MOEJ/GEC JCM Feasibility Study (FS) 2014
Summary of the Final Report

"(40MW-scale Hydro Power Generation in Lao Cai province)"

Implementing Entity: KYUSHU ELECTRIC POWER CO., INC., Voith Fuji Hydro K. K.

1. Overview of the Proposed JCM Project

Study partners	Mizuho Bank, Ltd. (Roles:Financial planning, economic evaluation, and JCM methodology)			
Project site	Lao Cai province, Vietnam			
Category of project	Renewable energy			
Description of project	It is estimated that Vietnam's electric power demand is rising by approximately 13% annually. The objective of the study is to promote small-medium scale hydropower as an alternative to thermal power plants and to reduce CO_2 emissions. For the proposed project, advanced hydropower technologies, which are based on extensive experience and lead to long-term stable plant operation, are to be provided from Japan. These technologies secure overall competitiveness against low-price and low-quality equipment from rising nations. Furthermore, a financing scheme for establishing a feasible business model is to be investigated. Soft technology - Appropriate power generation planning, design and construction planning, operation and maintenance. Hard technology - Hydro turbines and generators which are highly efficient, highly durable, and which create little environmental impact, etc.			
Expected project implementer	Japan	Japanese private company involved in electric power		
	Host country	Son Vu Energy Development Joint Stock Company		
Initial investment	1,486,314(10^6VND)		**Date of groundbreaking**	September, 2016
Annual maintenance cost	Constant cost 3,330(10^6VND)		**Construction period**	30Months
Willingness to investment	Yes		**Date of project commencement**	April, 2019

<table>
<tr><td>Financial plan of project</td><td>
<table>
<tr><td colspan="2">Equity : Debt</td><td>30% : 70%</td></tr>
<tr><td rowspan="3">Debt</td><td>Ratio</td><td>Japanese private bank : JBIC, etc. = 50% : 50%</td></tr>
<tr><td>Interest</td><td>Japanese private bank: 8%, JBIC, etc.: 4%</td></tr>
<tr><td>Loan Period</td><td>Japanese private bank: 10years, JBIC, etc.: 10years</td></tr>
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<tr><td>GHG emission reductions</td><td>93,822(tCO_2/year)</td></tr>
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2. Study Contents

2.1 Project development and implementation

2.1.1 Project planning

2.1.1.1 Project Site

Lao Cai province, where the project site is located, is on the border with China. A highway from Hanoi to Lao Cai province has been opened for traffic and the province has been developing. It is taking the role as a regional gateway to China for both land, and water via an international river. The project site is close to Tang Loong Industrial Area, and Sapa which is famous for tourism. In the region, electric power demand is expected to rise.

The area is mostly mountains and there are only a few lowlands along the Red River. It has a lot of villages of minority groups, and there are a lot of terraces on the mountains cultivated by those people.

The Nam Cun project site is also located in mountains that are 1,000m to 2,000m high, and tens of kilometers southeast from Sapa. The region has a subtropical climate with high annual rainfall. In the upstream and downstream of the same river as the Nam Cun project, hydro electric power plants have already been developed and these plants are under operation.

