Indonesia

(Indonesia)
THE PREPARATORY SURVEY ON SMALL HYDRO PROJECTS IN SUMATRA AND SULAWESI IN REPUBLIC OF INDONESIA
Final Report

<Lae Ordi II>

February 2014

Independent Administrative Corporation

Japan International Cooperation Agency

Industrial Decisions, Inc.

Hokuden Sougou Sekkei, Inc.

TABLE of CONTENTS

List of FIGURES

TABLES

Glossary

Abbreviation	English	Indonesian
AMDAL	Environmental Impact Assessment (EIA)	Analisis Mengenai Dampak Lingkungan
ASEAN	Association of South-East Asian Nations	
ARGR	Automatic Rain Gauge Recorder	
AVR	Automatic Voltage Regulator	
AWLR	Automatic Water Level Recorder	
BMG	The Bureau of Meteorology and Geophysics	
BPN	National Land Agency	Badan Pertanahan Nasional
BPPT	Agency for Assessment and Application of Technology	Badan Pengkajian dan Penerapan Teknologi (BPPT)
CDM	Clean Development Mechanism	
CER	Certified Emission Reduction (Unit for CDM)	
CF	Capacity Factor	
COD	Commercial Operation Date	
DESDM	Ministry of Energy and Mineral Resources (MEMR)	Departemen Energi dan Sumber Daya Mineral
EIA	Environmental Impact Assessment	AMDAL
EPC	Engineering, Procurement and Construction	
FIN	Feed In Tariff	
FS	Feasibility Study	
FTP	Fast Track Program	Crash Program (Another name)
GDP	Gross Domestic Product	
GHG	Greenhouse Gas	
GP	General Partnership	
GW	Gigawatt	
HEPCO	Hokkaido Electric Power Co., Inc	
HEPP	Hydro Electric Power Project	
IDI	Industrial Decisions Inc.	
IDI-I	IDI Infrastructures Inc.	

IDC	Interest During Construction	
IDX	Indonesia Stock Exchange	Bursa Efek Indonesia
IEA	International Energy Agency	
IEE	Initial Environmental Evaluation	
IMB	Indonesian building permit	Izin Mindirikan Banyunan Bupati
IMF	International Monetary Fund	
IPO	Initial Public Offering	
IPP	Independent Power Producers	
IT	Information Technology	
JICA	Japan International Cooperation Agency	
KKO		Kata Kerja Operational
kW	kilowatt	
kWh	kilowatt-hour	
LP	Limited Partnership	
M&A	Merger and Acquisition	
MEMR	Ministry of Energy and Mineral Resources	
MW	Megawatt	
MWh	Megawatt-hour	
NEF	New Energy Foundation	
NJOP	Selling Value of Taxed-Object	
NRECA	National Rural Electric Cooperative Association	
ODA	Official Development Assistance	
Perpres	Presidential Regulation (PR)	Peraturan Presiden
IIGF	Indonesian Infrastructure Guarantee Fund	PT Penjaminan Infrastruktur Indonesia
PIP		Pusat Investasi Pemerintah
PLN	State Electricity Company	Perusahaan Listik Negara
PP	Government Regulation	Peraturan Pemerintah
PPA	Power Purchase Agreement	
PPP	Public-Private Partnership	
SMI		Sarana Multi Infrastruktur
SPC	Special Purpose Company	
TWh	Terawatt-hour	

UKL	Environmental Management Procedure	
UPL	Environmental Monitoring Procedure	
WL	Water Level	

Chapter.1 Introduction

1-1. Background of the Preparatory Survey Regarding the Small Hydro Power Project in Sumatra and Sulawesi

The purpose of implementing the Preparatory survey (hereafter "the Survey") regarding the small hydro-power project in Sumatra and Sulawesi (hereafter "the Target Project") is to accelerate the development of the small hydro-power project in Indonesia. The Survey will be conducted according to the following viewpoints: business / project development plan of the Target Project, possibility of installing Japanese technology and equipment and possibility of utilizing funding (capital/loan).

The Survey has been led to start as the electricity demand in Indonesia is soaring and the Indonesian government has considerable expectations for the development of the small hydro-power plants. Sumatra and Sulawesi islands have growing demand in particular (see 1-1-1 for details), leading to higher power purchase price (see 2-4-1 for details), and preliminary study found project owners with intention to run the business for long time instead of planning to sell off the projects.

At the beginning of the Survey, two projects in Sumatra and one project in Sulawesi were selected as the Target Projects. After the project owner conducted the third party review by international technical consulting company and found that the generation capacity would be significantly smaller than previously assumed by the feasibility study, the project owner gave up development of the project. Thus, the Survey has replaced the Target Project from this Sulawesi project to the other in South Sumatra with high possibility of going forward, and the Survey has all three projects in Sumatra.

1-1-1. Development issues and situations of infrastructures and electricity demands in Indonesia

Although the electricity demand in Indonesia has steadily grown since the Economic Crisis in 1997, it has been recognized that electricity supply in the country is scarce compared to the commercial and industrial electricity demand, which is one of the bottleneck for the country's economic growth. For example, PLN does not have enough capacity to meet the rapidly growing electricity demand. In addition, the country's electrification ratio is mere 71.2% (as of 2011), which means that nearly 20 Million[1] households do not have publicly supplied electricity. In the case of Indonesia, it is projected that due to its rapid economic and population growth, the electricity demand will grow 7-9% p.a., which makes the electricity supply even more urgent.

The maximum electricity demand in Sumatra-grid is 4,601MW as of 2011, and is reaching 9,641MW by 2020. The maximum electricity demand in Sulawesi-grid is 1,087MW as of 2011, and is expected to grow by 2,718MW by 2020. It is essential for both grids to develop new power plants to meet the above demand, especially factoring in sudden stoppage due to decrepit existing facilities.

[1] Price Waterhouse Coopers "Electricity in Indonesia-Investment and Taxation Guide"

1-1-2. Necessity of developing the Target Project as Public Private Project

The fundamental of the governmental policy for the electricity issues is that the government has restrained the retail sales price of electricity in order to reduce the payment burden of households. Therefore, the cost of power generation is higher than the cost of electricity price in Indonesia. This has caused PLN some cash shortage and it is obvious that PLN has difficulty to develop the power generation plants by itself to meet country's growing electricity demand. Thus, the government of Indonesia amends Electricity Business Act, consolidates a legal system such as enacting FIT, and expects private capital emergence which can be seen in 'Fast Track Program'.

1-2. The Aim of the Survey

Although the policy pertaining to support renewable energy projects has been put into place, the development of the small hydro-power project has not seen much progress as expected. This is because that the local financial institutions usually do not provide the loan by project finance scheme, and instead assess projects by credit of the company. And most project owners of small hydro-power projects are small and medium size enterprises that they have difficulty even to get approval for Power Purchase Agreement (PPA) or other permission and authorization due to their low creditworthiness.

Hence, the aim of the Survey is to see how the small hydro-power projects can be developed by utilizing Japanese technology, equipment and funding and is to help the steady economic growth in Sumatra and Sulawesi by developing the small hydro power in both islands.

The survey report uses 111.200IDR/YEN as the reference rate of IDR/YEN as of December 31, 2012.

Chapter.2 Confirmation of the Current Status and Future Projections of Small Hydroelectric Power Projects in Indonesia

2-1. Current status, Challenges and the Future Plan of the Indonesian Electricity Sector with Some Focus on Renewable Energy

Indonesia possesses abundant oil, natural gas and coal. As a result, it is largely dependent on thermal power generation. As of 2010, generating capacity was 33.2GW and the gross generation was 169.8TWh. During the 20 years from 2010 to 2030, the gross generation will increase at the rate of approximately 9.1% per year.

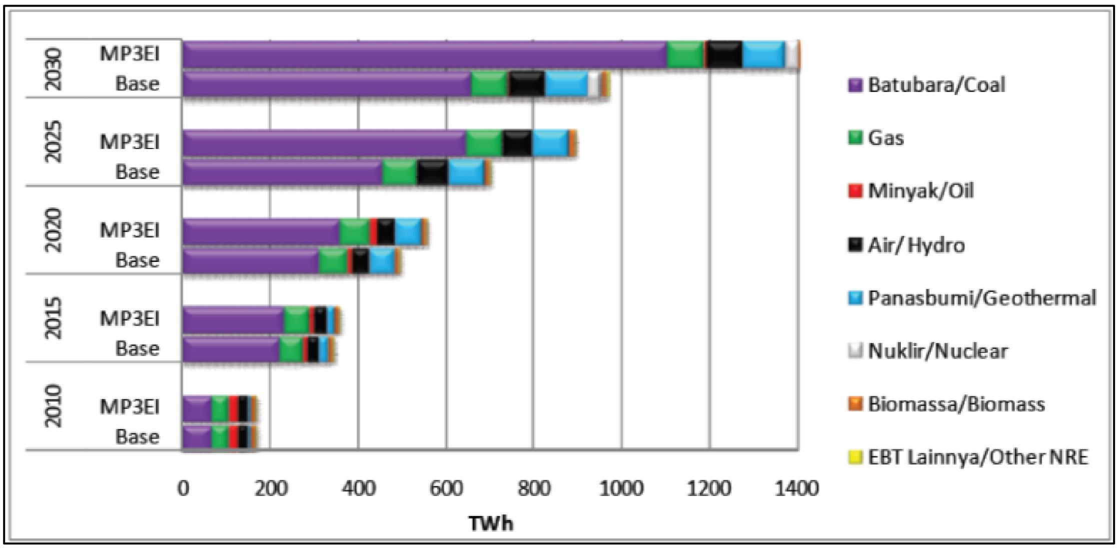


Figure 2-1 Trend of Gross Generation (By Fuel Type)[2]

Source: BPPT. “Outlook Energy Indonesia 2012”

However, due to the rapid economic development, since 2004 Indonesia has become a net-importer of oil. Combined with the rising global oil prices, the Indonesian government has stated that it will strive to reduce its dependency on oil[3]. Therefore, in order to compensate for the electricity demand, growing at the rate of more than 9% per year, Indonesian government has planned and executed “Fast Track Program”, aiming for the large scale development and construction of power generating plants by using coal and renewable energy sources.

---

[2] “MP33EI” is an abbreviation of “Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia”

[3] Ministry of Energy and Resources, “UPDATES ON POLICY TO PROMOTE RENEWABLE ENERGY DEVELOPMENT AND ENERGY CONSERVATION IN INDONESIA, November 2011”

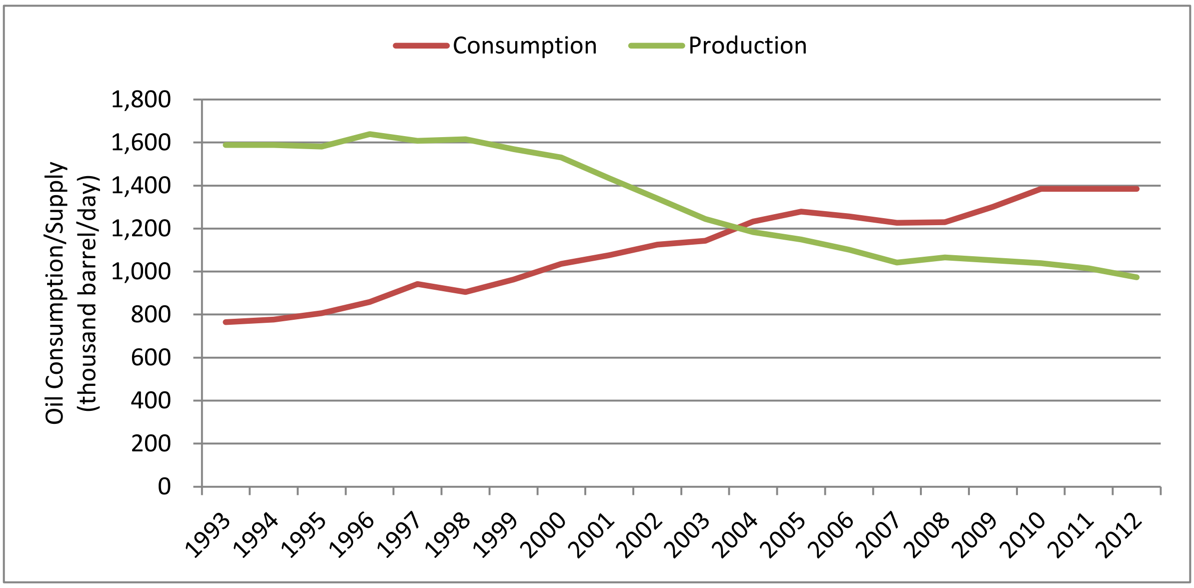


Figure 2-2 Volume of Oil Consumption and Supply

Source: Energy Information Association (U.S.A.)

In order to meet the expanding electricity demand, the "First Fast Track Program" planned to meet the electric development capacity target solely through coal-fired power plants. However, facing the environmental concerns, the government was requested to revisit the power development plan focusing on coal-fired power plants. Although the "First Fast Track Program" was executed by the PLN, the "Second Fast Track Program" outlined a plan to utilize Independent Power Producer (IPP). The "Second Fast Track Program" also planned to utilize renewable energy sources, with a development target of 18.1GW, close to four times as much as that of nowadays, by 2030[4].

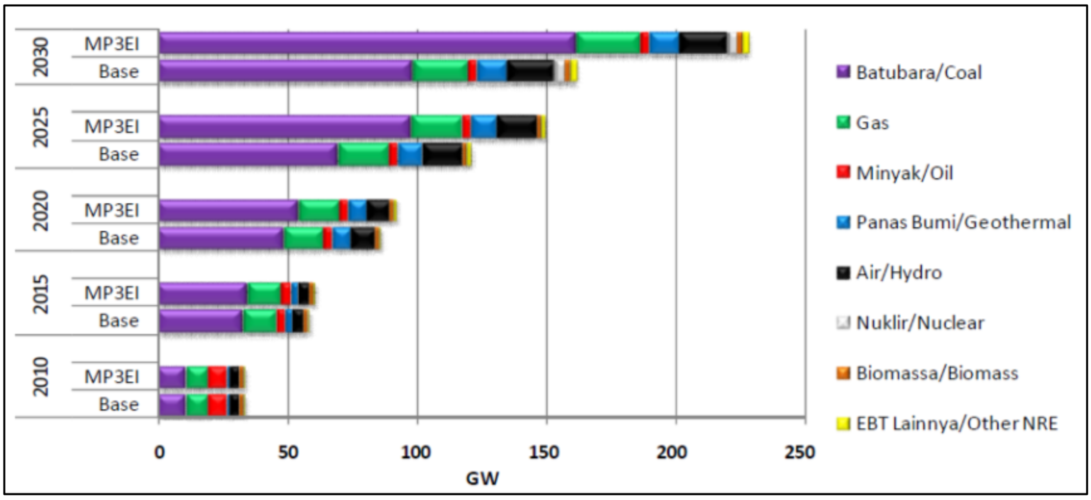


Figure 2-3 Estimated Composition of Generation Capacity by Fuel

Source: BPPT "Outlook Energi Indonesia 2012"

[4] Badan Pengkajian dan Penerapan Teknologi(BPPT), "Outlook Energy Indonesia 2011"

Table 2-1 Fast Track Programs

	First Fast Track Program	Second Fast Track Program
Period	2006～2009	2010～2014
Scale of Development	10,000MW	10,153MW
Type of Fuel	Coal 10,000 MW (100%)	Coal 3,312 MW (33%) Gas 1,660 MW (16%) Geo-thermal 3,977 MW (39%) Hydro 1,204 MW (12%)

Source: PLN

Indonesia has the highest potential in developing geo-thermal power plants. Due to this, many companies, including Japanese companies, are actively engaged in the development of boring geo-thermal and geo-thermal power plants projects. It has been pointed out that the development of the geothermal power generation generally takes much time and cost, from geological survey to the start of operations, therefore, limiting the potential developers to those companies which have abundant capital to implement the projects.

Table 2-2 Potential of Development of Thermal Power Plants

Country	Number of Active Volcanoes	Volume of Geo-thermal Source（MW）
Indonesia	150	27,791
USA	133	23,000
Japan	100	20,540
Philippine	53	6,000
Mexico	35	6,000
Iceland	33	58,000
New Zealand	19	3,650
Italy	14	3,267

Source: The Agency of Energy and Resource, “On the development of thermal resource”, Oct.2011

On the other hand, although the development cost of large size the hydraulic power plants with sufficiently abundant resources is likewise costly, the construction of small hydroelectric generation projects of 10MW or less does not require such high costs, thus, keeping initial investment low and having the development period short. Due to these reasons, considering the increasing electricity demand, small-scale hydroelectric power is considered to be the most suitable means to meet the demands.

Table 2-3 Development Potential of Hydro Power Plants (MW)

Type	Development Potential	Existing Generation Capacity	Rate
Hydro	75,769 MW	7,571 MW	9.99%
Geothermal	29,164 MW	1,341 MW	4.6%
Biomass	49,810 MW	1,644 MW	3.3%
Solar PV	4.80 $kWh/m^2/day$	42.78 MW	-
Wind	3 – 6 m/s	1.87 MW	-
Ocean	49 GW	0.01 MW	0%

Source：MEMR “Country Report: Renewable Energy in Indonesia (2012)”

2-2. Present Conditions and Challenges Facing the Electricity Sector and Future Development Plans with Some Focus on Renewable Energy of Sumatra

As of October 2011, according to the announcement of PLN, the electrification rate of Indonesia is 71.2%. Depending on the region, the electrification rate in and around the main urban areas such as Java and Sumatra is high, while there are still many under-developed regions, remote place of the mountains or the eastern Nusa Tenggara/ Papua area which have not been electrified. Although, originally, it was the deemed the responsibility of PLN to construct and maintain the electric infrastructure of these rural areas, due to the implementation of the Electricity Act in 2009, under the direction of the central and local governments, governmental/private enterprises and cooperatives were allowed to enter the market.

As of 2010, the electrification rate of Sumatra Island is about 62.5%. Its rate is higher than other areas except Java Island and Bali Island. The Sumatra grid system is a developed one which is synchronized by linking northern and southern grid systems with 150 kV power transmission line.[5] It is planned to further develop 275kV and 500kV grid system by PLN as shown in Figure 2-4.

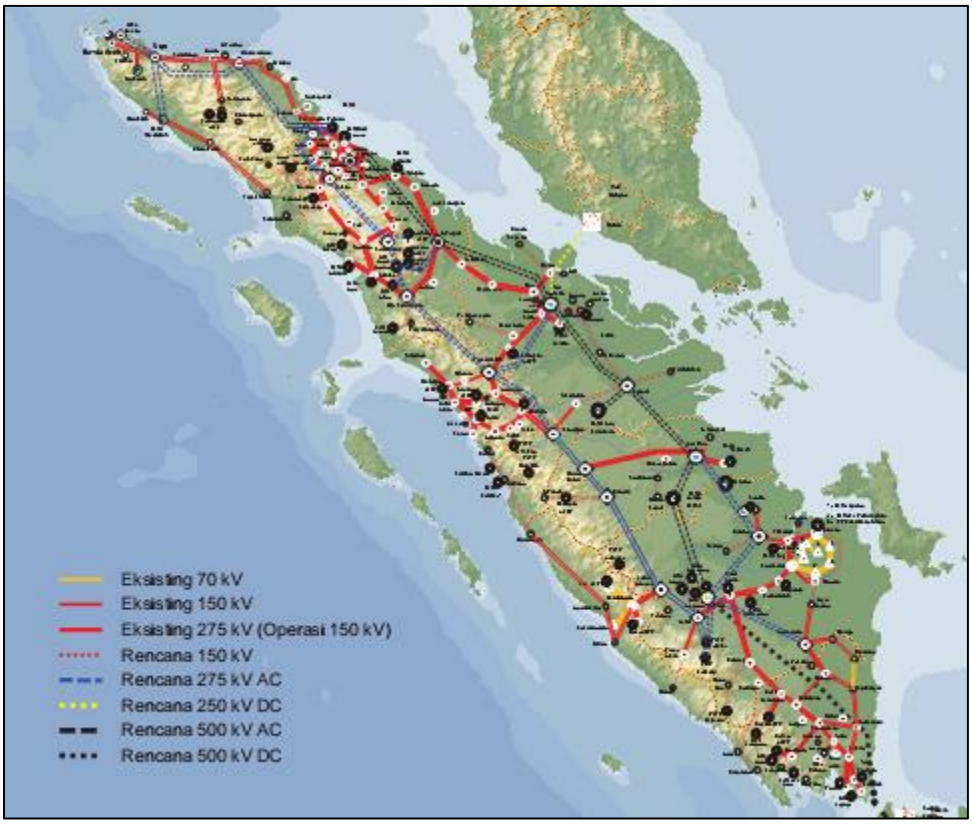


Figure 2-4 Sumatra Grid System Development Plan

Source: PLN "2012-2021 Power Development Plan (RUPTL)" Dec 2012

[5] Ministry of Energy and Mineral Resource, "2008-2027 National Electricity Global Planning 2008-2027"

For this reason, to construct and maintain the electric infrastructure of its rural areas show sound progress. North Sumatra Province and Bengkulu Province, the places where target projects are located, record 77.8% and 54.6% at electrification rate. On the other hand, Riau Province and Jambi Province record 40.2% and 31.7% respectively, and they still have many unelectrified areas.

Table 2-4 Each Province's Electrification Rate in Sumatra Island（2012）

Name of Province	Population (Thousand)	Household（Thousand）	Electrification Rate（%）
Ache	4,693.9	1,105.1	88.55
North Sumatra	13,215.4	3,112.5	84.61
West Sumatra	4,957.7	1,182.5	72.98
South Sumatra	7,701.5	1,870.2	63.09
Bengkulu	1,766.8	445.5	71.02
Riau Islands	811.5	192.1	72.13
Lampung	7,767.3	1,985.0	65.29
Bangka Belitung	1,298.2	324.6	73.94
Riau	5,929.2	1,394.7	56.52
Jambi	3,242.8	800.4	58.05
Total	51,384.3	12,412.6	71.69

Source: PLN. "PLN Statistics 2012" Mar 2013

According to 2012-2021 Power Development Plan (RUPTL) stated by PLN, the electricity demand in Sumatra is projected to increase to 65.4TWh by 2021 along with 7.1% annual average economic growth and an annual average increase of 8.2% in electric demand.

Moreover, this plan sets out a target of 97.6% electrification rate by 2021.

