7.98
41.00%	0.25	2.30	0.17	2.20	6.87	10.50	7.67
42.00%	0.25	2.30	0.17	2.20	6.87	10.50	7.41
43.00%	0.25	2.30	0.17	2.20	6.87	10.50	7.15
44.00%	0.25	2.30	0.17	2.20	6.87	10.50	6.89
45.00%	0.25	2.30	0.17	2.20	6.87	10.50	6.65
46.00%	0.25	2.30	0.17	2.20	6.87	10.50	6.44
47.00%	0.25	2.28	0.17	2.18	6.78	10.36	6.23
48.00%	0.25	2.27	0.17	2.17	6.78	10.35	6.03
49.00%	0.25	2.22	0.16	2.13	6.63	10.13	5.82
50.00%	0.24	2.21	0.16	2.11	6.58	10.05	5.65

	NamNgiep 2C Sanluang	NamNgiep 2C DamD3	NamNgiep 2C DamD3A	NamSongSieng Diversiondam	NamNgiep 2B Dam	NamNgiep 2A Dam	Meuang Mai
51.00%	0.24	2.19	0.16	2.10	6.54	10.00	5.39
52.00%	0.24	2.17	0.16	2.08	6.47	9.88	5.18
53.00%	0.24	2.17	0.16	2.07	6.46	9.87	5.03
54.00%	0.23	2.12	0.15	2.03	6.32	9.65	4.88
55.00%	0.22	2.02	0.15	1.93	6.03	9.21	4.74
56.00%	0.22	1.98	0.14	1.89	5.90	9.00	4.65
57.00%	0.22	1.96	0.14	1.88	5.86	8.95	4.55
58.00%	0.22	1.96	0.14	1.88	5.86	8.95	4.46
59.00%	0.22	1.96	0.14	1.88	5.86	8.95	4.38
60.00%	0.21	1.93	0.14	1.85	5.76	8.80	4.30
61.00%	0.21	1.90	0.14	1.81	5.66	8.64	4.20
62.00%	0.21	1.90	0.14	1.81	5.66	8.64	4.11
63.00%	0.21	1.90	0.14	1.81	5.66	8.64	4.04
64.00%	0.21	1.89	0.14	1.81	5.63	8.60	3.98
65.00%	0.20	1.85	0.13	1.77	5.52	8.43	3.89
66.00%	0.19	1.76	0.13	1.68	5.24	8.00	3.82
67.00%	0.19	1.71	0.12	1.64	5.11	7.80	3.74
68.00%	0.18	1.67	0.12	1.60	4.99	7.61	3.67
69.00%	0.18	1.65	0.12	1.58	4.91	7.50	3.61
70.00%	0.18	1.63	0.12	1.56	4.87	7.44	3.56
71.00%	0.18	1.62	0.12	1.55	4.82	7.36	3.51
72.00%	0.18	1.61	0.12	1.54	4.79	7.32	3.46
73.00%	0.17	1.56	0.11	1.49	4.64	7.08	3.43
74.00%	0.17	1.53	0.11	1.46	4.57	6.97	3.39
75.00%	0.16	1.49	0.11	1.42	4.43	6.77	3.35

	NamNgiep 2C Sanluang	NamNgiep 2C DamD3	NamNgiep 2C DamD3A	NamSongSieng Diversiondam	NamNgiep 2B Dam	NamNgiep 2A Dam	Meuang Mai
76.00%	0.16	1.49	0.11	1.42	4.43	6.77	3.31
77.00%	0.16	1.49	0.11	1.42	4.43	6.77	3.28
78.00%	0.16	1.44	0.11	1.38	4.29	6.56	3.25
79.00%	0.16	1.42	0.10	1.36	4.24	6.48	3.21
80.00%	0.15	1.40	0.10	1.34	4.18	6.38	3.18
81.00%	0.15	1.38	0.10	1.32	4.11	6.28	3.16
82.00%	0.15	1.35	0.10	1.29	4.03	6.16	3.13
83.00%	0.15	1.34	0.10	1.28	4.00	6.10	3.10
84.00%	0.14	1.31	0.10	1.25	3.90	5.95	3.08
85.00%	0.14	1.30	0.09	1.24	3.86	5.90	3.06
86.00%	0.14	1.27	0.09	1.21	3.78	5.77	3.03
87.00%	0.14	1.25	0.09	1.20	3.73	5.69	3.01
88.00%	0.14	1.24	0.09	1.18	3.69	5.64	2.99
89.00%	0.13	1.18	0.09	1.12	3.50	5.35	2.96
90.00%	0.12	1.11	0.08	1.06	3.31	5.05	2.94
91.00%	0.11	1.04	0.08	0.99	3.09	4.72	2.92
92.00%	0.11	0.96	0.07	0.92	2.86	4.37	2.89
93.00%	0.10	0.93	0.07	0.89	2.78	4.24	2.86
94.00%	0.10	0.92	0.07	0.88	2.74	4.18	2.83
95.00%	0.09	0.85	0.06	0.81	2.54	3.88	2.81
96.00%	0.09	0.80	0.06	0.76	2.38	3.64	2.78
97.00%	0.09	0.77	0.06	0.74	2.30	3.52	2.74
98.00%	0.08	0.72	0.05	0.69	2.15	3.28	2.70
99.00%	0.06	0.58	0.04	0.56	1.74	2.66	2.66
100.00%	0.04	0.34	0.03	0.33	1.03	1.57	2.61
Max	2.18	19.76	1.44	18.89	58.93	89.99	73.56
Min	0.04	0.34	0.03	0.33	1.03	1.57	2.61
Mean	0.31	2.83	0.21	2.71	8.45	12.90	11.52

Source: study team

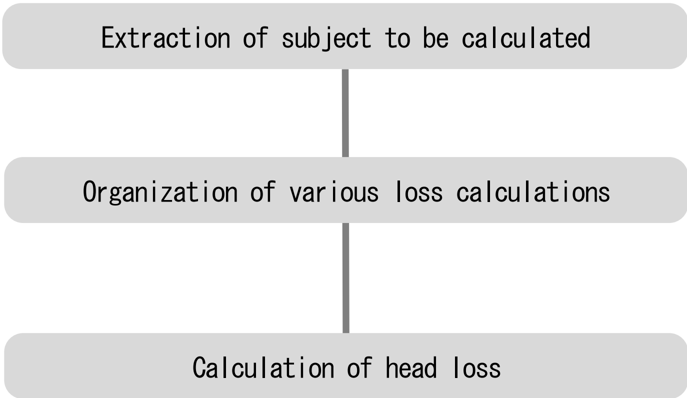
3) Outline and Confirmation of Head Loss and Rate Head in the Candidate Project

Head loss accompanying the friction, bending and the like of penstock and headrace has a large influence on the calculation of install capacity where the total head is relatively small.

(a) Outline of Estimating the Head Loss in F/S of Candidate Project

In the F/S of the candidate project, the outline of the calculation of the head loss is as follows.

Table 4.12 Calculation of Head Loss



Source: study team

In the F/S for the candidate project, mainly the following items are subject to head loss. However, since calculation formulas and calculation processes for these target items are not specified, it is necessary to verify that the head loss is appropriate.

(b) Outline of Head Loss/Install Capacity by Candidate Project

(i) Nam Ngiep 2A, 2B, 2C

① Subject to be Calculated for Head Loss

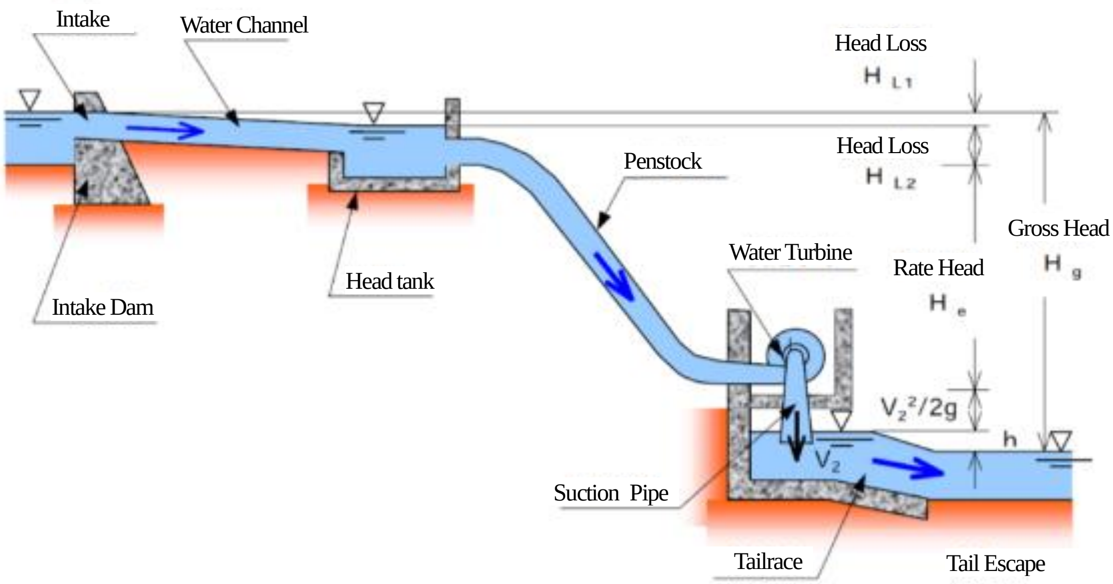
Nam Ngiep 2A, 2B, 2C are hydro power projects in the same river basin, and the sponsors are also the same Nonghai Group. However, the companies that formulated the F/S at each project site are different, so the method of calculating the head loss is slightly different. In addition, since the F/S do not clarify the concrete calculation formula and calculation process for the head loss, it is necessary to verify the validity of the rate loss. Calculation items for head loss by each project are as follows.

Table 4.13 Calculation Items for Head Loss

	2A	2B	2C	Remarks
Headrace	○		○	from intake to fore Bay, headrace tunnel
Penstock	○	○	○	friction loss, valve
Sluice way	○			
Diversion tunnel		○		branch pipe
others		○	○	trash rack, gate groove, Bell mouth

Source: study team

Figure 4.12 Outline of Head Loss



Source: study team

② Basic Information such as Gross Head, Rate Head, Install Capacity

The information on the gross head, rate head, install capacity, and design flow in Nam Ngiep 2A, 2B, and 2C is as follows. For points where the efficiency of the generator or turbine is not specified, it is calculated based on the rate head and install capacity. When there is a difference between the content indicated by the F/S, such as penstock length and diameter, and the completed drawing separately obtained in this survey, the latest acquired figure data was used.

Table 4.14 Salient Features of Nam Ngiep 2A, 2B, 2C

<table>
<tr><th>item</th><th>unit</th><th>2A</th><th>2B</th><th>2C</th><th>Remarks</th></tr>
<tr><td>Full supply level</td><td>m</td><td>442.0</td><td>590</td><td>995.0</td><td></td></tr>
<tr><td>Tail water level</td><td>m</td><td>371.33</td><td>448.5</td><td>(600)</td><td>() Calculated value</td></tr>
<tr><td>Gross head</td><td>m</td><td>(70.67)</td><td>(141.5)</td><td>395</td><td>() Calculated value</td></tr>
<tr><td>Rate loss</td><td>m</td><td>65.0</td><td>133.05</td><td>365</td><td></td></tr>
<tr><td>Head loss</td><td>m</td><td>(5.67)</td><td>(8.45)</td><td>(30.00)</td><td>() Calculated value</td></tr>
<tr><td>Design flow</td><td>m^3/s</td><td>18.0</td><td>16.0</td><td>4.86</td><td></td></tr>
<tr><td>Install capacity</td><td>MV</td><td>10.18</td><td>18.0</td><td>14.5</td><td></td></tr>
<tr><td>Headrace length</td><td>m</td><td>3,000</td><td>--
[2,889.07]</td><td>--
[276.46]</td><td>[ ] read from drawing</td></tr>
<tr><td>Penstock length</td><td>m</td><td>260.45</td><td>679.12
[474.5]</td><td>1,397.71
[1,572.26]</td><td>[ ] read from drawing</td></tr>
<tr><td>Penstock diameter</td><td>m</td><td>2.7</td><td>2.62
[2.20]</td><td>1.25</td><td>[ ] read from drawing</td></tr>
<tr><td>Roughness</td><td></td><td>0.012</td><td>0.012</td><td>0.012 (Iron)
0.014 (concrete)</td><td></td></tr>
<tr><td>Headrace loss</td><td>m</td><td>3.000</td><td>5.600</td><td>—</td><td></td></tr>
<tr><td>Penstock loss</td><td>m</td><td>1.026</td><td>2.350</td><td>—</td><td></td></tr>
<tr><td>Others loss</td><td>m</td><td>0.27</td><td>—</td><td>—</td><td></td></tr>
<tr><td>Turbine efficiency</td><td>%</td><td>92.2</td><td rowspan="2">86.28</td><td>—</td><td></td></tr>
<tr><td>Generator efficiency</td><td>%</td><td>96.0</td><td>96.5</td><td></td></tr>
</table>

Source: study team

(ii) Nam Ban

① Subject to be Calculated for Head Loss

Calculation formulas and calculation process concerning the head loss in the F/S are not clearly stated. Rate head is indicated in the table "Salient Features of Nam Ban".

② Basic Information such as Gross Head, Rate Head, Install Capacity

The information on the gross head, rate head, install capacity, and design flow in Nam Ngiep 2A, 2B, and 2C is as follows. For points where the efficiency of the generator or turbine is not specified, it is calculated based on the rate head and install capacity.

Table 4.15 Salient Features of Nam Ban

item	unit	Nam Ban	Remarks
Full supply level	m	440.00	
Tail water level	m	387.00	
Gross head	m	(53.00)	() Calculated value
Rate loss	m	51.10	
Head loss	m	1.37	
Design flow	m^3/s	31.80	
Install capacity	MV	14.00	
Headrace length	m	150	
Penstock diameter	m	4.00 (Before branch) 2.80 (After branch)	
Total efficiency	%	(87.91)	() Calculated value

Source: study team

(c) Confirmation of Head Loss Based on Acquired Data

Based on the F/S data, we calculated the head loss and confirmed the difference from that shown in the F/S. Information such as penstock length was obtained from the F/S, and for the calculation formula for the head and coefficients, Japanese hydrological official collection etc. was used. We calculated the head loss for the items listed below.

$$H = H1 + H2 + H3 + H4 + H5$$

H1 : Friction loss of headrace

H2 : Loss of penstock (h1+h2+h3+h4)

h1 : Friction loss

h2 : Bending loss

h3 : Branch loss

h4 : Valve loss

h5 : others

H3 : Surplus loss (about 3 to 5% of total loss)

(i) Calculation formula for each loss

The calculation formula of each loss is as follows.

① Friction loss of headrace and penstock

$$H = f' \times (L \times V^2) / (D \times 2g)$$

f' : Friction Loss Coefficient (caused by diameter, roughness)

L : Length of Headrace and Penstock

V : Average Flow Velocity (design flow)

D : Diameter

g : Gravitational Acceleration 9.8m²/s

② Bending Loss of Penstock

$$h2 = f1 \times f2 \times (V^2 / 2g)$$

f1 : Coefficient according to the ratio of bend radius to diameter

f2 : The ratio of the loss in the case of the turning angle θ and the loss in the case of a turning angle of 90°

V : Average Flow Velocity (design flow)

g : Gravitational Acceleration 9.8m²/s

③ Branch Loss of Penstock

h3 = $f_\beta \times (V^2 / 2g)$

f_β : Coefficient Given by Pipe Area Ratio, Intersection Angle Between Main Pipe and Branch Pipe

V : Average Flow Velocity (design flow)

g : Gravitational Acceleration 9.8m²/s

④ Valve loss

h4 = $fv \times (V^2 / 2g)$

fv : Coefficient according to valve type (Butterfly valve fv=0.20)

V : Average Flow Velocity (design flow)

g : Gravitational Acceleration 9.8m²/s

(ii) Calculation results for each loss

The calculation results for each loss are as follows.

Table 4.16 Comparison of Head Loss and Install Capacity at Nam Ngiep 2A

Item	F/S	Calculation for confirmation	
Design flow	18.0 m³/s	18.0 m³/s	Follow F/S
Gross head	—	(70.67 m)	Extract from F/S
Head loss	—	7.10 m	
Headrace loss	3.000 m	3.30 m	
Penstock loss	1.026 m	3.41 m	
Other losses	0.270 m	0.39 m	
Rate loss	65.0 m	63.6 m	(Δ1.40m)
Turbine efficiency	92.2 %	92.2 %	Follow F/S
Generator efficiency	96.0 %	96.0 %	Follow F/S
Install capacity	10.18 MV	9.93 MV	(Δ0.25MW)

Source: study team

Table 4.17 Comparison of Head Loss and Install Capacity at Nam Ngiep 2B

Item		F/S	Calculation for confirmation	
Design flow		16.0 m^3/s	16.0 m^3/s	Follow F/S
Gross head		—	(141.50 m)	Extract from F/S
Head loss		—	8.71 m	
	Headrace loss	5.60 m	2.50 m	
	Penstock loss	2.35 m	5.74 m	
	Other losses	—— m	0.47 m	
Rate loss		133.05 m	132.79 m	(△0.26m)
Total efficiency		86.28 %	86.28 %	Follow F/S
Install capacity		18.00 MV	17.97 MV	(△0.03MW)

Source: study team

Table 4.18 Comparison of Head Loss and Install Capacity at Nam Ngiep 2C

Item		F/S	Calculation for confirmation	
Design flow		4.86 m^3/s	4.86 m^3/s	Follow F/S
Gross head		395.0	(395.0 m)	Extract from F/S
Head loss		30.0	25.8 m	
	Headrace loss	—	5.40 m	
	Penstock loss	—	19.14 m	
	Other losses	—	1.26 m	
Rate loss		365.0 m	369.2 m	(4.20m)
Total efficiency		83.41 %	83.41 %	Follow F/S
Install capacity		14.5 MV	14.67 MV	(0.17MW)

Source: study team

Table 4.19 Comparison of Head Loss and Install Capacity at Nam Ban

Item	F/S	Calculation for confirmation	
Design flow	31.8 m^3/s	31.8 m^3/s	Follow F/S
Gross head	—	(52.0 m)	
Head loss	—	1.10 m	
Headrace loss	—	0.00 m	
Penstock loss	—	0.90 m	
Other losses	—	0.20 m	
Rate loss	51.1 m	50.9 m	(∆0.20m)
Total efficiency	87.9 %	87.9 %	Follow F/S
Install capacity	14.00 MV	13.94 MV	(∆0.06MW)

Source: study team

(d) Considerations in Loss Calculation and Install Capacity Calculation

In the F/S, there is no detailed rationale on the recording of the head loss, and there are statements calculated roughly using a uniform formula. The calculation of the head loss difference has not been clarified, such as it not matching the head loss difference calculated based on the power planning. However, it was found that the head loss shown in the F/S was not significantly different from the result obtained by the calculation in this survey. Friction Loss is greatly influenced at the planning point with a long pipeline. The friction loss increases in proportion to the square of the flow velocity in the pipeline. Each candidate project has a relatively small friction loss because the Average Flow Velocity of the pipeline is kept below 4.0 m/s.

4) Outline and Confirmation of Project Cost in Candidate Project

(a) Main Flow of Cost Calculation in Candidate Project F/S

In the F/S, the main flow in the cost calculation is as follows.

Table 4.20 Cost Calculation

Organization of construction conditions

Material procurement destination, transportation route etc.

Selection of material source and rock sampling place

Distribution of material sources (sand/gravel, aggregate)

Content of major construction items

Dam, Tunnel, Open channel, Powerhouse construction etc.

Overview of traffic construction

Main Traffic road, new temporary road

Outline of Construction Period

Calculation quantity by construction items

Calculation of project cost

Source: study team

(b) Outline of Construction Cost by Candidate Project

Each candidate project calculates the construction cost. Calculation items for the construction cost at Nam Ngiep 2C are as follows.