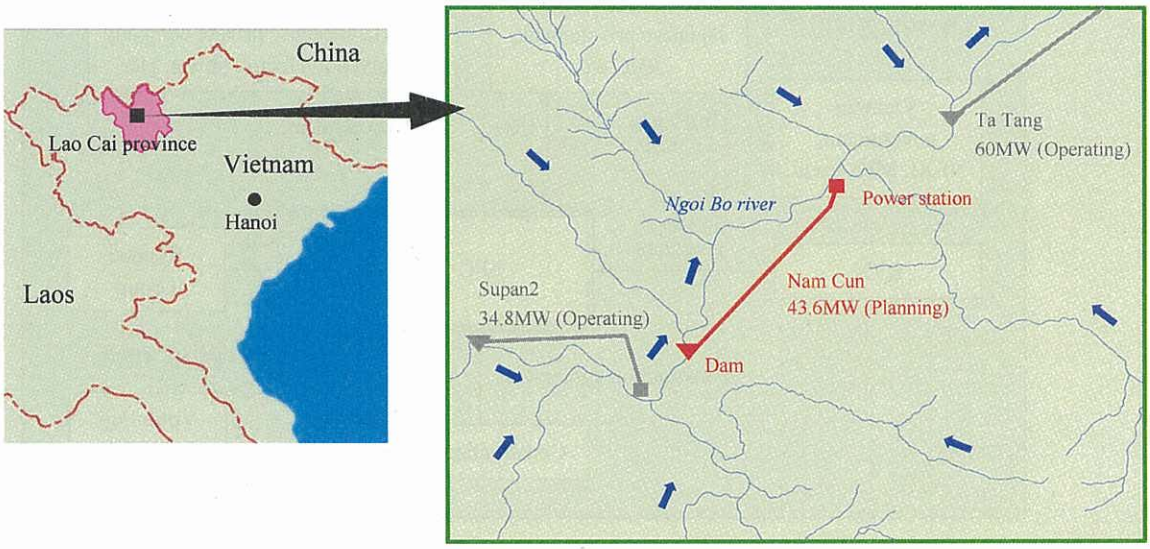

Fig 2.1 Nam Cun project site

Source: FS Consortium

2.1.1.2 Project Scheme

(1) Current Situation

The project was planned to be implemented by a consortium of Son Vu Energy Development Joint Stock Company (hereinafter referred as Son Vu) and Song Da at the beginning of the JCM FS. Since several years passed after the investment license for the Nam Cun project was issued, the license was terminated by the Lao Cai province People's Committee. After that, the people's committee recruited a new investor for the project and several companies proposed plans. Now the people's committee is carrying out a selection process for an appropriate company as an investor.

Except for the investment license, the necessary permissions for the project have already been obtained.

(2) Implementation Scheme

- Construction Planning (Development Planning)

Son Vu is actively involved in the project and considering a way to go forward with the project with the assumption that the investment license will be obtained.

In order to receive favorable tax treatment, Son Vu is planning to set up a new project company. In addition, a Japanese private company, which is involved in electric power, a Vietnamese construction company, and Voith Fuji Hydro a Japanese equipment maker, are supposed to join the project.

- Operating & Maintenance Planning

O&M for the project is supposed to be implemented by the SPC (special purpose company) that includes Son Vu, which owns Muong Hum (32MW), also in Lao Cai province. The SPC is to implement standard O&M in the same way as at Muong Hum. Overhaul is supposed to be implemented by Voith Fuji Hydro, and in addition, Japanese participants will try to transfer technology to Son Vu for O&M of each structure and dam operation.

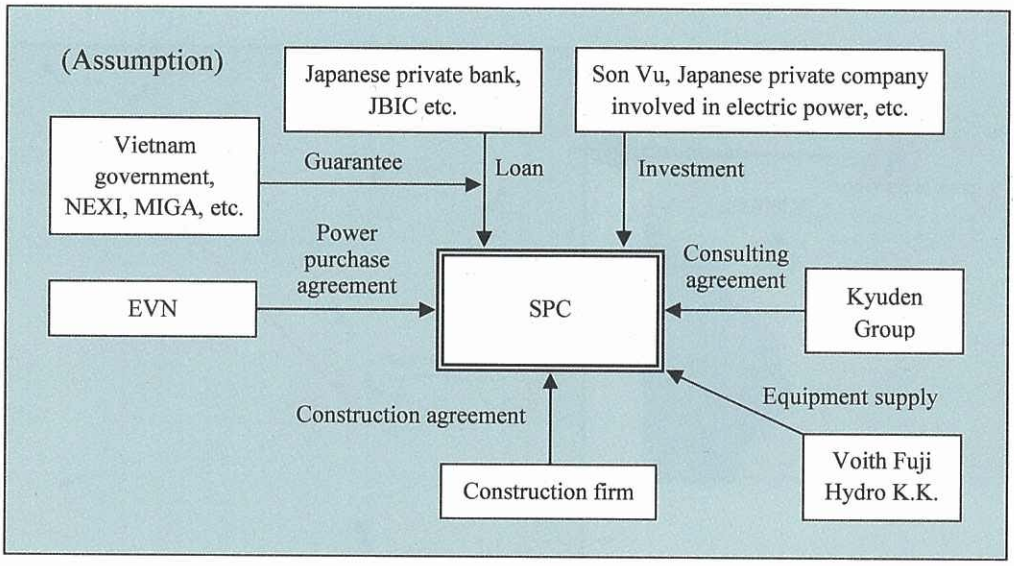

Figure 2.2 Project scheme

Source: FS Consortium

2.1.1.3 Management System and Achievements of Expected Project Implementer

(1) Management System

Son Vu, which is expected to be the project implementer is progressing renewable energy and infrastructure projects, and has group companies such as Son Vu Technical & Infrastructural Construction Investment Co., and Muong Hum Hydropower Co., Ltd.

Son Vu developed Muong Hum and has been operating the plants since April, 2011. The Muong Hum project was registered as a CDM by the United Nations. Son Vu is aiming to carry out further development of hydropower and expects Nam Cun to be a part of this further development. The profile of each Son Vu group company is shown in table 2.1.

Table 2.1 Son Vu group

Son Vu group	Capital / Number of Employees	Remarks
Son Vu Energy Development Joint Stock Company	Capital: 345BillionVND, Number of Employees: 100	Hydropower development and operation
Son Vu Technical & Infrastructural Construction Investment Co.	Capital: 150BillionVND, Number of Employees: 10	Civil engineering and construction
Muong Hum Hydropower Co., Ltd.	Capital: 280BillionVND, Number of Employees: 35	Electric power project

Source: Son Vu

(2) Management Achievements

In 2011 and 2012 just after the commencement of Muong Hum, Son Vu was in deficit, but in 2013, it turned to surplus, and its financial situation is now stable. The financial situation of Son Vu is shown in table 2.2.