Table 2-5 Average Indexes in Sumatra

Population Growth Rate	Annual Average Economic Growth Rate	Annual Average Electricity Demand Growth	Electricity Demand As of 2021 (MW)	Electricity Demand As of 2021 (GWh)
1.8%	7.1%	10%	10,516MW	55,272GWh

Source: PLN "2012-2021 Power Development Plan (RUPTL)" Dec 2012

According to PLN's 2012-2021 Power Development Plan (RUPTL), its baseline plans that while coal-fired thermal power remains as the nucleus of future development of power sources in Sumatra, 1.6 GW of hydro power is expected to be generated by 2021 and total hydro power installed capacity will be 2.6GW and shared 15.7%. Therefore, it is forecast that there will be certain hydro power development in Indonesia.

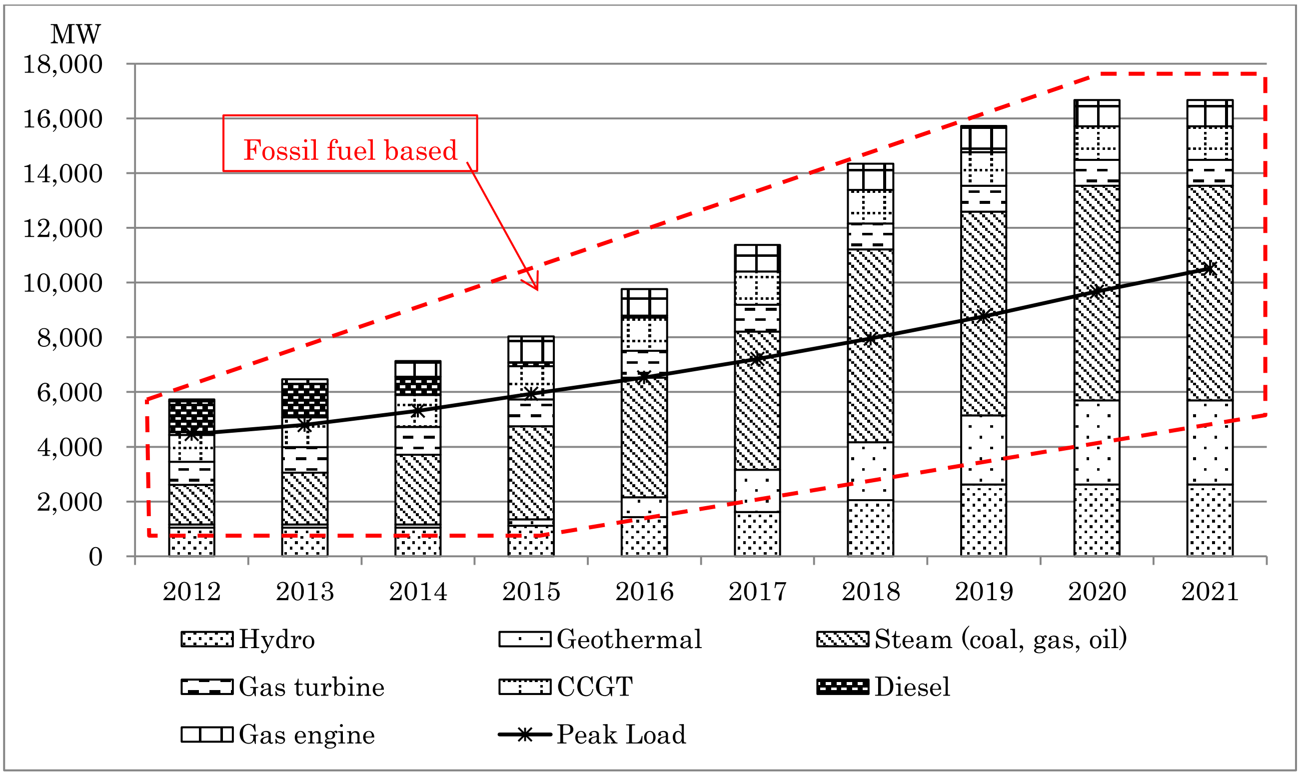


Figure 2-5 Forecast of Generation Capacity and Peak Load

Source: PLN "2012-2021 Power Development Plan (RUPTL)" Dec 2012

However, as shown in the figure below, generation cost of fossil fuel based power plants, given increased fuel cost, is much higher than hydro. Therefore, small hydro power is supposed to be prioritized for generation as it has competitive advantage in generation cost, over other plants.[6]

[6] PLN, as an off-taker of the electricity produced by small hydro power plants, is obligated to purchase all electricity during the contract period. Thus, regardless of the cost comparison with other power plants, electricity produced by small hydro will be purchased.

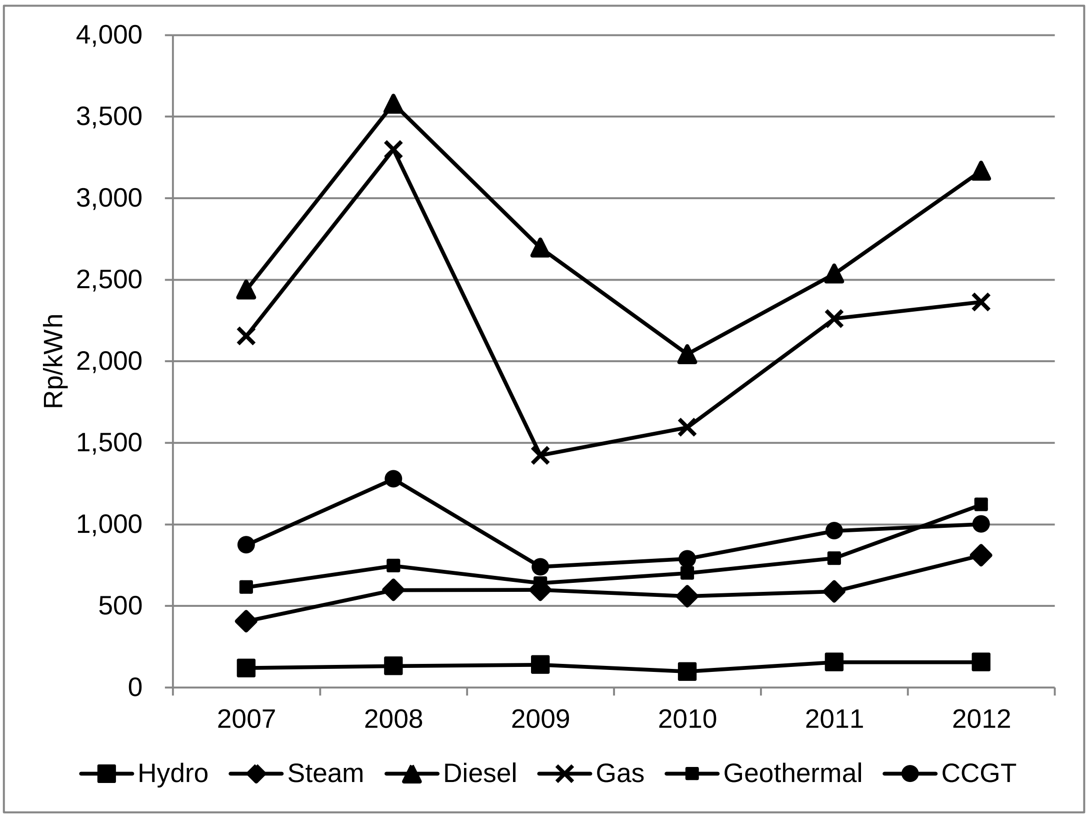


Figure 2-6 Generation Cost Comparison

Source: PLN "PLN Statistics 2012" Mar 2013

According to RUPTL, the following table is the power development plan in Bengkulu.

Table 2-6 Power Development Plan in Bengkulu (2012 – 2021)

Plant Name	Fuel	Capacity	Scheduled commencement of operations	Owner
Ipuh	Coal	6 MW	2013	PLN
Muko Muko	Coal	8 MW	2013	IPP
Simpang Aur	Hydro	23 MW	2015	IPP
Hululais	Geothermal	110 MW	2016	PLN
Ketahun-3	Hydro	61 MW	2019	PLN
Kepahiyang	Geothermal	220 MW	2020	PLN

Source: PLN "2012-2021 Power Development Plan (RUPTL)" Dec 2012

2-3. Summary of the Indonesian Laws Regulations, Policy and Structure Relating to Electricity Focusing on Renewable Energy and Public-Private Partnerships (PPP)

2-3-1. Background and summary of PPP structure and policy in Indonesia[7]

When the Yudhoyono administration was established, the Indonesian government was in a tight economic situation. To promote the growth of the national economy and the furtherance of infrastructure development, the government implemented PPP policies. By opening the areas previously controlled by the public sector such as 1) transport 2)high way 3)irrigation 4)water-works 5)refuse disposal 6)communication 7)electricity 8)oil and natural gas infrastructure to private investments, through the PPP scheme, the Indonesian government hopes to attract both the capital and expertise of foreign companies.

In January 2005, President Yudhoyono invited domestic and overseas investors to 'the Infrastructure Summit 2005'. In November of the same year, Presidential Regulation (PR) number 67/2005 concerning Public Private Partnership in Infrastructure Development was issued to promote PPPs. The objective of the PR 67/2005 was to develop the national infrastructure by utilizing the PPP system. Yet, despite having published 91 candidates for PPPs and selecting 10 model projects, due to the ambiguity of the government's responsibilities under the PR 67/2005, foreign investors failed to show interest and consequently feasibility studies of many of the PPP projects were not conducted. Subsequently, during the first Yudhoyono regime, no PPPs were formed.

However during Yudhoyono's second term of office (October 2009 to September 2014), PR 67/2005 was revised and PR 13/2010 was issued, which clearly defined the Indonesian government's responsibility with regard to PPP projects, including terms regarding the acquisition of land, government subsidies, governmental guarantee on loans. Consequently, the private sector's risks in entering the PPP projects have been greatly reduced.

Table 2-7 Modification from PR67th / 2005 to PR13th / 2010

Modification	PR 67/2005	PR 13/2010
Contracting Agent/Office	No designation regarding Contracting Agent Executing Agent limited to respective ministers, commissioners, the local government chairman	Executing Agent is also designated as the Contracting Agent (which includes provincial/state governments' development authorities)
Share Transfer	➢ No transferal of shares before commercial operation	➢ All or a part of shares are permitted to be transferred
Form and Range of the	Ambiguous terms of government support for projects	Defined the terms of government: ① Government responsibility:

[7] Mizuho Research Institute Ltd, "Indonesia, accelerating the investments for infrastructures with PPP", Oct.18th 2011.

Government Support		(e.g. expropriation of land, approval and license, provision of basic infrastructure) ② Government subsidies (e.g. operating cost) ③ Government guarantee for contingent liabilities
Funding procedures	No particular provisions	The project owner must complete funding within 12 months after the signing of the agreement If one of the following conditions are met, funding shall be deemed complete. ① All documents of all funding for this business are signed. ② The pre-determined amount specified in the finance contract has been spent.

Source：Engineering & Consulting Firms Association

In April 2011, Indonesian Infrastructure Guarantee Fund (IIGF) was established as a solely owned subsidiary of Indonesian Department of Finance with the aim of strengthening government guarantee. IIGF aims to cover government risks that private company cannot control, such as delay in decision making, default of contract and occurrence of events that lie outside the jurisdictions of existing ministries.

As a result of the implementation of policies and framework for the promotion of PPPs, combined with the economic growth driven by the domestic demand and the political stability, the Indonesian market has begun to attract more attention as a potential investment target.. In January 2012, Indonesia's investment rating was raised to BBB-.

2-3-2. Outline of Legal System Related to Electric Power in Indonesia

Regulations related to the electric power business in Indonesia are mainly defined in the Electricity Act of 2009 that was published in September 2009.

The Act defines the electricity supply business as power procurement through power generation, transmission, distribution, and sale to consumers[8]. Indonesian Government assumes principal

[8] The Electricity Act 30/2009, Article 1.

responsibility of power supply[9], but local government is also involved in making various plans and responsible for issuing certain permits necessary for the IPP developers. Under the act, National Electricity General Plan (RUKN) is developed based on the national energy policy through the process participated by the local government as well. In addition, based on the RUKN, local government makes Regional Electricity General Plan after discussion with local parliament.

PLN lost its complete exclusive rights over power supply by the Electricity Act 30/2009, and government owned company, publicly owned company, private company, cooperative, or NGO with power supply business permit (IUPTL) are allowed to conduct generation, transmission, distribution, and retail businesses. However, PLN has the priority to supply electricity to the public[10]. In transmission and distribution sector, the entry barrior could be high because PLN has dominated the market developing infrastructures.

As to the electrification of rural area, it is defined that central government and local government establish the fund for the people in poverty and develop power facilities, power supply to remote and rural area, and rural electrification facilities.

For the renewable energy projects with certain capacity size, Feed in Tariff system where it is possible to sign PPA with PLN for long term fixed price without price negotiation is installed by the MEMR Ministerial Regulation 31/2009 and 04/2012 (see 2-4-1 for details). FIT is based on the Electricity Act of 2009, which allows government owned company, publicly owned company, private company, cooperative, or NGO to conduct electricity supply business, and obligate PLN to purchase electricity produced by the renewable energy source of up to 10MW, developed by the project owners mentioned above.

Foreign investment in power generation sector is regulated by Negative Investment List (Presidential Regulation 36/2010) shown as the following. It is necessary to pay attention to the on-going discussion on its revision.

Table 2-8 Negative Investment List in Power Sector

Business Sector	Conditions
Generation (< 1MW)	Closed; Only for UMKMK[11]
Generation (1-10MW)	Partnership; no limitation for foregin investment but cooperation with UMKMK required (investment, outsourcing, rental or any kind of participation)

---

[9] The Electricity Act 30/2009, Article 3
[10] The Electricity Act 30/2009, Article 11
[11] UMKMK is a private or company satisfied with low No. 20/2008 concerning micro, small and medium enterprises and low No. 25/1992 concerning cooperatives.

Generation (> 10MW)	Foreign capital raito is up to 90%
Gepthermal plant operation and maintenance	Foreign capital raito is up to95%
Geothermal power	Foreign capital raito is up to 95%

Source：Presidential Regulation 36/2010

2-4. The Objectives, Policies and Institutions of the Central and the Local Government for Financial Resource and Subsidy System of Renewable Energy Development with a focus on Small Hydro Power

2-4-1. Summary of the government objectives for hydroelectric power

As noted earlier, the second Fast Track Program aimed to develop 1204MW by hydroelectric power and to introduce Feed-in-Tariff (FIT) for renewable energy of 10MW or less including small hydro.

The term for power purchase is not defined in the regulation, but about 10-20 years can be seen in the power purchase agreement generally, providing long-term stable power sales expectations. The FIT is applied to all renewable energy of 10MW or less, excluding geo-thermal which could be bigger to be qualified. Power plants over 10MW must negotiate directly with PLN for a PPA price. As the negotiation is often protracted, the risk of the project failing for those over 10MW is larger than those of 10MW and less. It is said that the size to be qualified for FIT may expand up to 15MW from 10MW.

At the conference held in September 2013, senior official of MEMR explained that FIT price for small hydro is being reviewed to be revised soon. The discussion is continued between MEMR and PLN where MEMR shoots for about 20% increase while PLN hopes to minimize the level of increase. Consequently, there is a need to seek timely information from the government and authorities concerned.

Table 2-9 FIT Pricing Structure

System	Hydro Wind Solar Power etc. (<10MW)		Biomass (<10MW) (*)		Thermal
	Medium Voltage (Rp/kWh)	Low Voltage (Rp/kWh)	Medium Voltage (Rp/kWh)	Low Voltage (Rp/kWh)	High Voltage (USD/kWh)
Java, Maudra, Bali	656	1,004	975	1,325	9.7cent ⇒11〜15cent
Sumatera, Sulawesi	787	1,205	1,170	1,590	
Kalimantan, Nusa Tenggara	853	1,305	1,268	1,723	
Maluku, Papua	984	1,506	1,463	1,988	

Source: The Regulation of Ministry of Energy and Mineral Resources No. 4 Year 2012

(*) The price varies if final disposal technology is used.

2-4-2. Preferential Tax Treatment

In order to promote the second Fast Track Program, which focuses on renewable energy, the Indonesian government issued preferential tax treatments for renewable energy power producers through the regulation of the Minister of Finance number 24/PMK.011/2011 dated January 29th 2010. The target businesses were those of geo-thermal, wind, biomass, solar PV, hydro, ocean current and ocean thermal generation. The preferential treatments are defined as a deduction of 30% of investment amount from taxable income, the shortening of the depreciation period of assets, exemption of value-added tax and import duties for imported machinery and equipment.

Table 2-10 Preferential Tax Treatment

Income Tax Credit	Deduction from taxable amount which is 30% of investments (Each year 5% deduction for 6 years)
	Shortening of amortization period of fixed assets
	Lower 10% of withholding tax against overseas profit transfer
	The period of carry-over of losses extends up to 10 years.
Exemption from Value-Added Tax	Exemption from Value-Added Tax when strategic related machines and equipment are imported
Exemption from Customs Duty	Exemption from customs duty of related machines and equipment

Source: JETRO Website[12]

The tax rate on the fund transfer is defined as the following by the Tax Treaty between Japan and Indonesia.

Table 2-11 Tax Treaty between Japan and Indonesia

Interest Tax		10%
Distribution Tax	Investment ratio over 25%	10%
	Investment ratio under 25%	15%
Royalty Tax on Transfer		10%

Source: JETRO Website[13]

In the Economic Partnership Agreement between Japan and Indonesia, elimination of tariffs in the power sector was put on hold, but it stated that 1) there will be no tightening of the regulation in the future and 2) there will be revisit to the regulation every three years.

[12] JETRO Website http://www.jetro.go.jp/jfile/report/07000456/indonesia_kankyo_seisaku.pdf (Jan 21st 2014)
[13] JETRO Website http://www.jetro.go.jp/world/asia/idn/invest_04/ (Jan 21st 2014)

2-5. Interests and Trends of Domestic and Foreign Investors in Renewable Energy Development, Especially in the Small Hydroelectricity Sector

It has been confirmed that Pusat Investasi Pemerintah (PIP - the Indonesian Investment Agency) whose main task is to invest infrastructures and PLN are currently supporting constructions of renewable energy power plants in Indonesia. Among the various renewable energy sources, they place a strong emphasis on small hydro and biomass projects in addition to geothermal. PIP can consider providing loans to IPP projects having PPAs with PLN[14]. However, PIP's area of focus for project support may change every year. Up to December 2013, PIP has not made any investment into renewable energy power project including small hydro.

There are some local energy companies in fossil fuel related business that plan to come into the renewable energy business including small hydro for corporate social responsibility or portfolio diversification. PT Sumberdaya Sewatama, which is one of the major local energy companies and subsidiary of PT ABM Investama Tbk, a public listed company with coal value chain from coal mining concession to coal fired IPP, is one example of local energy company planning to penetrate into renewable energy business[15].

On the other hand, although some support programs for renewable energy are being developed as explained above, the development of small hydro power projects by local companies has not necessarily seen much of the progress. There are mainly two issues behind this situation. Firstly, as explained in 1-2, project finance scheme is not regularly utilized, and local banks look at credit of the project owner rather than the project itself, creating difficult environment for small and medium size companies. There are local banks financing to small scale project owners for around 8 years with about 13% interest. However, some it is difficult for the project owner to pay back the debt immediately after commencement of commercial operation. Therefore, it is necessary for the project to be financed with balloon type loan in order not to go default.

Secondly, because small hydro power business became open for private company recently, many of the project owners are new entrants without good understanding of the importance of the engineering in the project. In order to meet the formal requirements, some project owners assign local technical consulting companies who can provide a report very quickly regardless of quality. Proceeding with this kind of FS is likely to create problems such as re-doing surveys, changing layouts, or acquiring additional land, resulting in longer time to actually develop it the project. As such, the financial and technical issues are there while some support programs and investments from overseas have been deployed.

The United States Department of Energy has indicated their intention to invest 1.2 million U.S.

14 Kabar24 HP, Access Aug,16th 2012
15 ABM Investama. "Annual Report 2012"

dollars in the renewable energy sector through the Sustainable Energy for Remote Indonesia Grids (SERIG), and is planning to cooperate with the Indonesian government in this field[16]. United States Agency for International Development (USAID) also agreed with the National Development Planning Agency (BAPPENAS) that they would invest renewable energy sectors in USD 332 million through the Green Prosperity Project by Millenium Challenge Corporation.[17]

In Germany, one of the leading countries in the field of renewable energy, 8 companies (EnBW AG, Ribelga Deutschland GmbH, Schnell Motoren AG, Suma GmbH, Consulectra GmbH, Maxxtec AG, Putmeister Solid Pumps GmbH, Pto2 Anlagentechnik GmbH) participated in German-Indonesia renewable energy conference in 2011, with many showing a strong interest in this field for investments in Indonesia[18].

As examples of foreign investments into Indonesian renewable energy projects, some state owned companies including following countries have made investments in IPP business. From China, China Power Investment, a Chinese state-owned company, announced its plan to invest about Rp. 17 billion together with the Chinese cement company into some hydro IPP projects in North Kalimantan totaling about 7GW[19]. From Korea, Korea Midland Power, a state owned generation company, is developing 284MW hydro power plant, Muara Juloi hydro power project, and signed MOU with PLN in April 2013.

As for Multilateral Development Bank, Asian Development Bank (ADB) is planning to actively become involved in the power sector in Indonesia by providing loans. ADB is planning to give USD 250 million loan to Sarulla geothermal power project (330MW) in North Sumatra developed by the Japanese companies and US plant manufacturer and also USD 2 million technical support grant to three hydro power repowering projects in West Papua in East Indonesia. ADB also approved providing a loan of USD 4.95 million to 220km 500kV transmission line in the Java-Bali grid along with substations, as well as 145km transmission line in West Kalimantan which enables electricity supply from hydro power plants in Malaysia. Other trend includes IFC's investment into Indonesian and foreign private equity funds so as to support renewable energy development[20] and IFC also announced its plan to support wind IPP last year.

As described above, the field of renewable energy in Indonesia is becoming recognized as having a high potentially both government agencies and private companies worldwide.