Table 4.21 Outline of Construction Costs at Nam Ngiep 2C

	Nam Ngiep 2C	
	Content notes	Reference
Basic Data		11.4.1
Unit Rate of Labor	Determining the labor force participation rate on a budget basis based on Laos' domestic price level	11.4.1
Prices of Main Materials		11.4.2
Sources and Prices of Main Mate	Set for steel, cement, wood, gasoline/diesel, explosives based on market price.	
Means of Transport	Based on road transportation, price setting by investigation of market price level	
Others	Consider environmental conservation activities, construction supervision costs, consulting fees, examination costs, insurance costs, taxes, etc.	11.6-8
Complex Work		11.9.1.1
Construction auxiliary works		
Construction and installation	Construction of roads and bridges. It is calculated by the number of units described in the method statement. Calculate the extension of the new construction road (W = 4.0 m) 14 km	11.9.1.3
Power supply works for construc	Calculated at the scale factor of the number of units described in the method statement 7.72 km	
Diversion works	Calculate by multiplying the designed quantity by the unit times 2,871 m3	
House building works for construction and management	Calculate in the residential area specified in the method statement, but the costs of the office and residential welfare facilities are analyzed according to the actual situation of HPP and calculated	
Other auxiliary works for constru	Calculated as 6% of total cost of auxiliary construction for construction	
Architectural work		11.9.1.4
Diversion Dam Sanluang Diversion Canal Sanluang Dam(D3,D3A,D3B) Intake Tunnel ♯1～3 Canal between tunnels Intake penstock Spillway Penstock Powerhouse	Calculate quantity from design drawing · Open excavation (soil, rock) · Tunnel excavation (soil, rock) · Concrete (open, · Slope protection · Embankment Soil / rock etc.	
Electrical & mechanical equipment	Set unit price of generator, turbine etc.	11.9.1.1
Metal structure and equipment installation		
Compensation for land acquisition and resettlement		
UXO clearance		
Independent Cost		
Project management fees	Management supervision, consulting, examination, insurance cost etc.	
Production preparation fee	Calculated with 0.5% of equipment cost	
Cost for scientific research, investigation and design	1% of construction and installation work amount.	
Cost for scientific research, investigati	396,933 USD	
Basic contingency cost 5%		
Contingency cost for price difference		
Credit fee		
Loan interest during construction period		

Source: study team

(c) Confirmation of Construction Cost

(ⅰ) Overview of Confirmation of Construction Cost

Each candidate project has issues regarding accurate confirmation because there is a difference in the accuracy of the calculation for construction costs and the calculation process is unclear. In the following, we will confirm the F/S and Japanese costs for material and labor. In addition, using the "Hydropower Plan Planning Construction Cost Evaluation Guide" (Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy, New Energy Foundation, General Foundation), which is the standard for summary calculation in Japan, for each candidate project we will confirm the difference between the calculated cost and the cost in the F/S. The main flow for confirmation of construction cost is as follows.

Table 4.22 Confirmation of Construction Cost

Comparison of setting conditions for material costs and labor costs

Comparison of F/S setting cost and costs in Japan

Calculation of construction cost according to Japan's standards

Construction cost calculation based on Japan's guidelines

Confirmation of construction cost by comparing calculation results

Compare and confirm the difference between construction cost based on F/S and construction cost based on Japanese guidance

Source: study team

(ⅱ) Comparison of Setting Conditions for Material Costs and Labor Costs

In the F/S for Nam Ngiep 2C, the material costs are indicated. The results of comparing these with the costs in Japan are as follows. In the comparison table (Table 4.20), raw material costs such as steel materials and cement are about 90% of the cost in Japan, which means that there is not much difference. However, the material cost in the F/S for Nam Ngiep 2C includes cargo costs, and expenses for storage.

Table 4.23 Comparison of Various Material Costs Between Laos and Japan

	Laos	Japan		diameter A/B	Remarks
	F/S unit price (A)	Construction price (2015.06) unit price (B)			
	(USD/t)※	(JPY/t)※	(USD/t)※		
Steel Bar	954.11	115,000	1,076.28	0.89	
Cement	115.00	9,000～13,800	82.23～129.15	0.88～1.40	
Sand	16.00	1,700～2,000	15.91～18.72	0.85～1.01	

※ 1 USD = 106.85 JPY ※ About unit price of sand, per m3

Source: study team

In the F/S for Nam Ngiep 2C, the labor force ratio based on Laos' domestic price level is shown. According to the table below (Table 4.21), Laos' labor costs are roughly 10% of those in Japan.

Table 4.24 Comparison of Various Labor Costs Between Laos and Japan

	Laos	Japan		diameter A/B	Remarks
	F/S unit price (A)	Public construction design labor unit price (B)			
	(USD/hr)	(JPY/8hr)	(USD/hr)		
Senior skilled worker	2.17	15,400～21,900	18.01～25.62	0.08～0.12	
Skilled worker	1.60	13,300～18,900	15.56～22.11	0.07～0.10	
Semi-skilled worker	1.25	10,500～13,200	12.28～15.44	0.08～0.10	
Unskilled worker	1.03	9,300～12,600	10.88～14.74	0.07～0.09	

※ 1 USD = 106.85 JPY

※ Public construction design labor unit price (Ministry of Land, Infrastructure, Transport and Tourism) is data from 2014

Source: study team

(iii) Calculation of Construction Cost According to Japan's Accumulation Standard at Nam Ngiep 2C

When formulating a small to medium hydropower generation plan in Japan, in order to study the optimum scale, "Hydropower Plan Planning Construction Cost Evaluation Guide" (March 2013, Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy, General Foundation, New Energy Foundation) is used. This guidance is mainly used to calculate construction costs for optimum scale considerations when considering a power generation plan using a 1/25,000 topographic map. The construction costs in this guidance are calculated using the relational expression obtained from design flow and install capacity. In this survey, the construction cost for each candidate project site is calculated based on this guidance and it is compared with the construction cost indicated by the F/S. However, as shown in the previous section, the material costs are little different between the two countries, but the labor costs are greatly different. Moreover, the cost difference varies depending on each item, due to the difference in classification of laborers, choice of construction method, expense ratio, etc. In this survey, the details of the construction costs in the F/S are unknown, so it is difficult to confirm the construction costs with high precision. Therefore, we compare the construction costs shown in the F/S with those based on Japanese guidance, and consider items with particular differences and their factors.

Photo 4.3 D3 Dam and Access Road, Nam Ngiep 2C

Source: study team

Photo 4.4 Penstock and Access Roads and Transmission Lines at Nam Ngiep 2C

Source: study team

① Construction cost comparison for each candidate project F/S

A comparison between construction costs at each candidate project site in the F/S and construction costs according to Japan's "Hydropower Plan Planning Construction Cost Estimation Guide" is as follows. There is an opening of 2.48 to 4.55 times' the construction cost in the F/S when 1 USD = 110 JPY is converted. However, a comparison of construction costs other than for Nam Ngiep 2C is shown as reference because the accuracy of the construction costs in the F/S is not sufficient.

Table 4.25 Comparison with F/S construction cost

【Nam Ngiep 2 A】

	Construction Cost by F/S (A) (10^4 USD)	Construction Cost by F/S (A) (10^6 JPY)	Calculation Estimate (10^6 JPY)	Ratio (B) / (A)	Remarks
1) Power House Building	31.97	35.2	114.5	3.25	
2) Construction Work	860.14	946.2	3,583.2	3.79	① + ②
① Water Channel	585.51	644.1	2,913.5	4.52	
a. Dam	158.39	174.2	572.5	3.29	Overflowd dam-flushing gate and side intake Grit chamber, desilting basin and flushing channel
b. Diversion Canal	319.43	351.4	1,909.3	5.43	
Culvert / Intake	3.66	4.0	25.5	6.34	Tunnel intake
Tunnel	315.77	347.3	1,883.8	5.42	2A diversion tunnel
c. Spillway Tailrace	8.53	9.4	53.9	5.74	Sluiceway
d. Penstock / Pressure Line	99.16	109.1	377.8	3.46	φ=2.70m, L=243.8m Pressure forebay, High-pressure pipeline
② Mechanical / Material Equipment	274.63	302.1	669.7	2.22	
e. Construction Work	102.62	112.9	344.0	3.05	
f. Mechanical / Metal Equipment	172.01	189.2	325.7	1.72	｛①+f｝× 10%
3) Electrical Equipment	354.33	389.8	1,079.8	2.77	P=10,180kW, H= 65.0m
4) Temporary / Auxiliary Work	259.65	285.6	450.1	1.58	｛2）+3）+4）｝×5%＋Temporary Road (3.0km)
5) Sub Total	1,506.08	1,656.7	5,227.4	3.16	Σ1）～5）
6) Power Supply	37.87	41.7	88.0	2.11	L = 4.0 km
7) Total	1,543.96	1,698.0	5,315.0	3.13	5）+ 6）

※ Conversion 1 USD ＝ 110 JPY

※ Construction cost items were adapted to the content of Japan's gudance "Hydropower plan planning cost estimation guidance"

Source: study team

【Nam Ngiep 2 B】

	Construction Cost by F/S (A) (10[4] USD)	(10[6] JPY)	Calculation Estimate (10[6] JPY)	Ratio (B) / (A)	Remarks
1) Power House Building	34.3	37.8	154.3	4.09	
2) Construction Work	1,050.3	1,155.4	3,530.1	3.06	① + ②
① Water Channel	705.2	775.8	2,808.9	3.62	
a. Dam	233.4	256.8	622.2	2.42	SS Dam, 2B dam
b. Diversion Canal	399.8	439.8	1,778.5	4.04	SS/2B diversion tunnel, SS intake SS diversion culvert
Culvert / Intake	0.0	0.0	0.0	0.00	
Tunnel	399.8	439.8	1,778.5	4.04	SS/2B diversion tunnel, SS intake SS diversion culvert
c. Spillway Tailrace	3.7	4.0	16.8	4.18	SS intake
d. Penstock / Pressure Line	68.4	75.2	391.3	5.20	φ=2.20m, L=474.5m 2B surge chamber/pressure pipeline
② Mechanical / Material Equipment	345.1	379.6	721.3	1.90	
e. Construction Work	101.9	112.1	400.4	3.57	
f. Mechanical / Metal Equipment	243.2	267.5	320.9	1.20	
3) Electrical Equipment	553.1	608.4	1,210.3	1.99	P = 18,000kW, H = 133.05m
4) Temporary / Auxiliary Work	482.2	530.4	779.3	1.47	｛2）＋3）｝×5%＋Temporary Road (7.9km)
5) Sub Total	2,120.0	2,332.0	5,674.1	2.43	Σ1）～ 4）
6) Power Supply	37.9	41.7	204.6	4.91	L = 9.30km
7) Total	2,157.8	2,373.6	5,879.0	2.48	5）+ 6）

※ Conversion 1 USD ＝ 110 JPY

※ Construction cost items were adapted to the content of Japan's gudance "Hydropower plan planning cost estimation guidance"

Source: study team

【Nam　Ngiep 2C】

	Construction Cost by F/S (A)		Calculation Estimate (B)	Ratio	Remarks
	(10^4 USD)	(10^6 JPY)	(10^6 JPY)	(B) / (A)	
1) Power House Building	38.2	42.0	164.8	3.92	
2) Construction Work	1,334.0	1,467.4	5,477.9	3.73	① + ②
① Water Channel	1,088.8	1,197.7	4,741.4	3.96	
a. Dam	531.5	584.6	2,874.8	4.92	Diversion Dam Sanluang Dam D3, Dam D3A, Dam D3B
b. Diversion Canal	374.5	412.0	854.1	2.07	
Culvert / Intake	114.9	126.4	343.0	2.71	Diversion Canal Sanluang, Canal between tunnel #1 and tunnel #2 Intake penstock
Tunnel	259.6	285.6	511.1	1.79	Tunnel #1, Tunnel #2, Tunnel #3
c. Spillway Tailrace	58.6	64.4	303.6	4.71	B=10.0m, H=2.5m, L=167.48m
d. Penstock / Pressure Line	124.2	136.7	708.9	5.19	φ=1.25m, L=1,397.71m
② Mechanical / Material Equipment	245.2	269.7	736.6	2.73	
e. Construction Work	71.2	78.3	238.6	3.05	
f. Mechanical / Metal Equipment	174.0	191.4	498.0	2.60	
3) Electrical Equipment	401.4	441.5	826.2	1.87	P = 14,500kW, H = 356.0m
4) Temporary / Auxiliary Work	413.3	454.6	1,320.0	2.90	｛2）＋3）＋4）｝×5%＋Temporary Road (14.0km)
5) Sub Total	2,186.8	2,405.5	7,789.0	3.24	Σ1）～5）
6) Power Supply	27.0	29.7	169.8	5.71	L = 7.72km
7) Total	2,213.9	2,435.3	7,958.9	3.27	5）＋6）

※　Conversion 1 USD ＝ 110 JPY

※　Construction cost items were adapted to the content of Japan's gudance "Hydropower plan planning cost estimation guidance"

Source: study team-produced

【Nam Ban】

	Construction Cost by F/S (A) (10^4 USD)	(10^6 JPY)	Calculation Estimate (10^6 JPY)	Ratio (B) / (A)	Remarks
1） Power House Building	110.1	121.1	135.2	1.12	
2） Construction Work	1,996.6	2,196.2	11,571.9	5.27	① + ②
① Water Channel (Tunnel)	1,871.6	2,058.7	10,601.1	5.15	
a. Dam	1,540.1	1,694.1	9,778.6	5.77	
b. Diversion Canal	69.0	75.9	74.8	0.98	Diversion Tunnel R=5.0m, L=130.0m
c. Spillway Tailrace	94.6	104.0	333.6	3.21	Spillway B=5.0m, H=5.0m, L=200m
d. Penstock / Pressure Line	167.9	184.7	414.1	2.24	φ=2.80m, L=150m
② Mechanical / Material Equipment	125.0	137.5	970.8	7.06	
e. Construction Work	0.0	0.0	419.8	0.00	
f. Mechanical / Metal Equipment	125.0	137.5	551.0	4.01	
3） Electrical Equipment	450.0	495.0	1,368.0	2.76	P = 14,000kW, H = 51.1m
4） Temporary / Auxiliary Work	342.0	376.2	1,379.8	3.67	｛2）＋3）｝×5%＋Temporary Road (10.0km)
5） Sub Total	2,898.7	3,188.6	14,454.8	4.53	Σ1）～5）
6） Power Supply	100.0	110.0	550.0	5.00	L = 25.0km
7） Total	2,998.7	3,298.6	15,005.0	4.55	5）＋6）

※ Conversion 1 USD ＝ 110 JPY

※ Construction cost items were adapted to the content of Japan's gudance "Hydropower plan planning cost estimation guidance"

Source: study team-produced

① Considerations in Comparing each Candidate Project's Construction Cost

In terms of construction costs in the F/S when converting at 1 USD = 110 JPY and construction costs based on Japan's guidance, an opening of 2.48 to 4.55 times is seen. Looking at the construction items, the cost of the power house building is about four times as expensive as for Nam Ngiep 2A, 2B and 2C, while the Nam Ban point is only about 1.1 times. It is expected that the expenses estimated in the F/S for Nam Ban will be set higher than in other districts. Regarding Dam costs, among water channel costs, there is a difference of 2.4 to 5.8 times for each candidate project. Especially at Nam Ban, the cost ratio of the Dam is about 50% of the total, and it is considered that the cost accuracy of the Dam greatly contributes to the economics of the project. Regarding the Penstock/Pressure Line cost, there is a difference of 2.2 to 5.2 times for each candidate project. In general, the cost gap at the Nam Ngiep site is large, but this is considered to be longer than the Nam Ban spot because the extension of the Penstock is long, leading to an increase in disparity. Regarding the Electrical Equipment cost, there is a difference of 1.99 to 2.77 times for each candidate project. Since the difference for each candidate project is not large compared with other cost items, the expense setting for the water turbine/generator introduction cost is generally stable. The construction cost per 1 kW is used as an index to evaluate the economic efficiency of a hydropower generation plan. Generally, for reservoirs and adjustment pond type hydropower generation, the construction cost per 1 kW is required to be low. Looking at the construction cost per 1 kW for each candidate project, it is 326.6 ~ 548.9 thousand yen/kW at the Nam Ngiep site, while 1,071 thousand yen/kW at the Nam Ban site. For this reason, it can be said that the Nam Ngiep site is more economical than the Nam Ban site.

Table 4.26 Comparison of F/S Construction Cost and Construction Cost Based on Japanese Guidance

Site		Nam Ngiep 2A			Nam Ngiep 2B			Nam Ngiep 2C			Nam Ban		
Basic Information	Install Capacity(kW)	10,180			18,000			14,500			14,000		
	Design Flow(m^3/s)	18.00			16.00			4.86			31.80		
	Rate Head (m)	65.00			133.05			356.00			51.10		
Items		F/S Cost (10^6JPY)	Correction Magnification (C)	Corrected Cost (10^6JPY)	F/S Cost (10^6JPY)	Correction Magnification (C)	Corrected Cost (10^6JPY)	F/S Cost (10^6JPY)	Calculation Estimate (10^6JPY)	Ratio (B) / (A)	F/S Cost (10^6JPY)	Correction Magnification (C)	Corrected Cost (10^6JPY)
1)	Power House Building	35.2	114.5	3.25	37.8	154.3	4.09	42.0	164.8	3.92	121.1	135.2	1.12
2)	Construction Work	946.2	3,583.2	3.79	1,155.4	3,530.1	3.06	1,467.4	5,477.9	3.73	2,196.2	11,571.9	5.27
	①Water Channel	644.1	2,913.5	4.52	775.8	2,808.9	3.62	1,197.7	4,741.4	3.96	2,058.7	10,601.1	5.15
	a. Dam	174.2	572.5	3.29	256.8	622.2	2.42	584.6	2,874.8	4.92	1,694.1	9,778.6	5.77
	b. Diversion Canal	351.4	1,909.3	5.43	439.8	1,778.5	4.04	412.0	854.1	2.07	75.9	74.8	0.98
	c. Spillway / Tailrace	9.4	53.9	5.74	4.0	16.8	4.18	64.4	303.6	4.71	104.0	333.6	3.21
	d. Penstock / Pressure Line	109.1	377.8	3.46	75.2	391.3	5.20	136.7	708.9	5.19	184.7	414.1	2.24
	② Mecanical / Material Equipment	302.1	669.7	2.22	379.6	721.3	1.90	269.7	736.6	2.73	137.5	970.8	7.06
3)	Electrical Equipment	389.8	1,079.8	2.77	608.4	1,210.3	1.99	441.5	826.2	1.87	495.0	1,368.0	2.76
4)	Tenmorary / Auxiliary Work	285.6	450.1	1.58	530.4	779.3	1.47	454.6	1,320.0	2.90	376.2	1,379.8	3.67
5)	Sub Total	1,656.7	5,227.4	3.16	2,332.0	5,674.1	2.43	2,405.5	7,789.0	3.24	3,188.6	14,454.8	4.53
6)	Power Supply	41.7	88.0	2.11	41.7	204.6	4.91	29.7	169.8	5.71	110.0	550.0	5.00
7)	Total	1,698.0	5,315.0	3.13	2,373.6	5,879.0	2.48	2,435.3	7,959.0	3.27	3,298.6	15,005.0	4.55
8)	Construction unit price (10^3JPY/kW)	522.1			326.6			548.9			1,071.8		

Source: study team

(IV) Considerations in Construction Cost

In the F/S, construction costs are calculated, such as labor costs and material costs. In addition, quantities based on the plan are shown for temporary roads and transmission lines necessary for construction. When considering the quantity by cost item at the point of Nam Ngiep 2C, it is thought that the precision of the construction cost is high because it seems to have been recorded based on detailed drawings, such as for the amount of concrete and the amount of excavation. However, there are the following items that are not unified, such as the necessity of accounting, or not being recorded, and there is a possibility that the investment amount may further increase considering these items.

- Removal cost for UXO
- Cost for relocation of settlements/residents in flooded areas

(5) Effect of Stable Energy Supply to Japan by Implementing Candidate Projects

In Japan, there have been little new hydropower electricity projects over the past two decades. In particular, no new hydropower dam is newly constructed by electric power companies after 2015. Henceforth, there is little opportunity to experience and inherit development know-how, from site selection to commercial operation, such as feasibility study, design, procurement, construction management and test run. In turn, increasing in portion are engineers who have only experienced the operation and management of hydropower dams even at electric power companies.

Construction and operation of hydropower dams, however, are essentially fungible and sequential processes. Therefore, experiencing and inheriting developmental know-how of hydropower dams shall result in further enhancement in its operation and maintenance skills too.

In Japan, the general and pumped storage hydropower accounts for approximately 20% of electric power source. The general hydropower is stable and less expensive source for base load, and the pumped storage hydropower is demand-flexible source for peak load. Moreover, the hydropower in general is CO_2-emission free, and makes usage of domestic resources independently from the fuel import.