Table 2.2 Son Vu financial situation (Unit: million VND)

Item	2011	2012	2013
Revenue in total	86,878	139,715	194,042
Expenses in total	162,247	167,602	172,442
Corporate Income Tax	0	0	0
Profit after Tax	▲ 75,369	▲ 27,887	21,600

Source: Son Vu

2.1.1.4 Cash Flow Analysis

(1) Case study

Cases for cash flow analysis are shown in table 2.3.

Table 2.3 Cash flow analysis cases

Case1	Case2	Case3
Use of rising nation hydro turbine and generator	Use of Japanese hydro turbine and generator	Use of Japanese hydro turbine and generator with 50% subsidy

(2) Assumptions

As for financing, to date, the ratio between equity and debt is assumed to be 30% : 70%. Equity is planned to be provided by Son Vu and Japanese private company involved in electric power. Debt is assumed to be provided by a syndicate of Japanese private banks and JBIC, etc. Assumptions for the analysis are shown below.

Table 2.4 Assumptions for analysis

Item		Case 1 Use of rising nation hydro turbine and generator	Case 2, Case 3 (50% equipment grant) Use of Japanese hydro turbine and generator
Project period		40 years	
Initial cost		1,271,626 (10^6VND)	1,486,314 (10^6VND)
O&M cost		3,330 (10^6VND)	
MRV cost		-	213 (10^6VND)
Capacity		40MW	43.6MW
Generated electricity		163GWh/year	170GWh/year
Net electricity		160.56GWh/year	167.45GWh/year
Tariff		1,128VND/kWh	1,135VND/kWh
Equity: Debt		30% : 70%	
Debt	Ratio	Vietnam Commercial Bank	Japanese Private Bank : JBIC, etc. = 50% : 50%
	Currency	VND	USD
	Interest rate	10%	Japanese Private Bank : 8%, JBIC, etc.: 4%
	Tenor	10 years	Japanese Private Bank: 10 years JBIC, etc.: 10years
Rate of exchange		1USD=21,345VND (1/26/2015)	
Corporate Income Tax		1Y～4Y: 0%, 5Y～13Y: 5.0%, 14Y～15Y: 10.0%, 16Y～:20.0%	

Source: FS Consortium

Based on the assumptions shown above, the results of profitability analysis are as follows:

Table 2.5 Results of profitability analysis

Item	Case1 Use of rising nation hydro turbine and generator	Case2 Use of Japanese hydro turbine and generator	Case3 Use of Japanese hydro turbine and generator with 50% subsidy
Project-IRR	11.14%	10.54%	12.81%
Equity-IRR	15.74%	13.18%	21.90%
Min DSCR	1.10	1.16	1.16
Pay-back period	7.24years	11.50years	10.14years

Source: FS Consortium

Comparing the Equity-IRR result of Case 1 with Case 2, the Equity-IRR result of Case 2 is less than Case 1. That is because the hydro turbine and generator cost for Case 2 is higher than that for Case 1.

For Case 3, the equipment is also more expensive than for Case 1, but a much improved profit results from the 50% equipment grant.

Results of sensitivity analysis are shown in table 2.6.

Table 2.6 Results of sensitivity analysis

Sensitivity Case	PIRR	EIRR	Min DSCR	Pay-back period
Base Case (Case2)	10.54%	13.18%	1.16	11.50 years
Civil Cost increases by 10%	10.08%	12.29%	1.11	11.97 years
Electricity generation decreases by 10%	9.36%	10.96%	1.05	12.78 years
O&M Cost increases by 10%	10.52%	13.13%	1.16	11.52 years

Source: FS Consortium

2.1.1.5 Financial Planning of Initial Cost, Maintenance Cost and MRV

Financial plan by project finance method is shown below.

Table 2.7 Financial plan

Equity : Debt		30% : 70%
Debt	Ratio	Japanese private bank : JBIC, etc. = 50% : 50%
	Currency	USD
	Interest	Japanese private bank: 8%, JBIC, etc.: 4%
	Loan period	10 years

Source: FS Consortium

2.1.1.6 Risk Analysis

Results of risk analysis are shown below.