---

[16] Eco-Business. http://www.eco-business.com/news/indonesia-aims-boost-electricity-capacity-renewable-energy/ 24th Jan 2014

[17] US Department of State. Website. http://www.state.gov/r/pa/prs/ps/2012/09/197980.htm 24th Jan 2014

[18] The Jakarta Post, Oct, 25th 2011

[19] The Jakarta Glove, May 29th 2013

[20] IFC Website, Accessed 2013

Chapter.3 Selection Process of the Project

In this research, one of the subjects of research is the following project; Lae Ordi II project which PT. Bakara Bumi Energi develops in North Sumatra. This project already acquired Izin prinsip and Izing Lokasi from Bupati, entered into PPA with PLN. It was chosen due to above conditions that the project has high possibility of being implemented in comparison with other potential projects in Indonesia.

Table 3-1 Researched Projects

No.	Name of Project	Location	Generating Method	Output	Maximum Discharge	Effective Head Differences	Electricity Generation
				MW	m^3/s	m	MWh/y
1	Lae Ordi II	North Sumatra	Run of River	10.0	11.43	106.4	76,531

Figure 3-1 Location of Lae Ordi II Project

Chapter.4 Lae Ordi II Project

4-1. Planning of Business and Funding Scheme

In order to identify and solve the challenges facing the realization of candidate projects, this section aims to evaluate the business scheme of the candidate projects and the validity of the funding schemes available to them, including JICA Private Sector Investment Finance Scheme.

4-1-1. Business Scheme Evaluation

4-1-1-1. Identifying the Optimum Project Structure

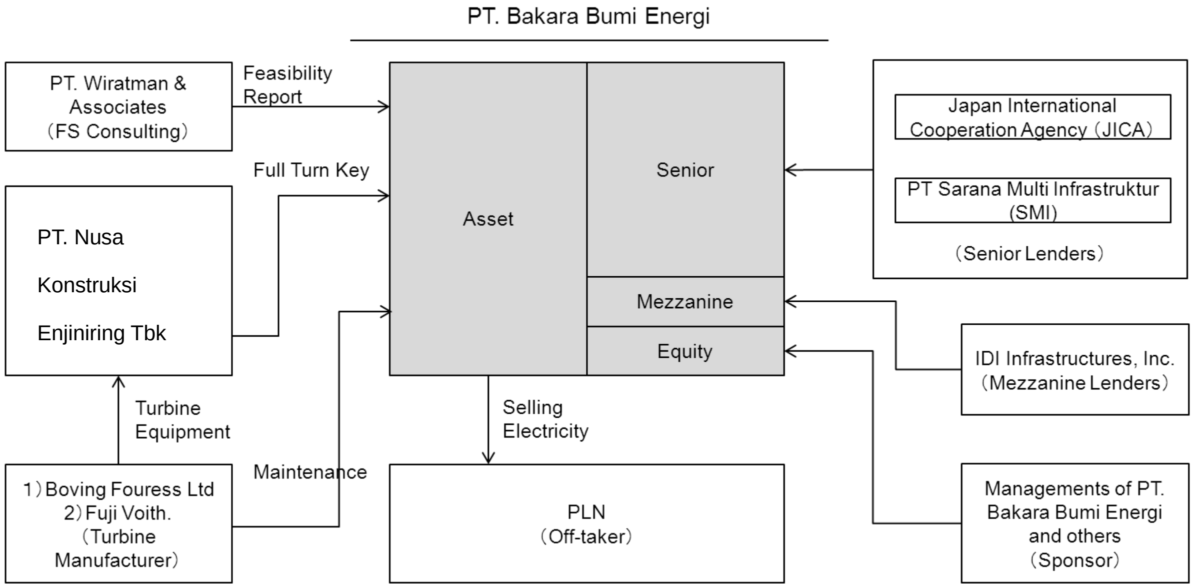


Figure 4-1 Finance Scheme

The Lae Ordi II Project is the hydropower project with its installed capacity of 10,000kW located in North Sumatra in Indonesia. PT. Bakara Bumi Energi (Bakara Bumi), the project company, has involved not only in small hydro business but also a 20 MW gas engine power plant in Manado and a 25 MW gas engine power plant in Makassar. The management of the company has experience in developing and constructing a 5 MW hydropower plant in Indonesia. Highlighted features of the project are that: 1) Bakara Bumi has obtained a 20 years fixed price PPA (Power Purchase Agreement) with PLN (the state owned electricity company), 2) the main contractor will be assigned with a full-turnkey basis by PT Nusa Konstruksi Enjiniring Tbk (NKE), 3) the turbine will be either Boving Fouress Ltd from India or Fuji Voith from Japan, 4) the financing structure will be with JICA and PT Sarana Multi Infrastruktur (SMI) as the senior lender and IDI Infrastructures Inc. (IDI-I) as the mezzanine lender under the current circumstance. One of the investment officers in SMI and the owner of Bakara Bumi has already conducted a meeting and SMI has conducted a review of the project. As for the equity, it is expected that Bakara Bumi will inject equity approximately 20% of the total project cost: mainly the owner of Bakara Bumi, Mr. Mahjuddin and other existing shareholders will inject equity amount.

4-1-1-2. Status of Permits, Licenses and a PPA

In general, project owners of a small power look for potential sites through personal networks such as influential in local communities, local PLN and Bupati (local government regent). After the potential site is identified, first step is to apply for the Izin Princip (Research Permit) for a field survey. It approximately takes 1 or 2 months to be formally approved by Bupati in the application process. Depending on the project, the owners may apply for the Izin Lokasi (Location Permit) issued by Bupati to secure the land usage of the potential site. The environmental assessment (UKL/UPL) is subsequently required. It shall be made by the owners and approved by Bupati.

Bupati shall not allow issuing the Research Permit and the Location Permit for several owners at the same location. In other words, it is important to obtain these permits to secure the project and prevent from others taking over. Next step is to apply for an IUKU issued by Ministry of Energy and Mineral Resources (MEMR) for the purpose of public electricity business license. Simultaneously, the owners discuss with local PLN regarding grid connection prior to a PPA signing. Lastly, the owners must obtain an IMB (Izin Mindirikan Banyunan Bupati), a detail engineering permit, before the commencement of constructing works.

In Lae Ordi II project, the owner plans to lease the land instead of acquiring. It is largely because the site is governed by the Ministry of Forestry. It is necessary to apply for a permit the Izin Penjam Pakan Kawasan Hutan (IPPKH), for leasing the land, and the owner has already obtained the permit.

Table 4-1 List of Bakara Bumi's Obtaining Progress of Approval and License

Types of Approval and License	Issuer	Outline	Progress
Research Permit	Bupati	Permit for conducting Pre-FS and FS	Already Obtained
Location Permit	Bupati	Permit for doing business in the specified area[21]	Already Obtained
UKL/UPL	Bupati	Plan for environment management and plan environment monitoring that requir es approval for project implementation	Already Obtained
IUKU/IUPTL	MEMR	Permit for doing electricity supply busin ess for public interest	Already Obtained
PPA	PPA	Power purchase agreement with PLN	Already Obtained
IPPKH (Land leasing permit)	Forestry Ministry	Permit necessary in case of leasing area of land belonging to Foreign Ministry	Already Obtained
IMB (Building Permit)	Bupati	Permit for detailed designs and start co nstruction	To be obtained

[21] Location permit is not a requirement for conducting electricity supply business, but in order to prevent someone else also acquiring the land and develop for the same purpose, a developer usually obtain the permit for the business in the area from Bupati

4-1-2. Evaluation of the Project Owner

4-1-2-1. Company Overview

Table 4-2 Company overview of Bakara Bumi

1	Company Name	✓ PT. Bakara Bumi Energi (Bakara Bumi)
2	Date of Establishment	✓ August 19 2008
3	Type of Business	✓ Gas-engine power development and operation ✓ Small hydro power development and operation
4	Shareholder Composition	✓ Mr. Ir Don Ardner Mahjuddin：IDR 8billion（8,000 shares） ✓ Mr. Arry Ridwan Haryanto：IDR 8billion（8,000 shares) ✓ Mr. Taufik Mahjuddin：IDR 4billion（4,000 shares）
5	Numbers of Employee	✓ Approximately 40 employees
6	Location of Head Office	✓ J1 Danau Jempang B 3/27, Jakarta, Indonesia

4-1-2-2. Financial Status

According to the audited financial statements of Bakara Bumi, total assets are approximately IDR 186.7 billion as of December 31, 2012 (approximately JPY 1.679 billion under the exchange rate of December 31 2012). The share capital is IDR 20 billion (approximately JPY 180 million). In 2012, the gas-engine power plant in Makassar had not operated throughout the year, and the gas-engine power in Manado was still under construction. For this reason, the net loss falls into approximately IDR 22 billion (approximately JPY 198 million). It is, however, expected that the net profit in 2013 will improve due to the stable operation of the power plants.

4-1-2-3. Track record

Lae Ordi II Project is the first small hydro project for Bakara Bumi. It is noted that the managements have experience in developing/constructing a 5MW of small hydro power plant in north Sumatra in addition to having being involved in the gas-engine power plants in Makassar and Manado. It shows that the managements have sufficient experiences regarding power businesses, showing that the gas engine power business and Lae Ordi II Project, a small hydro power business have similar characteristics and high relevance to the business development. It is expected that around 20% of necessary equity amount out of total project cost will be covered by current existing shareholders including the owner of Bakara Bumi, Mr. Mahjuddin; hence, it is confirmed that there is the sponsor taking a responsibility for this project in terms of financial aspects.

Bakara Bumi has experience in operating gas engine power plants by using own internal engineers, and it is therefore that Bakara Bumi has ability to perform well in terms of technical aspects.

4-1-2-4. Mid-term Strategy and Business plan

Bakara Bumi currently develops other small hydro projects to increase the total capacity (MW). Bakara Bumi also plants to develop larger size hydro projects in mid to long term.

4-1-3. Evaluation of the Off-taker

In this project, the off-taker is the State Electricity Company of Indonesia, the Perusahaan Listrik Negara ("PLN")

- Date of Establishment: October 27, 1945
- Shareholder Composition: 100% Indonesian Government
- Numbers of employees: 47,615 (December 2011)
- Management profile: Composed of seven directors. The president commissioner is from the MEMR, with other commissioners from the former vice-president of the International Monetary Fund (IMF) to the head of the Jakarta Police Department, showing the wide variety of personnel from various backgrounds.
- Business overview: PLN is legally authorized to have power generation, transmission line, and distribution line in a vertical integration business structure dominating the power market of Indonesia. Power generation is managed by its subsidiary companies and IPPs (Independent Power Producer) whereas PLN as a monopoly over power transmission and power distribution. PLN's market share for the capacity of power generation capacity in Indonesia is 85% (4,934MW) and its share in power transmission is 100% (36,741km of transmission network) and power distribution is also 100% (685,785km network). Currently, in order to promote private investment, Indonesian Government is supporting investment for IPPs by implementing a long term PPA.
- Financial status as of 2011 fiscal year: Sales – approximately IDR 208 trillion, net income approximately IDR 7 trillion (approximately JPY 1.9 trillion and JPY 62.9 billion, respectively under the exchange rate of December 31 2012).

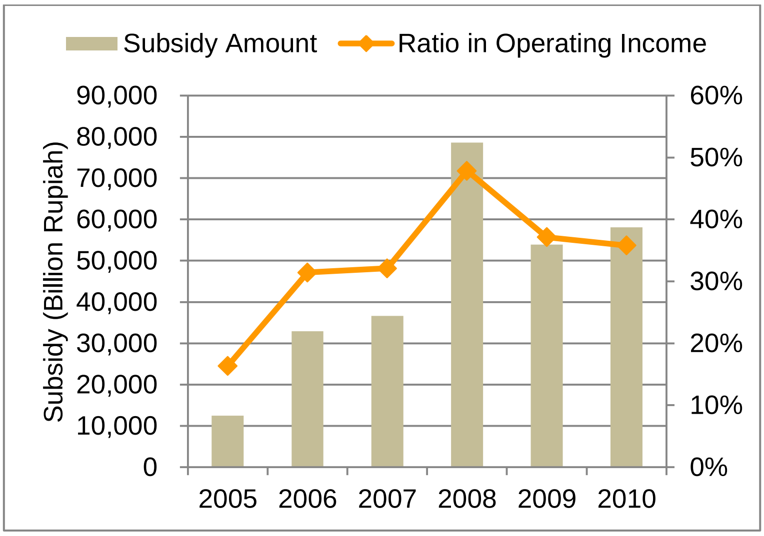


Figure 4-2 Subsidy PLN Receive from Government and its Ratio in Operating Income

The credit rating of the Indonesian government bond has been raised to investment grade by multiple rating companies.

Table 4-3 Credit Rating of Indonesian Government Bond

Rating Company	Rating	Forecast
Standard & Poor's	BB + (Investment Grade -1)	Stable
Moody's	Baa 3 (Investment Grade)	Stable
Fitch	BBB - (Investment Grade)	Stable

Source: Websites of Rating Companies

4-1-4. Evaluation of the Current Project's EPC Contractor and Turbine Manufacturer

The EPC contractor and turbine manufacturer candidates of this project are as follows:

4-1-4-1. EPC Contractor

(1) PT Nusa Konstruksi Enjiniring Tbk (NKE)[22]

- Company Overview: the company was established in 1982. Initially, it started by providing engineering and construction services mainly for commercial infrastructure in Indonesia. The company obtained ISO 9001 in 2000, ISO 14001 in 2008, and SMK3L in 2006. In 2007, the company became listed on the Indonesia Stock Exchange and in 2008 expanded its business to mining construction and its market coverage to Brunei and East Timor in 2009. In 2010, the company entered into energy business. In 2011, the company set up a subsidiary named PT. Duta Inti Energi in order to enter into the renewable energy market, especially in small hydro.
- Shareholder composition: PT. Lintas Kebayoran Kota, an Indonesian legal entity holds 33%. PT. Rezeki Segitiga Emas holds 9%. Hudson River Group Pte Ltd, Singapore marketing company holds 15%, and the rest 33% is held by other investors.
- Number of employees: 1293
- Management Profile: the board of directors contains 5 directors, and 4 of them spent more than 6 years at current positions. Administrative board contains 8 administrative officers. 3 of them spent more than 15 years, and other 4 of them spent 5 years at current positions. Both board of directors and administrative board are operated by experienced officers.
- Financial Status: As of Dec. 31, 2012 Revenue – IDR 1.099 trillion. Operating profit – IDR 60.8 billion. Total assets: IDR 1.485 trillion. (Approximately JPY 9.9 billion, JPY 0.55 billion and JPY 13.4 billion respectively, according the exchange rate of December 31 2012)

In this project, Bakara Bumi selects NKE as a potential candidate. The further discussion will be

[22] PT Nusa Konstruksi Enjiniring Tbk HP http://nusakonstruksi.com/

conducted. In this process, it is important to confirm the background of engineers in the project team and track record of small hydro projects in addition to the information above.

4-1-4-2. Turbine Manufacturer

(1) Boving Fouress Ltd

- Company Overview: the company was established in India as a joint venture company between Fouress Engineering and GE Energy in 1985. The core business covers production of turbines, power generators, and control devices for small hydro power size up to 20 MW.
- Shareholder: Fouress Engineering and GE Energy
- Number of Employees: over 100 (Detailed number of employees is not disclosed)
- Management Profile: N/A
- Financial Status: N/A

(2) Fuji-Voith Hydro

- Company Overview: the company was established in 1997 as a joint venture company between Voith Siemens and Fuji Electric. This company widely manufactures in the size of 50kW-Micro water turbine up to 500MW scale of large water turbine including power generator and peripheral equipments. Fuji-Voith Hydro acquired the line of business of hydropower equipment from EBARA Corporation in June 2011. Currently, the company reinforces marketing and sales forces in Asia, aiming at the annual sales of 10 billion yen.
- Shareholder Composition: Fuji Electric and Voith Hydro, each owns half of stocks.
- Employee: N/A
- Management Profile: N/A
- Financial Status: Sales－Approximately 6 billion JPY(No Disclosure regarding other financial status)

In this project, Bakara Bumi selects 1) Boving Fouress Ltd and 2) Fuji-Voith Hydro as potential candidates. Further consideration is necessary, and it is important to confirm with background of engineers in the project team and track record of small hydro installment in addition to the information above.

4-1-5. Analysis of Financials and Investment Effect

4-1-5-1. Analysis of Cash flow of the Business

(1) Financial Arrangements

Bakara Bumi currently assumes that the total project cost is approximately IDR 260,620 million. In the financial structure, PT Sarana Multi Infrastruktur (SMI), state owned financial institution, and Japan International Cooperation Agency (JICA) are potential candidates for senior lenders. One of the investment officers in SMI and the owner of Bakara Bumi had a meeting in 25th June 2013, and SMI has conducted a review for the project. For the senior and mezzanine finance, the prospective lender’s terms are: 2 year grace period, 7 year repayment period after the commercial operation. Interest

During Construction (IDC) is provided by the senior and mezzanine lenders. The type of mezzanine finance is to have a convertible right with subordinated bonds. In other words, Bakara Bumi issues the convertible bonds, and IDI-I underwrites them all.

Overall capital structure at this stage comprise with around 70% of total project cost that comes from the senior lenders; the potential candidates are JICA and SMI providing same amount of principle to the project, and around 10% of total project cost will be covered by IDI-I as mezzanine finance, and around 20% of total project cost will be injected by current existing shareholders.

Detail information regarding financial structure is listed below.

Table 4-4 Details of Financial Arrangement

PT. Bakara Bumi Energi - Financial Arrangements for Lae Ordi II Project

Unit: million IDR

Asset		Liabilities	
EPC Cost & Others	226,140	Senior Loan (Principal)	
Interests during Construction		SMI	81,000
SMI	10,987	JICA	81,000
JICA	9,890	Senior Loan (Interests)	
IDI-I	5,160	SMI	9,801
		JICA	8,910
		Mezzanine Finance (Principle)	
		IDI-I	21,754
		Mezzanine Finance (Interests)	
		IDI-I	4,307
Compensate Balance (DSRA)	4,928	Net Assets	
Others	3,515	Net Assets	53,847
Total Assets	260,620	Liabilities & Net Assets	260,620

Unit: million IDR

Investors	Amounts	%
SMI	90,801	34.84%
JICA	89,910	34.50%
IDI-I	26,061	10.00%
Sponsor	53,847	20.66%
Total	260,620	100.00%

Unit: million IDR

Funding Method	金額	%
Senior Loan	180,711	69.34%
Mezzanine Finance	26,061	10.00%
Equity	53,847	20.66%
Total	260,620	100.00%

The total project cost breakdown is as follows. Noted is that the EPC cost is calculated by a local consulting company applying the cost based on local standard.

Table 4-5 Total project cost breakdown

Unit: IDR MM

Total project cost breakdown	Cost amount
Development cost	6,825
EPC cost	219,315
waterway	178,278
intake, weir	19,383
power house, turbines	13,325
penstocks	4,783
tailrace, etc.	3,546
IDC (SMI, JICA, IDI-I)	26,037
DSRA	4,928
Others	3,515
Total project cost	260,620

(2) Basic Assumptions

Basic assumptions are listed below. Noted importantly that the assumptions are based on information proved by the owner or just estimate reasonably predicted at this moment.

Table 4-6 Detailed Conditions

Base Item	Details	Unit	Value	Detail
Basic Specification				
	Installed capacity	kW	10,000	reference by PPA
	Annual power production	kWh	76,441,000	reference by conducted study *table4-22 Annual Available Power Energy
	Power Selling Price (Y1 - Y5)	IDR / kWh	878	reference by PPA
	Power Selling Price (Y6 - Y20)	Year	714	reference by PPA
	Annual Power Selling Revenue (Y1 - Y5)	million IDR	67,115	
	Annual Power Selling Revenue (Y6 - Y20)	million IDR	54,603	
Loan Condition				
	Senior Loan (SMI)			
	The Amount of Loan	million IDR	94,399	*detail shall be discussed (suppose that JICA and SMI provide same amount of principle)
	Interest	% / year	11.00%	*detail shall be discussed
	Period of deferment for Principle	Year	2	expected construction period
	Repayment Period	Year	7	usual repayment period
	Senior Loan (JICA)			
	The Amount of Loan	million IDR	89,910	*detail shall be discussed (suppose that JICA and SMI provide same amount of principle)
	Interest (Yen Rate 3%+SWAP rate7% addition)	% / year	10.00%	*detail shall be discussed
	Period of deferment for Principle	Year	2	expected construction period
	Repayment Period	Year	7	usual repayment period
	Mezzanine Loan (IDI-I)			
	The Amount of Loan	million IDR	26,337	*detail shall be discussed (suppose that IDI-I provids 10% amount out of total project cost)
	Interest	% / year	18.00%	*detail shall be discussed
	Period of deferment for Principle	Year	2	expected construction period
	Repayment Period	Year	7	usual repayment period
Opearational Cost				
	Cost of water-use	IDR / kWh	5	based on informaton provided by the owner
	Opearational Cost	million IDR	3,800	referece by other similar project cost
	Insurance Cost	million IDR	650	referece by other similar project cost

(3) Business Plan（Financial Statements）

The 10 years after the commercial operation business forecasts of the project consisting of an income statement, a balance statement, and a cash flow statement are shown below. If the operation of the plant runs well along with the predication, the repayment of senior and mezzanine would be made throughout the periods by the source of stable income selling electricity to PLN. The revenue of this project is heavily relied on selling electricity to PLN, and its selling price is agreed on PPA which is determined by FIT.