For electric power companies in Japan, henceforth, participation into green field hydropower projects in overseas shall result in further enhancement of operation and maintenance of domestic hydropower facilities and new development of hydropower projects in the future, thereby contributing to the stable energy supply in Japan.

Capter5 Evaluation of Environmental and Social Impacts

(1) Analysis of present state of environmental and social aspects

Laos is a landlocked country located in the Indochinese peninsula of Southeast Asia, bordering China in the north, Vietnam in the east, Cambodia and Thailand in the south, and Myanmar in the west. The total state size is 238,000 km2, which is about 60% of the size of Japan, with a population of approximately 6,492,000 people[1], equivalent to about 5% of Japan's population. The political system is a socialist state, with the country governed by the Lao People's Revolutionary Party.

1) Natural environment

Laos has the highest forest occupation rate in Southeast Asia, over 80% of the country being natural forest, forest plantation and unstocked forest.

Table 5-1 The statistics for land use and forest cover in Lao PDR in 2013

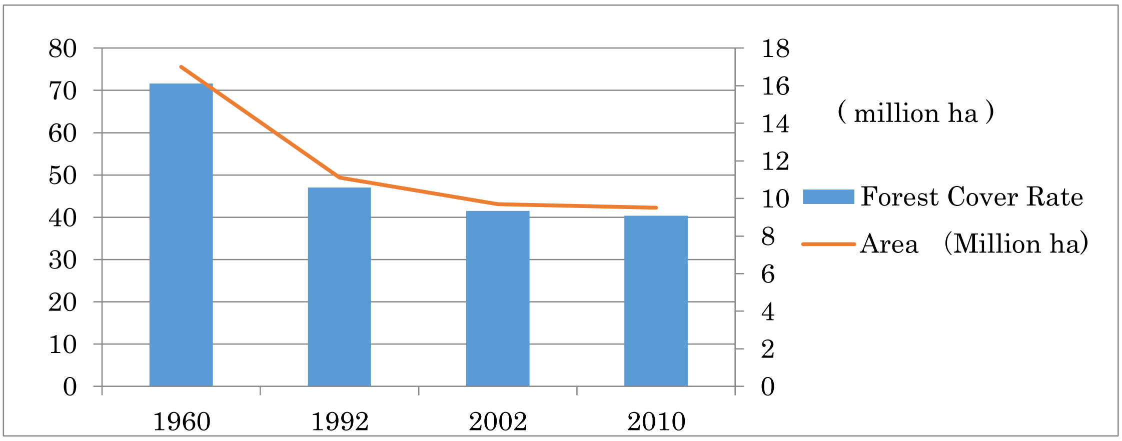
No.	Land use category	Area (ha)	Area (%)
I	**Forest Cover**	**10,474,201**	**48.13**
1	Natural forest	10,235,707	47.03
2	Forest plantation	238,493	1.10
II	**Unstocked forest**	**8,052,336**	**37.00**
III	**Agricultural land**	**2,335,934**	**10.73**
3	Upland rice	182,435	0.84
4	Paddy rice	661,424	3.04
5	Other agriculture	803,091	3.69
6	Fruit tree	12,413	0.06
7	Pasture	676,571	3.11
IV	**Other land**	**2,817,529**	**4.14**
8	Other land	2,817,529	4.14
	Total	**23,680,000**	**100.00**

Source: Department of Agriculture, Land Management and Development data used for creation by Study team

In the period between 1992 and 2002, forest decline caused by illegal logging and deforestation became a big social problem in Laos. It is said that the forests disappeared at a pace of 1.25% (140,000 ha in area) a year from 1992 to 2002.

[1] Results of Population and Housing Census 2015, by Statistics Bureau of Laos

Figure 5.1 Forest Cover Rate and Area in Laos

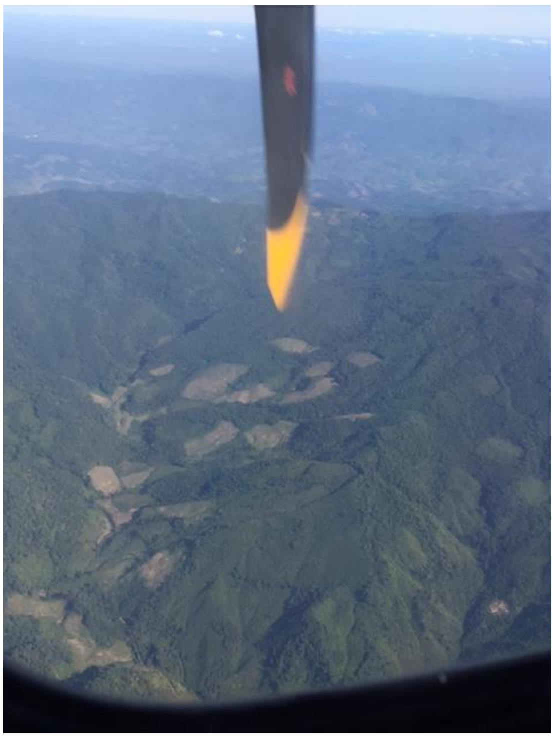


Source: USAID Lowering Emissions in Asia's Forests (USAID LEAF)
Drivers of Deforestation in the Greater Mekong Subregion, Lao PDR Country Report,
Ian Lloyd Thomas, September 2015 used for creation by Study team

In our field survey, we found that many areas of forest have disappeared. When traveling on a domestic flight, we noticed circular deforestation, and found that such scenes were widespread. The local people said that mainly ethnic minorities such as the Mon tribe have cut down forests for the purpose of cultivating maize and other crops.

With regard to such logging for agriculture, which occurs repeatedly in various places, it seems to be difficult for the Lao government to ascertain accurate figures. Forests are called "green dams", having the function of storing water, but there is growing concern that the green dam function will be lost due to the frequent occurrence of such partial deforestation.

Photo 5-1 Deforestation viewed from the sky



Source: taken by Study team

Photo 5-2 Mudslide due to deforestation

Source: taken by Study team

On the way to a dam site for our field survey, we also found an extensive watermelon field cultivated by a Chinese company, with the watermelons being for export to China. The farm, operated by the Chinese company, hires many local people as farmers. Therefore, it seems it will be difficult to stop the disappearance of forests as long as such agricultural activities provide socioeconomic benefits to the farmers and local economies.

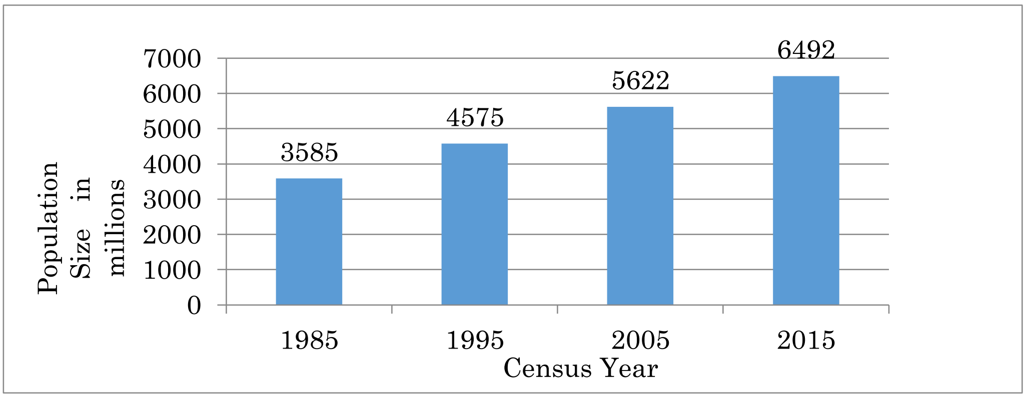
Photo 5-3 Watermelon field operated by a Chinese company for export

Source: taken by Study team

2) Socio-economic environment

The population of Laos is on an increasing trend. In 2015, the population was about 6,492,000, nearly twice that of in 1985. The average annual growth rate from 2005 to 2015 reached 1.45%.

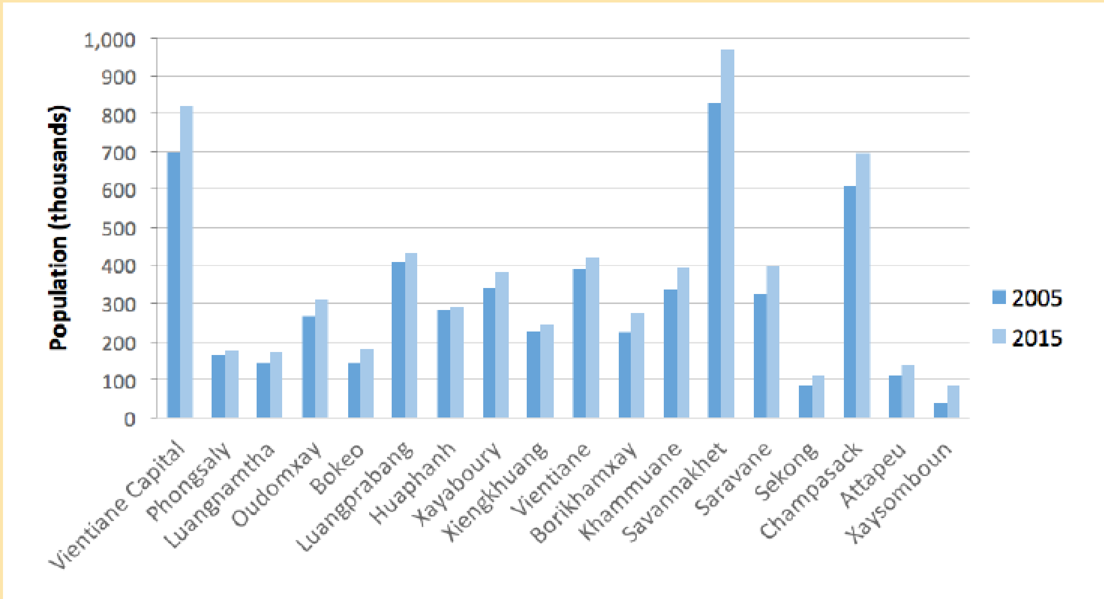
Figure 5.2 Population Growth, 1985-2015



Source: Results of Population and Housing Census 2015, Statistics Bureau of Laos used for creation by Study team

As for the population distribution by prefecture and the regional distribution of the working population, about 1,123,000 people (31.6%) are in urban areas, about 2,157,000 (60.8%) are in regions with improved road connections, and about 268,000 (7.6%) are in regions with not yet improved road connections.

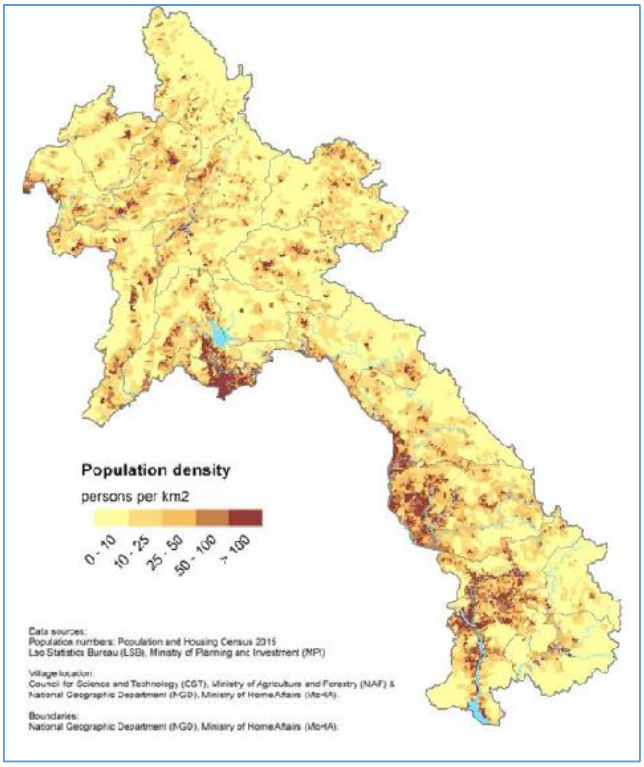
Figure 5-3 Population by Province, 1985-2015



Source: Table 2.1 (2005 PHC Report) and Table P1.1 (2015 PHC, Appendix 1)

Source: Results of Population and Housing Census 2015, Statistics Bureau of Laos

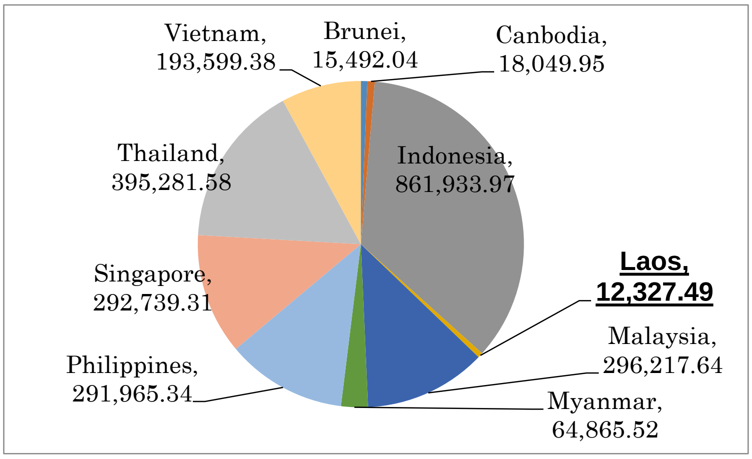
Figure 5-4 Density Map of Laos, 2015



Source: Results of Population and Housing Census 2015, Statistics Bureau of Laos

Laos' GDP in 2015 is US$ 12.33 billion, which was the lowest among ASEAN countries. Its GDP growth rate is 7%.

Figure 5.5 GDP of ASEAN Countries, 2015



Source: Creation by Study team

In 2012, the country's GDP is almost evenly (1/3 each) shared by three industries: service (37%), manufacturing (31%), and agriculture/forestry/fishery (26%). Workers engaged in the primary industries, such as agriculture, forest and fishery, account for as much as 72.3% of the total working population, with 6.3% in government-related industry including the military, 5.3% in retailing, and 2.3% in education-related jobs. Thus, an overwhelming share of the working population is employed in the agriculture industry.[2]

3) Ethnic minorities

Laos is an ethnically diverse country. Although approximately 99% of people living in Laos have their nationality as Laotian, they include various ethnic minority groups. Some ethnic groups live in mountainous areas and speak their own languages. Moreover, some ethnic groups living in the central part of Laos are regarded as anti-government armed groups. Especially since 2015, in Xiengkhouang Province and Xaysomboun Province, there have been several attacks on Chinese investors. Now, the Laos police department patrols the center of Xiengkhouang Province on a 24-hour basis to strengthen vigilance against such criminal offenses.[3]

In several hydropower development projects, there have been cases of the Lao government army following the project teams from the investigation stage to the construction stage. A request can be made very easily just by submitting a request form. The required cost amounts to gasoline and food charges only. After submission of the request form to the military department, an estimation will be sent back.

[2] FY 2014 Laos/Cambodia Electric Power Case Survey Report by Japan Electric Power Information Center (JEPIC)

[3] Website of Ministry of Foreign Affairs: "Overseas Travel Safety Information"

Figure 5.6 Population by Ethnic Group

	Population	% to total Population
Lao	3,427,665	53.2
Khmou	708,412	11.0
Hmong	595,028	9.2
Phouthay	218,108	3.4
Tai	201,576	3.1
Makong	163,285	2.5
Katang	144,255	2.2
Lue	126,229	2.0
Akha	112,979	1.8
Others	749,153	11.6

Source: Table P2.7 (2015 PHC, Appendix 1)

Source: Results of Population and Housing Census 2015, Statistics Bureau of Laos

(2) Environmental improvement effects from the candidate projects

The candidate projects form a hydroelectric system that does not produce carbon dioxide (CO2) during power generation. At present, the energy sources supplying electricity to Laos include those imported from such neighboring countries as Thailand, Vietnam and China. Laos mainly uses hydroelectric power, and the volume of electricity domestically produced from fossil fuels is extremely small. However, during the dry season, energy sources are imported from the neighboring countries, which include those derived from fossil fuels.

If all the candidate projects are carried out, CO2 emissions in Laos will be reduced by 63,078.9 tons, compared with the amount based on the current power supply systems.

The calculation method to obtain the above-mentioned greenhouse gas emissions reduction effect is as follows:

1) Setting of a baseline

The baseline is the amount of CO_2 emissions generated by the current power supply systems in Laos when they supply an equivalent amount of electricity through each project.

2) Calculation of the baseline

The 2012 electricity supply and demand balance in Laos is used as a reference.

In 2012, all of the electric energy produced was covered by hydroelectric power, which consists of 1,896 GWh from EDL-owned systems and 10,865 GWh from IPPs, totaling 12,761 GWh. Among this, the amount of electricity exported to neighboring countries was 10,363 GWh. The electricity for domestic use was 2,398 GWh. Since hydropower generation systems are subject to power shortages in the dry season, electricity was imported from neighboring countries: 1,180 GWh from Thailand, 37 GWh from Vietnam, and 113 GWh from China, totaling 3,726 GWh.

The amount of domestic power supply in Laos was 3,726 GWh in 2012, with a power loss of 651 GWh (17.5%) and an electric sales amount of 3,075 GWh (82.5%).[4]

The following table shows a breakdown of electricity supply sources for domestic use in Laos and respective CO_2 emission factors.

[4] FY 2014 Laos/Cambodia Electric Power Case Survey Report by Japan Electric Power Information Center (JEPIC)

Table 5.3 Breakdown of electricity sources for Laos and respective CO_2 emission factors

Supply source	GWh	%	CO_2 emission factor (t-CO_2/MWh)
Laos's domestic hydropower facilities	2398	64.4	0
Thailand	1180	31.7	0.5796 [5]
Vietnam	37	1.0	0.6808 [6]
China	113	3.0	0.9515 [7]

Source: Creation by Study team

The baseline is calculated as follows.
Calculation formula:

(64.4%×0) + (31.7%×0.5796) + (1%×0.6808) + (3%×0.9515) ÷100 = 0.2191 t-CO_2/MWh

3) Estimation of effect

The performance of each candidate project is as follows.

Calculation formula: Annual power generation (MWh)

= Planned output (MW) × 24 (h) × 365 (days) × Annual facility utilization rate

Calculation formula: Annual CO2 emission reduction effect (t)

= Annual power generation amount (MWh) × 0.2191 t - CO2 / MWh

Table 5.4 Performance of each candidate project, planned output, Annual facility utilization rate, Annual power generation, and Annual CO_2 emission reduction effect

Candidate project name	Planned output (MW)	Annual facility utilization rate (%)	Annual power generation amount (MWh)	Annual CO_2 emission reduction effect
Nam Ngiep 2C	14.5	62.5	79,387.5	17,393.8
Nam Ngiep 2B	18	58.67	92,510.9	20,269.1
Nam Ngiep 2A	10	58.74	51,456.2	11,274.1
Nam Ban	14	52.63	64,545.4	14,141.9

Source: Creation by Study team

According to the above table, the annual CO_2 reduction amount becomes 63,078.9 tons if all candidate projects are carried out.

(3) Environmental and social impacts associated with candidate project implementation

Based on the Screening Style and Check List (Appendix 4) of JICA's "Guidelines for Environmental and Social Considerations", we conducted a survey to identify environmental and social impact items related to the candidate projects covered by this survey.

[5] 2010 Operating Margin from IGES Grid Emission Factor List
[6] 2013 Operating Margin from IGES Grid Emission Factor List
[7] 2011-2013 Average Operating Margin (Central China power network) from IGES Grid Emission Factor List

As a result, we concluded that no significant environmental or social impact was observed for each of the Nam Ngiep 2C, 2B and 2A projects, which are under construction. In addition, for the Nam Ban project at the FS phase, there is no serious environmental impact though there are two kinds of social impacts: one is the need for relocation of residents, and the other is road construction in the vicinity. The village near the development target is located in a deep mountainous area and there are no access roads, so the villagers have to come and go by boat along a river, which runs in the area for the planned dam site. According to our interviews with the villagers in the field survey, they have already been consulted about the relocation, and it has been determined that they will return to the place where they previously resided. Therefore, there is no serious negative impact concerning the relocation at present. Regarding the construction of an access road to the village, there was originally a plan with a military budget. However, the plan was postponed when the dam project arose, with the expectation that the access road would be built for the dam construction. If this project does not move forward, the construction of the access road to the village may be delayed. Even in that case, the residents would still be able to come and go by boat along the river as usual, so this would not cause any serious impact.