Table 2.8 Results of risk analysis

Risk items		Correspondence	Countermeasures	Feasibility
Sponsor risk	Bankruptcy of co-investor	Possession	–	-Confirmation of an investor besides Son Vu who is interested in the project
	Failure of decision-making among sponsors	Reduction	-Secure opposition right by investing share of more than 25%	-High possibility due to Vietnamese expectations for Japanese technology
Financing risk	Failure of project finance	Reduction	-Planning of detailed discussion with Japanese private bank, JBIC, etc.	-Confirmation of hydropower projects loan achievement (Confirmation of achievement of project loan)
Completion risk	Excess of budget for construction	Reduction	-Construction agreement at fixed price -Including preliminary budget	-Planning of Construction agreement by BQ(Bill of Quantities) method
	Delay in construction	Transfer	-Planning of Construction agreement which includes compensation for loss	-Request for compensation for rising interest rates during construction
Technical risk	–	–	–	–
Operation risk	Increase of O&M cost	Reduction	-Appropriate operation of equipment	-Drawing manual for operation of equipment -Practical training programs for O&M at Muong Hum
	Stop of operation due to equipment problems	Reduction and Transfer	-Early identification and repair to resolve equipment problems -Taking out insurance for equipment damage and stop of operation	-Including regular inspection by Japanese maker -Covering unexpected accidents by insurance

Water shortage risk	Sharp decrease of electricity sales	Possession	–	-Availability of repayment even in water shortage years for approximately 50 years
Market risk	Loss of off-taker	Reduction	-Power purchase agreement for long term	-Availability of stable profit for 20 years by agreement with EVN NPC
Environmental risk	Environmental regulations	Possession	-Compliance with environmental regulations ensured by construction agreement	-Plan to inspect waste to be produced during construction by construction work control -Confirmation of compliance with environmental regulations as a condition of completion
Related infrastructure risk	–	–	–	–
Off-take risk	Nonpayment by EVN NPC	Possession	–	-Low possibility of nonpayment by EVN NPC due to importance of private company power generation which is more than 30% of installed capacity
	Restriction of electricity sales	Possession	–	-Confirmation of sufficient current transmission capacity in Lao Cai province
Macro economic risk	Increase of O&M cost by rising prices	Possession	–	-Availability of repayment even with annual rising O&M cost by approximately 10% from commencement year to year 10
Exchange risk	Deterioration of profit by currency fluctuation	Possession	–	-Still holding risk
	Currency restrictions on exchange and remittance	–	–	-No currency restrictions in Vietnam -Exchange of money with reasonable service charge through Japanese private bank in Vietnam
Change of legal system risk	Abolition of favorable treatment system for investment	Possession	–	-Low possibility of abolition of favorable treatment system for investment because Lao Cai province is categorized as region that needs such treatment
Accident - disaster risk	Stop of operation caused by catastrophic earthquake or flood	Possession	-Design of main structure by using stricter standards of Japan or Vietnam	-Confirmation of stability of dam by static analysis -Implementation of dam design considering 500- year flood probability, which is Vietnamese standard

Source: FS Consortium

2.1.2 Permits and Licenses for the project development and implementation

In order to implement the project, firstly, an investor must receive a validation of the Feasibility Study results and an approval of the Environmental Impact Assessment. Secondly, that investor is required to apply for an investment license and get the license from the people's committee in local government. The people's committee issues investment licenses. The Nam Cum project has already obtained the validation of Feasibility Study results and the approval of the Environmental Impact Assessment.

For this project, Lao Cai province People's Committee granted development rights to Song Da Hoang Lien Hydropower Joint Stock Company in September 2008, once all the necessary approval procedures had been completed. At the time Song Da Hoang Lien Hydropower Joint Stock Company was the largest shareholder, although the project was stalled by lack of funds. Then Son Vu joined the project and became the largest shareholder. But the project did not progress because of lack of funds.

Consequently, Lao Cai province People's Committee has withdrawn the development rights of the project. Several companies including Son Vu made proposals to Lao Cai province People's Committee.

Lao Cai province People's Committee is selecting a grantee for the development rights as of February 2015.

It should be noted that authorization for the project except for the development rights has already been granted. If there is no change in the extent of land modifications, amount of water intake or other details, the related permissions do not need to be re-obtained after development rights have been granted again. Though, the compensation payments for the land acquisition are left in part, correspondence related to licensing required for project implementation has been completed except for the acquisition of development rights.

2.1.3 Advantage of Japanese technology

A lot of cheaper hydro power generating equipment has being supplied by manufacturers in developing countries for Vietnamese small-medium scale (less than 30MW) hydro power station. In last 5 or 6 years, Indian products supplied by European manufacturer have been increased according to the tender result in Vietnam.

Japanese products have the following advantage against the products made by manufacturers in developing countries.

(1) Turbine efficiency

Turbine efficiency indicated by manufacturers in developing countries is not optimized, because they use same turbine which was supplied another hydro power station before and has similar specification such as effective head and discharge. And, the efficiency indicated by them is neither certified by model test and/or CFD (Computational Fluid Dynamics) analysis and nor confirmed by site efficiency test. Therefore, the reliability of turbine efficiency indicated by them is low. On the other hand, Japanese major manufacturers make optimized design by using model test result of similar turbine and/or CFD analysis, and then indicate higher turbine efficiency as guarantee value.

(2) Price of turbine and generator

According to the bidding result of supplying hydro power equipment to Vietnam in 2009, price offered by a manufacturer in developing country was one third of that of Japanese manufacturer.