Table 4-7 Business Plan(Financial Statements)

Income Statement		Y 2013	Y 2014	Y 2015	Y 2016	Y 2017	Y 2018	Y 2019	Y 2020	Y 2021	Y 2022	Y 2023	Y 2024
Unit: million IDR		-2 nd	-1 st	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th
Income	Revenue	0	0	67,115	67,115	67,115	67,115	67,115	54,603	54,603	54,603	54,603	54,603
	Expenses	0	0	30,254	30,471	30,700	30,940	31,191	31,456	31,733	32,025	32,331	32,650
	Gross Profit	0	0	36,861	36,644	36,415	36,176	35,924	23,148	22,870	22,578	22,272	21,953
	Sales Administrative Expense	100	100	100	105	110	116	122	128	134	141	148	155
	Operational Profit	-100	-100	36,761	36,539	36,305	36,060	35,802	23,020	22,736	22,438	22,125	21,798
	Non-Operating Expense	0	0	25,489	22,940	20,391	17,842	15,293	11,470	6,372	0	0	0
	current earnings	-100	-100	11,272	13,599	15,914	18,218	20,509	11,550	16,364	22,438	22,125	21,798
	Corporate Tax	0	0	0	0	0	0	0	2,887	4,091	5,609	5,531	5,449
	After-tax Income	-100	-100	11,272	13,599	15,914	18,218	20,509	8,662	12,273	16,828	16,594	16,348

Balance Sheet		Y 2013	Y 2014	Y 2015	Y 2016	Y 2017	Y 2018	Y 2019	Y 2020	Y 2021	Y 2022	Y 2023	Y 2024
Unit: million IDR		-2 nd	-1 st	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th
Assets	Total Assets	73,613	263,095	253,303	245,837	240,686	237,839	226,751	193,284	152,895	65,810	65,810	65,810
Liabilities	Long-term Debts (Senior)	18,431	184,309	165,878	147,448	129,017	110,586	82,939	46,077	0	0	0	0
	Long-term Debts (Mezzanine)	2,634	26,337	23,703	21,070	18,436	15,802	11,852	6,584	0	0	0	0
	Fixed Liabilities	21,065	210,647	189,582	168,517	147,453	126,388	94,791	52,662	0	0	0	0
Capital	Total Capital	52,548	52,448	63,721	77,319	93,234	111,451	131,960	140,623	152,895	65,810	65,810	65,810
	Liabilities and Capital	73,613	263,095	253,303	245,837	240,686	237,839	226,751	193,284	152,895	65,810	65,810	65,810

Cash Flow Statements		Y 2013	Y 2014	Y 2015	Y 2016	Y 2017	Y 2018	Y 2019	Y 2020	Y 2021	Y 2022	Y 2023	Y 2024
Unit: million IDR		-2 nd	-1 st	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th
Operational Cash Flow		-100	-100	36,791	39,117	41,432	43,736	46,027	34,181	37,791	42,347	42,112	41,865
Investment Cash Flow		-47,777	-207,406	0	0	0	0	0	0	0	0	0	0
	EPC Cost	-45,228	-180,912	0	0	0	0	0	0	0	0	0	0
	IDC (Senior)	-1,937	-19,375	0	0	0	0	0	0	0	0	0	0
	IDC (Mezzanine)	-474	-4,741	0	0	0	0	0	0	0	0	0	0
	Others	-137	-2,378	0	0	0	0	0	0	0	0	0	0
Financial Cash Flow		73,713	182,170	-20,534	-20,534	-20,534	-21,587	-31,854	-42,121	-46,072	-103,914	-16,594	-16,348
	Long-term Debts (Senior)	18,431	165,878	-18,431	-18,431	-18,431	-18,431	-27,646	-36,862	-46,077	0	0	0
	Long-term Debts (Mezzanine)	2,634	23,703	-2,634	-2,634	-2,634	-2,634	-3,951	-5,267	-6,584	0	0	0
	Others	0	-7,412	531	531	531	-522	-257	9	6,590	0	0	0
	Capital	52,648	0	0	0	0	0	0	0	0	0	0	0
	Dividend Payment	0	0	0	0	0	0	0	0	0	103,914	16,594	16,348
Changes in Cash		25,836	-25,336	16,257	18,583	20,898	22,149	14,174	-7,940	-8,281	-61,567	25,518	25,516
Cash at the beginning		0	25,836	500	16,757	35,340	56,238	78,388	92,561	84,621	76,341	14,774	40,292
Cash at the end		25,836	500	16,757	35,340	56,238	78,388	92,561	84,621	76,341	14,774	40,292	65,808

(4) Investment return and sensitivity analysis

Based on the business plan as the base case, Equity IRR, average DSCR (senior) and Financial IRR will be calculated with conducting of sensitivity analysis shown as follows:

Table 4-8 Investment return and sensitivity analysis

Case	Equity IRR	Average DSCR (senior)	Financial IRR
Base case	18.89%	1.55	19.50%
EPC cost increased by 10%	16.32%	1.54	17.16%
Price increased by 10%	17.74%	1.53	18.79%
SWAP rate increased by 10%	18.68%	1.52	19.43%
Power production decreased by 10%	16.22%	1.38	16.90%

Even in the event of power production decreased by 10%, Equity IRR still remains above 16%; average DSCR is over 1.3 and Financial IRR is more than 15%; hence, it is considered as attractive project from the stand point of investors.

(5) Economic analysis (Economic IRR calculation)

Economic IRR is an indicator to analyze the performance of efficiency in allocating the national economic resources. In Economic IRR, expenses are considered as something that decreases the national income; revenues are, on the other hand, considered as something that increases the national income. First of all, the Standard Conversion Factor (SCF), a factor that applies when converting non tradable commodities into international standardized price, shall be calculated:

SCF=（I+E） / [（I+Id）+（E+Ed）]

I：Total import amounts (CIF)

E：Total export amounts (FOB)

Id：Total import duties

Ed：Total export duties

Table 4-9 Standard Conversion Factor (SCF)

Unit: billion IDR

Items	Y 2007	Y 2008	Y 2009	Y 2010	Y 2011	5 years ave.
Total import	3,961	22,764	18,105	19,759	28,856	18,689
Total export	16,976	0	0	0	25,266	8,448
Total import duties	942,431	1,032,278	932,249	1,074,569	1,221,229	1,040,551
Total export duties	756,895	833,342	708,529	831,418	942,297	814,496
SCF	0.99	0.99	0.99	0.99	0.98	0.99

Source: JETRO and World Bank, World Development Indicators

Economic expenses are calculated as follows. Civil costs are local currency expenses, and turbines and electrical equipment are foreign currency expenses. In economic expense, tax and interest expense are not considered as a decrease of national resources; hence, it can be ignored.

Table 4-10 Economic expenses

＜Economic expenses＞ Unit: million IDR

No.	Cost items	Foreign currnecy	Economic expense (1)	Local currnecy	SCF	Economic expense (2)	Total (1)+(2)
1	Civil cost	-	-	212,815	0.99	210,687	210,687
2	Electrical and turbine cost	13,325	13,325				13,325
3	Others (lawyers, etc.)	700	700				700
4:1+2+3	Total economic expenses	14,025	14,025	212,815		210,687	224,712

Economic revenues are based on the replacement reduction values of diesel engines and small hydro selling price.

Table 4-11 Economic revenues

＜Economic revenues＞

No.	Items	Unit	Value
1	Diesel engine cost	IDR / kWh	3,470
2	PPA price of small hydro	IDR / kWh	755
3:1-2	Replacement deduction unit revenue	IDR / kWh	2,715
4	Transmitted power generation	kWh / Year	76,441,000
5:3*4	Replacement deduction value	MM IDR / Year	207,524

Source: PLN. “PLN Statistics 2010”

The cash flow statement including Economic expenses and Economic revenues is as follows. Operational costs are based on costs in other similar projects and price escalation shall not be considered as it is not affect resource consumption.

Table 4-12 Cash Flow

＜Economic expenses＞ Unit: million IDR

No.	Cost items	Foreign currency	Economic expense (1)	Local currency	SCF	Economic expense (2)	Total (1)+(2)
1	Civil cost	-	-	212,815	0.99	210,687	210,687
2	Electrical and turbine cost	13,325	13,325				13,325
3	Others (lawyers, etc.)	700	700				700
4:1+2+3	Total economic expenses	14,025	14,025	212,815		210,687	224,712

＜Economic revenues＞

No.	Items	Unit	Value
1	Diesel engine cost	IDR / kWh	3,470
2	PPA price of small hydro	IDR / kWh	755
3:1-2	Replacement deduction unit revenue	IDR / kWh	2,715
4	Transmitted power generation	kWh / Year	76,441,000
5:3*4	Replacement deduction value	MM IDR / Year	207,524

<Cash flow statement> Unit: million IDR

Year	Initial cost	Operation cost	Total cost	Revenue
1	44,942		44,942	
2	179,769		179,769	
3		3,770	3,770	207,524
4		3,770	3,770	207,524
5		3,770	3,770	207,524
6		3,770	3,770	207,524
7		3,770	3,770	207,524
8		3,770	3,770	207,524
9		3,770	3,770	207,524
10		3,770	3,770	207,524
11		3,770	3,770	207,524
12		3,770	3,770	207,524
13		3,770	3,770	207,524
14		3,770	3,770	207,524
15		3,770	3,770	207,524
16		3,770	3,770	207,524
17		3,770	3,770	207,524
18		3,770	3,770	207,524
19		3,770	3,770	207,524
20		3,770	3,770	207,524
21		3,770	3,770	207,524
22		3,770	3,770	207,524
計	224,712	75,400	300,112	4,150,481

Economic IRR calculated by the above cash flow is 78.5%, and the average social discount rate is considered as 12%; therefore, this project shall bring add value to the nation.

(6) Operational Performance Indicator

The following is the operational performance indicator to monitor the power plant. The down time ratio and transmission loss etc. are estimates as well as capacity factor and power generation. After the commercial operation, monthly monitoring these indicators shall be conducted.

Table 4-13 Operational Performance Indicator

Indicators	Value
Down time ratio by trouble shooting, etc.	5% of expected power generation
Transmission loss and self consumption, etc.	2% of expected power generation
Capacity factor	87.26%
Transmitted power generation (kWh)	76,441,000
Installed capacity (kW)	10,000

4-1-6. Review on Business Risks and Contract Conditions

4-1-6-1. Risks associated with projects and considerations on a security package

The general business risks and evaluations on project finance are as follows:

Table 4-14 Operational Performance Indicator

1	Sponsor risk (evaluation of sponsor)	✓ The majority of shareholder is Mr. Mahjuddin, the owner of Bakara Bumi, so there is management risk heavily relied on Mr. Mahjuddin. ✓ The owner of Bakara Bumi, Mr. Mahajuddin, has experience in developing, constructing of a 5MW small hydro project in North Sumatra. Also, Bakara Bumi has already proven track record in operating of gas engine project in Makassar and constructing in the Manado gas engine project as well. The company of Bakara Bumi has well know-how and experience in IPP businesses. ✓ It is expected that around 20% of equity amount will be covered by existing shareholders mainly Mr. Mahjuddin; therefore, it is seen the commitment of the sponsor showing its responsibility for this project from the financial aspects. ✓ It is expected to have personal guarantee to Mr. Mahjuddin during the construction period so as the sponsor to be responsible for this project in case unexpected cost overrun happens. ✓ For supplemental information, one of the candidates in senior lender of this project, SMI, has experience to provide loans to a 7.5MW small hydro project in West Sumatra while the developer does not have experience in developing IPP business. SMI sees the developer from the aspect of being capable of contractor and ask the developer to utilize international consulting company to review hydrology and FS report and EPC management to minimize the risk of the project.
2	Construction /	✓ At this moment, NKE is a candidate of potential EPC contractor but

	technical risks (evaluation of EPC contractor)	detail discussion has not yet conducted. Bakara Bumi has asked one of the well know international technical consulting company called AECOM for the feasibility review, and Bakara Bumi has considered to utilize some of the EPC contractor that AECOM has relationship with, so the EPC contactor's detail in technical, financial and contract, will be confirmed and evaluated in the selection timing.
3	Operational risk (evaluation of operators)	✓ Operation in small hydro is simple unlike thermal plants. Bakara Bumi plans to utilize local stuff for security and basic operation, and will also hire some of the skilled engineers internally to come to the site a couple of time monthly. ✓ It is common that in other small hydro projects, the company hire local stuff as much as possible while hire skill engineers to come to the site to confirm but usually evaluation on operators is just before the commercial operation begins. ✓ It is therefore this project will be expected to be the Sponsor Support type, it is necessary to confirm the price and work of scope carefully and to evaluate the ability to carry out the communication, countermeasures in emergency situations, safety management in a sudden accident.
4	Sale, transaction and revenue risk	✓ This project is based on 20 years PPA, obligating PLN, the off-taker, to purchase all electricity it could produce. The evaluation of capability of PLN as an off-taker is examined in the section 4-1-3. ✓ There is no provision on the adaptation of the revised tariff, for the existing project in case there is any such revision, written in the FIT related regulations. In general, when there is a new regulation introduced, then it will be reflected on the new project. Therefore, the risk of decreasing FIT price for this project can be quite limited. The standard PPA defines the tariff can be revised in case the cost for water-use is adjusted based on the new regulation. Thus, if the cost for water-use is increased, then the tariff for this project can also be increased.
5	Supply and fuel risk	✓ This project is a run of river type of small hydro, and the risk of supply and fuel is limited to the flowing river. Around the project site, it is protected by Ministry of Forestry that it need various permits to develop around the area and it takes usually for 2 – 3 years to obtain the permits; therefore, the risk of supply and fuel is limited to the reduction of the catchment area of this project.
6	Other risks	✓ There are not seen any valuable species and animals around the site, and not seen any local community going against this project. The rental agreement of the land has been agreed with Ministry of Forestry

	for 20 years. ✓ Related to the utility risk, the plant needs additional capacity increase for the sub-station that accepts generated electricity from the plant. Current situation, the sub-station cannot accept all the electricity from the plant because of the lack of capacity unit; therefore, it needs to carefully monitor that PLN will work on the sub-station to increase the capacity. ✓ The price escalation will affect construction cost, operational cost including maintenance and managing costs. With the construction cost, it is possible to minimize the price escalation risk by making an agreement with EPC contractor with a fix lamp sum. With the operational cost, supply and fuel are flow that comes from the river with no costs, and maintenance cost could be fixed for long term or to maintenance by own to minimize the risk.

Detail risks of the project are as follows:

(1) Power Purchase Agreement (PPA)

In concluding PPA, PLN tests technical acceptability of the power grid by conducting feasibility study called Kata Kerja Operational (KKO). The study not only covers technical aspect but also validates the financial aspect by checking credit of the project owner whether or not they are able to start up the project at the same time. Generally in PPA, there is a name of the project owner, generation capacity, name of substation and conditions for connection, power purchase price, duration of contract, planned date for power purchase, and so on. It is important to confirm if the PLN-owned substation has excess capacity for accepting power from the plant. In case substation capacity needs to be enhanced, it is necessary to check out the construction period and commencement day.

In Lae Ordi II project, Bakara Bumi signed a PPA on Dec 28, 2009 with PLN. It is understood that the existing substation does not seem to have sufficient capacity to accept all the electricity generated from the plant.; therefore, it is important to confirm that enhancement of the substation capacity will be carried out by PLN in terms of the budgeting and the implementation schedule.

In the letter that Bakara Bumi received from PLN, the commercial operation date (COD) should be before Sep 26, 2013. Bakara Bumi just obtained the license of IPPKH from Ministry of Forestry, and it is expected that PLN will allow Bakara Bumi to extend COD for additional 2 years. Under such circumstances, approval of extension of COD from PLN will have to be closely watched

(2) Purchase of the land

Regarding the land to start small hydropower generation, the cost to purchase the land is cheaper than what is in Japan**.** It is common to purchase**,** not rental, land for the project in Indonesia. In case the purchase is not completed at the time of considering a loan, complete purchase of the land is usually a conditions precedent that is defined in the loan agreement.

For Lae Ordi II project, Bakara Bumi plans to lease the land instead of acquiring. The land owner of this project is the Ministry of Forestry, and Bakara Bumi has already obtained the permit of IPPKH. With the permit, it is now possible for Bakara Bumi to lease the land from the Ministry of Forestry. Since there are no residents at the project site, forced relocation in the local community is not expected to occur. Necessary compensations for the plantation at the project site have been already conducted.

(3) River flow rate

There are two approaches to forecast river flow rate; 1) forecast based on rainfall rate in the neighboring gauging stations, 2) forecast based on actual river flow rate at gauging stations in the target river. Depending on the Bupati, it may be required to sluice maintenance flow. Therefore, it needs to be factored in when calculating the annual power generation. If the forecast river flow rate is different from the actual rate, the power generation would be lower than the predicted value. Stress test assuming risk scenario of lower-than-forecasted river flow rate leading to lower power generation needs to be conducted. By identifying acceptable range of risk, examination on the feasibility of this project with reasonable capital structure needs to be conducted.

In Lae Ordi II project, the forecasted based on rainfall rate at the nearest gauging station is used due to the fact that there is no forecast based on actual river flow rate available. One of the largest local technical consulting company, PT. Wiratman& Associates, provides FS report and calculating the flow data and power generating amount. For the calculation of the generated electricity on this report, it is based on Wiratman's FS report using the NRECA model additionally taking into consideration of the maintenance flow with Japanese standard, effective loss, self consumption and transmission loss.

(4) Consensus building in the local community

Because a small hydropower generation project is a long-term project with PPA of about 20 years using local resources of the river, it is important to obtain general consent and to build a consensus with local residents. It is already confirmed that Bakara Bumi had already held public hearings in Lae Ordi II project at multiple times. When the site visit was conducted, no sign of opposition by the local community was seen. It was confirmed that Bakara Bumi deals effectively with local residents for building the local consensus.

(5) Engineering

Prior to signing PPA, a technical consulting company conducts basic design in terms of hydrology and master plan designing, and an EPC contractor or an engineering company conducts detailed engineering after signing PPA. It is necessary to conduct the status check of the construction whether or not it is conducted according to the detailed engineering design. An third party engineering company or members who are familiar with engineering tasks within IDI deal with it. .

Lae Ordi II project plans to use an EPC contractor with a full turnkey contract. It is planned to hire some engineering experts as internal stuff to manage the progress of construction; however appropriateness of the proposed engineers in terms of their track record and experience needs to be carefully checked upon.

(6) EPC contractor

In choosing an EPC contractor for a small hydro power project in Indonesia, it is important to look at their track record, particularly on construction of hydropower facilities in order to determine their capability to keep to the schedule and execute the contract. However, small hydro power projects are usually not a full turnkey, and thus there are few EPC contractors with the experience. Moreover, there are some cases where large national construction company with rich experience in large scale hydro delays its construction. Therefore, it is necessary to confirm handling with the risk of delay, nonperforming risk, and risk of guarantee against defects, before discussing the contracts.

There is a candidate for EPC contractor for Lae Ordi II project; NKE. Bakara Bumi has considered to utilize some of the EPC contractor that AECOM has relationship with, so the EPC contactor's detail in technical, financial and contract, will be confirmed and evaluated in the selection timing

- NKE was established in 1982. Initially, it started the business by providing engineering and construction services mainly for commercial infrastructure in Indonesia. The company obtained ISO 9001 in 2000, ISO 14001 in 2008, and SMK3L in 2006. In 2007, the company became listed on the Indonesia Stock Exchange and expanded its business to mining construction and its market to Brunei and East Timor in 2009. In 2010, the company entered into energy business. In 2011, the company set up a subsidiary named PT. Duta Inti Energi in order to enter into the renewable energy market, especially in small hydro.

(7) Turbine manufacturer / maintenance

Selection of turbines falls into 2 categories; 1) widely used yet relatively expensive turbines made in EU or Japan, 2) limitedly used yet less expensive ones made in China. The selection depends on preference of owners but it is highly preferred to meet certain quality standard as a turbine is expected to use for a long period in small hydro power projects. Since it is possible to have turbine trouble just after start of commercial operation, it often requires the turbine manufacturer to guarantee spare parts. For several years after the end of guarantee period, one idea is to sign a maintenance contract with the turbine manufacturer until maintenance capability can be internalized.

In selection of the turbine manufacturer, maintenance framework for supporting the project needs to be confirmed. Especially, it is important to clarify risks related to the local maintenance support system for trouble shooting and the scope of services for being capable of.

There are 2 candidates for turbine manufacturer for Lae Ordi II project; Boving Fouress Ltd and Fuji Voith Hydro.

1. Boving Fouress Ltd Established in India as a joint venture company between Fouress Engineering and GE Energy in 1985. Its main businesses are production of turbines, power generators, and control device for small hydro power up to 20 MW.
2. Fuji-Voith Hydro was established as a joint venture between German Voit Semens and Fuji Electric in 1997, and its sales are recorded all over the world.

(8) Operation

The daily operation and maintenance is usually conducted either to internally hire employees or to outsource. The main operation works consist of monitoring the operational progress, maintaining equipment and managing, making daily or weekly reports, and preparing the necessary documents at the site in the case of insurance claims.

In Lae Ordi II Project, Bakara Bumi plans to hire several local staff for operation work and to send own engineers to the site to coordinate maintenance work for a few times a month. Daily work is not complicated compared to thermal power plants. However, it is necessary to confirm their capability to carry out communication, countermeasures in emergency situations, safety management in a sudden accident.

(9) Insurance Contract

The most commonly used insurances in a small hydro power generation are marine transit insurance, assembling insurance, and third party liability insurance during the construction phase. It is usually the case that EPC contractor covers marine insurance, assembling insurance and third party liability insurance. After construction, there are property insurance, business interruption insurance, and third party liability insurance, but some project owners do not contract for business interruption insurance. In some cases, some financial institutions require them to do so. It would be a problem if the insurance firm would be incapable of paying the sum insured. Therefore it is needed to select the insurance firm by checking their financial strength, ratings and solvency margin. Sometimes the lenders may have the requirement to enter in a contract with an insurance firm which has the rating above certain level.

First of all, it is necessary to confirm which original insurance firm project owner is selecting and the contents of the insurance. Assembling insurance during the construction period is for making compensation for the property losses caused by sudden accidents in the site and natural disaster. It is necessary to confirm what are the risks not covered by the policy clause. Also, The coverage of property insurance contracted after construction should be confirmed likewise.

It is desirable that the sum insured for physical damage is basically Full Replacement Value which enables reconstruction of a power plant. However if the sum insured is enlarged, the premium would be raised. Therefore the project owner sometimes does not choose Full Replacement Value to restrain the premium cost. For the lender, if it is possible to prove the damage is limited in scope based on Maximum Probable Loss calculated by the Trusted Third Party, it may be acceptable to apply Maximum Probable Loss as the sum insured.

As for any other important matters, it is necessary to confirm the deductible amount within an accident. If the exemption from responsibility is quite large within an accident, physical damage amount becomes less than the amount of the exemption from responsibility. Then, the insurance cannot be claimed. If the exemption from responsibility is decreased, the premium tends to be increased. Therefore it is important to consult with the project owner about the optimum exemption from responsibility.

In Lae Ordi II project, insurance has not been contracted, and at the moment there is no candidate. Thus, this matter shall be closely followed up.

4-1-6-2. Outline of Various Contracts (Off-take, EPC, O&M, etc)

(1) PPA（Off-take Agreement）

In Lae Ordi II project, PPA has already entered into according to the business operator. Below summary only lists main confirmations.