Table 5.5 Survey results based on environmental checklist

Category	Check item	Nam Ngiep 2C/2B/2A	Nam Ban
Permission/ explanation	EIA and environment-related permissions	Finished	For the scale of this project, IEE is required instead of EIA. IEE must be prepared in the future.
	Explanation to local residents	Finished	Since it is necessary to relocate residents, they have already been consulted.
Pollution control measures	Air quality	No pollution from hydroelectric power generation	
	Water quality	No pollution from hydroelectric power generation	
	Waste	No pollution from hydroelectric power generation	
	Soil contamination	No contamination from hydroelectric power generation	
	Noise and vibration	Some houses are dotted along the road, so noise from construction trucks etc. must be considered. However, at present, there are no complaints or other problems.	The village is located about 10 minutes by boat from the development point, and will suffer limited impact.
	Ground subsidence	There is no possibility of ground subsidence to be caused by pumping up groundwater or constructing foundation work.	Any ground subsidence to be caused by pumping up groundwater or constructing foundation work is not considered.
	Bad odors	No bad smells from hydroelectric power generation	
Natural environment	Protected zone	Not applicable	Not applicable
	Ecosystem	There is no impact.	Installation of fishway is planned.
	Hydrometeor	There is a possibility of decrease in river inflow volume due to water intake.	
	Terrain/geology	No important terrain is found in the vicinity.	
Social environment	Resident relocation	None	Two villages, including 80 households and 200 cattle/buffalo, need to be relocated. The relocation area is located downstream, taking an hour on foot, (where one of the two villages had been until 2000)
	Living life	Since there are no villages nearby, there is no impact.	Currently, river shrimp and riverweed are cultivated (prime of life in March to April). After the dam construction, aquaculture business is planned to be conducted at the reservoir.
	Cultural heritage	No impact	No impact
	Landscape	No impact	No impact
	Ethnic minorities and indigenous peoples	None	The ethnic group that needs relocation is Kam. Interpreters for Lao and Kam languages are needed.
	Working environment	Residential facilities for workers and offices near the construction site are in place. These facilities are well maintained.	The working environment will be prepared according to the progress of the project.

Others	Impact during construction	Because the villages are scattered along the national roads, some noise from construction vehicles needs to be considered, but the construction site is in the mountains, so the effect would be small.	Apart from the villages to be relocated, private houses are far from the construction site, and the impact seems to be little.
	Accident prevention measures	Some Chinese workers did not wear helmets or boots, or use safety ropes, for work at heights. Safety education and technical guidance for accident prevention will be required from now on.	Safety education and technical guidance for accident prevention are required.
	Monitoring	Environmental monitoring will be carried out at the regional and prefectural levels during and after construction.	It will be prepared according to the progress of the project.
	Others		There was a road construction plan by the military for access to nearby villages, but the plan was postponed as soon as the dam project was announced.

Source: Creation by Study team

(4) Outline of the partner country’s laws and regulations related to environmental and social considerations and necessary measures for compliance with them

1) Constitution of the Lao People’s Democratic Republic (2015 revision)

Revised in 2003, this constitution specified the national obligation to protect the environment by stating, “All organizations and citizens are obliged to protect the environment and natural resources” (Article 19). In order to strengthen the authority of the state with respect to natural resources, the constitution was revised again in 2015 by adding: "Natural resources such as land, minerals, water, air, forest, non-timber forest products, aquatic organisms, and wildlife are owned by the national community represented by the government, and the State ensures the rights to use, transfer and inherit them (natural resources) nationwide in accordance with the laws" (Article 17).

2) Environmental Protection Law (2012 revision)

The Environmental Protection Law was enacted in 1999 as a law embodying Article 19 of the Constitution of the Lao People’s Democratic Republic, and it requires the implementation of an Environmental Assessment (EA) for any projects that may affect the protection, conservation or utilization of natural resources.

Thereafter, in 2010, the following decree, regulation and guidelines were set to specify the details of the environmental assessment.

- Decree on Environmental Impact Assessment (2010)
- Regulation for the Agreement on Lao National Environmental Standards (2010)
- Environmental Impact Assessment Guidelines "EIA Guidelines" (2012)
- Ministerial Instruction on the Process of Initial Environmental Examination (IEE) for Investment Projects and Activities No. 8029 (by the Minister of Natural Resources and Environment)

・ Ministerial Instruction on Environmental and Social Impact Assessment (ESIA) Process for Investment Projects and Activities No. 8030 (by the Minister of Natural Resources and Environment)

According to the Decree on Environmental Impact Assessment, all hydroelectric power projects are classified into two categories depending on the scale of project, and an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) is required.

Table 5-6 Categories of environmental impact assessment survey

Scale		Category 1 (IEE)	Category 2 (EIA)
Power plant		<15 MW or Reservoir capacity < 1,500 ha	≥15MW or Reservoir capacity >1,500 ha
Power line	X>230 kV	≤50 km	>50 km
	X<230 kV	all	A significant environmental impact is presumed in a protected area designated by the country.
Substation	High voltage substation	<10 ha	>10 ha

Source: Creation by Study team

3) Water and Water Resource Law (1996 and 2013)

This law is scheduled to be amended in April 2017. With its revision, various relevant manuals are expected to be upgraded. In the revised draft, establishment of a data and information system is mentioned, and it seems that automatic collection of water volume data is being considered with the use of the system. At the time of our interview in December 2016, however, they said that no prospect of establishing the center or introducing the system had yet emerged.

With the Presidential Decree dated December 15, 2015, an obligation for payment of a service fee for water use was established.

Table 5-7 Water resources usage fee for hydroelectric power project

Type of project	Ratio to total income
Hydropower project for export purposes	5% or more
Hydropower project for domestic use (over 15 MW)	
Hydropower project for domestic use (15 MW or less)	5%

Source: Creation by Study team

4) The Lao Land Law (1997)

Land is a state-owned asset, so it is managed by the state in a unified manner. Rights of utilization, lease, transfer, and inheritance of land are given to individuals, households and organizations.

・ Government decree concerning land expropriation and compensation
(Decree on Compensation and Resettlement No. 192/PM 2005)

・ Regulation concerning compensation and relocation for persons affected by development projects
(Regulation for the Agreement on Lao National Environmental Standards 2010)

5) Forest Law revised (2007 revision)

Natural forests and forest areas are state-owned assets, so they are managed by the state in a unified manner. However, customary use of forests by local residents is allowed.

6) Wildlife and Aquatic Law (2007)

Wildlife and aquatic animals are classified into three categories: Prohibition, Management, and Common/general. For utilization of animals falling into the Prohibition category, government permission is required. For those falling into the Management category, proper management is required. For the Common or general category, it is required that the utilization of such animals will not cause a decrease in their number.

7) Decree on the Preservation of Cultural, Historical and Natural Heritage (1997)

In Article 5, natural heritage is stated as a national heritage, and in Article 8 it is required to preserve the current national heritage environment, such as Khon Phapheng waterfall in Champasak, Tat Kuangsy waterfall and Ting Cave in Luang Prabang and various others.

(5) Matters to be implemented by the relevant country (implementing agency and other relevant agencies) to realize the candidate projects

Our field survey conducted in Laos has revealed the expansion of deforestation. Although the impact of the expanding deforestation on hydroelectric power generation has not yet been clarified, it is easy to imagine that the forests' decreasing ability to retain water resources will lead to the increasing occurrence of landslides. Both the decreasing water retention function and the increasing occurrence of landslides will seriously affect hydroelectric power generation projects, so investors remain concerned about stable investment return.

In addition, there are still conflicts between ethnic minority groups and the government in some domestic areas, so some of the national roads are dangerous to use. In this situation, it is difficult for Japanese companies to send their workers because their lives may be in danger.

Based on the above, for investors it is desirable that the government provide support for the local people to recognize the importance of the forests' water retention function and explain this to ethnic minorities and local residents.

Capter6　　Financial and Economic Evaluation

(1) Estimation of Project costs

In this section, in order to examine the financial and economic feasibility of the proposed projects, an estimation of project costs was conducted as the basis of the examination.

1) Comparison of project costs of proposed projects

An estimation of project costs for the proposed projects was conducted. For this, the validity of the projects' contents and amounts is verified based on their respective feasibility studies. As construction costs for the proposed projects have been verified in section 4-4-c of Chapter 4 "Confirmation of Construction Cost", verification of construction cost shall be omitted, and an analysis of items other than this, as well as an overall analysis, shall be conducted in this chapter.

Based on the respective feasibility studies of the proposed projects, the amounts of individual items and the percentages of the total amount are shown in Table 6.1 below.

Table 6.1 Comparison of project costs of proposed projects

Item	Project							
	Nam Ngiep						Nam Ban	
	2A		2B		2C			
	Mil. USD	Ratio	Mil. USD	Ratio	Mil. USD	Ratio	Mil. USD	Ratio
1) Power House Building	0.3	1.7%	0.3	1.1%	0.4	1.3%	1.1	2.6%
2) Construction Work	8.6	46.0%	10.5	33.5%	13.3	47.0%	20.0	47.1%
①Water Channel	5.9	31.3%	7.1	22.5%	10.9	38.4%	18.7	44.2%
②Mechanical / Material Equipment	2.7	14.7%	3.5	11.0%	2.5	8.6%	1.3	3.0%
3) Electrical Equipment	3.5	19.0%	5.5	17.6%	4.0	14.2%	4.5	10.6%
4) Temporary / Auxiliary Work	2.6	13.9%	4.8	15.4%	4.1	14.6%	3.4	8.1%
5) Power Supply	0.4	2.0%	0.4	1.2%	0.3	1.0%	1.0	2.4%
Sub Total (Construction cost)	15.4	82.6%	21.6	68.7%	22.1	78.1%	30.0	70.8%
6) 115KV outgoing line project cost	0.0	0.0%	3.1	9.8%	0.0	0.0%	0.0	0.0%
7) Environmental and UXO clearance cost	0.2	1.1%	0.5	1.5%	0.6	2.0%	2.5	5.9%
8) Consulting fee, etc.	2.1	11.5%	5.2	16.6%	4.3	15.2%	6.6	15.6%
10) Basic contingency cost	0.9	4.8%	1.1	3.4%	1.4	4.8%	3.2	7.7%
Total	18.7	100.0%	31.4	100.0%	28.4	100.0%	42.3	100.0%

※ Construction cost is quoted from Chapter 4, "Table 4.22 Comparison with F/S construction cost"

Source: Study team

In all the proposed projects, construction work accounts for a significant portion, of 33% to 48%. For items other than construction cost, the consulting fee accounts for a large proportion, of around 11% to 17%. Basic contingency cost is set at 3% to 8% of the total. For the specific costs of the project, the cost of a 115 kV transmission line is required for Nam Ngiep 2B, so related expenses are recorded. No unusual items were detected from the overall cost structure.

In the section "2) Analysis of project costs for each proposed project", we will verify consulting expenses etc., which account for a large percentage of the total cost.

2) Analysis of project costs for each proposed project

The details of project costs for each proposed project are shown in Table 6.2 to Table 6.5. For estimation of these, the following estimation conditions were set.

- All power generation equipment shall be imported from outside Laos, and such equipment costs shall be estimated as CIF price in US Dollars.
- The exchange rate is set at 110 yen to 1 dollar.

Table 6.2 Details of Project costs for Nam Ngiep 2A

Item		Sub Item		USD			JPY		
				Domestic goods (Mil. USD)	Foreign goods (Mil. USD)	Total (Mil. USD)	Domestic goods (Mil. JPY)	Foreign goods (Mil. JPY)	Total (Mil. JPY)
I	Construction cost	1	Power House Building	0.3		0.3	35.2		35.2
		2	Construction Work	8.2	0.4	8.6	906.9	39.3	946.2
			①Water Channel	5.9		5.9	644.1		644.1
			②Mechanical / Material Equipment	2.4	0.4	2.7	262.8	39.3	302.1
		3	Electrical Equipment	0.4	3.1	3.5	46.2	343.5	389.8
		4	Temporary / Auxiliary Work	2.6		2.6	285.6		285.6
		5	Power Supply	0.4		0.4	41.7		41.7
			Sub Total	12.0	3.5	15.4	1,315.6	382.8	1,698.4
Ⅱ	Environmental and UXO clearance cost	1	Submerging treatment of reservoir, permanent land occupation & temporary land occupation for construction	0.2		0.2	23.5		23.5
		2	Environmental work			0.0			0.0
		3	UXO clearance			0.0			0.0
			Sub Total	0.2		0.2	23.5		23.5
Ⅲ	Consulting fee	1	Project acceptance fee	0.0		0.0	5.1		5.1
		2	Production preparation fee	0.1		0.1	8.0		8.0
		3	Preliminary engineering fee	0.3		0.3	33.0		33.0
		4	Research and survey and design fee	0.8		0.8	92.1		92.1
		5	Construction management fee	0.3		0.3	35.2		35.2
		6	Construction supervision fee	0.2		0.2	23.6		23.6
		7	Consulting service fee	0.1		0.1	7.9		7.9
		8	Project technical and economic assessment fee	0.0		0.0	5.1		5.1
			Sub Total	1.9		1.9	210.1		210.1
Ⅳ	Project insurance cost		Sub Total	0.1		0.1	12.7		12.7
Ⅵ	Taxes		Sub Total	0.1		0.1	13.0		13.0
Ⅴ	Basic contingency cost		Sub Total	0.9		0.9	97.9		97.9
Ⅵ	Total			15.2	3.5	18.7	1,672.8	382.8	2,055.6

Source: Study team

Table 6.3 Details of Project costs for Nam Ngiep 2B

Item		Sub Item		USD			JPY		
				Domestic goods (Mil. USD)	Foreign goods (Mil. USD)	Total (Mil. USD)	Domestic goods (Mil. JPY)	Foreign goods (Mil. JPY)	Total (Mil. JPY)
I	Construction cost	1	Power House Building	0.3		0.3	37.7		37.7
		2	Construction Work	9.1	1.4	10.5	997.0	158.3	1,155.3
			①Water Channel	7.1		7.1	775.7		775.7
			②Mechanical / Material Equipment	2.0	1.4	3.5	221.3	158.3	379.6
		3	Electrical Equipment	1.0	4.5	5.5	110.0	498.4	608.4
		4	Temporary / Auxiliary Work	4.8		4.8	530.4		530.4
		5	Power Supply	0.4		0.4	41.7		41.7
			Sub Total	15.6	6.0	21.6	1,716.8	656.7	2,373.6
Ⅱ	Environmental and UXO clearance cost	1	Submerging treatment of reservoir, permanent land occupation & temporary land occupation for construction	0.2		0.2	23.5		23.5
		2	Environmental work	0.3		0.3	27.5		27.5
		3	UXO clearance			0.0			0.0
			Sub Total	0.5		0.5	51.0		51.0
Ⅲ	115kv outgoing line project cost		Sub Total	3.1		3.1	337.1		337.1
Ⅳ	Consulting fee	1	Project acceptance fee	0.1		0.1	11.9		11.9
		2	Production preparation fee	0.1		0.1	13.9		13.9
		3	Preliminary engineering fee	2.5		2.5	277.5		277.5
		4	Research and survey and design fee	0.8		0.8	85.8		85.8
		5	Construction management fee	0.5		0.5	51.2		51.2
		6	Construction supervision fee	0.4		0.4	39.5		39.5
		7	Consulting service fee	0.1		0.1	10.9		10.9
		8	Project technical and economic assessment fee	0.1		0.1	11.9		11.9
			Sub Total	4.6		4.6	502.6		502.6
Ⅴ	Project insurance cost		Sub Total	0.2		0.2	19.0		19.0
Ⅵ	Taxes		Sub Total	0.5		0.5	51.5		51.5
Ⅶ	Basic contingency cost		Sub Total	1.1		1.1	118.7		118.7
Ⅷ	Total			25.4	6.0	31.4	2,796.8	656.7	3,453.5

Source: Study team

Table 6.4 Details of Project costs for Nam Ngiep 2C

Item		Sub Item		USD Domestic goods (Mil. USD)	USD Foreign goods (Mil. USD)	USD Total (Mil. USD)	JPY Domestic goods (Mil. JPY)	JPY Foreign goods (Mil. JPY)	JPY Total (Mil. JPY)
Ⅰ	Construction cost	1	Power House Building	0.4		0.4	42.0		42.0
		2	Construction Work	12.1	1.3	13.3	1,326.9	140.5	1,467.4
			①Water Channel	10.9		10.9	1,197.7		1,197.7
			②Mechanical / Material Equipment	1.2	1.3	2.5	129.2	140.5	269.7
		3	Electrical Equipment	0.4	3.6	4.0	45.1	396.4	441.5
		4	Temporary / Auxiliary Work	4.1		4.1	454.6		454.6
		5	Power Supply	0.3		0.3	29.7		29.7
			Sub Total	17.3	4.9	22.1	1,898.4	536.9	2,435.3
Ⅱ	Environmental and UXO clearance cost	1	Submerging treatment of reservoir, permanent land occupation & temporary land occupation for construction	0.3		0.3	30.0		30.0
		2	Environmental work			0.0			0.0
		3	UXO clearance	0.3		0.3	32.3		32.3
			Sub Total	0.6		0.6	62.3		62.3
Ⅲ	Consulting fee	1	Project acceptance fee	0.1		0.1	5.7		5.7
		2	Production preparation fee	0.0		0.0	2.7		2.7
		3	Preliminary engineering fee	0.7		0.7	80.9		80.9
		4	Research and survey and design fee	1.0		1.0	113.9		113.9
		5	Construction management fee	0.5		0.5	50.7		50.7
		6	Construction supervision fee	0.8		0.8	83.8		83.8
		7	Consulting service fee	0.6		0.6	66.1		66.1
		8	Project technical and economic assessment fee	0.1		0.1	5.7		5.7
			Sub Total	3.7		3.7	406.8		406.8
Ⅳ	Project insurance cost		Sub Total	0.2		0.2	22.8		22.8
Ⅴ	Taxes		Sub Total	0.4		0.4	43.7		43.7
Ⅴ	Basic contingency cost		Sub Total	1.4		1.4	148.5		148.5
Ⅵ	Total			23.5	4.9	28.4	2,582.5	536.9	3,119.4

Source: Study team

Table 6.5 Details of Project costs for Nam Ban

Item		Sub Item		USD Domestic goods (Mil. USD)	USD Foreign goods (Mil. USD)	USD Total (Mil. USD)	JPY Domestic goods (Mil. JPY)	JPY Foreign goods (Mil. JPY)	JPY Total (Mil. JPY)
Ⅰ	Construction cost	1	Power House Building	1.1		1.1	121.1		121.1
		2	Construction Work	18.8	1.2	20.0	2,064.3	132.0	2,196.3
			①Water Channel	18.7		18.7	2,058.8		2,058.8
			②Mechanical / Material Equipment	0.1	1.2	1.3	5.5	132.0	137.5
		3	Electrical Equipment		4.5	4.5		495.0	495.0
		4	Temporary / Auxiliary Work	3.4		3.4	376.2		376.2
		5	Power Supply		1.0	1.0		110.0	110.0
			Sub Total	23.3	6.7	30.0	2,561.6	737.0	3,298.6
Ⅱ	Environmental and UXO clearance cost	1	Submerging treatment of reservoir, permanent land occupation & temporary land occupation for construction			0.0			0.0
		2	Environmental work	2.5		2.5	275.0		275.0
		3	UXO clearance			0.0			0.0
			Sub Total	2.5		2.5	275.0		275.0
Ⅲ	Consulting fee and taxes		Sub Total	6.6		6.6	727.2		727.2
Ⅳ	Basic contingency cost		Sub Total	3.2		3.2	357.4		357.4
Ⅴ	Total			35.6	6.7	42.3	3,921.1	737.0	4,658.1

Source: Study team

In addition, the adequacy of the consulting fee amount, project insurance cost and various taxes (hereinafter referred to as consulting expenses, etc.) within the construction expenses was calculated based on actual data for electric power companies in Japan and the estimated amount of consulting fees, etc. A conservative estimate was carried out, comparing it with the F/S amount. In calculating the estimated amount, the following conditions were set.

- In the F/S, consulting expenses are classified into sub items and recorded, but with reference to the data for electric power companies in Japan, 10% of the construction costs are collectively recorded.
- The project insurance cost was set at 0.75% of the construction cost with reference to the data for electric power companies in Japan.
- Taxes are taken as 10% of imported goods, taking into account the high value-added tax rate.