(3) Quality of equipment

The evaluation of the developing country's product by Vietnamese user is as follows.

- Drawings, operation and maintenance manuals are not provided.
- Water leakage and oil leakage are occurred, but in the current situation, turbine and generator are operated.
- Quality of generating system is low, i.e. turbine and generator can not be operated automatically even though in the case automatic system should be supplied.
- A lot of troubles on auxiliary equipment for turbine and generator are occurred.

(4) Technology for maintenance free

Unmanned for hydro power station has been promoted in Japan and almost of Japanese hydro power stations are unmanned. On the other hand, most of trouble occurs often in auxiliary equipment such as pressure oil system, lubricating oil system and water system than turbine and generator. Therefore, in Japan, technology for not only maintenance free but also for improving reliability and environmental measure has been developed and applied. Table 2.9 shows summary for advantage of

Japanese technology.

Table 2.9 Advantage of Japanese technology

Item	Turbine and generator made in developing country	Turbine and generator made in Japan
Turbine efficiency	Low reliability - Not optimize to each project, because past turbine with similar design are applied. - Reliability of turbine efficiency is low, because it is neither certified by model test, nor confirmed by site efficiency test.	High reliability - Optimize to each project by using model test result of similar turbine or CFD analysis. - High reliable turbine efficiency certified by model test result or CFD.
Price	Lower price - About one third of price of Japanese supplier according to past bidding result.	Higher price
Quality	No document is submitted - Drawings and O&M manual are not submitted Trouble on main equipment - Water leakage and oil leakage are found, but not hinder operation. Manual control - Turbine and generator can not be operated automatically, even though in the case automatic system should be supplied. Trouble on auxiliary equipment - Trouble of auxiliary equipment such as pump, compressor, etc. occurs often.	Documents are submitted - Drawings and O&M manual are submitted Less trouble on main equipment - No water leakage, no oil leakage Automatic control - Almost of hydro power station are unmanned and controlled automatically. Less trouble on auxiliary equipment - Reduced by elimination of auxiliary equipment
Maintenance free technology	Using water and operating oil - Cooling and operating oil are used regardless of turbine and generator output.	Water less, oil less - Oil-less and water-less technologies are developed. Saving maintenance work by eliminating auxiliary equipment applying such technologies. (Electric servo, generator air cooled bearing, etc.) - Circumstance measure technology also developed. (Water lubricated bearing for turbine)

2.1.4 MRV structure

(1) MRV system and hands-on training

In this project, the project company will carry out monitoring of the amount of power generated (M) and reporting (R). Son Vu, which has hydropower CDM project experience in Vietnam, is to be the central driving force in this project. For this reason, it is not necessary for Son Vu staff to receive training on how to measure power generated. Once the specific method for preservation of monitoring records is established, monitoring and recording will be carried out without any problems. For verification (V), a party will be selected from institutions that have been certified as third parties by the Joint Committee of Vietnam.

(2) Selection of required instrumentation for monitoring

Monitoring equipment that complies with the standards established by Vietnam standards, and performs monitoring of the net amount of power generated supplied to the grid system, will be introduced.

Table 2.10 Monitoring equipment

Equipment	Specifications
Power meter	- Gets monitoring data
CT: Current Transformer	- Uses secondary winding - Rated secondary currency is 1A or 5A - Accuracy of main facilities, which comply with international standard IEC 60044-1,etc. , is 0.2s class - Accuracy of backup equipment, which complies with international standard IEC 60044-1, etc. , is 0.5s class
VT: Voltage Transformer	- Uses secondary winding - Rated secondary voltage is 100Vor 110V - Accuracy of main facilities: For induced voltage devices, which comply with international standard IEC 60044-2, accuracy is 0.2s class; for capacitor type transformers, which comply with international standard IEC 60044-5, accuracy is 0.2s class - Accuracy of backup facilities: For induced voltage devices, which comply with international standard IEC 60044-2, accuracy is 0.5s class; for capacitor type transformers, which comply with international standard IEC 60044-5, accuracy is 0.5s class - Secondary circuit for measuring works independently or no effect on the accuracy of the measuring system
Data collection equipment	- Collects data from management center

Source: Circular No.27/.2009/TT-BCT (MOIT, 2009/9/25), Decision No.25/2007/QD-BKHCN (MOST, 2007/10/5)

(3) Methods of measurement and maintenance of monitoring records

In CDM methodology, it is stipulated that electric energy is to be "Continuously monitored, hourly measured and at least monthly recorded".

However, in Vietnam in general, operators and EVN (off-taker) witness the recording of data from measuring equipment, and payment is made based on that data. Especially in remote mountainous areas, measurement is actually done once a day or once a month. Despite this large discrepancy in frequency of measurement, the accuracy is same, and performing the measurement every hour in accordance with CDM methodology is considered an excessive burden to business operator. In this methodology, measuring and recording will be performed monthly, and it is assumed that cross-checking of data with electric power sales invoices issued to EVN will also be performed. For the project, the following data will be monitored during a credit period.