Table 4-15 PPA detail information

1	Party in Charge	✓ PLN and Bakara Bumi enter into PPA
2	Plant Output	✓ Two * 5MW turbines
3	Selling Price	✓ From the first year of commercial operation to its fifth year, the selling price is Rp. 878/kwh, and from the sixth year of commercial operation to its 20th year, the selling price is Rp. 714.32 /kwh.
4	Selling Term	✓ Twenty years are the typical term for the commercial operation.
5	Expected Day of Selling Electricity	✓ PPA in this project was contracted on Dec 28 2009, and it is stated that the commercial operations needed to begin by Sep 26 2013 in the letter of PLN. According to Bakara Bumi, the extension of the start of commercial operation will be allowed by PLN after IPPKH is acquired from Ministry of Forestry. Therefore, the extension from PLN needs to be closely watched.
6	System Connection Conditions	✓ Bakara Bumi, the business owner of this project, has to construct the electric line to connect to PLN's 20kv electric transmission network which is the nearest one to this project site. The owner ship of the transmission line shall be transferred to PLN after the construction is complete.
7	Other Conditions	✓ Bakara Bumi charges electric power selling to PLN every month,

	and PLN is obliged to pay within twelve business days after receiving the invoice from Bakara Bumi.

(2) EPC Contracts

In Lae Ordi II project, ECP contract has not been discussed in details yet. Details of contracts need to be confirmed later. For that reason, below summary only lists main confirmations.

Table 4-16 EPC contracts detail confirmation

1. Party in Charge	✓ Ordering Party： Bakara Bumi ✓ Contractor: Name of EPC contractor (To Be Confirmed)
2. Scope of Contractor Service	✓ It's necessary to list a range of jurisdiction so that every item is covered as a full turnkey contract consisting of procurement, construction, trial run duties, the training, machine parts necessary for the completion of this generation facilities. ✓ More specifically, the work of assisting all business approvals, report generation facilities, electrical equipment, and related construction, civil works, installation of equipment, procurement of spare parts, training of operating personnel, all the other necessary tasks to fulfill the contract.
3. Contract Amount	✓ Needs to be confirmed, it is desirable for (fixed price) fix lump-sum.
4. Payment Conditions	✓ Payment based on the construction progress or the payment based on the set date is common. The refund bond (guarantee of repayment of advanced payment) in the form of bank guarantee is seen by a large-scale international bid project, but it is not common in a small hydro project in Indonesia.
5. Delivery Conditions	✓ Define the date of delivery and the final completion date (Warranty period starts from the time of completion of construction).
6. Reporting Requirement	✓ It is desirable that the contractor makes a progress report monthly.
7. Insurance	✓ Policy holder：Contractor ✓ Insured: the project owner, the contractor, subcontractors, lenders, etc. ✓ Type of Insurance ➢ Transport Insurance ➢ Assembling Insurance ➢ Third Party Compensation Insurance
8. Guarantee Against	✓ Necessary to set the term of the insurance

Defects	
9. Performance Guarantee	✓ Necessary to have a guarantee for output(kW) capacity of generators
10. Liquidated Damages	✓ Liquidated Damages（Set the amount of compensation per day delay. The amount of compensation per day is expected to be calculated on the basis of expected annual sales ÷ annual operational days, however, it is necessary to confirm.）

(3) Maintenance Contract

In Lae Ordi II project, maintenance contract has not been discussed in details yet. Details of contracts need to be confirmed later. For that reason, below summary only lists main confirmations.

Table 4-17 Maintenance contracts detail confirmation

1. Party in Charge	✓ Generally, consignor is the project operator. ✓ Consignee is the maintenance company.
2. Term of Contract	✓ Generally speaking, turbine manufacturers offer necessary materials and parts for maintenance for one year after the start of commercial operation and it is expected to have the contract for the maintenance for several years after the end of the warranty period. Then it is expected to reduce the cost by establishing its own maintenance structure afterward. It is necessary to confirm that project operator actually follow above scenario.
3. Expense for Commission	✓ Total annual payment is divided by 12 and the payment is commonly made monthly.
4. Scope of Service and Obligation	✓ The periodical maintenance is assumed as regular maintenance to the project related facilities in line with the maintenance manual provided by the manufacture（including the making necessary documents, commissioning and supervising outside supplier and so on）. Scope of maintenance needs to be confirmed. ✓ Large-scale maintenance duties are a large-scale maintenance work planned in a long-term operation maintenance plan. It is expected to inform the details of work, schedule and additional cost in advance. It is common to create a set of documents to report the results.
5. Acceptance	✓ It has to be accepted by the project owner. It is necessary to check the results with the consignor within the several days after the completion of the periodical and the large-scale maintenance.
6. Guarantee for	✓ The warranty against defects guarantees that there are no defects

Service	in the products offered. ✓ Usually, warranty period is about 12 months after the completion of the work ✓ At the time of violation of the guarantee, the trustee pays the cost at his own expense, and it is common to carry out the following necessary repairs. ✓ The damage to generation facilities due to the violation of guarantee ✓ The maintenance of product in conjunction with the violation of guarantee ✓ The performance warranty has to be set to compensate the amount to cover the damage caused by failing to achieve the insured output capacity to the consignor.

4-1-7. Conditions and Issues toward Building Financial Scheme

4-1-7-1. Confirmation of Available Equity Amount for the Project Owner

Firstly, it needs to be confirmed that what kind of scheme the project owner intends. Generally, a Holding Company (HD) is established, and Special Purpose Company (SPC) is also established for each project. It is often the case that the equity is injected from the HD. This is because it is difficult to sign PPA for several projects under the same project company name with PLN. From PLN's point of view, there are many failed projects due to funding issues in a small hydropower, and thus PLN thinks it should be difficult for the same company to finance multiple projects at the same time. Therefore, project owner is required to take above scheme.

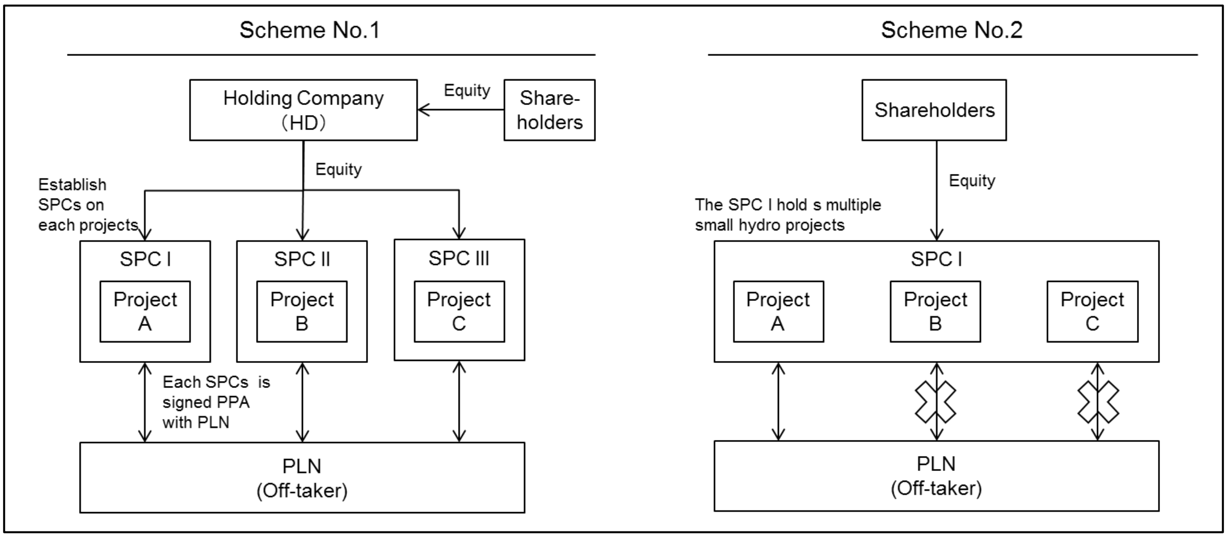


Figure 4-3 Project Schemes

However occasionally, there are some cases where project owners attain permits and develop with the same SPC name in the multiple projects without establishing HD (See above scheme(2)). Therefore it needs to be confirmed that the project owner raise the capital for SPC through HD or the equity holders provide the capital directly without HD if it is the first project for the project owner. In addition, it also needs to be confirmed that how much equity portion the project owner can provide for the project. Even though the project owners have sufficient capital, in case they have several projects in the pipeline, they may intend to leverage by reducing equity amount and increasing the debt amount. On the other hand, the project owners who do not have enough funding ability may have their limitations, and then the equity amount should be determined accordingly.

In Lae Ordi II project, it is the first small hydro project for Bakara Bumi, the project owner. At present, it is the case of scheme (2) where equity holders invest directly to SPC without HD. Bakara Bumi has conducted gas-engine power business in Manado and Makassar and entered into four year rental contracts with PLN. Bakara Bumi has also entered into PPA with PLN, and they have several rental contracts under the name of the same company at the same time. It is confirmed with PLN North Sumatra Regional Office that there would be no influence on the PPA because these rental contacts are agreed by the respective authority in the different working area.

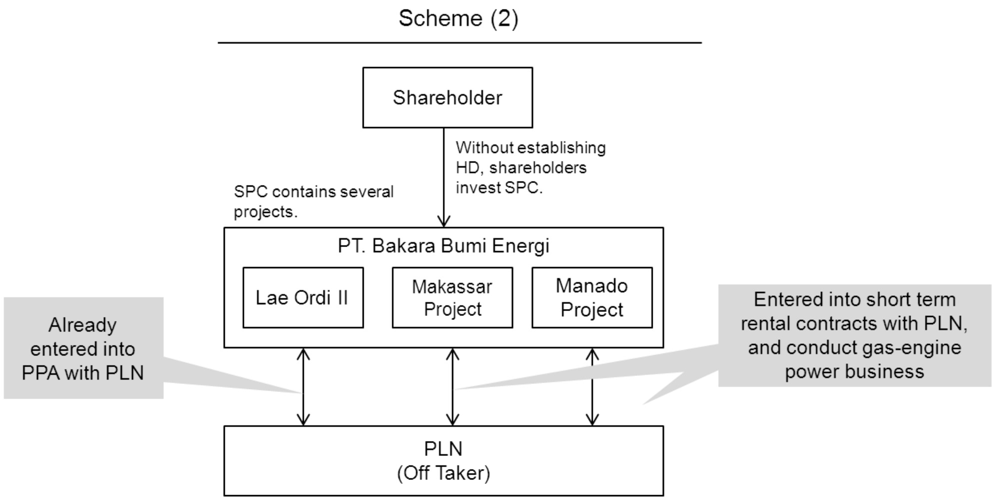


Figure 4-4 Situation of Bakara Bumi

4-1-7-2. Confirmation of available debt amount from senior lenders

It is extremely important to confirm whether local, governmental, and foreign-affiliated financial institutions in Indonesia can provide loans during construction period of a small hydropower generation. After introduction of FIT, small hydropower is starting to be expanded as a base power source, but there are only a few financial institutions which have provided loans for a small hydropower. Therefore, many institutions generally provide loans as a corporate finance depending on the credit of the project owners, a private guarantee and collateral. In fact financial institutions which can provide project finance type loan, taking construction risk, are quite limited.

The financial institutions which can tolerate risks during the construction period mention that their internal regulation permits to provide up to 80% of total project cost. Thus project owners with high credit also have to provide equity for at least 20%. However in case that they have to allocate the limited capital to other pipeline, or they cannot provide their own equity for 20% of total project cost, they have to call up mezzanine lenders which are subordinated lender.

One of the investment officers in SMI and the owner of Bakara Bumi had a meeting in 25th June 2013, and SMI has conducted a review for the project. Also, AECOM has reviewed the project FS report. Detail terms and conditions will begin to discuss when AECOM's review is completed.

4-1-7-3. Possibility of inviting mezzanine lenders

There is a finance method called mezzanine other than equity and senior loan mentioned above. Though mezzanine finance is given low-priority to senior finance, it has a priority to equity finance. Therefore, it stands in the middle between the two as a finance method. When the project owner has limitation in their equity amount they can provide and so does senior lenders, in the case where the total sum of both parties does not cover the total project cost, the project owner needs to consider inviting mezzanine lenders. Hence, there is a need to invite mezzanine lenders from both project owner and senior lenders.

The typical way of Mezzanine is an investment by mezzanine loans and class shares. Both instruments are inferior to senior lenders in the ranking of repayment. That means that repayment for senior lender has a priority to be repaid from the sales of electricity except for tax or necessary expenses. Therefore, from the senior lender's point of view, inviting mezzanine means capital enhancement. On the other hand, from the project owner's point of view, as it is not an investment by ordinary share, the project owner can avoid lowering the return on equity, dilution of voting share, and at the same time, is able to keep the flexibility in the management.

Candidates for mezzanine lenders are local governmental financial institutions such as securities company type or investment bank type, or mezzanine section of foreign-affiliated financial institutions. However, such financial institutions that take risks aggressively during construction are quite limited.

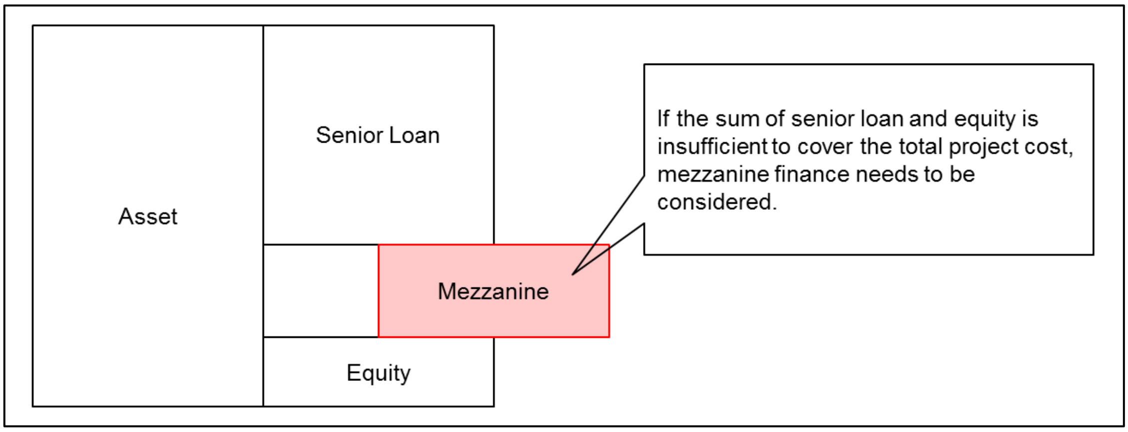


Figure 4-5 Structure of Mezzanine Financing

Bakara Bumi already started the discussion regarding the financial arrangements with IDI-I which is a mezzanine lender candidate. Detail terms and conditions will begin to discuss when AECOM's review is completed.

4-1-7-4. Terms and Conditions of Possible Loans from Local Financial Institutions / Governmental Financial Institutions

In Lae Ordi II project, discussion with financial institutions, expected senior lenders, has not advanced in details yet. Details of contracts need to be confirmed later. For that reason, below summary only lists main confirmations.

Table 4-18 Maintenance Contracts Detail Confirmation

1. Party in Charge	✓ Lessor : Senior Lender ✓ Lessee : Bakara Bumi
2. Loan Amount	✓ Necessary to confirm whether IDC amounts can be added to the loan amount.
3. Period of Repayment	✓ During the construction period (2-3 years), the repayment is deferred. The repayment on principal will begin after the start of commercial operation. The repayment period is usually was during 7 years to 9 years.
4. Interest	✓ It varies depending on the creditworthiness of the project owners and projects.
5. Repayment Terms	✓ Phased payment along with the progress of constructions
6. Up-Front Fee and Agent Fee	✓ It is necessary to confirm possible fees such as up front and agent fee
7. Prepayment prior to the maturity date	✓ There are cases where the penalties may be required for repayment (total amount or a part of the loan)prior to the maturity date of the loan..
8. Default Charge	✓ When return of an interest rate or the capital is delayed, default charges are caused.
9. Cash water fall mechanism	✓ In case of Project Finance, Cash waterfall mechanism is adopted and priority of payment is decided beforehand. Dedicated account is opened, managed and operated by the agent (General accounts are as follows). ➢ Account for Project ➢ Account for tax payment ➢ Account for Payment Expenses ➢ Account for Repayment Senior Debt ➢ Account for Debt Service Reserved ➢ Account for Repayment Mezzanine ➢ Account for Sponsor Release

	➢ Deposit Account for taxes and insurance fund
10. Covenants	✓ Terms which leads to 「Forfeiture of benefit of time」. In Indonesia, it is common to provide a set of financial statements lien land and facilities, other than non-payment to the use of the funds, the business model cannot be changed, audited, the books can be viewed, such as financial debt service coverage ratio and the debt-to-equity ratio case note that covenants are generally.
11. Forfeiture of benefit of time	✓ If the violation of covenants not corrected the above situation will continue for a certain period of time, the operator is prompted for a lump-sum repayment from the lender.
12. Mortgage	✓ Senior Lenders usually get the first priority security interest in the assets of such a set of land and equipment needed to operate a small hydro project.

4-1-7-5. Clarification of terms and conditions in executing loans

Financial institutions generally enter into a loan agreement with stipulating Conditional Precedent, and if the Conditional Precedent is not satisfied in advance, the loan is not executed. The subjective contracts are a complete set of the project related contracts, such as acquisition of land, EPC, contract to purchase turbines, PPA, and insurances.

Table 4-19 Classification of Necessary Conditions for Investment Execution

1. Contracts of Project	✓ Agreement must be entered into a set of related projects that are necessary to continue to operate on small hydro projects.
2. Guarantee	✓ Personal guarantee of such a representative, if necessary
3. Mortgage	✓ Must be assured of the security interest set of assets, including land and equipment
4. Environmental impact assessment	✓ Small hydro projects below 10MW, but in many cases it does not need (AMBIL) environmental impact assessment. Approval of UKL / UPL's (Environmental Management Efforts and Environmental Monitoring Efforts) is required by lenders, so it needs to be confirmed.
5. Valuation of Assets	✓ Asset valuation conducted by a third party lender have ordered
6. Financing Payment	✓ Third-party engineering firm render was ordered to check the progress of construction, make loan payments depending on their progress.
7. Director	✓ In some cases, it is required to appoint directors in the mezzanine lender.
8. Cost Overrun	✓ There is a need to raise equity in the EPC if the amount determined in advance by the increase.

4-1-7-6. Clarification of terms and condition of loans for JICA Private Sector Investment Finance Scheme

In the case of utilizing JICA Private Sector Investment Finance Scheme, above terms and conditions of loans from the local commercial banks and government financial institutions may be required as well. A form of loan by project finance is assumed, thus terms and the way of repayment should be examined under the consideration of the project. In the case of loan from JICA independently, it is anticipated that there will be quite some efforts required in negotiating with the project owners such as monitoring after the execution of the loan and resolving troubles. Therefore one idea is to co-finance with local financial institutions, or to offer a packaged proposal by inviting mezzanine lenders who are having a good relationship with the project owners in order to reduce the risk.

Table 4-20 Clarification of the Specific Terms of Investment and Loans

1. Party in Charge	✓ Lessor : Independent Administrative Corporation Japan International Cooperation Agency (JICA) ✓ Lessee：Bakara Bumi
2. Loan Amount	✓ It is desirable to add it to a financing amount of money, and to contribute the-based average interest rate (Interest During Construction)
3. Pay-Back Period	✓ As for (2 through 3), it assumes 7 through 9 during the return period when it is after a commercial startup, and it reckoned it from the interval at the-based middle for capital return period of deferment during a construction period that capital return is started
4. Interest	✓ To Be Settled
5. Financing Payment	✓ It is desirable to pay depending on construction progress progressively
6. Up Front Fees and Agent Fees	✓ The agent duties assume that they depend on a local financial institution or the governmental financial institution
7. Repayment Before Maturity	✓ Assuming the same conditions as the local financial institutions or government-affiliated financial institutions
8. Late Payment Charges	✓ Same as the above
9. Cash Waterfall Mechanism	✓ Same as the above
10. Covenants	✓ Same as the above
11. Forfeiture of Benefit of Time	✓ Same as the above
12. Mortgage	✓ Same as the above

4-2. Survey overview

4-2-1. Descriptions of proposed locations for the survey

4-2-1-1. Site information

The planned site of Lae Ordi II small hydropower project lies in Lae Ordi river in Kecupak I Village, Pergeteng-Geteng Commune, Pakpak Bharat District, North Sumatra Province (for planned layout: see Figure 4-6). The site lies at around 2° 34 north latitude, and at 98° 10 east longitude.