Table 6.6 Verification of consulting fee, etc. for Nam Ngiep 2A

Item	Construction cost / Total (Mil. USD)	Construction cost / Foreign goods (Mil. USD)	Estimation conditions	(a) Estimated amount (Mil. USD)	(b) refer from F/S (Mil. USD)	(a)-(b) Difference (Mil. USD)
Consulting fee	15.4	–	10.00%	1.5	1.9	(0.4)
Project insurance cost	15.4	–	0.75%	0.1	0.1	0.0
Taxes	–	3.5	10.00%	0.3	0.1	0.2
			Total	2.0	2.1	(0.1)

Source: Study team

In the F/S, the amount of the consulting fee is conservatively estimated, but it seems that the estimates of various taxes are small. Because it is assumed that consulting expenses will occur more frequently in Laos than in Japan, it is rational that the consulting cost estimate be conservative. In total, the F/S figures are higher than the estimated amount, so the F/S consulting fee, etc. are considered reasonable in light of general standards.

Nam Ngiep 2B, Nam Ngiep 2C and Nam Ban also conservatively estimate the consulting fee, etc. Therefore, it is considered that the implementation of the consulting fee, etc. is carried out within a reasonable range.

Table 6.7 Verification of consulting fee, etc. for Nam Ngiep 2B

Item	Construction cost / Total (Mil. USD)	Construction cost / Foreign goods (Mil. USD)	Estimation conditions	(a) Estimated amount (Mil. USD)	(b) refer from F/S (Mil. USD)	(a)-(b) Difference (Mil. USD)
Consulting fee	21.6	–	10.00%	2.2	4.6	(2.4)
Project insurance cost	21.6	–	0.75%	0.2	0.2	(0.0)
Taxes	–	6.0	10.00%	0.6	0.5	0.1
			Total	2.9	5.2	(2.3)

Source: Study team

Table 6.8 Verification of consulting fee, etc. for Nam Ngiep 2C

Item	Construction cost / Total (Mil. USD)	Construction cost / Foreign goods (Mil. USD)	Estimation conditions	(a) Estimated amount (Mil. USD)	(b) refer from F/S (Mil. USD)	(a)-(b) Difference (Mil. USD)
Consulting fee	22.1	–	10.00%	2.2	3.7	(1.5)
Project insurance cost	22.1	–	0.75%	0.2	0.2	(0.0)
Taxes	–	4.9	10.00%	0.5	0.4	0.1
			Total	2.9	4.3	(1.4)

Source: Study team

Table 6.9 Verification of consulting fee, etc. for Nam Ban

Item	Construction cost / Total (Mil. USD)	Construction cost / Foreign goods (Mil. USD)	Estimation conditions	(a) Estimated amount (Mil. USD)	(b) refer from F/S (Mil. USD)	(a)-(b) Difference (Mil. USD)
Consulting fee	30.0	–	10.00%	3.0		–
Project insurance cost	30.0	–	0.75%	0.2	6.6	–
Taxes	–	6.7	10.00%	0.7		–
			Total	3.9	6.6	(2.7)

Source: Study team

3) Calculation of cost of proposed project over project period

To calculate the cost of the proposed project over the project period, the following estimation conditions were set.

- All power generation equipment shall be imported from outside Laos, and equipment costs shall be estimated as CIF price in US Dollars.

- Compensation costs, environmental spending, and UXO survey and removal costs shall be included.
- Basic contingency cost was set at 3% to 8% of total project cost with reference to F/S figures.
- The progress rate for 3 years of construction period was assumed as 30% in the first year, 50% in the second year and 20% in the third year, and the project costs were assumed to be disbursed in proportion to such progress rate.
- Yearly operation and maintenance costs (maintenance costs excluding depreciation cost, payment interest expense and taxes) such as repair costs, etc. for hydropower generation structure and related electrical equipment was set as equivalent to 1.5% of the static project cost, with reference to not only hydropower IPP projects in Laos but also actual data for Japanese power companies.
- It was assumed that there should be no facility renewal cost required for an economic service life of 30 years.
- For Nam Ngiep, revenues from sales of electric power to EDL were set at 6.7 USC/kWh from start of operation to 14th year, 5.7 USC/kWh from 15th year to 27th year, and 6.0 USC/kWh from 28th year onward, based on PPA concluded between EDL and sponsors. For Nam Ban, revenues were set at 6.5 USC/kWh from start of operation.
- The cost for hydropower generation royalty was set at an amount equal to 2% of total revenues.
- Profit tax was set at 24%, based on Laos Tax Law, and tax exemption period as investment incentive was set at 6 years from the start of operation.

Table 6.10 summarizes the cost parameters over the project period for each proposed project based on the above estimation conditions.

Table 6.10 Parameters that affect the cost of each project

Item	Unit	Project			
		Nam Ngiep			Nam Ban
		2A	2B	2C	
PPA Tariff Rate (Start of operation-14 years)	USC/kWh	6.7	6.7	6.7	6.5
PPA Tariff Rate (15 years-27 years)	USC/kWh	5.7	5.7	5.7	6.5
PPA Tariff Rate (28 years-)	USC/kWh	6.0	6.0	6.0	6.5
Annual O&M/Static Project Cost	%	1.5%	1.5%	1.5%	1.0%
Royalty/Annual Income	%	2.0%	2.0%	2.0%	2.0%
Profit Tax Rate	%	24.00%	24.00%	24.00%	24.00%
Tax Holiday	year	6	6	6	6
Capacity	MW	10.18	18.00	14.50	14.00
Average Annual Energy	GWh/year	52.40	92.51	71.73	65.01
Average Annual Energy (Except for in-house electricity consumption)	GWh/year	52.4	91.6	71.0	65.0
Depreciation Period	year	30	30	30	30
Total Annual Energy during depreciation period	GWh	1,572	2,775	2,152	1,950
Total cost of depreciation, loan interest and O&M cost	Million USD	34.8	46.2	56.1	79.1
Cost of power generation	USC/kWh	2.2	1.7	2.6	4.1

Source: Study team

(2) Outline of preliminary Financial and Economic Analysis results

Economic evaluation, from the public standpoint of nation level, and the social and economic benefits which can be gained by implementation of the project, were evaluated by comparison with the costs required for the project, and a financial evaluation, from the enterprise's standpoint of project profitability, was conducted.

1) Economic Analysis

From the Laotian national economy's point of view, the economic effect that would be brought by construction and operation of a new hydropower generation plant in Laos was measured in the Economic Analysis. Economic values of costs and benefits were compared by the discounted cash flow method. The evaluation was carried out with the indices of Net Present Value (NPV), which is calculated using benefits to be created by the project and its required costs, Benefit Cost Ratio (B/C) and Economic Internal Rate of Return (EIRR).

a) Preconditions

The following preconditions were set in consideration of other power generation projects, etc. in Laos.

① Economic Analysis process

The evaluation was performed via the following process.

(1) Domestic income transfer items (taxes and customs duties including VAT, subsidies, land compensations for resettlement, interest during construction) that are only transfers between people of the nation from the national economy's point of view, and are not costs, were excluded from market prices in the calculation of costs and benefits. Depreciation cost was not treated as cost.

(2) As shadow price is used in the calculation of costs and benefits. The costs in (i) were converted to economic cost (Table 6.11) after division into foreign goods (traded goods) and domestic goods (non-traded goods and labor, etc.). Standard Conversion Factor to convert the domestic goods portion such as construction costs, etc., which were estimated based on market prices, to shadow price was 0.95 as used in other projects of international organizations.

(3) The internal rate of return calculated by the economic cost was compared and evaluated with the opportunity cost of capital in Laos.

Table 6.11 Economic cost of initial investment in Nam Ngiep 2C project

Standard conversion factor @ 95%

Description	Ist Year		2nd Year		3rd Year		Total		
	LC	FC	LC	FC	LC	FC	LC	FC	LC + FC
1. Construction Cost									
Construction auxiliary work	867.7	0.0	1,446.1	0.0	578.4	0.0	2,892.2	0.0	2,892.2
Architectural work	3,824.8	0.0	6,374.7	0.0	2,549.9	0.0	12,749.4	0.0	12,749.4
Electrical & mechanical equipment including equipment and installation	116.9	1,081.2	194.8	1,802.0	77.9	720.8	389.5	3,603.9	3,993.4
Steel Structure/Equipment and Installation	109.2	383.1	182.0	638.6	72.8	255.4	364.0	1,277.1	1,641.1
Total	4,918.5	1,464.3	8,197.5	2,440.5	3,279.0	976.2	16,395.1	4,881.0	21,276.1
2. Environmental Protection Cost									
Compensation for land acquisition and resettlement									
Environmental work	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UXO clearance	83.6	0.0	139.4	0.0	55.8	0.0	278.8	0.0	278.8
Total	83.6	0.0	139.4	0.0	55.8	0.0	278.8	0.0	278.8
3. Independent Cost	1,233.1	0.0	2,055.2	0.0	822.1	0.0	4,110.4	0.0	4,110.4
Sum of 1-3	6,235.3	1,464.3	10,392.2	2,440.5	4,156.9	976.2	20,784.3	4,881.0	25,665.3
4. Basic Contingency Cost	315.7	73.2	526.1	122.0	210.4	48.8	1,052.2	244.1	1,296.2
Static Cost (Sum of 1-4)	6,551.0	1,537.5	10,918.3	2,562.5	4,367.3	1,025.0	21,836.5	5,125.1	26,961.6
	8,088.5		13,480.8		5,392.3		26,961.6		

Source: Study team

② Opportunity cost of capital (social discount rate)

Opportunity cost of capital (interest rate at investment), which is the target to compare with EIRR, was set as 10%, and was used as a discount rate for estimation of Present Value. This was set with reference to JICA's development survey report "The Master Plan Study on Small-Hydro in Northern Laos" (2005) and JICA's survey report "Preparatory Survey on Nam Ngum 1 Hydropower Station Expansion" (2010).

For reference, long-term loan interest rates (in the case that the loan period is 5 years or longer and borrower creditworthiness is classified as Class AA, which is in the middle of 3 stages) at Laotian domestic commercial banks were 9.25% in US Dollars and 10.25% in Lao Kip, prevailing as of January 2017. If long-term loan interest is considered as a substitute for the opportunity of cost, the above discount rate is presumed to be a reasonable level.

③ Calculation period and price escalation

The calculation period was set as 33 years in total, which includes 3 years of detailed design and construction in addition to an economic service life of 30 years. The constant prices were employed without price escalation.

b) Economic benefits

In terms of economic benefits, the value of alternative power generation which would be required if this project were not to materialize shall be estimated. In Laos, power generation relies predominantly on hydropower though diesel power generators have been used in rural areas for dispersed power generation. Accordingly, hydropower generation plays a leading part in the Power Development Plan (PDP) of Laos, except for small-sized power generation that will not be connected with the power grid. In this survey, two options for power generation other than hydropower, namely ① power imports from EGAT (Electricity Generating Authority of Thailand) in Thailand, and ② thermal power generation, were studied.

① Power imports from EGAT

Laos exports power to neighboring countries such as Thailand, Cambodia and Vietnam. For the import and export of power between Laos and Thailand, the export surplus of power from Laos to Thailand continues when it is considered as the whole of Laos, including IPPs in Laos in addition to EDL. However, when we look at the breakdown of power exports from Laos to Thailand, IPPs had a 94% share and EDL had only a 6% share of the total exports in 2015. If it is limited to power imports and exports between EGAT and EDL, the tendency of import surplus over exports from EGAT to EDL continued from 2007 to 2015, except for 2011 when exports from Laos exceeded imports. In 2015, the power imports from EGAT to EDL increased due to high growth of power demand in Laos, while the exports from EDL to EGAT decreased. A breakdown is shown in Table 6.12 below.

Table 6.12 Electricity trade between EDL and EGAT

Electricity Generation, Consumption, Export and Import 2005-2015 (GWh)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Generation	3,509.40	3,595.00	3,373.60	3,717.00	3,384.30	8,449.00	12,979.50	12,760.10	15,511.60	15,270.10	16,501.10
Domestic Consumption	1,007.40	1,114.30	1,298.40	1,915.70	2,257.70	2,440.70	2,555.80	3,074.90	3,381.00	3,791.30	4,239.10
Import	329.50	631.10	793.40	844.50	1,175.10	1,209.70	904.30	1,329.10	1,271.70	1,559.10	2,049.80
Export	2,506.00	2,487.40	2,230.40	2,315.40	1,920.80	6,646.50	10,668.40	10,363.00	12,494.00	11,936.20	10,842.40
Balance=Export - Import	+2,176.50	+1,856.30	+1,437.00	+1,470.90	+745.70	+5,436.80	+9,764.10	+9,033.90	+11,222.30	+10,377.10	+8,792.60

Electricity Export From EDL Grids and IPP: 2005-2015 (GWh)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EDL	727.80	547.00	268.00	391.80	231.60	366.40	717.00	320.40	690.80	445.20	655.40
IPP	1,778.20	1,940.30	1,962.40	1,923.60	1,691.30	6,305.20	9,900.20	10,042.70	11,803.20	11,491.00	10,187.00
EDL＋IPP	2,506.00	2,487.30	2,230.40	2,315.40	1,922.90	6,671.60	10,617.20	10,363.10	12,494.00	11,936.20	10,842.40

Balance of Export and Import Between EGAT and EDL 2005-2015 (GWh)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Import from EGAT to EDL	289.30	290.50	409.40	431.00	719.00	819.80	526.90	908.40	882.10	1,137.70	1,364.20
Export to EGAT from EDL	727.80	547.00	268.00	391.80	229.50	341.30	678.30	320.40	690.80	445.20	655.40
Balance=Export - Import	+438.50	+256.50	▲141.40	▲39.20	▲489.50	▲478.50	+151.40	▲588.00	▲191.30	▲692.50	▲708.80

Source: Department of Energy Policy and Planning, Ministry of Energy and Mines, "Electricity StatisticsYearbook 2015 of Lao P.D.R."

Next, an increase in power imports from EGAT to EDL was assumed as an alternative power generation source to the development of new hydropower IPP in Laos, and an Economic Analysis was conducted with such assumption. In other words, it is verified whether avoidance of an increase in the import surplus of power from Thailand to Laos via development of new hydropower IPP has economic rationality or not.

EDL and EGAT are currently in a mutual power interchange relationship and the tariff for power imports and exports is shown in Table 6.6. As for the increase in power imports from EGAT to EDL which will be caused by no new development of hydropower IPP under the constant import surplus situation of power from EGAT to EDL, EDL has to pay a Surcharge Payment against the power import surplus in addition to Normal Import Tariff if EDL has any import surplus in the yearly balance of power imports and exports.

Applicable tariffs in the power interchange contract between EDL and EGAT, which were confirmed with EDL in January 2017, are shown in Table 6.13. The unit price for power import from EGAT to EDL (normal time) is relatively expensive in comparison with power export from EDL to EGAT. In addition, the Surcharge Payment against import surplus was revised by the Government of Thailand in November 2015. Though the next revision is not yet scheduled, it was said that its level tends to increase for these years.

Table 6.13 Electricity trade tariff between EDL and EGAT as of January 2017

Preconditions		Tariff to be applied
GWh of Exports (EDL → EGAT) are LARGER than GWh of Imports (EGAT → EDL)		Normal price
GWh of Exports (EDL → EGAT) are SMALLER than GWh of Imports (EGAT → EDL)	For GWh of Exports (EDL→EGAT) and GWh of Imports (EGAT→EDL) not exceeding Exports	Normal price
	For Excess GWh of Imports over Exports	Surcharge (valid since November 2015)

Normal price (Unit:Thai Baht)

Time zone	Export EDL→EGAT	Import EGAT→EDL	
		Normal	Emergency
Peak	1.60	1.74	1.60
Off Peak	1.20	1.34	1.20

Peak: 09:00～22:00 (Mon-Fri)
Off Peak: 22:00～09:00 (Mon-Fri)
00:00～24:00 (Sat, Sun, National Holidays of Thailand)

Surcharge
(valid since November 2015) (Unit:Thai Baht)

Time zone	Export EDL→EGAT	Import EGAT→ EDL
Peak	—	4.0476
Off Peak		2.3555

Peak: 09:00～22:00 (Mon-Fri)
Off Peak: 22:00～09:00 (Mon-Fri)
00:00～24:00 (Sat, Sun, National Holidays of Thailand)

Source: Study team interviewed EDL (Jan. 2017)

The results of the Economic Analysis comparing the new development cost of hydropower IPP with avoidable cost regarding the increase in import surplus of power from EGAT (additional payment amount from EDL to EGAT including Surcharge Payment) are shown in Table 6.14. EIRR is 27.3%, which exceeds the 10.0% deemed as the opportunity cost of capital in Laos, and B/C is 2.63, more than 1.0. Therefore, this project can be considered valid from the standpoint of national society and the overall economy of Laos.

The power interchange between EDL and EGAT is performed with a much lower price level than their own domestic power retail prices in the respective countries. For EDL, it can be said of the level that imports from EGAT could be more beneficial than new construction of power generation facilities in Laos. However, there is a question in the appropriateness of the estimation for the benefits as the value of power generation to be developed in Laos, based on such price level. Furthermore, from Laos' energy security point of view under the trend of an increasing import surplus of power from EGAT to EDL, it shall be verified further whether such continuation of power imports can be considered as a premise, placing priority on power imports from a neighboring country rather than new domestic development of power generation.

Table 6.14 Economic evaluation of Nam Ngiep 2C project /

Calculation of EIRR: the case of increase in electricity imports from EGAT

Year	Cost			Benefit						Net Benefit
	Construction and Reinvestment	Operation and Maintenance	Total	Increase in Excess Import	Normal Import Tariff	Normal Import Payment	Import Surcharge Tariff	Surcharge Payment	Total	
	Mil.USD	Mil.USD	Mil.USD	GWh	USD/kWh	Mil.USD	USD/kWh	Mil.USD	Mil.USD	Mil.USD
1	8.09	0.00	8.09	0				0.00	0.00	-8.09
2	13.48	0.00	13.48	0				0.00	0.00	-13.48
3	5.39	0.20	5.59	35.51	0.0421	1.49	0.0841	2.99	4.48	-1.11
4		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
5		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
6		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
7		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
8		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
9		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
10		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
11		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
12		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
13		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
14		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
15		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
16		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
17		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
18		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
19		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
20		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
21		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
22		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
23		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
24		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
25		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
26		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
27		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
28		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
29		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
30		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
31		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
32		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
33		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
34		0.40	0.4	71.01	0.0421	2.99	0.0841	5.97	8.96	8.56
Total	26.96	12.60	39.56			94.17012		188.12	282.29	242.73

Discount Rate: 10.0% PV(Cost): 25.54 PV(Benefit): 67.19

EIRR:		27.3%
NPV:	41.644	Mil.USD
B/C:		2.63

Source: Study team

For calculation of the cost for an increase in the import surplus of power from EGAT to EDL (avoidable cost), the hydropower IPP development under study was assumed to be operated as flat power generation for 24 hours a day throughout the year (not with more power generation in the peak power demand time zone) in order to conduct the analysis simply and the verification conservatively. The analysis was conducted on the assumption that there would be no restriction in power transmission line capacity even if the power imports from EGAT to EDL increase, in consideration of the fact that construction of a 500,000 V large-capacity power transmission line is planned for within a few years, and output of the hydropower IPP supposed in this project is about 10 to 20 MW.

② Thermal power generation

In estimation of the economic benefits in the alternative thermal power method, the cost of thermal power generation was considered as the benefit of the hydropower generation project on the assumption that thermal power generation would be constructed and operated as an alternative to this hydropower IPP project. The benefits regarding the power generation capacity of a hydropower IPP are represented by the construction cost averaged annually for alternative thermal power generation and fixed costs (kW value). The energy generated by the hydropower IPP is represented by valuable costs (kWh value) such as fuel cost, etc. of the alternative thermal power generation.