Table 2.11 Monitoring data

Data/Variable	$EG_{PJ,y}$
Unit	MWh/y
Description	Net amount of power generated to be supplied to grid system, generated as a result of implementation of the project in year y
Source	Measured by power meter $EG_{export,y}$: Amount of power transmitted to grid system, $EG_{import,y}$: Amount of power received from grid system
Calculation	$EG_{PJ,y} = EG_{export,y} - EG_{import,y}$ (calculation of net amount of transmitted power)
Frequency	Continuously measured by power meter and recorded every month
QA/QC	Monitoring equipment calibrated by qualified third party organization once a year
Purpose	Calculation of reference emissions (RE_y)

2.1.5 Environmental integrity and Sustainable development in host country

2.1.5.1.1Negative impacts caused by the project

This project is intended to carry out hydroelectric power generation on a small-medium scale. Although adverse effects on the environment will be very minor, land modification will be necessary for construction of the dam, balancing reservoir, penstock, powerhouse and access roads, and in addition, turbid water discharge will occur during the construction period.

However, the extent of modifications is limited to the locations of these facilities. And the greatest impact on the environment is limited to the approximately three-year construction period. After power plant goes into operation, environmental impact can be mostly avoided by proper operation of the dam and balancing reservoir.

Moreover, the authorities have already given their approval to the project's environmental impact assessment report. There are no private houses within the project area, and there will be no resettlement associated with this project. Therefore, mitigation measures for each environmental impact item that has been evaluated in the report should be done so as not to create inappropriate development.

2.1.5.2 Positive impacts caused by the project

(1)Natural environment

This project is a renewable-energy hydroelectric power project that will not use fossil fuels. So, it will greatly contribute to reducing emissions of GHG into the natural environment. In addition, the storage effect of the balancing reservoir will cut the peak flood amount, and it can be expected that this will to some extent contribute to the reduction of flood damage. GHG emissions reduction (amount of power generated by this project) will be secured by stable generation with high efficiency and high capacity utilization. This will result from the high-performance and high durability of the water wheels, generators, and auxiliary equipment, which will enable maintenance labor-saving in this project. In addition, education by the equipment manufacturer and hands-on training at Muong Hum hydroelectric power plant will be provided for operators and maintenance crews, and periodic inspection by the equipment manufacturer will be planned. Through such programs, appropriate operation of equipment can be carried out by them. For flood counter-measures also, through hands-on training at Muong Hum

hydroelectric power plant, it will be possible for operators to learn appropriate operation of dam gates and balancing reservoir operation techniques. Such skills will ensure reduction of flood damage.

(2) Social environment

In this project, employment of power plant operation and maintenance workers and construction laborers, purchase of construction materials and equipment, building of new roads and maintenance of the existing road, and increase in resident population during the construction period, will contribute to the development and revitalization of the local economy. Concerning construction of new roads, part of the access road was built in the prior implementation of this project, and is already being utilized by local residents.

2.1.6 Toward project realization (planned schedule and possible obstacles to be overcome)

2.1.6.1 Planned schedule

A draft implementation schedule is shown in table 2.12, and a draft installation schedule for hydro turbine and generator equipment is shown in table 2.13.

Table 2.12 Draft implementation schedule

Draft schedule	Fiscal year				
	2015	2016	2017	2018	2019
Detailed analysis of profitability, Financing	Consideration of countermeasures for currency fluctuation Detailed analysis of profitability Investigation of availability of guarantee by MIGA Discussion about debt conditions	▼ Finance close			
JCM Model project, Construction	Detailed confirmation of conditions, and prospects of adoption as model project Preparation of construction and equipment supply contracts	▼ Application for project to be accepted as model project ▼ Construction contracts ▼ Equipment supply contracts ▼ Commencement (Civil work)		▼ Completion	

Source: FS Consortium

Table 2.13 Draft installation schedule for hydro turbine and generator equipment

Draft schedule	Fiscal year											
	2016				2017				2018			
Design and manufacture of hydro turbine and generator equipment					Draft tube, casing, runners, etc							
					Stators, rotors, brackets, etc							
					Inlet valves, speed governors, etc							
Installation at the site								Draft tube, casing, etc				
								Hydro turbine and generator Unit1				
								Hydro turbine and generator Unit2				
Wet test								Hydro turbine and generator Unit1				
								Hydro turbine and generator Unit2				

Source: FS Consortium

2.1.6.2 Possible obstacles to be overcome

Possible obstacles to the realization of this project are summarized in the following four points:

- Development rights (Investment license)
- Risk of currency fluctuations (Profitability for Japanese investors)
- Financing (Debt)
- Determination of expected implementer of Japan and adoption as a JCM model project (Subsidy)

(1) Development rights (Investment license)

In this study, feasibility was evaluated on the condition that Son Vu is the implementing entity and Japanese private company involved in electric power is the joint investor.