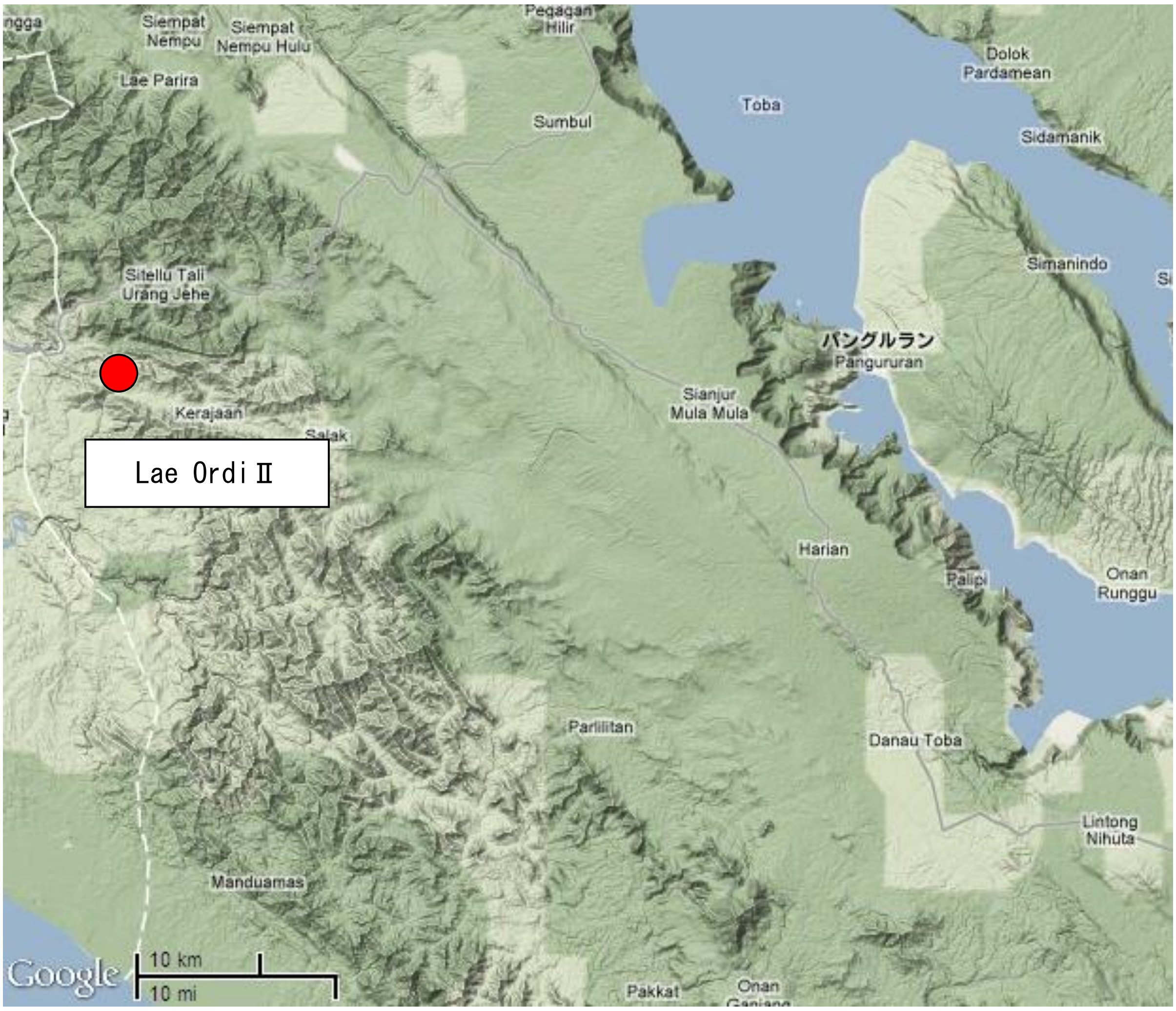


Figure 4-6 The area at and around the planned site

Source: PFS Report

4-2-1-2. Geological features

Pakpak Bharat District is located 400 ~ 700m above sea level. Project site is in hilly terrain with slope of 40~60%.

4-2-1-3. Geology

1) Intake weir

Geology around intake weir includes river alluvial deposits formed by deposition of heterogeneous pebble and conglomerate in welded tuff or pebbled sandstone. Coefficient of hydraulic permeability of rock is relatively high as 1×10^{-3}～5×10^{2}cm/s. Alluvial deposit was accumulated in both side of river, so that the sporadic conglomerated appearance of welded tuff can be observed on the left bank of the river.

2) Waterway

Water is conducted through opened water channel on the surface of ground and passes area where are alluvial deposits.

3) Location of penstock and power plant

Penstock and power plant will be constructed on andesite.

4-2-1-4. Hydrology

The catchment area of intake weir site of the Lae Ordi II small hydropower project is 296.4km^2. Lae Ordi River has many tributaries on the upstream and downstream of intake weir.

Precipitation in this area is very high which is very favorable for this project.

4-2-1-5. Climate

The nearest climate observatory of this project site is Sidikalang precipitation station in Dairi Regency. The average of monthly precipitation in this area is over 100mm in any months that means it rains through the year. Annual average precipitation of this surrounding area is about 2600mm, annual average temperature is 20 ℃, mean humidity is 90%, and the average wind speed is 0.45m/s.

4-2-2. Overview of power generation plan

4-2-2-1. General

1) Local plan and Japanese method

The project intends to exploit untapped head of Lae Ordi river, and the influx of water is accumulated in a reservoir before being channeled through the generator. The power generation plan proposed that water for power generation withdrawn through an intake weir is conducted through opened or culvert formed headrace into head tank in 2.4km downstream of weir. Then it runs through a penstock (320m) to the power plant to generate energy, and finally the water joins Lae Ordi river.

In the local F/S plan, it is planned that the maximum discharge (11.43 m^3/s) is taken through the intake weir and generates maximum output of 10,000 kW gaining effective head of 106.4m. However, the analysis of combined efficiency of general water turbine and generator shows that output will not reach 10,000 kW.

Therefore, the maximum discharge is increased to 11.63m^3/s in order to reach output of 10,000kW for the local plan. Japanese method which is adjusted maximum discharge to 11.20 m^3/s in order to reach output 10,000 kW using value of combined efficiency provided from manufacturer, and local method are compared.

The planning specifications of this power generation project are summarized in Table 4-21.

Table 4-21 Specifics of power plant project (Location of Lae Ordi II)

Contents			Feature(Japanese method)	Features(local method)	Summary
Name of river			LaeOrdi River		
Basin area			296.00 k㎡		
River flow (㎥/s)			Conversion flow by NRECA model(Average from 1993-2008)		
			Maximum 98.78 35days 36.76 High water 22.89 Average water 15.15 Low water 10.57 Dry weather water 6.60 Minimum 5.94 Annual average 19.27		
Electric power planning	Type of power generation		Run-of-river		
	Intake water level		631.00 m		
	Tailwater level		520.00 m		
	Gross head		111.00 m		
	Effective head		106.40 m		
	Maximum water discharge		11.20 ㎥/s	11.63 ㎥/s	
	Output		10,000 kW	10,000 kW	
	Output L_5		8,482 kW	-	
	Annually electricity		82,107 MWh	81,347 MWh	
General equipment	Intake weir		Height 7.0m, Length 29.6m		
	Intake		—		
	Settling basin		Open-air, Length:56.20m, Width:9.00m		
	Head tank		Open-air, Length:73.50m, Width:12.00m		
	waterway	Headrace	Open-air or subterranean L=2,426m, I=1/3,333		
		Penstock	Inner diameter 2.0m 、L＝ 320.0m		
		Spillway channel	L＝70.4m		
	Power station		Above ground		
	Turbine		Francis water turbine with lateral axis, 3 turbines		
	Generator type		3,333kW×3 units		
River utilization	Water for river maintenance		0.89 ㎥/s	-	
	Plant factor		93.7%	92.9%	
	River utilization rate		58.2%	-	
Total cost			10,847 million yen	1,917 million yen	Japanese method calculation standard NEF
Unit price of construction cost per kW			1,085 thousand yen	192 thousand yen	
Unit price of construction cost per kWh			132.1 yen/kWh	23.6 yen/kWh	

2) Improvement plan

To verify the local FS plan, power generation plan and main structures are reviewed based on FS report and design drawings. Since there are many issues such as shape of headrace, gradient and route of penstock, locations of power plant and position for tail water, improved power generation plan is proposed.

Specific contents of improvement plan are as following.

- Minimizing cross-section of waterway by adjusting gradient of headrace to reduce number of constructions.
- Changing route of penstock and location of power plant to reduce number of constructions

Table 4-21 shows details of comparison between local FS plan (Japanese method) and improvement plan. In the improvement plan, gradient of headrace is changed from 1/3,052 to 1/1,000, length of penstock is extended, and tail water level is set higher by changing location of power plant. For these changes, effective head and annual available power energy will be reduced.

However, since it is expected to reduce number of constructions due to minimize cross-sections of headrace and penstock excavation, construction cost for each kWh of local FS plan changes from 132.1 yen to 131.0 yen, thus economic efficiency will increase.

Table 4-22 Comparison of power generation plan
(Improvement plan and local FS plan-Japanese method)

Contents			Improvement plan	Local F/S plan (Japanese method)	Summary
Electric power plan		Type of power generation	Run-of river, Conduit	Run-of river, Conduit	
		Intake water level	631.00 m	631.00 m	
		Tailwater level	525.00 m	520.00 m	
		Gross head	106.00 m	111.00 m	
		Effective head	100.30 m	106.40 m	
		Maximum water discharge	11.90 m^3/s	11.20 m^3/s	
		Output	10,000 kW	10,000 kW	
		Output L_5	8,493 kW	8,482 kW	
		Annually electricity	80,993 MWh	81,347 MWh	
General equipments		Intake weir	Height 7.0m Crest length 29.6m	Height 7.0m Crest length 29.6m	
		Intake	—	—	
		Settling basin	Opened conduit length 56.20m, Width9.0m	Opened conduit length 56.20m, Width9.0m	
		Head tank	Opened conduit length 73.50m, Width12.0m	Opened conduit length 73.50m, Width12.0m	
	Waterway	Headrace	Opened conduit L=2,426m I=1/1,000	Opened conduit L=2,426m I=1/3,333	
		Penstock	Diameter 2.0m, L 347.0m	Diameter 2.0, L 320.m	
		Tailwater way	L＝70.4m	L = 70.4m	
		Power plant	Above ground type	Above ground type	
		Turbine type	Francis horizontal shaft 3 turbines	Francis horizontal shaft 3 turbines	
		Generator type	3,999kW × 3 units	3,999kW × 3 units	
Water utilization		Water for river maintenance	0.89 m^3/s	0.89 m^3/s	
		Plan factor	92.5%	92.9%	
		River utilization rate	57.8%	58.2%	
Total cost			10,611 million yen	10,847 million yen	
Unit price of construction cost per kW			1,061 thousand yen	1,085 thousand yen	
Unit price of construction cost per kWh			131.0 yen/kWh	132.1 yen/kWh	

4-2-2-2. Generating capacity and power output L_5

The output capacity propounded by the local company was compared with that calculated, as described above, using the Japanese standard method. Both results – power output capacity calculated in this review and the value submitted by local authority/company – despite differences in calculation conditions, agreed relatively well: the differences between them is around 760 MWh.

(Major differences in calculation condition)

- Power generation efficiency
- Maximum output
- Method to establishing the maintenance flow

① Power generating capacity according to the local F/S plan (Local method)

Annually available electricity generation = 81,347MWh/year

Maximum discharge 11.43 m^3/s, Effective head 106.4m

② Power generating capacity according to the local F/S plan (Japanese method) (Plan 2)

Annually available electricity generation =82,107MWh/year

Maximum discharge 11.20 m^3/s, Effective head 106.4m

Table 4-23 Power generation capacity and L_5 output

Induced electricity generation

Unit:MWh

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plan1	4,436	4,069	4,381	4,320	4,464	4,316	4,442	4,271	4,309	4,444	4,320	4,463	52,235
Plan2	7,007	6,393	6,697	7,056	7,192	6,900	6,814	6,270	6,516	7,023	7,044	7,196	82,107
Plan3	8,837	7,868	8,285	9,039	9,385	8,748	8,086	7,196	7,794	9,080	9,466	9,513	103,296
Plan4	10,091	8,886	9,607	10,811	11,222	9,973	8,844	7,824	8,899	11,089	11,567	11,244	120,057
Plan5	10,584	9,298	10,250	11,677	11,880	10,396	9,171	8,044	9,465	12,083	12,514	11,848	127,210
Local document	–												81,347

Output L5

Unit:MWh

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plan1	5,867	5,910	5,658	6,000	6,000	5,965	5,853	5,351	5,915	5,859	6,000	5,990	5,864
Plan2	8,857	8,328	8,029	9,262	8,995	9,126	7,781	6,657	7,617	8,295	9,496	9,336	8,482
Plan3	9,203	8,669	9,130	10,353	10,653	10,041	8,111	6,702	8,096	9,280	11,953	11,163	9,446
Plan4	9,326	8,709	9,998	11,220	11,108	10,252	8,086	6,635	8,538	10,145	13,500	11,674	9,933
Plan5	9,267	8,653	10,449	11,658	11,097	10,219	8,043	6,572	8,940	10,643	13,704	11,744	10,082

Gradient of headrace is modified from 1/3,052 to 1/1,000 and length of penstock is extended for the improvement plan. Thus, effective head will be reduced and annually available electricity generation will reduce as well.

③ Electricity generation of improvement plan

Annually available electricity generation =80,933MWh/year

Maximum discharge 11.90 m^3/s, Effective head 100.3m

4-2-2-3. Estimated cost of construction

The construction cost submitted by the local company and that estimated by this review are shown below. The cost indicated by the local company was cheaper by a factor of 1/6 as that estimated by this review, which assumed that all construction works take place in Japan. The wide margin can be attributed to the difference in labor and material cost in Japan and Indonesia.

1) Construction costs presented by the local company

Estimated project expenses：1,917.4 million yen （＝226,140million IDR）

Construction price/kWh：23.6 yen/kWh

As project expense comparison was made with a hydropower project (Nasal MPHH), similar both in type and scale, which indicated that the level of construction cost was nearly same. Therefore, the construction cost is considered to be at a proper level for a project undertaken in Indonesia.

Table 4-24 Comparison of project expenses and economy: Lae Ordi Ⅱ and Nasal project

Name of project		Lae Ordi II	Nasal
Maximum output	kW	10,000	12000
Plant discharge	m^3/s	10.63	17.36
Effective head	m	106.4	80.8
Total of project cost	million Rp	226,140	275,382
Construction cost for each kW	Rp/kW	22,614,000	22,948,500

2) Estimated construction costs in local F/S plan (Japanese method)

Table 4-25 Breakdown of estimated cost （Japanese method）

Contents		Estimated cost (million yen)	Remarks
1)	Land compensation expense	10.0	
2)	Relating to building	200.2	Underground type
3)	Relating to civil construction	3,992.0	
	① Conduit	3,226.0	
	a. Intake weir	167.6	Height 7.0m、Dam length 29.6m
	b. Intake	108.0	
	c. Settling basin	199.8	
	d. Headrace	1,850.0	Opened or closed conduit L＝2426m
	e. Head tank	131.0	Head tank
	f. Spill way	83.3	L＝70.4m
	g. Penstock	373.9	L＝320.0m
	h. Tailrace	-	L＝0m
	i. Outlet	19.1	
	j. Others	293.3	10% execution expense of above headrace (headrace bridge, intake reconstruction excluded)
	② Reservoir	-	
	③ Equipment and machine	766.0	
	k. Jack	403.1	Semi-subterranean type
	l. Some equipment	362.9	(①+②+jack)×10.0%
4)	Relating to electricity equipment	3,251.3	
	o. Turbine	1,155.4	Francis
	p. Generator	942.2	Synchronous
	q. Surplus water reducer	-	
	r. Other equipment	1,153.7	Expense for main transformer and electric switchgear
5)	Temporary equipment expense	758.7	Temporary road:L=1900m (access road of intake weir:slant distance 980m×1.5, access road of power station :slant distance 280m×1.5)
④	Construction cost in progress	547.1	{2)＋3)＋4)＋5)}×0.07
6)	(Subtotal)	8,759.3	{1)～6)}
7)	Dam dispersal expense	-	No added
8)	Interest rate in construction period	-	No added
9)	Relevant dispersal expense	87.6	Subtotal × 0.01
10)	(Total)	10,846.9	
Unit price of construction cost per kWh (yen/kWh)		131.6	

*Cost of relating to electricity equipment is not estimated by individual cost of component parts. It is calculated cost of all by estimated calculation and expense rate based on past cases in Japan.

3) Estimated construction cost in improvement plan

Table 4-26 Breakdown of estimated cost （Improvement plan）

	Contents	Estimated cost (million yen)	Remarks
1)	Land compensation expense	10.0	
2)	Relating to building	200.2	Underground type
3)	Relating to civil construction	3,720.5	
	① Conduit	2,972.1	
	a. Intake weir	167.6	Height 7.0m、Dam length 29.6m
	b. Intake	114.4	
	c. Settling basin	212.2	
	d. Headrace	1,671.4	Open conduit or closed conduit L＝2426m
	e. Head tank	138.2	Head tank
	f. Spillway	86.2	L＝70.4m
	g. Penstock	292.0	L＝320.0m
	h. Tailrace	-	L＝0m
	i. Outlet	19.9	
	j. Others	270.2	10% of execution expense of above headrace (headrace bridge and intake reconstruction excluded)
	② Reservoir	—	
	③ Equipment and machine	748.4	
	k. Jack	410.2	Semi-subterranean type
	l. Some equipment	338.2	(①＋②＋jack)×10.0%
4)	Relating to electricity equipment	3,315.3	
	o. Turbine	1,174.5	Francis
	p. Generator	964.4	Synchronous
	q. Surplus water reducer	-	
	r. Other equipment	1,176.4	Expense for main transformer and electric switchgear (55% of turbine and generator)
5)	Temporary equipment expense	748.3	Temporary road:L=1900m (Access road to weir:slant distance 980x1.5, access road to power station:slant distance 280x1.5)
④	Construction cost in progress	531.8	{2)＋3)＋4)＋5)}×0.07
6)	(Subtotal)	8,526.1	{1)～6)}
7)	Dam dispersal expense	—	No added
8)	Interest rate in construction period	0	No added
9)	Relevant dispersal expense	85.3	Subtotal×0.01
10)	(Total)	10,611.4	
Unit price of construction cost per kWh (yen/kWh)		131.0	

4-2-3. Review of power generation plan

4-2-3-1. Waterway Route

Waterway route of the Lae Ordi II small hydropower project (run-of-river and the conduit type) is shown in Figure4-7.

Intake Weir (624m high above sea level) is located from the completed neighborhood road and running through the middle of the forest. Tree grows lushly in the forest, so that we need to clear tree in order to construct the access road.

Water which is taken through intake weir runs into head tank by the headrace (length 2,426m, slope 1/3,052) via the settling basin. Then water runs from the tank to the power plant through penstock with length of 310m (divided into 3 branches in front of the power plant).

(This Page is Intentionally Left Blank)

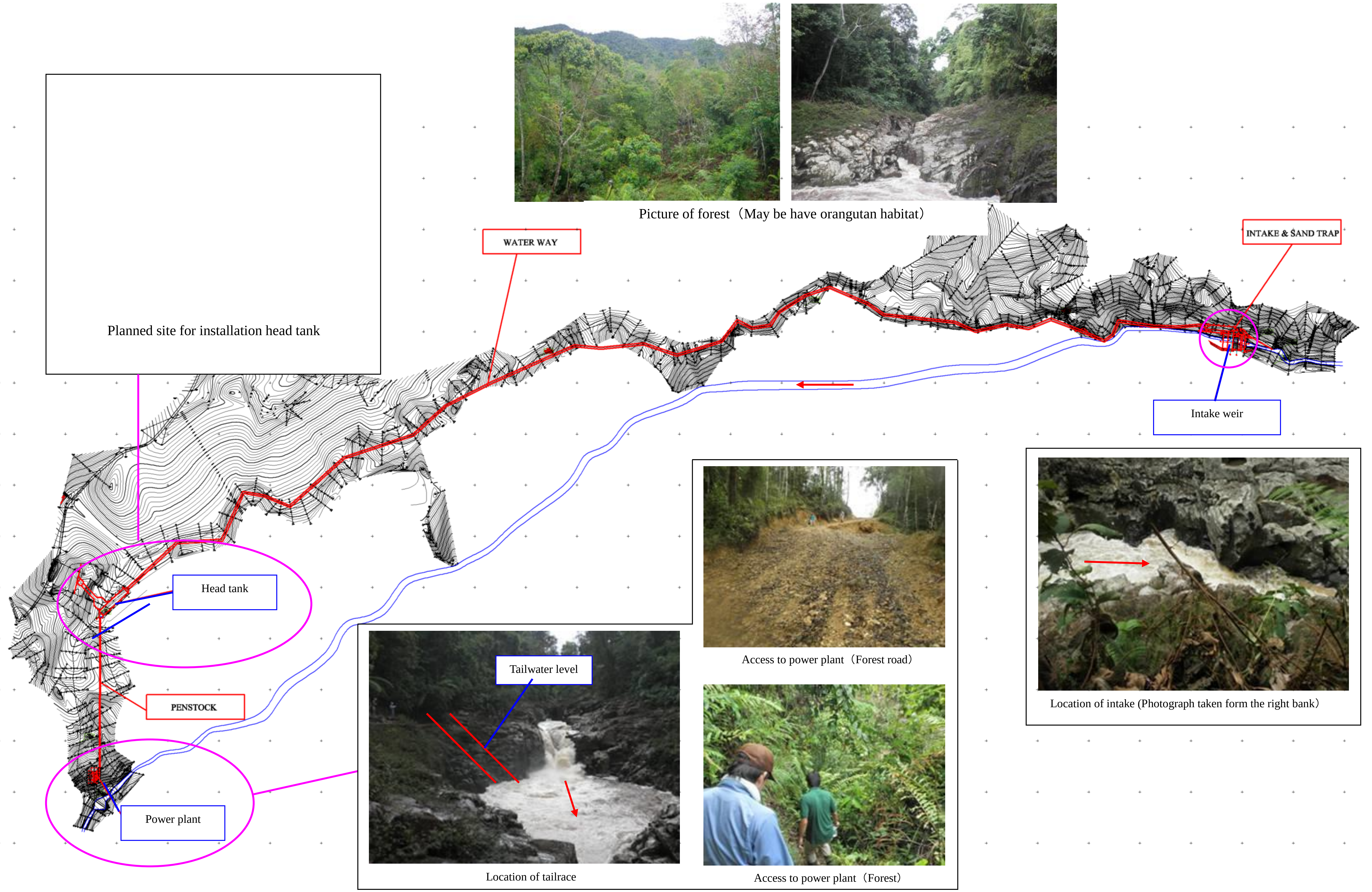


Figure4-7 Waterway Route map

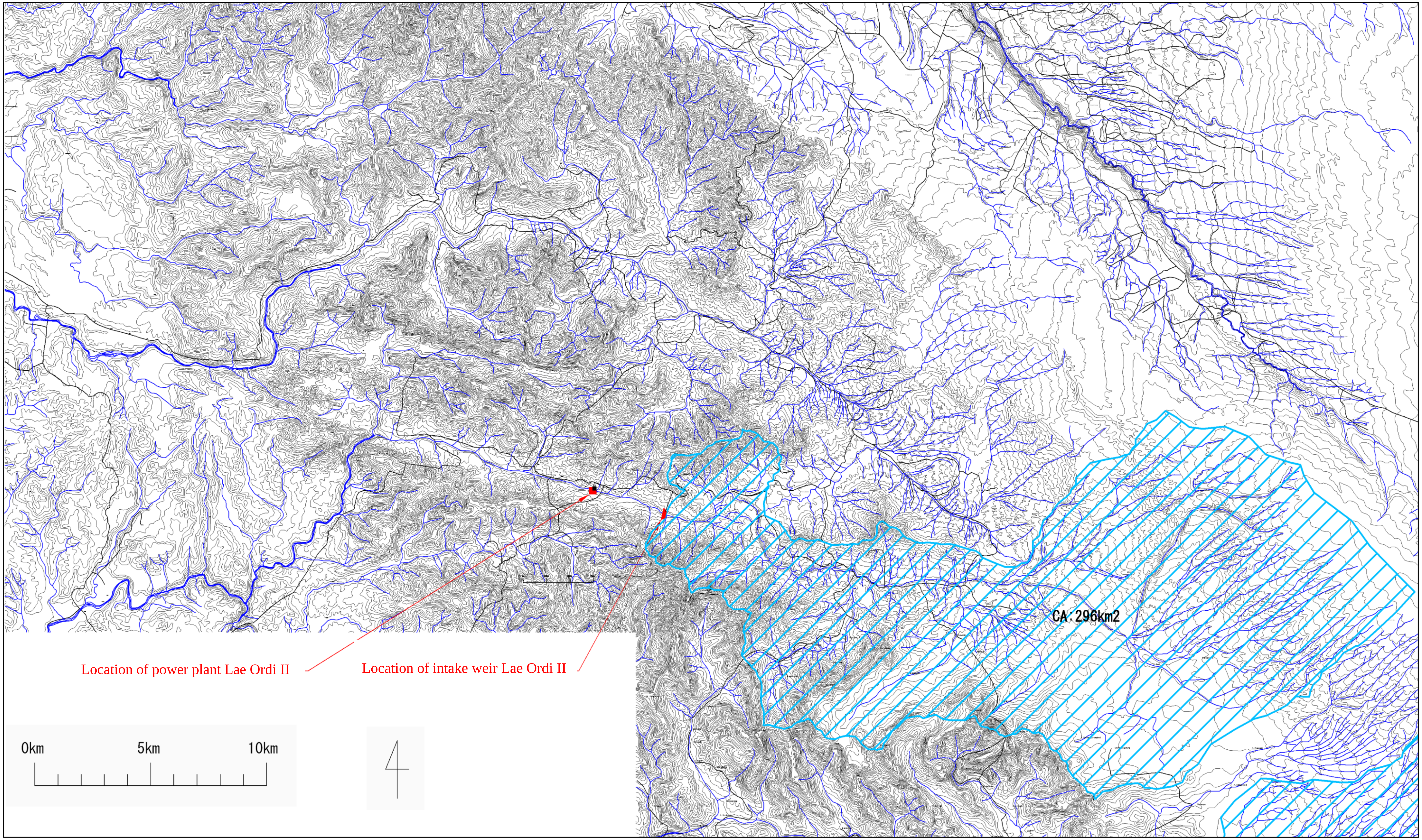


Figure 4-8 Location of the Plan

4-2-3-2. Stream regime at the water intake

In this section, an attempt is made to sort out the stream regime information on and around the project site, and to establish a guideline to figure out the amount of water to be used.