Laos is poor in fossil fuel resources other than coal. As Laos, a landlocked country, has neither any open ocean port nor any petroleum refining facilities, the import of fossil fuels is restricted, and petroleum products are mainly for gasoline and living fuel, and depend on imports from Thailand and Vietnam. According to an interview at a large national Laotian oil distributor, Lao State Fuel Company (conducted in January 2017), a volume equal to about 80% of the total import volume is imported from Thailand, and the remainder from Vietnam in the case of heavy oil (gross calorific value 9,900 kcal/g). Diesel oil has a larger gross calorific value per unit (gross calorific value 10,700 kcal/g), but diesel oil is 6,850 LAK/L for the wholesale price of a company in Xiengkhouang Province, versus a heavy oil price of 4,650 LAK/L (as of January 2017). This is because consumption tax (20%) is imposed on diesel oil in addition to national tax (5% or less) and VAT (10%) but only national tax (5% or less) and VAT (10%) are imposed on heavy oil.

As for coal, lignite and anthracite are distributed throughout Laos and the estimated reserves are 600 million tons. Good quality lignite is produced in Hongsa of Xayabouly Province, close to the Thai border in the North, and a survey report by the Asian Development Bank (ADB) said that it would be possible to generate power of 2,000 MW with such coal resources (The Institute of Energy Economics, Japan "Current Situation and Future Trends of Energy and Power in Laos (October 2003)"). Hongsa Power Generation Plant, which is the first lignite thermal power generation in Laos, and which Ratchaburi Electricity Generating Holding ((RATCH), a large private electric power company in Thailand), and Banpu Public Company Limited (a large coal company in Thailand) financed jointly with the Government of Laos, started operation of its No.1 through 3 generators (output 625 MW X 3 = 1,878 MW) gradually from 2015 to 2016. The majority of the generated energy is exported to EGAT. As there is a redundant capacity in lignite production at Hongsa, RATCH was sounding the Government of Laos out on additional construction of a No. 4 generator (output 626 MW). However, the Government of Laos had not yet determined as of November 2016 whether No. 4 lignite thermal power generation shall be added or not, because its future electric power policy is still under study. Since lignite thermal power generation has lower mobility than diesel power generation or gas-turbine power generation, it is operated as normal base power generation. Therefore, it is considered that lignite thermal power generation is not an appropriate alternative to hydropower generation. Moreover, as lignite thermal power generation is assumed in the PDP as 1,500 MW or more of large-sized power generation (capacity utilization 80%), we judged that it is not suitable for alternative power generation.

It is not easy to suppose natural gas as fuel for alternative power generation in consideration of the difficulties in import and transportation, construction cost for the power generation, and so on.

Based on these considerations, we judged that diesel power generation with a fuel of heavy oil, which is cheaper than diesel oil, is suitable for alternative thermal power generation. kW value and kWh were estimated as follows, based on two kinds of diesel power generation data (from JICA's past survey results).

First, adjustment factors to compensate for the difference in the loss rates of thermal power generation and hydropower generation were calculated for the kW value and kWh value respectively as shown in Table 6.15. Then, the kW value was calculated from construction cost and fixed cost for 2 types of diesel generators (medium speed and low speed) and the kWh value was calculated from fuel cost and valuable cost (Table 6.16). As a medium speed diesel generator has a relatively high kWh value efficiency, as well as better mobility, compared with medium speed and low speed diesel generators, we decided to adopt it for the alternative power generation. The economic benefits were estimated based on the kW value and kWh value calculated, as well as yearly-generated energy and guaranteed output for each year.

Table 6.15 Adjustment factors for thermal plant

Item	kW	kWh	Hydropower		Diesel Power	
Transmission Loss	○	○	6.00%	a	6.00%	a'
Overhaul and Maintenance	○		0.00%	b	7.67%	b'
Auxiliary Power Consumption	○	○	0.50%	c	4.60%	c'
Forced Outage	○		0.50%	d	2.19%	d'
kW Adjustment Factor			-		1.149	e
kWh Adjustment Factor			-		1.043	f

e =((1-a)*(1-b)*(1-c)*(1-d))/((1-a')*(1-b')*(1-c')*(1-d'))

f =((1-a)*(1-c))/((1-a')*(1-c'))

Source: Feasibility Study on The Sihanoukville Combined Cycle Power Development Project in The Kingdom of Cambodia, JICA (Jan 2002)

Table 6.16 "kW value" and "kWh value"

Value	Diesel Power Generation	Unit	Diesel Power Speed (MW/unit)	Middle 90	Low 90
kW	Construction Cost per kW	US$/kW	g	1,370.0	2,020.0
	Price escalation		h	177.00%	177.00%
	Adjusted for price escalation	US$/kW	i=g*h	2,424.9	3,575.4
	Economic life	years	j	20	20
	Discount rate		k	10%	10%
	Capital Recovery Rate		l=k/(1-(1+k)^(-j))	0.1175	0.1175
	Fixed O&M Cost	US$/kW	m	21.0	21.0
	Adjusted for price escalation	US$/kW	n=m*h	37.2	37.2
	kW Adjustment Factor		e	1.149	1.149
	kW Value (Power Value)	US$/kW	o=(i*l+n)*e	370.13	525.48
kWh	Fuel Type		p	Heavy fuel oil	Heavy fuel oil
	Fuel Price	US$/L	q	0.60	0.60
	Caloric Value	kcal/L	r	9,958	9,958
		kcal/kWh	s	860	860
	Thermal Efficiency		t	43%	49%
	Heat Rate	kcal/kWh	u=s/t	2,000.0	1,755.1
	Fuel Amount	L/kWh	v=u/r	0.2008	0.1763
	Fuel Cost	US$/kWh	w=q*v	0.1205	0.1058
	Variable O&M Cost	US$/kWh	x	0.003	0.003
	kWh Adjustment Factor		f	1.043	1.043
	kWh Value (Energy Value)	US$/kWh	z=(w+x)*f	0.1288	0.1134

Sources:

g, j, m, p, r, t, x :Feasibility Study on The Sihanoukville Combined Cycle Power Development Project in The Kingdom of Cambodia, JICA (Jan 2002)

h :Average inflation rates of world prices (2002-2016), retrieved from World Economic Outlook, IMF (2016)

q :Wholesale heavy fuel oil price per litter in Xieng Khouang province: Lao State Fuel Company (Jan., 2017)

EIRR was calculated after the development of economic costs and benefits onto the cash flow table. As shown in Table 6.17, EIRR became 44.2%, and NPV 85.29 million US Dollars, with a discount rate of 10% and B/C 4.34 respectively.

Because EIRR greatly exceeds the social discount rate of 10%, and NPV is indicating a positive figure, we can evaluate this project as economically feasible.

Table 6.17 Economic evaluation of Nam Ngiep 2C project /

Calculation of EIRR: the case of thermal power plant

Year	Cost			Benefit							Net Benefit
	Construction and Reinvestment	Operation and Maintenance	Total	Dependable Peak Capacity	kW Value	Capacity Benefit	Annual Energy	kWh Value	Energy Benefit	Total	
	Mil.USD	Mil.USD	Mil.USD	MW	US$/kW	Mil.USD	GWh	US$/kWh	Mil.USD	Mil.USD	Mil.USD
1	8.09	0.00	8.09				0		0.00	0.00	-8.09
2	13.48	0.00	13.48				0		0.00	0.00	-13.48
3	5.39	0.20	5.59	14.5	370.13	5.37	35.51	0.1288	4.57	9.94	4.35
4		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
5		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
6		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
7		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
8		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
9		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
10		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
11		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
12		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
13		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
14		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
15		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
16		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
17		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
18		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
19		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
20		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
21		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
22		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
23		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
24		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
25		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
26		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
27		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
28		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
29		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
30		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
31		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
32		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
33		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
34		0.40	0.4	14.5	370.13	5.37	71.01	0.1288	9.15	14.51	14.11
Total	26.96	12.60	39.56			171.7413	2236.82		288.13	459.88	420.32
Discount Rate:	10.0%	PV(Cost):	25.54						PV(Benefit):	110.83	

EIRR:		44.2%
NPV:	85.290	Mil.USD
B/C:		4.34

Source: Study team

Table 6.18 shows EIRR, B/C and NPV for the four candidate projects.

Table 6.18 EIRRs for the four candidate projects

Analysis	Project	Nam Ngiep 2A			Nam Ngiep 2B			Nam Ngiep 2C			Nam Ban		
	Case	EIRR (%)	B/C	NPV (Mil.USD)	EIRR (%)	B/C	NPV (Mil.USD)	EIRR (%)	B/C	NPV (Mil.USD)	EIRR (%)	B/C	NPV (Mil.USD)
EIRR	Electricity Import from EGAT	27.0	2.78	30.00	28.1	2.91	53.75	27.3	2.63	41.64	16.0	1.57	21.19
	Thermal Power Plant	43.6	4.60	60.49	40.6	4.65	102.62	44.2	4.34	85.29	25.0	2.60	59.09

Source: Study team

2) Financial Analysis

a) Evaluation method

In the Financial Analysis, the financial profitability of this project was evaluated by the calculation of Financial Internal Rate of Return (FIRR), similar to the Economic Analysis. Handling of calculation period, price escalation and interest during the construction period is common to the Preconditions of Economic Analysis.

b) Financial costs and benefits

Benefits and costs were handled by the use of market prices. The financial costs are the initial investment amount by market prices, and maintenance costs/facility renewal costs (if applicable) based on the initial investment. As for the handling of transfer payments such as taxes, interest, subsidies, etc., taxes and interest were treated as costs but subsidies were treated as benefits from the project owner's standpoint. Depreciation cost was not treated as a cost as in the Economic Analysis. In the case of the Nam Ngiep 2C project, revenues from sales of electric power to EDL, which shall be benefits, were set at 6.7 USC/kWh from start of operation to 14th year, 5.7 USC/kWh from 15th year to 27th year, and 6.0 USC/kWh from 28th year onward, based on the PPA concluded between EDL and sponsors. The cost for hydropower generation royalty was set at an amount equal to 2% of total revenues from the sales of electric power with reference to other hydropower generation projects in Laos. In addition, profit tax was set at 24%, based on Laos Tax Law, and tax exemption period as investment incentive was set at 6 years from the start of operation. The financial cost of Nam Ngiep 2C is shown in Table 6.19.

Table 6.19 Financial cost of initial investment in Nam Ngiep 2C project

Description	Ist Year		2nd Year		3rd Year		Total		
	LC	FC	LC	FC	LC	FC	LC	FC	LC + FC
1. Construction Cost									
Construction auxiliary work	913.3	0.0	1,522.2	0.0	608.9	0.0	3,044.4	0.0	3,044.4
Architectural work	4,026.1	0.0	6,710.2	0.0	2,684.1	0.0	13,420.4	0.0	13,420.4
Electrical & mechanical equipment including equipment and installation	123.0	1,081.2	205.0	1,802.0	82.0	720.8	410.0	3,603.9	4,013.9
Steel Structure/Equipment and Installation	115.0	383.1	191.6	638.6	76.6	255.4	383.2	1,277.1	1,660.3
Total	5,177.4	1,464.3	8,629.0	2,440.5	3,451.6	976.2	17,258.0	4,881.0	22,139.0
2. Environmental Protection Cost									
Compensation for land acquisition and resettlement	81.9	0.0	136.5	0.0	54.6	0.0	273.0	0.0	273.0
Environmental work	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UXO clearance	88.1	0.0	146.8	0.0	58.7	0.0	293.5	0.0	293.5
Total	170.0	0.0	283.3	0.0	113.3	0.0	566.5	0.0	566.5
3. Independent Cost	1,298.0	0.0	2,163.4	0.0	865.4	0.0	4,326.8	0.0	4,326.8
Sum of 1-3	6,645.4	1,464.3	11,075.6	2,440.5	4,430.2	976.2	22,151.2	4,881.0	27,032.3
4. Basic Contingency Cost	332.3	73.2	553.8	122.0	221.5	48.8	1,107.6	244.1	1,351.6
Static Cost (Sum of 1-4)	6,977.6	1,537.5	11,629.4	2,562.5	4,651.8	1,025.0	23,258.8	5,125.1	28,383.9
	8,515.2		14,191.9		5,676.8		28,383.9		

Source: Study team

c) WACC

In the Financial Analysis that performs the cash flow analysis for this project, the judgment is made by comparison of Financial Internal Rate of Return (FIRR) and Weighted Average Cost of Capital (WACC), which is assumed as the capital-raising cost of this project. The WACC to be compared with FIRR was calculated at 6.7% in conformity with the Guideline of the Asian Development Bank (ADB) and based on expected lending rates for loans from MDBs and hurdle rates for equity holders.

d) Calculation of FIRR and analysis results

Calculation results for FIRR are as shown in Table 6.20 after development of financial costs and benefits onto the cash flow table. FIRR became 12.03%, which exceeds the judgment index of the above WACC. Accordingly, we can also evaluate this project as financially feasible.

Table 6.20 Financial evaluation of Nam Ngiep 2C project / Calculation of FIRR

Year	Cost					Benefit				Net Benefit
	Construction and Reinvestment	Operation and Maintenance	Royalty	Profit Tax	Total	Annual Energy	Tariff Rate	Tariff Revenue	Total	
	Mil.USD	Mil.USD	Mil.USD	Mil.USD	Mil.USD	GWh	US￠/kWh	Mil.USD	Mil.USD	Mil.USD
1	8.52	0.00	0.00	0.00	8.52	0	0.00	0.00	0.00	-8.52
2	14.19	0.00	0.00	0.00	14.19	0	0.00	0.00	0.00	-14.19
3	5.68	0.22	0.06	0.00	5.955	35.51	6.70	2.38	2.38	-3.58
4		0.43	0.10	0.00	0.53	71.01	6.70	4.76	4.76	4.23
5		0.43	0.10	0.00	0.53	71.01	6.70	4.76	4.76	4.23
6		0.43	0.10	0.00	0.53	71.01	6.70	4.76	4.76	4.23
7		0.43	0.10	0.00	0.53	71.01	6.70	4.76	4.76	4.23
8		0.43	0.10	0.00	0.53	71.01	6.70	4.76	4.76	4.23
9		0.43	0.10	0.00	0.53	71.01	6.70	4.76	4.76	4.23
10		0.43	0.10	0.63	1.16	71.01	6.70	4.76	4.76	3.60
11		0.43	0.10	0.89	1.42	71.01	6.70	4.76	4.76	3.34
12		0.43	0.10	0.74	1.27	71.01	6.70	4.76	4.76	3.49
13		0.43	0.10	0.80	1.33	71.01	6.70	4.76	4.76	3.43
14		0.43	0.10	0.80	1.33	71.01	6.70	4.76	4.76	3.43
15		0.43	0.10	0.80	1.33	71.01	6.70	4.76	4.76	3.43
16		0.43	0.10	0.80	1.33	71.01	6.70	4.76	4.76	3.43
17		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
18		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
19		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
20		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
21		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
22		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
23		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
24		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
25		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
26		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
27		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
28		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
29		0.43	0.08	0.63	1.14	71.01	5.70	4.05	4.05	2.91
30		0.43	0.09	0.68	1.2	71.01	6.00	4.26	4.26	3.06
31		0.43	0.09	0.68	1.2	71.01	6.00	4.26	4.26	3.06
32		0.43	0.09	0.68	1.2	71.01	6.00	4.26	4.26	3.06
33		0.43	0.09	0.68	1.2	71.01	6.00	4.26	4.26	3.06
34		0.43	0.09	0.68	1.2	71.01	6.00	4.26	4.26	3.06
Total	28.39	13.55	2.85	17.05	61.835	2236.82	197.90	138.15	138.15	76.32
									FIRR:	12.03%

Source: Study team

Table 6.21 shows the results of the financial analysis for the four candidate projects.

Table 6.21 FIRR for the four candidate projects

Analysis	Project	Nam Ngiep 2A	Nam Ngiep 2B	Nam Ngiep 2C	Nam Ban
FIRR	(%)	12.8	13.4	12.0	6.4

Source: Study team

3) Sensitivity analysis

Sensitivity analysis was conducted for a case in which any precondition of the Economic Analysis or Financial Analysis changes. The analysis was conducted for the Nam Ngiep 2C project on the assumption of the following cases.

a) Sensitivity analysis in Economic Analysis

As shown in Table 6.22, it was indicated that even Case 3, which has the most severe preconditions, is economically feasible as EIRR exceeds the discount rate in either case, irrespective of alternative power generation, i.e. increase in power imports from EGAT or alternative thermal power generation.

Table 6.20 Sensitivity analysis for economic analysis

Case		Condition	EIRR	Discount Rate
Electricity Import from EGAT	Base	-	27.3%	10.0%
	1	Initial Investment increases by 10%	25.0%	
	2	Import Surcharge decreases by 50%	18.5%	
	3	Initial Investment increases by 10% and Import Surcharge decreases by 50%	16.9%	
Thermal Power Plant	Base	-	44.2%	
	1	Initial Investment increases by 10%	40.6%	
	2	Thermal Fuel Cost decreases by 50%	32.3%	
	3	Initial Investment increases by 10% and Thermal Fuel Cost decreases by 50%	29.5%	

Source: Study team

b) Sensitivity analysis in Financial Analysis

As shown in Table 6.23, it was indicated that even Case 3, which has the most severe preconditions, is financially feasible as FIRR exceeds the above-mentioned Weighted Average Cost of Capital (WACC) that is assumed as the capital-raising cost of this project.

Table 6.23 Sensitivity Analyses for Financial Analyses

Case	Precondition	EIRR
Base	-	12.0%
1	Initial Investment increases by 10%	10.6%
2	Electricity sold to EDL decreases by 10%	10.2%
3	Initial Investment increases by 10% and Electricity sold to EDL decreases by 10%	8.9%

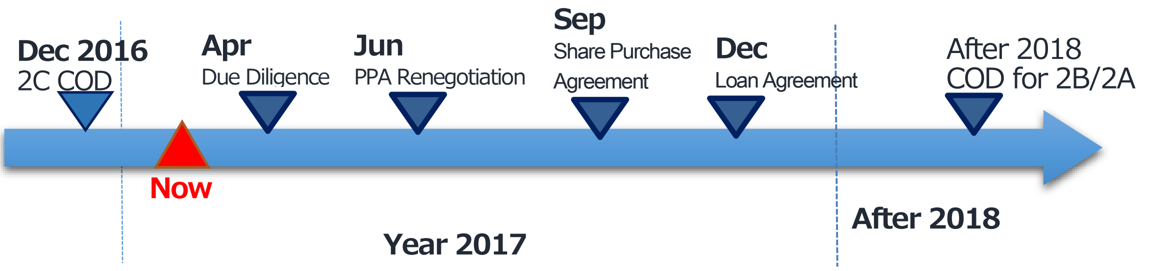
Source: Study team

Capter7 Planned Project Schedule

(1) Nam Ngiep 2C・2B・2A

Due to the fact that a common sponsor is undertaking Nam Ngiep 2C, 2B and 2A, it is more effective and sensible to bundle 2C (commercially commissioned in December 2016), and 2B and 2A (both under construction) into one project. The sponsor has made an investment in these three projects with its own equity, partially with the government's concessional finance. The sponsor intends to move on to the development of larger projects based on its experience in the construction and management of these medium-sized projects. The sponsor would like to secure development funds quickly by monetizing part of the equity, by selling off to strategic partners and debt financing. The following exhibit presents the implementation schedule for the Japanese sponsor's equity participation in the project. It is noted that if the project company needs external debt financing, it should re-negotiate the current PPA into a more bankable one.

Figure 7.1 Implementation Schedule (Nam Ngiep 2C/B/A)

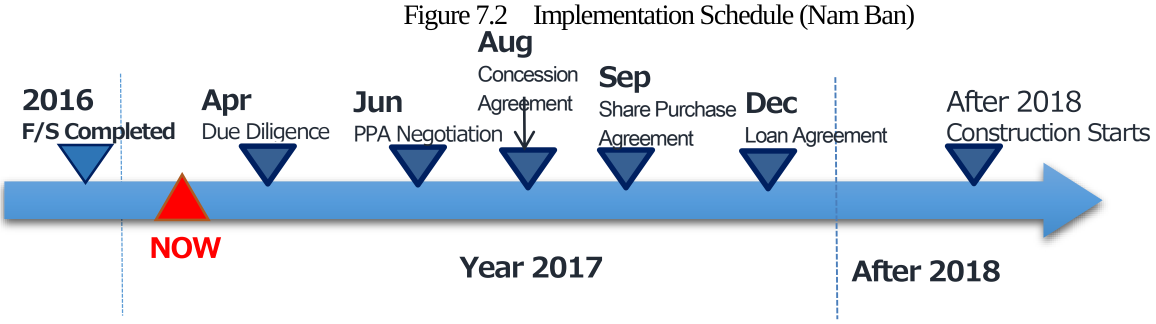


Source: Study Team

(2) Nam Ban

The sponsor has not yet received a further project development permit since almost finalizing the feasibility study for Nam Ban. One of the biggest reasons for the non-performance is lack of funding. With the presence of a Japanese sponsor in the equity holding of the project company, the project is expected to secure financing from JICA and others, giving rise to its realization. This sponsor holds an MOU on a potential 30MW project nearby. By combining Nam Ban with the 30MW project, the total project becomes sizeable, leading to more favorable financing terms. The PPA's off-take conditions currently assumed for Nam Ban have some issues. By bundling with another larger project, the sponsor can negotiate with the off-taker more advantageously. The following exhibit shows the implementation schedule for Nam Ban.