Lao Cai province People's Committee is selecting a grantee of the development rights as of February 2015. If Son Vu can not acquire the development rights, it will be necessary to carry out consultations with the new investor (for explanation of this survey result, financing method, etc.) in order to implement this project as a JCM project.

(2) Risk of currency fluctuations (Profitability for Japanese investors)

In this project, electricity sales revenue will be VND - denominated, while debt will be JPY or USD - denominated, and Japanese corporate profits (dividends) will be JPY - denominated. Therefore, debt payment and profitability will be directly affected by currency fluctuations.

For this reason, in conjunction with consideration of whether or not a subsidy will be received and the conditions to be applied in the case of receiving a subsidy, together with conditions of financing (collateral, interest rate, repayment period, etc.), it is necessary to analyze the maximum degree of currency fluctuation risk and risk reduction measures in detail.

(3) Financing (Debt)

Since the credit line to hydroelectric power projects by Vietnamese commercial banks is very restricted, to cover the construction cost of this project it will be necessary to borrow from banks other than banks in Vietnam including those in Japan. However, guarantee of repayment from the Vietnam government is limited to the investment ratio of Vietnamese enterprises, and EVN (off-taker) is in deficit, so many banks are concerned about the risk of non-payment. Therefore, many issues on loan negotiation remain to be resolved.

As is often the case with businesses in Vietnam, this project will be difficult to finance, and the funding method is undecided at the present time. So, the study of a guarantee by Vietnamese government or MIGA, which seems an important matter for the project, should be continued.

(4) Determination of expected implementer of Japan and adoption as a JCM model project (Subsidy)

In this study, an expected implementer of Japan for JCM model project has not been decided yet. Therefore, the expected implementer has to be determined considering the model project. In addition, the results of financial analysis show that it is essential to provide assistance for the purchase and installation cost of Japanese products in order to make this project financially viable. Therefore, it is necessary to assess the conditions and business potential of adoption.

(5) Other possible obstacles

Equipment price is about twice that of Son Vu's previous plan (using emerging nation products). To achieve production cost reduction there are plans to examine the allocation of component production to manufacturers in emerging nations to the extent possible.

2.2 JCM methodology development

2.2.1 Eligibility criteria

Eligibility criterion 1 :   Supply grid with electricity

The electrification rate in Vietnam becomes 97.3% as of 2012 by report of ASEAN-RESP, and it is estimated that there is almost not the no-electrification area at present. On the other hand, nationwide electricity shortage becomes the problem in Vietnam, and it is future task how to secure a power supply. From such a background, the criteria that a hydro power station which supplies Grid with electricity is set by this JCM methodology.

Eligibility criterion 2 :   Present a document certifying turbine and generator efficiency such as model test report of similar turbine and calculation sheet of generator loss.

According to the survey results of the existing small-medium scale hydro power stations in Lao Cai, actual efficiency of the turbine is unidentified, because there is not model test report and site efficiency

test was not performed.

In addition, almost of small-medium scale manufacturers do not have model test report, and then turbine efficiency is estimated from the similar turbine. Therefore, the turbine efficiency is not guaranteed by the supplier and turbine output is not secured. From such a background, the above criteria is set in order to secure power house output and generating power product by this JCM methodology.

Eligibility criterion 3 :

Adopt turbine and generator with long term durability. And supplied by manufacturer who has supplying record of turbine and its auxiliary, generator and its auxiliary and control system to similar power station, which has more than 10 years operation.

Similar power station : Hydro power station which has same type of hydro turbine with effective head and output the degree or more than that of target hydro power station. And hydro power station which has vertical 3 phase synchronous generator with output and speed the degree or more than that of target hydro power station.

Operation without trouble: No long term stopping more than 1 month.

Application range of Vertical Francis turbine applied to Nam Cun hydro power station is wide and Vertical Francis turbine is often used for small-medium scale hydro power station. However, for the medium scale hydro turbine more than output 10MW, only a major company has the production results in Japan. Therefore, the production result of similar scale hydro turbine is one of indication to evaluate manufacturer's capability.

The other hand, there is a great deal of dissatisfaction of the use for the durability of hydro power equipment supplied to Vietnam by manufacturer in developing company. For example, the damage of the bearing causes the long-term stop of the power station; water leakage from guide vane shaft causes an efficiency drop of turbine. As a result, they will cause economic deterioration of the business.

In Japan, hydro power equipment is used for more than 60 years while performing overhaul or part exchange periodically, and operated continuously stably without big trouble.

Therefore, it is one of indication that the hydropower equipment is operated without long-term stop more than 1 month by trouble between each overhaul in order to evaluate the durability.