1) Flow rate data

1) Method used on site

Though there exists no water-gauging facility in the neighborhood of the planned site, precipitation station is also placed at Sidikalang Province, Dairi District. Precipitation data from 1993 to 2008 was available, and in this review, these precipitation data were converted to flow rate through application of NRECA model.

Location of this plan is shown in Figure 4-8.

Table4-27 Precipitation station in surrounding the project site

	Name of river	Basin area	Period of available data	Note
Sidikalang precipitation station	―	―	1993～2008	No missing data

2) Methods used in Japan

The guideline applied to hydropower constructions in Japan prescribes that, in case no water-gauging facility is available in the immediate or moderate neighborhood of the project site, a simplified precipitation measurement should be taken for a year to figure out the flow rate. Based on the measured flow rate and the data obtained from the water-gauging facilities along the neighboring rivers, correlation favor of mutually complementary use of these set of data, flow rate is forecast using regression analysis for the period of ten years.

Therefore, in the light of method used in Japan, flow data must be measured on site.

Although an accuracy check of the flow rate data is deemed necessary, measured flow rate data is not available from the neighborhood of the project site. Given this situation, this review uses the flow rate data available from the on-site planning document (converted from precipitation data using NRECA model) for analysis.

2) Stream regime

Flow duration charts at intake location is made using local method and adopted method based on the average daily discharge at the location of water – gauging station.

Table4-28 and Figure 4-9 show the map and table of flow duration curve pursuant to local method. Table 4-29 shows the map and table of flow duration curve pursuant to method used in Japan adjusting the flow condition with potential probability is made in accordance with the average daily discharge gained by the local method. Accordingly, the date of arising probability is changed to outline the diagram of flow condition of method used in Japan. For example, Japan's rainy season (95 days) would correspond to Q26% (95 days ÷ 365 days).

Table4-28 Stream regime ー Local method（Lae Ordi II）

Probability	Sidikalang rainfall Measurement observation station
Q 5%	77.32
Q 10%	59.18
Q 15%	49.33
Q 20%	42.92
Q 25%	37.96
Q 30%	35.40
Q 35%	33.82
Q 40%	31.84
Q 45%	30.01
Q 50%	28.01
Q 55%	26.28
Q 60%	24.24
Q 65%	22.03
Q 70%	19.87
Q 75%	18.16
Q 80%	16.54
Q 85%	15.38
Q 90%	13.58
Q 95%	11.48

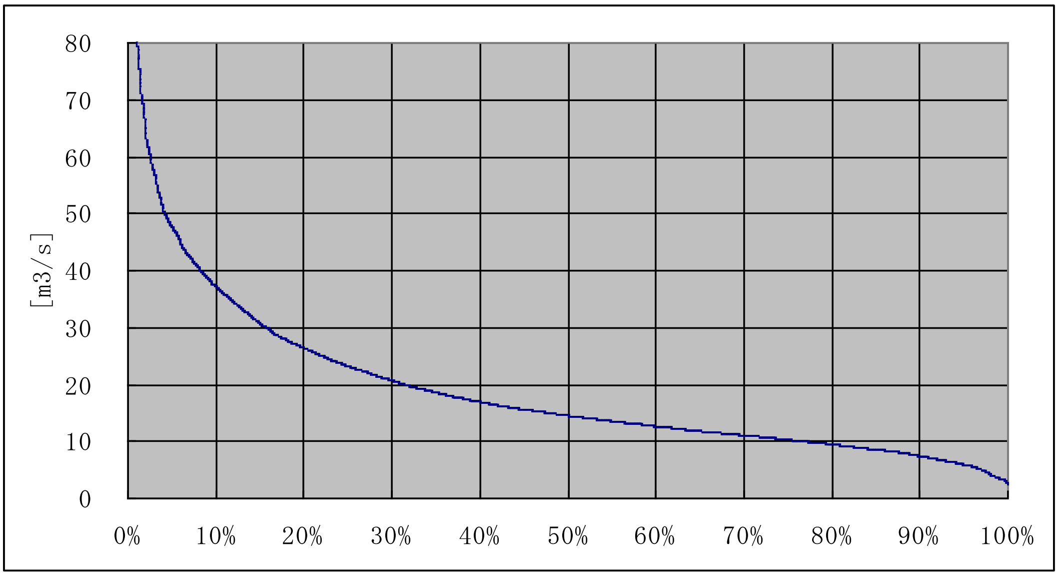


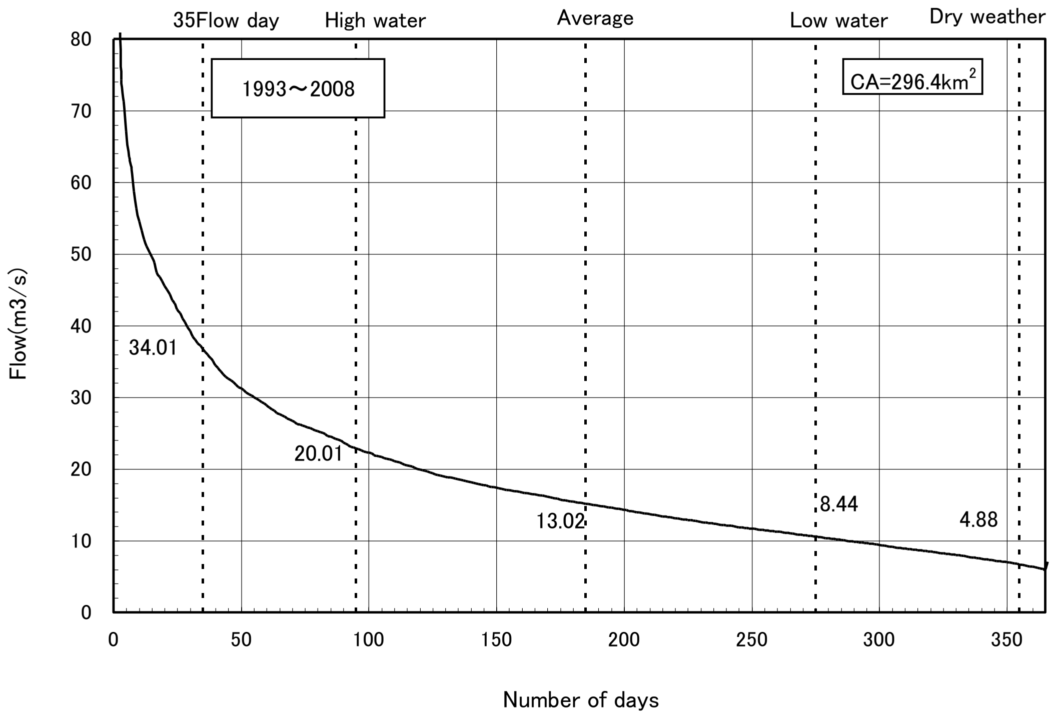
Figure 4-9 Stream regime - local method (Lae Ordi II)

Table 4-29 Stream regime at Lae Ordi Ⅱ, estimated by method used in Japan

[1993]～

【CA=296.400km2】 (Unit : m^3/s)

	Max flow	Flow 35day	High water 95day	Average water 185day	Low water 275day	Dry weather water 355day	Min flow	Total annual water	Annually average
[1993]	96.98	46.16	23.00	11.56	8.00	5.34	5.00	7,203.36	19.74
[1994]	164.89	59.39	33.07	21.09	14.12	9.24	8.22	10,122.99	27.73
[1995]	166.37	59.52	36.14	20.06	10.72	8.03	6.93	10,284.02	28.18
[1996]	88.91	32.58	22.87	15.86	12.57	8.35	7.48	7,119.35	19.45
Adjust data from the year 1993 to the year 2008									
average	98.78	36.73	22.89	15.15	10.57	6.60	5.94	7,051.63	19.27



4-2-3-3. Review of power generation capacity

Power generation capacity of relevant location has the utilizable discharge of 11.63m^3/s and the peak output power of 10,000kW. It is necessary to verify the power generation capacity using alternative inspection method used in Japan. In addition, in such case, it is necessary to confirm the appropriateness of factors.

(1) Intake level, tail water level and effective head

1) Intake level

Figure 4-10 represents the plane view and cross-section of the intake weir. The intake weir (height 7.0m) is constructed on a river bed whose altitude is 624.0m above sea level, and its intake level is set to the altitude of the overflow weir, 631.0m. It is deemed to be suitable to the project.

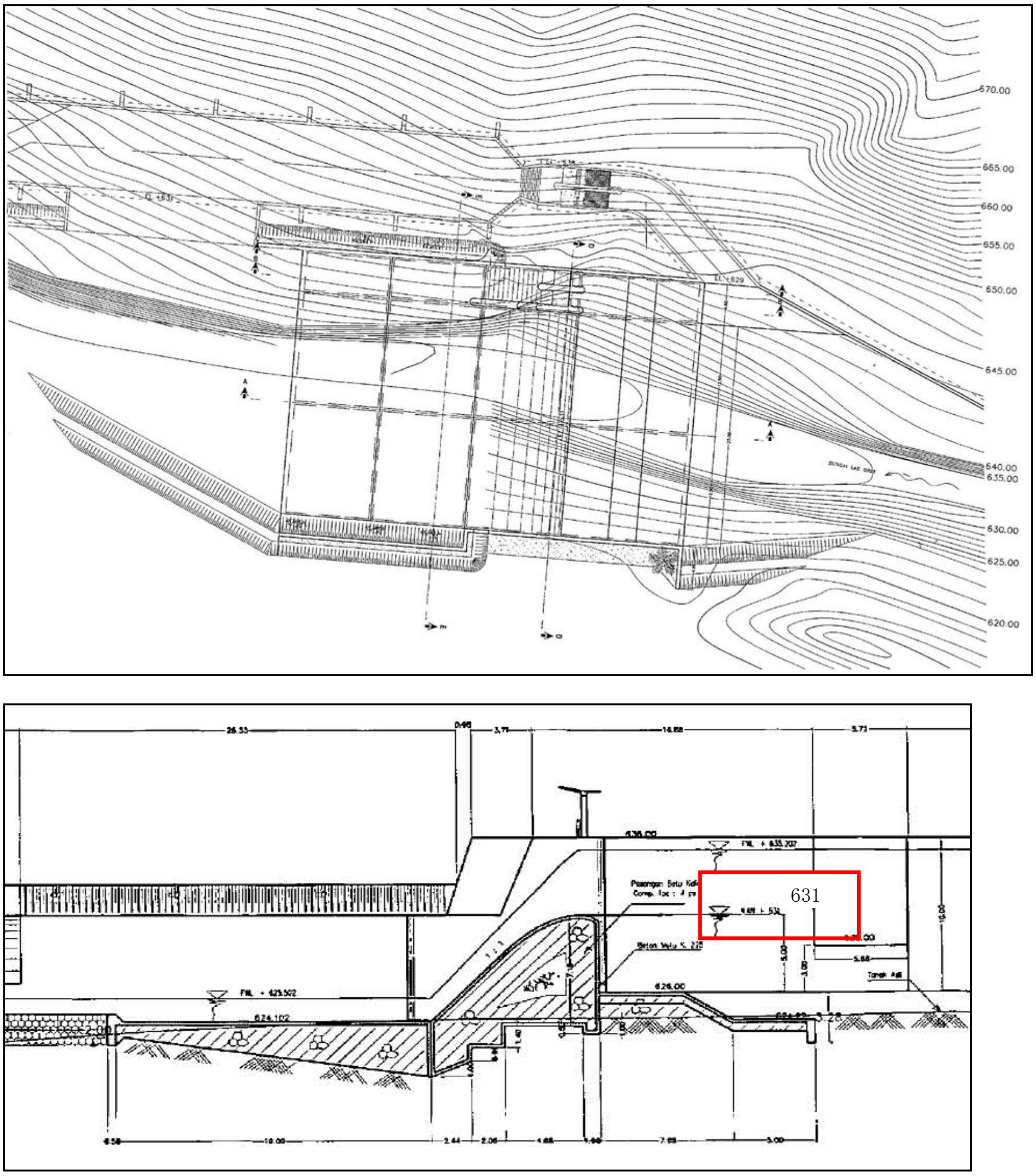


Figure 4-10 Intake Weir at Lae Ordi II (Above: Plane view, below: cross- section）

2) Tail water level

Figure 4-11 shows plane view of power plant and cross-section of penstock and power plant based on local company. As the cross-section view shows, it is required to cut the slope of mountain and install penstock as exposed, and power plant will be constructed as above ground type. In addition, tail water level is set at 520m same as river water level.

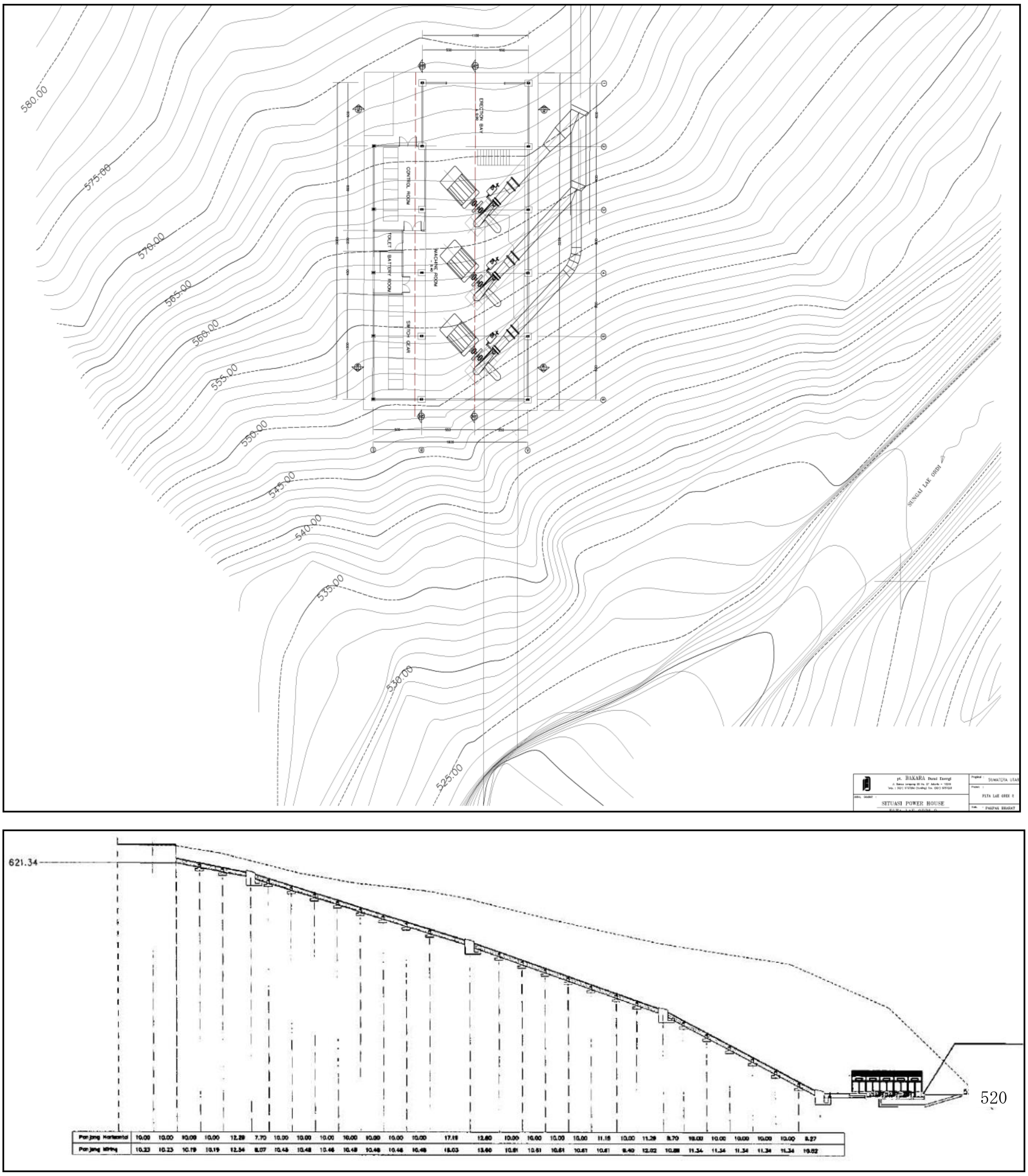


Figure 4-11 Power plant- Lae Ordi II (above: plane view, below: cross-section）

3) Effective head

(A) Method used to determine the appropriateness of effective head

Normal procedure in Japan to calculate an effective head is: "Effective head = intake water level – tail water level– loss head". Here, loss head is calculated using the normal procedure employed in Japan, and the result is applied to check validity of the effective head.

- Intake water level : 631.00m
- Head tank level : 630.20m
- Tail water level : 520.00m
- Gross head : 106.40m

(B) Calculation of head loss

Table 4-30 shows the results of loss head calculation in this review, and Table 4-31 shows results of effective head loss calculation.

The flow runs through the facility in the following sequence: Intake weir → Intake gate → Settling basin → Headrace →Head tank →Penstock → Power plant".

The portion of loss head that arises upstream of the head tank was calculated using backwater analysis, wherein the head tank level was used as the base level. The results of analysis indicated an allowance of 0.285m, enabling the flow to run through without hitch.

The portion of loss head downstream of the head tank indicated a loss while running through the penstock. These concluded a net head loss 4.60m (an allowance of 0.084m inclusive).

For further information on the calculations, see Appendix L4-1.

Table 4-30 Calculation of the Head Loss (Lae Ordi II) (Unit：m)

Intake	Flow	0.146
	Pier	0.015
	Allowance	0.285
Settling basin	cross-section change	0.000
	Flow	0.047
Headrace	Friction	0.307
Head tank	cross-section largement	0.000
Penstock	Flow	0.035
	Friction (Before branch)	2.699
	Branch	0.983
Other allowance		0.084
Total		4.600

Table 4-31 Calculation of Effective Head (Lae Ordi II)

Contents	Unit	Max	Regular
Plant discharge	m^3/s	11.630	5.710
Intake level	m	631.000	631.000
Tailrace level	m	520.000	520.000
Gross head	m	111.000	111.000
Head loss	m	4.600	1.300
Effective head	m	106.400	109.700

(2) Turbine - generator coupling efficiency

1) Selection of a types of water turbine

The type of water turbine to be employed should be determined in view of the effective head and discharge on site.

In the projects undertaken in Japan, the type of a turbine to be employed is determined at the design stage with the help of a turbine selection nomogram such as the one shown in Figure 4-12. As the project goes into the execution design stage, it is a normal practice to grasp detailed information – turbine shape, loading efficiency and others – through extensive hearings from the manufacturer, which will be reflected in the analysis of power generation capacity.

A horizontal shaft Francis turbine is selected in Lae Ordi II.

Effective head and useable discharge at the site of this project are:

Effective head : 106.4m

Utilizable water : 11.63m^3/s

From the data, a horizontal shaft Francis turbine should be a proper choice in reference to the nomogram used in Japan.