Figure 7.2 Implementation Schedule (Nam Ban)



Source: Study Team

Capter8 Present Status of Legal Improvement regarding Implementation of IPP Projects in Lao PDR

(1) Relevant laws

1) Law on Electricity (2011)

(a) Concession business

The Law on Electricity provides for that both public and private sectors in general are allowed to conduct electricity business in generation and transmission, subject to concessions granted by MPI in accordance with the Law on Investment Promotion.

(b) Approval authority

Approval authority for power generation projects is fourfold by the Law on Electricity.

① Standing Committee of National Assembly

Generation capacity: more than 100MW, or projects with reservoir areas with more than ten thousand hectares, or projects with severe socioeconomic and natural impacts

② Government

Generation capacity: more than 15MW, up to 100MW

③ Provincial or city governor

Generation capacity: more than 0.1MW, up to 15MW

④ District or municipal governor

Generation capacity: up to 0.1MW

(c) Investment forms

The Law on Electricity provides for four investment forms in the electricity business. Relevant to IPPs business is BOT, BT and BOO.

① Build, Operate and Transfer (BOT)

② Build and Transfer (BT)

③ Build, Operate and Own (BOO)

④ Directly by the state through State Owned Enterprise (SOE)

(d) Concession period

The Law on Electricity limits concession periods up to 30 years after commercial operation dates (CODs), and provides that, after the concession period, the facilities shall be transferred to the state at no cost.

(e) Concession procedure

The Law on Electricity subdivides concession procedure into three as follows.

① Memorandum of Understanding (MOU)

The Law is silent on the length of MOUs, which is generally good for 18 months, but stipulates that the extension thereof cannot extend more than 9 months. Usually pre-feasibility studies are conducted during the validity of MOUs.

② Project Development Agreement (PDA)

The Law is silent on the length of PDAs, but stipulates that the extension thereof cannot extend more than 6 months, and the number of extensions for export and domestic projects are limited up to, respectively, 3 and 2 times. Usually detailed feasibility studies are conducted during the validity of PDAs.

③ Concession Agreement (CA)

CAs are valid for up to 30 years after CODs, and the Law stipulates that the construction can be commenced only after CAs are effectuated. In general, CAs explicitly defines concessionaires' rights and obligations including royalty, corporate income tax, and, if any, fiscal incentives.

(f) Exemption from Concession Agreement and Foreign Limit

The Law on Electricity provides for that the following three businesses need not to secure concessions, and the small hydropower projects with generating capacity of less than 15MW are only available for Lao citizens.

① Businesses by the state through SOEs

② Small hydropower projects with generating capacity of less than 15 MW and with no significant social and environmental impact

③ Renewable energy projects with generating capacity of less than 0.5MW

(g) Land provision

The Law on Electricity stipulates that the government shall provide concessionaires with necessary land use rights in accordance with the Law on Land.

2) Regulation on Small Hydropower Development

The Law on Electricity says that another regulation shall define procedures for projects exempted from CAs, and accordingly in July 2016 MEM promulgated the Regulation on Development of Small Hydropower Project, aimed for projects with generation capacity of less than 15MW.

(a) Project procedure

The Regulation subdivides project procedure into three as follows. Incumbent MOUs and PDAs holders are regarded as in the first step, feasibility study stage.

① Feasibility Study (including PPAs with EDL)

・Feasibility studies need to be submitted to the approval authority, i.e. provincial or city governors, within 24 months after the initial approval to conduct the study

② Construction (including approvals of basic design, construction permit, and completion certification)

・Construction needs to be commenced within 6 months after the construction permit in general or at maximum within 24 months in case with good reasons

・Construction period and completion target at discretion of project companies

③ Commercial Operation

(b) Small Hydropower Operational Agreement (SHOA)

Small hydropower projects with generation capacity of less than 15MW are not required to secure CAs. Instead it is general practice that provincial or city investment and planning departments and project companies or sponsors conclude Small Hydropower Operational Agreements (SHOAs) or similar agreements in order for defining rights and obligations of project companies. The name of SHOAs, however, is not standardized and in fact varies across provinces, and the Regulation is silent on SHOAs or similar agreements either.

3) Law on Investment Promotion (2009)

(a) Investment category

The Law on Investment Promotion categorizes investment into three as follows. Electricity business including IPPs fall into the second category of concession business.

① General business

② Concession business

③ Development business of special and specific economic zone

(b) Investment type

The Law on Investment Promotion subdivides investment type into three as follows.

① Investment solely by Lao investors or foreign investors

② Joint venture by both Lao and foreign investors (wherein foreign investors' share in equity must be more than 10%)

③ Business cooperation agreement between Lao and foreign investors (without incorporation of juristic person in joint venture)

(c) Investment incentives

The Law on Investment Promotion provides for three level of fiscal incentives per priority and location. Power generation, however, is not vested with explicit or outright fiscal incentives by the Law, but CAs, SHOAs or similar agreements occasionally and variably give certain incentives to investors.

4) Law on Enterprise (2013)

(a) Juristic person types

The Law on Enterprise provides for five types of juristic person as follows. Majority of sponsors and project companies for IPPs are presumably limited companies.

① Public company (more than 9 shareholders with limited liability)

② Limited company (sole or from 2 to less than 30 shareholders with limited liability)

③ Partnership (necessitating partner with unlimited liability)

④ Branch (for certain foreign businesses such as bank and airline)

⑤ Representative office

(b) Specific Purpose Company (SPC)

In Lao PDR, Specific Purpose Company (SPC) is not explicitly stipulated by the Law on Enterprise and other existing laws.

5) Other relevant laws

Other than abovementioned laws, laws and decree-laws relevant to IPPs include laws on tax, customs, land, construction, water resource, aquatic and wildlife.

(2) Relevant authorities

1) Ministry of Energy and Mines (MEM)

At MEM, Dept. of Energy Business (DEB) takes charge of electricity concession businesses including IPPs in accordance with the Law on Electricity. More precisely, for instance, DEB is responsible for technical assessment and consent on hydropower projects with generation capacity of more than 15MW during the course of IPPs concession procedure.

Meanwhile, Dept. of Energy Policy and Planning (DEPP) currently takes charge of drafting the amendment of the Law on Electricity, with technical assistance from the World Bank.

2) Ministry of Planning and Investment (MPI)

At MPI, Investment Promotion Dept. (IPD) takes charge of electricity concession businesses including IPPs. More precisely, for instance, IPD is responsible for endorsing project approvals to the government or the Standing Committee of National Assembly with prior technical consent from MEM.

IPD functions as the one-stop service for investors, and facilitates to process company registration, concession registration and taxpayer registration, among other administrative necessities.

3) Province and Vientiane Capital

Power development project with generating capacity of less than 15MW is approved by provinces and Vientiane capital city, depending on location, and its procedures and requirements vary among provinces.

The study team visited several provinces and obtained information on existing MOUs, as exhibited in Table 8.1, and found there were expired and extended MOUs. Extension thereof seemed to be easily given after concise reasoning. Moreover, in a few provinces, projects profiles were intentionally scattered into less than 15MW, so as to avoid the approval necessity from the central government.

Table 8.1 MOUs Status in Visited Provinces

	Province	Date of visit	Valid MOUs	Expired MOUs	Extended MOUs	As of
1	Xiengkhouang	2016/9/26	47	5	2	2016/9/16
2	Oudomxay	2016/10/25	8	0	0	unknown
3	Phongsaly	2016/10/26	9	3	4	unknown
4	Luang Prabang	2016/10/28	8	0	0	2016/9/8
5	Champasak	2016/11/1	17	0	1	unknown
6	Attapeu	2016/11/2	16	4	4	2016/10/31
7	Xekong	2016/11/2	25	0	6	unknown
8	Vientiane	2016/12/9	12	1	4	2015/6/29

Source: Aggregated by the study team

There were several projects whose MOUs had gone expired and where expiration dates had been extended. Reasons for extension may be taking more time in F/S than expected. Such excuse was accepted throughout discussions between a prefecture office and a sponsor. In addition, in prefectures such as Luang Prabang and Vientiane, there were many cases where a project was applied as one below 15MW to a prefecture but later converted to a project larger than 15MW. Some projects were handed over to the central government, namely MEM, while output capacities of other projects were added by sponsors' applying incremental capacity of X MW to 15MW to the prefecture office.

(3) Necessary Measures from the Viewpoint of Japanese Companies

Financial and institutional capacity of EDL is still not strong enough, and Japanese electric power companies and

governmental financial institutions are most likely unable to take the off-taker risk of EDL yet. It is inevitable, therefore, to secure the Lao government's guarantee onto the EDL's payment obligation under PPAs, so that Japanese electric power companies and governmental financial institutions can participate into the domestic IPPs projects, respectively, as sponsors and lenders.
By now only a few domestic IPPs projects with generation capacity of more than 100MW have secured the governmental guarantee, according to EDL. However, when Japanese electric power companies invest into domestic IPPs, the governmental guarantee shall be the prerequisite even for smaller generation capacity.

(4) Insufficiency and Deregulation from the Viewpoint of Japanese Companies

1) Insufficient regulatory arrangement

The Law on Electricity gives the approval authority to the central government and provinces or city, respectively, more than 15MW and up to 15MW in generation capacity. Coordination and information sharing between the central government and provinces/city is not necessarily sufficient, and consequently duplicated projects approval takes place in the adjacent areas on the same river flow.
The draft amendment of the Law envisages to limit the approval authority of provinces and city up to 2MW. As there are not so many projects with less than 2MW, the chance of duplicated projects approval shall be significantly decreased, should the draft amendment pass. Nevertheless, the coordination and information sharing between the central government and provinces and city needs to be strengthened anyway.

2) Deregulation request

The Law on Electricity provides for that power development projects with generation capacity of up to 15MW are reserved for Lao citizens (which may implicitly include juristic persons which are majority owned by Lao). Japanese electric power companies may also invest in a project up to 15MW or a set of such projects in the cascaded manner, hence may want to request for deregulation on this nationality limitation.

Capter9 Activities of Key Local Sponsors and the Off-Taker

(1) Sponsor (EDL-Gen)

The previous Law on Electricity did require the government to invest in the IPPs as part of sponsors, and hence even after its amendment in 2011 it is still common that the governmental organization takes part of IPPs as sponsor. Currently there are full or quasi state owned enterprises which invest into IPPs as sponsor: EDL-Gen and LHSE. However, LHSE invest in export oriented IPPs whose majority market is offshore. Besides, several private sponsors are examined in Chapter 4. This subchapter hence pertains to EDL-Gen only.

1) Outline of EDL-Gen

EDL-Gen is a public company incorporated under the Law on Enterprise by transferring the generating asset and corresponding liabilities which were previously owned and operated by EDL. EDL was listed in 2011 in Lao Stock Exchange. EDL-Gen's 25% of shares have been sold to investors in the capital market, but the remaining 75% is still owned by EDL, its parent company.
As of June 2016. EDL-Gen has 732 directors and employees and owns, operates and maintains 10 hydropower facilities with total generation capacity of 1,131MW. All of these hydropower facilities sell its generated electricity exclusively to EDL.
According to EDL-Gen's business plan, it plans to increase the total generation capacity to more than 2,200MW by 2020, by further transfer of hydropower plants from EDL and by constructing new ones.

2) Sponsorship of EDL-Gen

As of June 2016, EDL-Gen has equity investments into 5 IPPs. Lower Houay Lamphan is the only project developed by EDL-Gen, and other five hydropower plants have been transferred from EDL.

① Theun Hinboun (220MW, equity share 60%, off-taker EGAT)
② Houay Ho (152MW, equity share 20%, off-taker EGAT)
③ Nam Gum 2 (615MW, equity share 25%, off-taker EGAT)
④ Nam Lik 1-2 (100MW, equity share 20%, off-taker EDL)
⑤ Nam Ngum 5 (120MW, equity share 15%, off-taker EDL)
⑥ Lower Houay Lamphan (15MW, equity share 60%, off-taker EDL)

According to EDL-Gen's business plan, it plans to buy out 11 IPPs shares still held by EDL and to develop another series of IPPs by itself.

(2) Off-taker (EDL)

1) Outline of EDL

Electricite du Lao (EDL) was established under the Ministry of Energy then in 1959, and was incorporated as a juristic person under the Law on Enterprise. It is a state owned enterprise, fully owned by the government of Lao PDR.
Previously EDL used to be the single and only organization engaged in generation, transmission and distribution of electricity within the domestic market. Since 2010, hydropower plants have been transferred from EDL to its subsidiary, EDL-Gen, and consequently EDL has only 8 very small plants, all of which are less than 2MW in generation capacity, at the year end of 2015.
Equity shares of IPPs have been also transferred from EDL to EDL-Gen, but EDL still has less than 10 IPPs shares.
On the other hand, transmission and distribution remains as the EDL's domain of business in monopoly, and there is no concrete

plan to privatize or unbundle it.

2) Off-taking by EDL

Type of IPPs with EDL as off-taker can be twofold: EDL as main off-taker, and EDL as marginal off-taker (in which case there is other main off-taker such as EGAT in Thailand). For IPPs with EDL as main off-taker, those under construction outnumbers operating ones in project number and generation capacity, as of June 2016.

Table 9.1. Off-taking by EDL

		Operating	Under construction
EDL as main off-taker	No. of projects	12	16
	Generation capacity	1,055 MW	2,458 MW
EDL as marginal off-taker	No. of projects	6	5
	Generation capacity	257 MW	314 MW

Source: MEM, “IPPs Projects Update,” June 2016

(3) Challenges from the Viewpoint of Japanese Companies

This subchapter examines possible challenges on PPAs with EDL as the main off-taker, from the viewpoint of Japanese electric power companies (besides the governmental guarantee on PPAs, which is examined in Chapter 8).

1) Take-or-pay clause

Majority of EDL’s PPAs effectively entail the take-and-pay clause, whereby EDL pays only for the volume of electricity generated and bought at the predetermined unit cost. In turn, only a few PPAs, with generation capacity of more than 100MW, have the take-or-pay clause, whereby EDL pays out predetermined amount of fee, regardless of the volume of electricity generated and bought, at least for the period of loan tenure.

When Japanese electric power companies invest in domestic IPP as sponsor, it is inevitable to secure the take-or-pay clause, regardless of the generation capacity, in order for obtaining project financings from Japanese governmental financial institutions and their possible co-lenders.

2) Settlement currency

The model PPA and MEM’s Regulation on Domestic IPPs Purchasing Price (May 2016) use USD as the denomination currency. However, as an example, the model PPA exhibits its settlement currency as follows.

- 1 to 12 year USD 70%, LAK 30%
- 13 to 27 year USD 20%, LAK 80%

EDL says that the formula, though example, is intended to minimize the currency risk, as the EDL’s receivables from distribution business is essentially in LAK. However, as far as the contracted price is denominated or determined (and regulated) in USD, even if settlement currency is LAK, then the currency risk is not alleviated. Rather it is likely that debt financing of IPP project companies are disadvantaged by the portion of LAK, which has virtually no circulation outside the country. When Japanese electric power companies invest in IPP as sponsor, it is inevitable to secure all or almost all settlement in USD, or in another word, minimal to zero settlement in LAK.

By the way, change in proportion between USD and LAK at 12-13 years implies that the debt financing tenures for existing IPPs for domestic market average the same period more or less. This is in general much shorter than debt financing tenures by Japanese governmental financial institutions and their possible co-lenders.

Capter10 Activities of Other Local Investors

(1) Activities of investors who have concluded MOUs

According to the June 2016 IPP project list obtained from MEM, there are about 130 companies that have concluded MOUs, and most of them have constructed roads, bridges, and dams in Laos. They are domestic companies in Laos who are engaged in manufacturing and construction related to the construction industry or electric power business. Many companies are diversified, with interests such as the urban development business, real estate industry, and agriculture, in addition to the power generation business and construction industry.

Few companies have completed hydroelectric power plants. According to the IPP list, the number of IPP companies with hydraulic power plants in operation is about 30, more than half of which are foreign companies that invest in large capacity power plants. As investors, there are limited businesses with construction experience in hydropower plants (including those under construction).

Opportunities to enter the hydroelectric power generation business are often gained through connections, with the government and EDL, due to power-related work such as dam construction. Although they have the technologies required for the construction of dams, due to the lack of funds construction is not progressing.

Other investors apart from domestic enterprises in Laos are companies from Thailand, Vietnam, China and other neighboring countries, but they mainly invest in hydropower development projects for export abroad.

(2) Development status based on MOUs for projects owned by other investors

The total number of IPP hydroelectric power plants already in operation in Laos has reached 40, but the number of IPP operators that are in operation, such as EDL-Gen, are limited. For other investors, the site development situation is that some investors are steadily starting construction after implementing FS, while others have no prospect of procuring the necessary funds for construction. The fund procurement situation depends greatly on the project, and considerable differences were seen depending on the case. They are looking for joint developments with other businesses, including businesses outside of Laos, as they have insufficient funds due to other projects owned by investors and financing with other hydraulic project developments. There are many such cases.

In developments up to FS and construction, there were many cases using manufacturers and research companies with considerable global hydraulic development experience, such as in Europe, China, and India.

(3) Causes of development stagnation

The main cause of the stagnation is a shortage of funds. They tried to acquire income from hydropower projects because of the lack of funds in construction projects other than hydropower, but funds in the construction of power plants were insufficient, and even though we investigated, businesses are not proceeding to construction. There are many similar cases. Some businesses have sold existing projects to raise funds to advance the next project development.

Regarding PPA negotiations, businesses considering favorable contracts for raising funds such as Take or pay were not encountered in interviews for this survey. Many businesses did not know the mechanism of Take or pay. Even if they can implement the construction of the first project with their own funds, there is a danger that funds to advance the next project will be lacking.

From a technical aspect, there were cases in which access to the site could not be gained due to the weather in some areas, with few access roads to the site, such as in Phongsaly province, so the survey did not progress as expected.

Capter11　Technical Advantages of Japanese Company

(1) Possible participation forms for Japanese companies

Participation forms for hydropower IPP projects in general can be threefold: i) sponsorship, ii) construction and equipment, and iii) operation and maintenance. On the premise that Japanese companies as sponsors shall invest in the equity of project companies, the possible participation forms for Japanese companies can be generalized as follows.

1) Sponsorship

Sponsorship of IPPs means that Japanese companies invest in the equity of project companies. Lao companies holding concessions as well as full or quasi-state owned companies such as EDL-Gen and LHSE may also jointly invest.
The proportion of the equity shares is subject to negotiation with other sponsors, but Japanese companies may want to invest and hold at least 30% of the equity so that they can have a certain controlling power in the development and operation of the IPP project company.

2) Construction and equipment

Construction contractors and equipment procurement are determined by the sponsors who invest in the IPP project company. Nevertheless, in the case of Japanese sponsors, it is likely that the construction is commissioned to Japanese contractors, especially those based in Lao PDR or Thailand, and that equipment such as generators, turbines and control panels is sourced from Japanese manufacturers. Should equipment made in Japan not be competitively priced, then that made in other countries (such as China) by Japanese manufacturers may be alternatively sourced.

3) Operation and maintenance

The operation and maintenance formation is also determined by the sponsors who invest in the IPP project company. Nevertheless, in the case of Japanese sponsors, it is likely that they or their affiliated companies may be contracted by the IPP project company for operation and maintenance or technical advisory thereof.