From such a background, the criteria that the manufacturer should satisfy the above supply record and be able to get certificate issued by user, in which the equipment is operated continuously more than 10 years without long-term stop more than 1 month, is set by this JCM methodology.

Eligibility criterion 4 :

Present operation and maintenance manual and drawings for turbine, generator and control system and have an experience of making such documents.

According to survey results, generating units are operated by experience and the perception of experienced operator and it is the situation that an accident could occur anytime, because operation and maintenance manual and drawing were not supplied and function of automatic control system is not

satisfied.

Eligibility criterion 5:

Electric servo system (unit output not more than about 20MW) or hybrid servo system (unit output not more than about 50MW) is applied for guide vane operation.

Not only high performance of turbine and generator but also technology of simplification of auxiliary equipment and maintenance free for unmanned operation are required in Japan. Especially for small-medium scale power station, reduction of maintenance cost is important to improve total feasibility.

From such a background, the criteria that such technology can be applied for reducing maintenance cost are set.

Table 2.14 Summary of Competent Requirement

Eligibility criteria	Purpose of the setting	Judgment (documentary evidence)
Criterion 1 Supply grid with electricity	Limitation of business type	—
Criterion 2 Presentation of documents certifying turbine and generator efficiency	Secure the power generating product	Turbine: Model test report of similar turbine Generator: Loss calculation sheet
Criterion 3 Long-term durability of turbine and generator	Secure the durability	Supplying record of products and certificate by user
Criterion 4 Presentation of operation and maintenance manual and drawings. In addition, having experience of making those things	Secure the stability of operation and maintenance	Operation and maintenance manual and drawings for products
Criterion 5 Applying for guide vane operation using electric servo system (unit output not more than about 20MW) or hybrid servo system (unit output not more than about 50MW). In addition, having experience of making those system	Maintenance free	Experience of product (drawing, calculation sheet etc.)

2.2.2 Calculation of GHG Emissions (including reference and project emissions)

This JCM methodology is to be applied to hydropower projects that generate electricity and supply to specified customers via the national grid. For electricity buyers, electricity supplied by the project activity is regarded to be replacement of electricity generated by grid-connected power plants.

CO_2 emissions from electricity generated by fossil-fuel-fired power plants are regarded as reference emissions.

Calculation of reference emissions

REy = EGPJ,y × EFy

Where:

REy	Reference CO_2 emissions in year y [tCO_2/y]
EGPJ,y	Quantity of net electricity generation that is produced and fed to the national grid as a result of the implementation of the project activity in year y [MWh/y]
EFy	CO_2 emission factor of electricity in year y = 0.5408 [tCO_2/MWh]

Calculation of project emissions

PEy = PEHP,y

Where:

PEy	Project emissions in year y [tCO_2/y]
PEHP,y	Project emissions from water reservoirs of hydropower plants in year y [tCO_2/y]

The power density (PD) of the project activity is calculated as follows:

$$PD = \frac{Cap_{PJ} - Cap_{BL}}{A_{PJ} - A_{BL}}$$

Where:

PD	Power density of the project activity [W/m^2]
Cap_{PJ}	Installed capacity of the hydro power plant after the implementation of the project activity [W]
Cap_{BL}	Installed capacity of the hydro power plant before the implementation of the project activity [W]. For new hydro power plants, this value is zero
A_{PJ}	Area of the single or multiple reservoirs measured by the surface area of the water, after the implementation of the project activity, when the reservoir is full [m^2]
A_{BL}	Area of the single or multiple reservoirs measured by the surface area of the water, before the implementation of the project activity, when the reservoir is full [m^2]. For new reservoirs, this value is zero

(a) If the power density of the project activity or in case of integrated hydro power project is greater than 4 W/m^2 and less than or equal to 10 W/m^2

$$PE_{HP,y} = \frac{EF_{Res} * EG_{PJ,y}}{1000}$$

Where:

EFRes	Default emission factor for emissions from reservoirs of hydro power plants = 90 [$kgCO_2/MWh$]
EGPJ,y	Total electricity produced by the project activity, including the electricity supplied to the grid and the electricity supplied to internal loads, in year y [MWh/y]

(b) If the power density of the project activity is greater than 10 W/m^2
$PE_{HP,y} = 0$

Calculation of emission reductions

ERy = REy - PEy

Where:

ERy	GHG reduction in year y [tCO_2/y]
REy	Reference emissions in year y [tCO_2/y]
PEy	Project emissions in year y [tCO_2/y]

2.2.3 Data and Parameters Fixed *Ex Ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Table 2.9 Parameters fixed *ex ante*

Parameter	Description of data	Source
EFy	CO_2 emission factor of electricity in year y = 0.5603 [tCO_2/MWh]	MONRE ("Vietnam electricity emission factor", published on 2014/4/21)
EFRes	Default emission factor for emissions from reservoirs of hydro power plants = 90 [$kgCO_2/MWh$]	ACM0002 (Large-scale Consolidated Methodology of CDM)

Source: FS Consortium