(2) Advantages and disadvantages of Japanese companies in project implementation (technical and economic aspects)

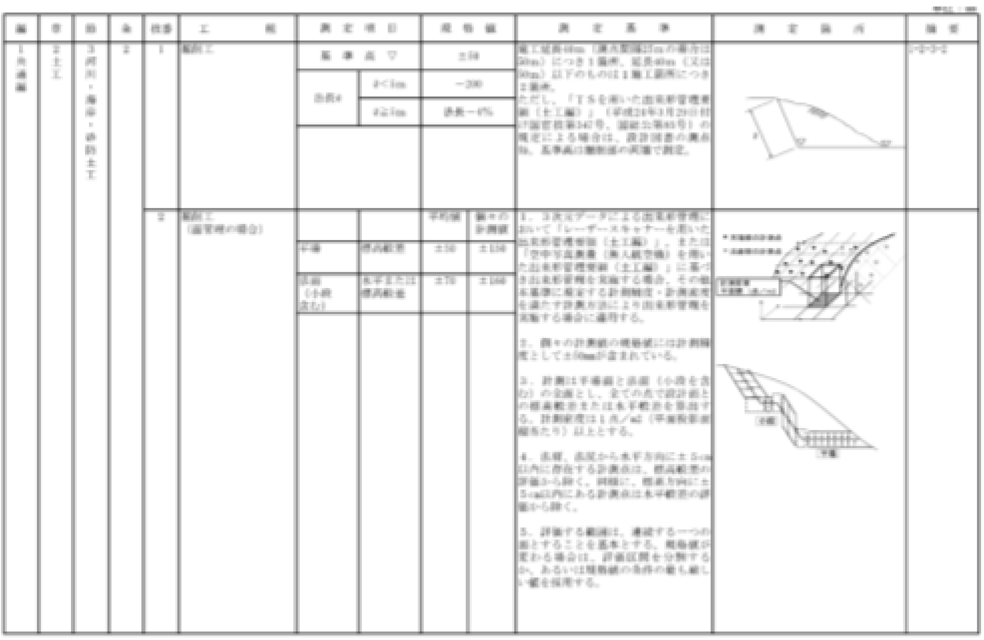
1) Technology advantages

(a) Thorough quality control

If construction or product quality is poor, it will cause problems until the end of the plant's lifetime, such as expense increases due to frequent occurrence of breakdowns and accidents, repairs and increases in operation stoppages. Therefore, increasing construction quality is very important for hydroelectric power plants that are to operate for a long time. Japanese companies rigorously implement checks and supervision based on standards to maintain a high quality of construction and procurement in construction work. For example, "Civil Engineering Construction Management Standard (draft) March 28, Heisei 28, Ministry of Land, Infrastructure and Transport" indicates that "for the construction of civil engineering work, the purpose is to ensure the construction period, the form of the construction object and the quality standards stipulated in the contract document”. This criterion specifies fine control regarding quality control together with process management and form control. For quality control, in Japan, management is carried out according to the test items, test methods and test standards stipulated in the quality management standards, and it is confirmed whether or not each actual measured (test/inspection/measurement) value satisfies the standard value. Lao Electric Power Technical Standards (Lao Electric Power Technical Standards) are in place for the development of power in Laos, and compliance with design and construction standards is mandated. However, in the study of a construction site during the second survey, there was no evidence that tests and the like for quality control are being carried out and the construction quality at the same construction site also showed differences, so there is concern that the quality control based on the basic standards/viewpoints is not sufficient. At hydropower plants in Japan, periodic inspections, cleaning, and small-scale repair are carried out about every three years after starting operation. Practicing appropriate maintenance activities to maintain the functions of these facilities enables early detection of abnormal symptoms, extension of large-scale repair cycles such as those for water wheel runners and reduction of outage periods due to planned repair schedule adjustment.

From this, it seems that Japanese companies have superiority in terms of quality assurance and management, such as in civil engineering.

Table 11.1 Excerpt of civil engineering construction management standard (draft)



Source: Quoted from civil engineering construction management standard (draft)

Photo 11.1　D3 dam at Nam Ngiep 2C

Source: study team

写真 11.2　NamNgiep2C　水圧管路ｽﾗｽﾄﾌﾞﾛｯｸ部の状況

Source: study team

(b) Enhancement of construction management system

In recent years, construction work, including that for power generation facilities, has been rapidly progressing in Laos, and demand for local construction companies is increasing. However, it was also pointed out in a past survey report that local workers are less conscious of securing process, even after working overtime (Laos National Small Hydroelectric Power Project Preliminary Survey Report, March 2013, International Cooperation Organization, p. 3-4). For a Japanese company, it is necessary to confirm the construction progress at the facility, compare it with the initial process, confirm the procurement situation regarding equipment and materials, identify the process delay factors, and carry out confirmation and adjustment at regular step process meetings. Extension of the construction period will increase personnel expenses, equipment costs, etc., which will cause a deterioration of economic efficiency, so construction control and process control are extremely important. For this reason, in terms of construction management and process control in construction, Japanese companies are considered to have superiority.

(c) Thorough implementation of safety management system

In addition to construction management and quality control, it is important to conduct management and guidance so that construction can be carried out safely. Insufficient safety control raises the risk of machine accidents and injury accidents, which may lead to suspension of work and a decrease in labor. For this reason, it is necessary to prevent accidents such as electric shocks and traffic accidents, and to take measures such as implementing safety patrols, and establishing and displaying emergency contact networks. In Japanese companies, standards for safety management are stipulated in accordance with the Occupational Safety and Health Law, and safety management systems are established and implemented such that each company sets its own guidelines. During the tour of the construction site in the second survey, there were places where a sufficient safety management system, such as clothing for workers and safety equipment, was not in effect. In terms of safety management in construction, it is considered that Japanese companies are superior.

Photo 11.3 Status of powerhouse construction site at Nam Ngiep 2C

Source: study team

(d) Introduction of quality Operation and Maintenance (O&M) practices

In ASEAN countries, non-performance of maintenance (in other words, breakdown maintenance), rough operation under heavy rain, unavailability of completion drawings, accidents and malfunctions caused by non-existence of O&M manuals, shortening of facility life, and decreases of plant factor are frequently observed. As an example of such trouble, in one ASEAN country, turbine runners became heavily damaged within only seven years after start of operation, which is roughly half the large-scale inspection-repair interval in Japan. This resulted in operation well below rated output capacity. In this study, the team was unable to visit existing IPP power plants in Lao PDR and confirm such incidents directly. However, according to some of the sponsors the team met, similar cases where power plants are left unable to operate at rated capacity, even right after their commissioning, also seem to occur in Lao PDR. It is estimated that improper O&M structure is one of the causes of such trouble.

In Japan, through periodic inspections, the state of each piece of equipment is well monitored, and proper replacement intervals for them are established by preventive maintenance practices. In the case of muddy water after heavy rainfall, water intake is quickly suspended as an operational procedure in Japan. Therefore, incidents leading to long down-times of power plants rarely take place. It can be said that quality O&M structure, comprising adequate undertaking of patrols/inspections, early identification of problems, established operational procedures such as water intake suspension under natural disasters like heavy rainfall, accident management, proper maintenance of various manuals/drawings, and education/training of power plant staff members, is a significant strength of Japanese firms.

2) Non-technical Disadvantages

(a) Construction Period

In ODA projects mainly in Southeast Asia, few projects use special methods with dominant differences in technologies, such as special bridges, underwater structures, PCs, etc. Countries other than Japan have also increased their abilities and carry out ODA projects with no difference in technical level. Of the composition of construction cost, although material costs and labor costs are not very different, there is a possibility that the construction period will be the greatest difference. In the case of Japan, various inspections (reinforcing bars, formworks, concrete, etc.) are carried out according to the directions of the ordering side as the construction progresses. Moreover, since the schedule for the actual examination is made to accommodate the inspector, there are many cases in which waiting times cause delays in the construction period. (The construction company wants to proceed quickly, but must wait for inspectors.) Although it is possible that the construction period in other countries is shorter, streamlining the inspections, these companies will not possess Japanese know-how, and shortening the construction period can cause inferior work.

(b) Land Acquisition

Land acquisition is generally left to the owner and cases are seen where the construction period is postponed. In other countries, land acquisition contractors, which influence the construction period, actively participate in land acquisition to prevent delays. In the case of Japanese companies, there is concern that such a system or know-how in acquiring land is not in place and the process will be inferior.

(c) Composition of the Contractor

In the case of Japan, a major contractor will subcontract, procure machinery and provisional equipment every time a contract is commissioned, and organize a team on a project basis. However, in other countries, people, goods, machinery, etc. are always in place and they have an advantage in terms of mobility and cost because they move all at once, anytime, anywhere. For this reason, there is concern that Japanese companies will be inferior in the composition of contractors.

(d) Method of responding to trouble that occurs during the construction work

In Japan, we act on the basis of compliance with laws and regulations, and it takes time for surveys, procedures and compensation based on laws and ordinances. However, in other countries, cases such as trouble-handling on the compensation side are resolved quickly. As for the speediness of response to trouble, there is concern that Japanese companies will be inferior.

3) Good practice power generation project by Japanese company in Laos

To serve as a reference when a Japanese company performs IPP business in Laos, a Japanese company (TEPCO) conducted an investigation of the Houay Xe hybrid power system project, which was implemented in Laos in 2005.

1. Project outline

Contracted to TEPCO from the Japanese government's affiliate NEDO (the New Energy and Industrial Technology Development Organization), a demonstrative research project on a small scale pumped-storage power generation system with photovoltaics was carried out.

(1) Project name

The Demonstrative Research Project on Small-Scale Pumping Power Generation System in Lao People's Democratic Republic

(2) Purpose of this study

Construction of a hybrid generation system with clean energy.

Conventional system is solar Generator + Battery + Diesel Generator.

- Verification of the effect of omitting the Storage batteries
- Verification of stable power supply in the isolated power system
- Technical transfer of the O&M skills
- Research of sustainable development

(3) Contract Period

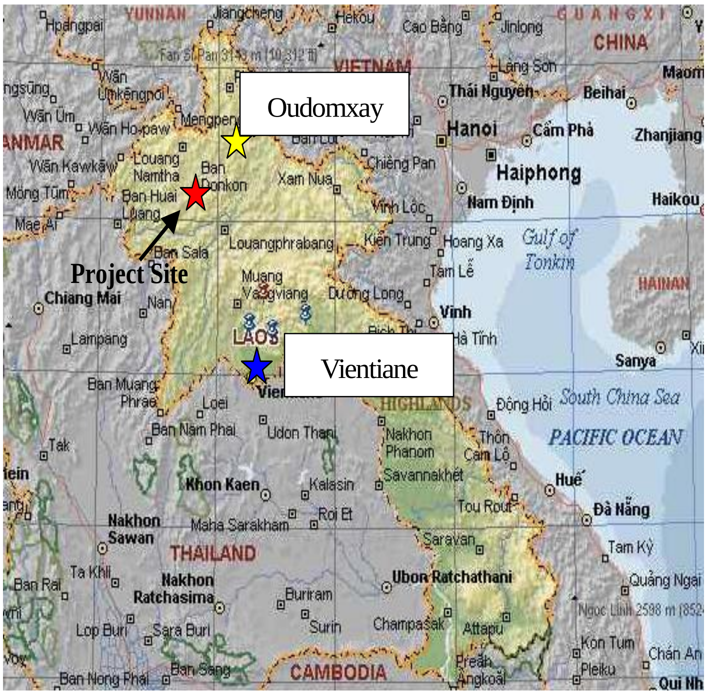
2003.10 ～ 2005.12

(4) Research point

Nga district, Oudomxay Province in Laos

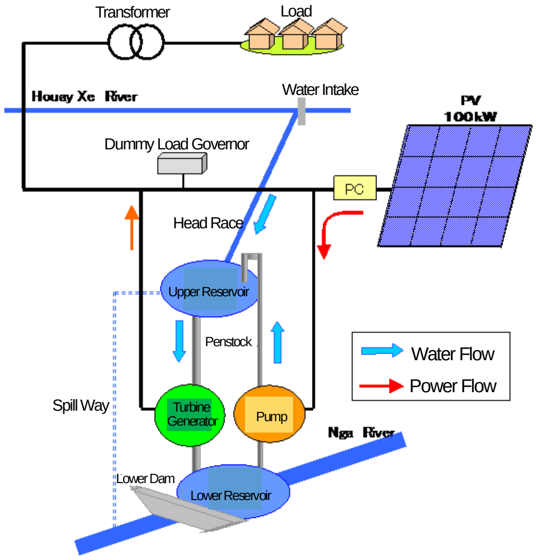
Location of Houay-Xe hybrid power generation project

Figure 11.1 Location of Houay-Xe hybrid power generation project



2. System configuration

An outline of the system, which combined photovoltaics, micro hydropower generation, and a storage pump, is as follows.



Outline of the System

Dam facilities

- Upper Dam: Concrete gravity type (H:4.3m,W:13.15m)
- Lower Dam: Concrete gravity type(H:1.6m,W:18.4m)
- Upper reservoir: (Storage Capacity14,000t)

Photovoltaics generation system 100kW

- Solar modules number of 880

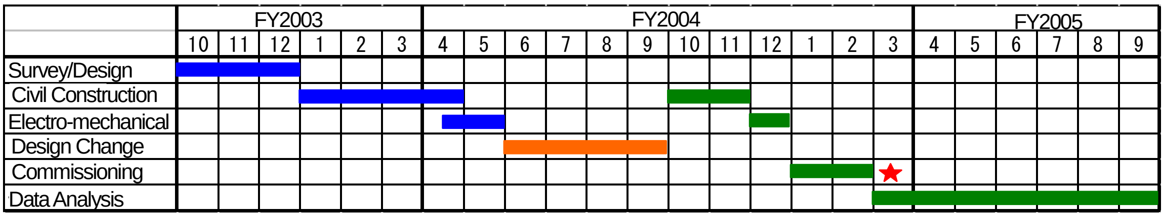
Hydro power generation system 80kW

- Micro Tubular Turbine. Number of 1
- Maximum net Head19.3m(Maxflow0.57m3/s)

Pump system 60kW

- 7.5kW,Number of 8(Maxpumpflow16 m3/s)

3. Construction schedule



Final Workshop Dec 2005

Events during construction period.

- While setting up main electrical machines (17th May 2004), large water flow hit the power station.
- The power house design was re-examined as a measure against flooding, and civil work resumed from October.
- Submerged apparatus had insurance and was fixed by a repair company in Thailand. (conveyance to Vientiane was completed in October 2004)
- Electrical Facility installation resumed from December 2004.
- Operation started in March 2005.The contract with NEDO was renewed and extended until December 2005.

4. The present situation

- This successful rural electrification project is highly evaluated in Laos
- At Houay-Xe Hybrid power station, 13 years have passed since installation and 11 years have passed since completion.
- Solar modules and hydraulic generators are fully operational, and no serious damage to civil engineering structures has been seen
- Electrification of the Nga district has been completed by extension of the national grid.
- At the time, standalone generation was used for rural villages but there is now parallel operation, connected to the national grid.
- Although the first system supplied an unelectrified area, when it changed after extension to the national grid, it was performing efficient operations.
- The operation staff are local residents contracted by EDL.
- Moreover, this was also utilized as a training center to cultivate IPP entrepreneur-oriented operation members.

This project is considered to be a success model for hydro-power generation business undertaken by Japanese companies in Laos. In order to be able to request local residents to perform operation and maintenance (O&M), we had them participate in the construction from the construction phase in this project.
When Japanese companies undertake IPP business in Laos, they may request O&M from local residents.
As in the Houay-xe hybrid power project, we think that the building of friendly relations with local residents will enable them to perform O&M smoothly following commencement of commercial operation.

(3) Measures to Enhance Japanese Companies' Participation

This study assumes that Japanese companies invest in an IPP project company, but their proportion of the equity share is still undetermined. Uncertain also, therefore, is to what extent such Japanese sponsors may be able to influence the selection and procurement of contractors, equipment and operation and maintenance providers.
Nevertheless, it still makes sense to invite relevant Lao parties such as government officials and local sponsors to Japan, in order to enhance the possibility of procurement of Japanese contractors, equipment and operation and maintenance providers.
In Lao PDR, there have been no hydropower plants completed and operated by Japanese sponsors yet. Understanding of the high quality of Japanese companies in designing, constructing, operating and maintaining hydropower plants by the relevant Lao parties will heighten the possibility of them procuring Japanese contractors, equipment and operation and maintenance providers.
A few Japanese manufacturers have also tried to gain price competitiveness by, for instance, shifting manufacturing sites for generators and water wheels to their own or affiliated factories overseas, in countries such as China. Such Japanese manufacturers need to strengthen their sales activities in Lao PDR, together with extended credit to Lao buyers, as many hydropower plants are procured from Chinese manufacturers but these are not necessarily of satisfactory quality.
In a market like Lao PDR, where impeccable engineering quality is not necessarily required, it is difficult to distinguish products and equipment manufactured by Japanese firms. As the price competitiveness of Japanese products is inferior, it is a great challenge to increase sales under the current circumstances. Nevertheless, if Japanese firms invest in IPPs in Lao PDR, actively take part in the management of special purpose companies and deeply involve themselves in technical decision making, then proper engineering services such as planning, design, construction supervision, O&M, accident management and the like will be introduced. Therefore, from now on, it is important to combine investment and various engineering services into a single package in order to exercise general competitiveness in the IPP business. As a result, the technical reliability of power plants in which Japanese firms make investments will rise, leading to stability of generation output through the avoidance of long down-time for generators, service life lengthening for power generation facilities, and improvement of profitability for IPP business entities. In the end, as these effects will be widely recognized in emerging markets, it is expected that the competitiveness of Japanese projects will improve over the mid-to-long term.

（様式２）

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Title: Study on Independent Power Producers (IPPs) in Lao People's Democratic Republic

Prepared by: Study on Economic Partnership Projects in Developing Coutries in FY2016

Tokyo Electric Power Company Holdings, Inc.

Page	Caption Number	Title
4-6	Figure 4.1	The Positions and Coordinates of the Dams of Nam Ngiep 2A, 2B, and 2C
4-7	Figure 4.2	Drainage Basin Area List at Each Location of Nam Ngiep
4-7	Figure 4.3	Locations of Meteorological Stations
4-8	Table 4.5	Observed Mean Annual Precipitation at Meteorological Stations
4-9	Figure 4.4	Hydrographs of Specific Daily Mean Discharge at the Nam Hai/Composite 2Cb-SSN and Nam Ngiep/Muong Mai Stations
4-9	Figure 4.5	Composite 2Cb-SSN and Muong Mai Hydrometric Stations - Correlation of Monthly Mean Discharge -
4-11	Figure 4.6	Catchment Areas of Dam Site and Meteorological Station (M.Ngoy)
4-12	Figure 4.7	Locations of Meteorological Stations
4-12	Table 4.6	List of Rainfall Stations Scattered in the Surrounding Project Area
4-13	Table 4.7	Generated Monthly Runoff of Nam Ban Basin at Dam Site
4-15	Table 4.9	Comparison of Catchment Area at Nam Ngiep Site
4-16	Figure 4.8	Catchment Area of Nam Ngiep Site Measurement Chart with 1/150,000 Topographic Map
4-17	Table 4.10	Comparison of Catchment Area at Nam Ban Site
4-17	Figure 4.9	Catchment Area of Nam Ban Site Measurement Chart with 1/150,000 Topographic Map
4-19	Figure 4.10	Composite 2Cb-SSN and Muong Mai Hydrometric Stations
4-19	Figure 4.11	Mean Discharge of Nam Ngiep Area
4-20	Table 4.11	Long Term Discharge table in Each Area of Nam Ngiep
4-26	Table 4.14	Salient Features of Nam Ngiep 2A, 2B, 2C
4-27	Table 4.15	Salient Features of Nam Ban
4-29	Table 4.16	Comparison of Head Loss and Install Capacity at Nam Ngiep 2A
4-30	Table 4.17	Comparison of Head Loss and Install Capacity at Nam Ngiep 2B
4-30	Table 4.18	Comparison of Head Loss and Install Capacity at Nam Ngiep 2C
4-31	Table 4.19	Comparison of Head Loss and Install Capacity at Nam Ban
4-35	Table 4.23	Comparison of Various Material Costs Between Laos and Japan
4-35	Table 4.24	Comparison of Various Labor Costs Between Laos and Japan
4-38	Table 4.25	Comparison with F/S construction cost
4-43	Table 4.26	Comparison of F/S Construction Cost and Construction Cost Based on Japanese Guidance
6-1	Table 6.1	Comparison of project costs of proposed projects
6-2	Table 6.2	Details of Project costs for Nam Ngiep 2A
6-2	Table 6.3	Details of Project costs for Nam Ngiep 2B
6-3	Table 6.4	Details of Project costs for Nam Ngiep 2C
6-3	Table 6.5	Details of Project costs for Nam Ban