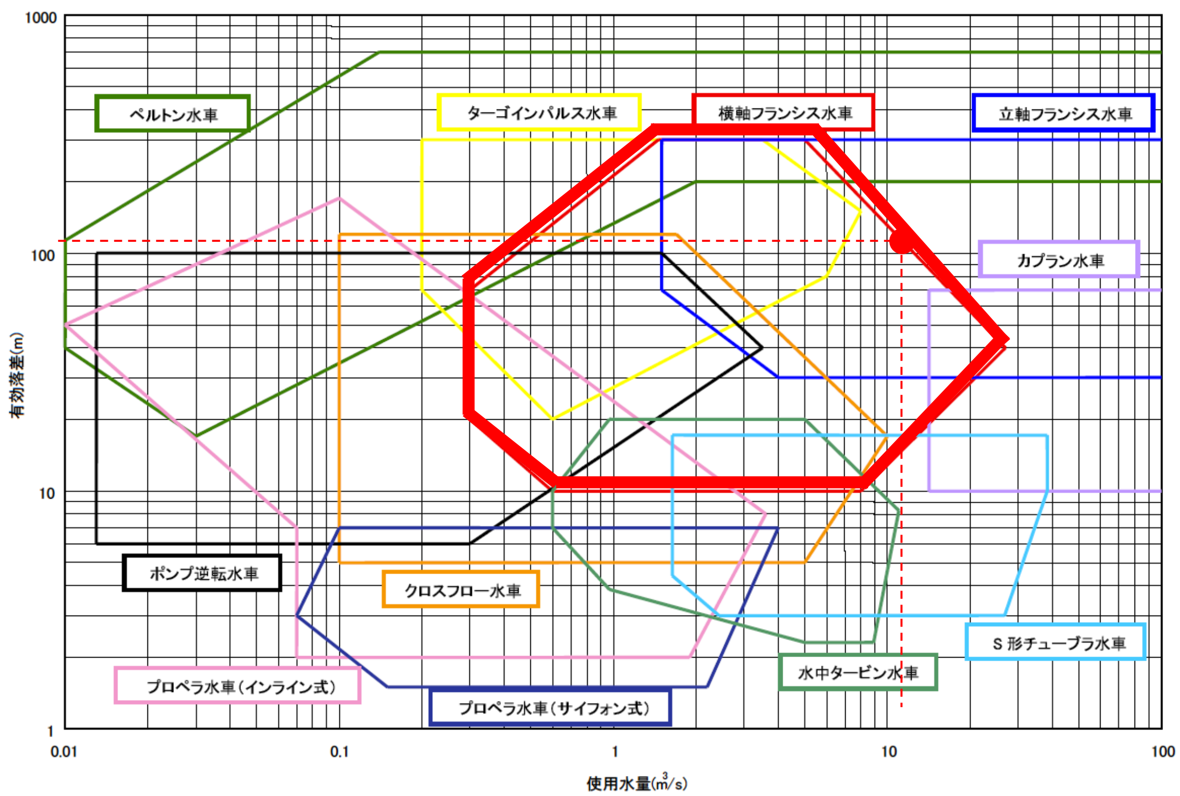


Figure 4-12 Nomogram for turbine selection

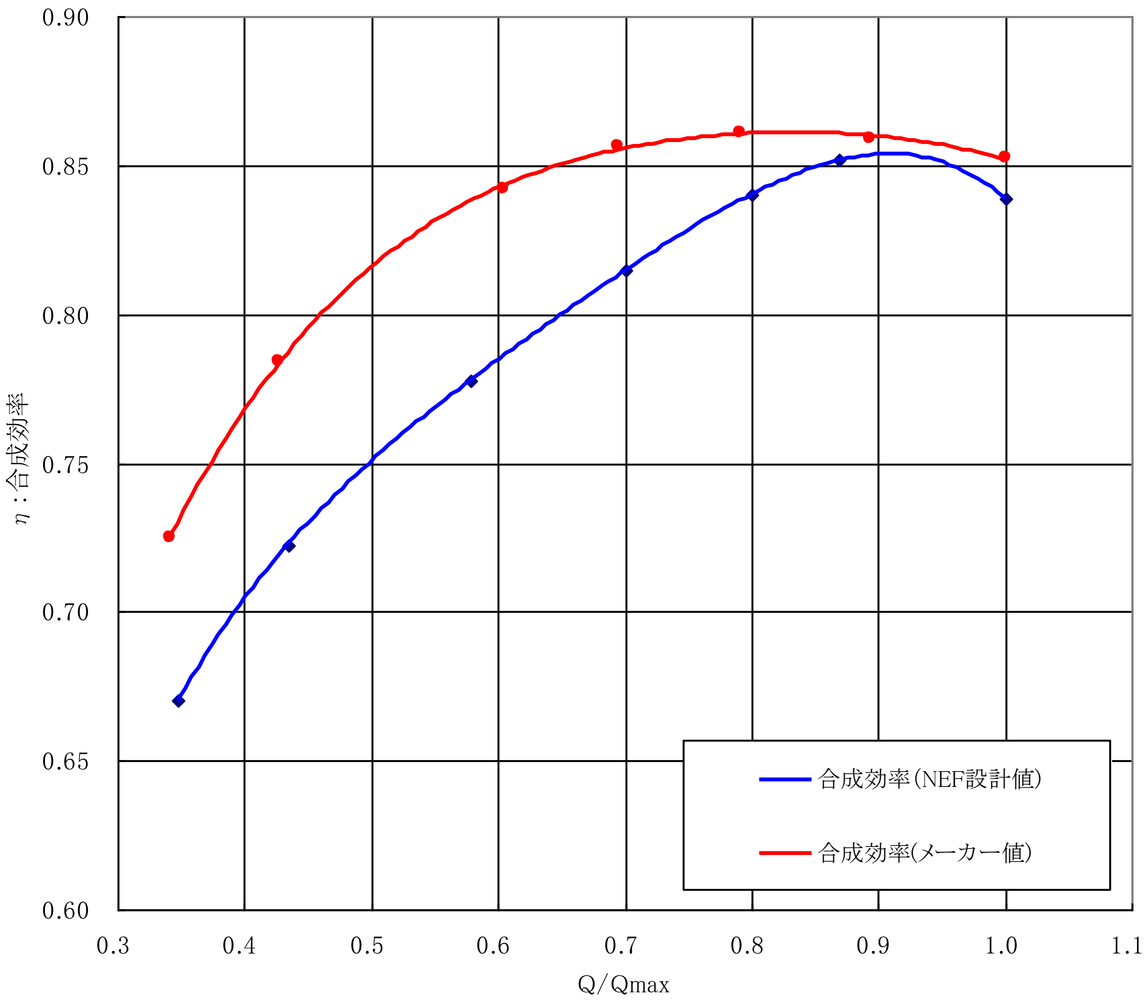
Source: "Hydro Valley plan guidebook"（New energy foundation）

2) Efficiency of turbine and generator

Turbine -generator coupling efficiency – an essential factor for the analysis of power output capacity – is calculated using data obtained through hearings from the turbine manufacturer. Figure 4-13 shows the coupling efficiency curve prepared based on hearings from the turbine manufacturer, as well as the one prepared following the steps prescribed by "Small and medium hydroelectric guidebook, Ver. 5" (New Energy Foundation). (The approximation formula shown in the figure is based on the values provided by the manufacturer.)

Efficiency values based on manufacturer information is consistently higher than those of NEF design. In this examination, the coupling efficiency curve based on the manufacturer data is adopted as it is considered more practical for real application.

The minimal discharge for power generation is set to be 40% of its maximum in view of track records in the past.



$$y = -1.2367x^4 + 4.074x^3 - 5.3174x^2 + 3.238x + 0.0941$$

Figure 4-13 Turbine – generator coupling efficiency curve

(3) Case study: examination on power generation capacity

Following the standard procedure in place in Japan, an examination was made to evaluate power generation capacity of the project: important parameters (generator output, electric energy generated, and estimated construction cost) were figured out by varying maximum flow rate available in view of the characteristics of the stream regime.

The set of data used in the case study is listed in Table 4-32. In plan 2, peak output power is 10,000kW same as the local plan and 11.20m^2/s of utilizable water. The water volume is 0.4m^3/s less than local plan with 11.63m^3/s of the water. It is caused of high generating performance compare to local setting value by using reference value from Japanese manufacturer.

The generating performance calculated according to this survey：85.2%
The generating performance calculated according to the survey in use：82.5%

Table 4-32 Content of Generating Scale Consideration

Contents			Features					Local features
Name of River			LaeOrdi River					
Basin area			296.00 k㎡					
Intake level			EL. 631.00 m					
Tailrace level			EL. 520.00 m					
Gross head			111.00 m					
Effective head			106.40 m					
Maximum water discharge			Plan1	Plan2	Plan3	Plan4	Plan5	Local features
			6.80 ㎥/s	11.20 ㎥/s	15.80 ㎥/s	21.40 ㎥/s	24.80 ㎥/s	11.63 ㎥/s
Maximum output			6,000 kW	10,000 kW	14,000 kW	19,000 kW	22,000 kW	10,000 kW
Water for river maintenance			0.89 ㎥/s					N/A
General equipment	Intake weir		Height 7.0m, Length 29.6m					
	waterway	Headrace	Open or closed channel L＝2,426m (Syphone)					
		Penstock	Inner diameter 2.0m, L＝320.0m					
		Spillway channel	L＝70.4m					
	Powerhouse		Above ground					
	Turbin		Francis water turbine with horizontal shaft × 3					
	Generator type		Synchronous generator × 3					

※The yellow cells indicates the case where the amount of water used is set to the same level as Indonesian plan.

(4) Power generation capacity

1) Maximum annual electricity generation

The available power energy is calculated based on the elements of the generating scale inspection given above.

According to the local hearings, relevant plans do not carry out irrigation in the downstream, thus the discharge maintenance is not required. However, after considering the environment, it is recommended that the discharge remains as before.

In "Assurance of the maintenance discharge of river pursuant to changes in each period (usually called generating guideline), statement S63.7.14" in Japan, the standard of maintenance discharge for each 100km^2 basin area is 0.1~0.3m^3/s. In this survey this value is regarded as the reference value, and the maintenance discharge is set as below.

Maintenance discharge＝Basin area 296km^2 × 0.3m^3/s/100km^2 × 100＝0.89m^3/s

Annual available power energy and power output L_5 are represented in Table 4-33. In plan 2, the maximum utilizable water of this plan is 11.20m^3/s, although there is difference from the calculation condition below, it is 760MWh in comparison with the available power energy in local documents, so the value is almost the same.

(Differences in principal calculating conditions)

- Power generation efficiency
- Maximum output
- Method to establish the maintenance flow

Table 4-33 Maximum annual electricity generation and L_5 output

Induced electricity generation

Unit:MWh

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plan1	4,436	4,069	4,381	4,320	4,464	4,316	4,442	4,271	4,309	4,444	4,320	4,463	52,235
Plan2	7,007	6,393	6,697	7,056	7,192	6,900	6,814	6,270	6,516	7,023	7,044	7,196	82,107
Plan3	8,837	7,868	8,285	9,039	9,385	8,748	8,086	7,196	7,794	9,080	9,466	9,513	103,296
Plan4	10,091	8,886	9,607	10,811	11,222	9,973	8,844	7,824	8,899	11,089	11,567	11,244	120,057
Plan5	10,584	9,298	10,250	11,677	11,880	10,396	9,171	8,044	9,465	12,083	12,514	11,848	127,210
Local document	－												81,347

Output L5

Unit:MWh

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plan1	5,867	5,910	5,658	6,000	6,000	5,965	5,853	5,351	5,915	5,859	6,000	5,990	5,864
Plan2	8,857	8,328	8,029	9,262	8,995	9,126	7,781	6,657	7,617	8,295	9,496	9,336	8,482
Plan3	9,203	8,669	9,130	10,353	10,653	10,041	8,111	6,702	8,096	9,280	11,953	11,163	9,446
Plan4	9,326	8,709	9,998	11,220	11,108	10,252	8,086	6,635	8,538	10,145	13,500	11,674	9,933
Plan5	9,267	8,653	10,449	11,658	11,097	10,219	8,043	6,572	8,940	10,643	13,704	11,744	10,082

2) Annual electricity generation

The FS report prepared by local engineers does not contain any mention on in-house electricity consumption within the power plant, nor downtime ratio – due to failures, inspections , and maintenance/repair.

Small and medium hydroelectric guidebook in Japan refers that the power outage rate due to power failure is 5% (generating terminal). Based on domestic result, power consumption and wastage on the line are calculated as 2% (receiving terminal).

The annual available power energy of different cases is shown in Table 4-34.

Annual electricity generation (generating end)＝Maximum annual electricity generation×0.95

Annual electricity generation (receiving end)＝Maximum annual electricity generation×0.95×0.98

Table 4-34 Annual electricity generation

Unit:MWh

	Annually available power energy	Annually available power	Annually available power
Plan 1	52,235	49,624	48,631
Plan 2	82,107	78,001	76,441
Plan 3	103,296	98,131	96,168
Plan 4	120,057	114,055	111,773
Plan 5	127,210	120,849	118,432
Local document	81,347	78,093	76,531

(5) Estimated cost of construction

Rough estimation of construction cost was worked out based on the instructions given in the Standard Procedure for Evaluating Construction Cost of Hydroelectric Power Planning (unit price, projection chart, and others) in "Standard of cost estimate for the hydroelectric plant (March, 2005)" (New Energy Foundation).

To take fluctuation on prices in recent years (i.e. from 2003 to 2010) into account, it was also decided that construction cost should be multiplied by sector-dependent correction factors – "construction" and "civil engineering" sectors by + 12.4%, and so on.

Compared with the construction cost evaluation made by local engineers (cited in the document, especially its 2nd plan), the evaluation made by applying standard Japanese procedures (standard method describe above) showed about 6 times higher cost. The wide margin can be attributed to the differences in labor and material cost in Japan and Indonesia.

Table 4-35 Rough estimate of construction cost (Unit：million yen)

	Contents		Case of study						Summary
			Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Local	
1)	Land compensation expense		10.0	10.0	10.0	10.0	10.0		
2)	Relating to housing works		156.0	200.2	232.9	268.0	289.8		Underground type
3)	Relating to construction		3,068.5	3,992.0	4,822.4	5,790.4	6,337.4		
	①	Waterway	2,524.9	3,226.0	3,845.7	4,567.9	4,972.7		
	a.	Intake weir	167.6	167.6	167.6	167.6	167.6		Fixed weir
	b.	Intake	70.3	108.0	146.5	192.5	219.4		
	c.	Settling basin	124.1	199.8	278.9	376.1	435.0		
	d.	Headrace	1,424.0	1,850.0	2,215.5	2,598.4	2,806.8		
	d. Headrace	Tunnel	0.0	0.0	0.0	0.0	0.0		
		Opened channel	1,424.0	1,850.0	2,215.5	2,598.4	2,806.8		
		Closed channel	0.0	0.0	0.0	0.0	0.0		
	e.	Head tank	83.3	131.0	178.8	235.5	269.9		
	f.	Spillway channel	71.5	83.3	94.4	105.2	110.6		
	g.	Penstock	340.3	373.9	391.3	449.4	481.0		
	f.	Tailrace channel	0.0	0.0	0.0	0.0	0.0		
	h. Spillway channel	Tunnel	0.0	0.0	0.0	0.0	0.0		
		Closed channel	0.0	0.0	0.0	0.0	0.0		
		Opened channel	0.0	0.0	0.0	0.0	0.0		
	i.	Spillway channel	14.3	19.1	23.1	27.9	30.3		
	j.	Others	229.5	293.3	349.6	415.3	452.1	–	10.0% execution expense of above headrace
	②	Regulating pond	—	—	—	—	—		
	③	Equipment and machine	543.6	766.0	976.7	1,222.5	1,364.7		
	k.	Jack	264.6	403.1	538.3	696.1	788.6		Semi-subterranean type
	l.	Some equipment	279.0	362.9	438.4	526.4	576.1		(①+②+jack)×10.0%
	④	Others	0.0	0.0	0.0	0.0	0.0		
	m.	Bypass bridge	0.0	0.0	0.0	0.0	0.0		
	n.	Remodel of intake weir	0.0	0.0	0.0	0.0	0.0		
4)	Relating to electricity		2,348.4	3,251.3	4,030.8	4,741.3	5,387.5		
	o.	Turbine	856.2	1,155.4	1,406.9	1,632.9	1,836.6		Frances
	p.	Generator	658.9	942.2	1,193.6	1,426.0	1,639.2		Synchronous
	q.	Surplus water reducer	0.0	0.0	0.0	0.0	0.0		
			0.0	0.0	0.0	0.0	0.0		
	r.	Other equipment	0.0	0.0	0.0	0.0	0.0		
			0.0	0.0	0.0	0.0	0.0		
			833.3	1,153.7	1,430.3	1,682.4	1,911.7		Expense for main transformer and electric seichgear(55% of turbin and generator)
5)	Temporary equipment expense		665.1	758.7	840.8	926.5	987.2		
④	Total expense		409.6	547.1	667.8	793.8	883.1		{2)+3)+4)+5)}×0.07
6)	(Subtotal)		6,657.7	8,759.3	10,604.7	12,530.0	13,895.0		{1)~6)}
7)	Dam dispersal expense		—	—	—	—	—		Not calculated
8)	Interest rate in constructi		0	0	0	0	0		Not added
9)	Relevant dispersal expense		66.6	87.6	106.0	125.3	138.9		Sub Total×0.01
10)	Expense for electoricity cable		2,000.0	2,000.0	2,000.0	2,000.0	2,000.0		
11)	(Total)		8,724.3	10,846.9	12,710.7	14,655.3	16,033.9	1,917.0	

Construction cost of local material is estimated as approximate cost by local consulting company based on other similar hydro project in Indonesia. The project cost of this review was compared to other hydro project with similar scale (Nasal MPHH) and characteristic in Indonesia. Therefore, construction cost for each kW is almost equivalent which is proved as an appropriate amount for construction cost in Indonesia.

In the future, it is necessary to estimate precise cost of construction through the adequate consideration of structure design and construction schedule.

Table4-36 Comparison of project cost and economy with other hydro project

Name of project		Lae Ordi II	Nasal
Maximum output	kW	10,000	12000
Plant discharge	m^3/s	10.63	17.36
Effective head	m	106.4	80.8
Total of project cost	million Rp	226,140	275,382
Construction cost for each kW	Rp/kW	22,614,000	22,948,500

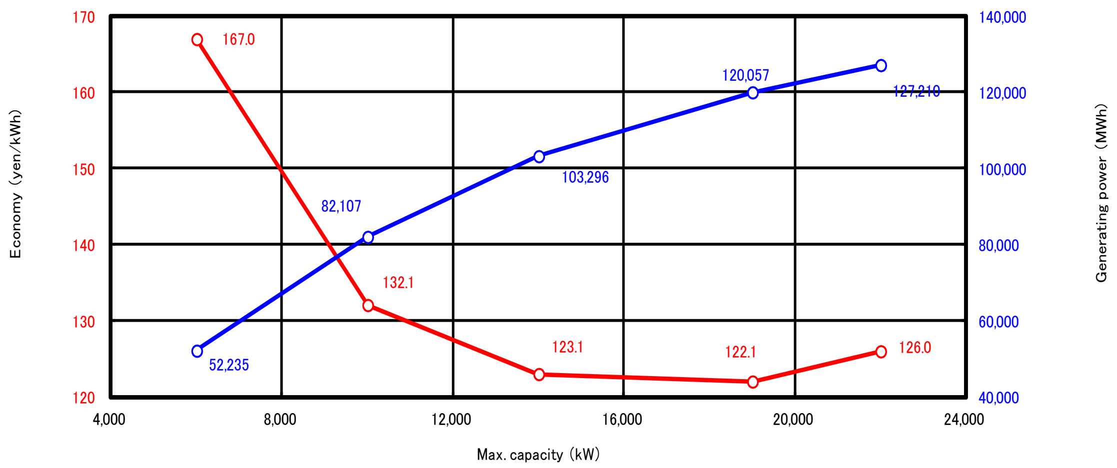
(6) Review summary: capacity of electric generation

Table 4-37 shows the results of capacity review of the electric power generation project, which was carries out using standard procedures employed in Japan. The 3rd plan was found to be optimum: adopting this generation capacity leads to cheapest construction cost per kWh (i.e. 122.1 yen) with maximum output 18,000kW (max. flow rate 21.4 m^3/s). However, the fixed purchase price is applied in Indonesia, only for the power under 10,000 kW, thus, peak power of 10,000 kW (max. flow rate 11.20 m^3/s) in 2nd plan (construction cost per kWh is 132.1 yen) is considered the most appropriate capacity.

Thus, capacity of electricity generation with output 10,000kW selected for local plan is deemed to be appropriate.

Table 4-37 Comparison and analysis of generation capacity plans

Items		Case of study: Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	On-site data
Name of river system and river		LaeOrdi 川					
Basin area		296.00 km^2					
Discharge of river (m^3/s)		Conversion discharge by NRECA model of DolokSunggul rainfall measurement observation station (Average1977-1999)					
		MAX 88.79 35 days 34.01 High water 20.01 Medium water 13.02					
		Low water 8.44 Dry weather water 4.88 Minimum 4.27 Annual average 16.96					
Generation plan	Type of power generation	Run-off-river, conduit type					
	Intake water level	631.00 m	631.00 m	631.00 m	631.00 m	631.00 m	631.00 m
	Tailwater level	520.00 m	520.00 m	520.00 m	520.00 m	520.00 m	525.00 m
	Gross head	111.00 m	111.00 m	111.00 m	111.00 m	111.00 m	106.00 m
	Effective head	106.40 m	106.40 m	106.40 m	106.40 m	106.40 m	102.80 m
	Maximum water discharge	6.80 m^3/s	11.20 m^3/s	15.80 m^3/s	21.40 m^3/s	24.80 m^3/s	11.63 m^3/s
	Output	6,000 kW	10,000 kW	14,000 kW	19,000 kW	22,000 kW	10,000 kW
	Output L_5	5,864 kW	8,482 kW	9,446 kW	9,933 kW	10,082 kW	-
	Annually electricity generation	52,235 MWh	82,107 MWh	103,296 MWh	120,057 MWh	127,210 MWh	81,347 MWh
General equipment	Intake weir	Height 7.0m, Length 29.6m					
	Intake	—					
	Settling basin	Open-air, Length:56.20m, Width:9.00m					
	Head tank	Open-air, Length:73.50m, Width:12.00m					
	Waterway: Headrace	Open-air or subterranean L=2,426m, I=1/3,333					
	Waterway: Penstock	Inner diameter 2.0m 、 L= 320.0m					
	Waterway: Spillway channnel	L=70.4m					
	Power station	Above ground					
	Turbine	Francis water turbine with horizontal axis, 3 turbines					
	Generator type	3,333kW×3 units					
River utilization	Water for river maintenance	0.89 m^3/s					N/A
	Plant factor	99.4%	93.7%	84.2%	72.1%	66.0%	92.9%
	River utilization rate	38.1%	58.2%	70.5%	78.2%	83.4%	N/A
Total cost of the project		8,724 million yen	10,847 million yen	12,711 million yen	14,655 million yen	16,034 million yen	1,917 million yen
Construction cost equivalent to kW		1,454 million yen	1,085 thousand yen	908 thousand yen	771 thousand yen	729 thousand yen	192 thousand yen
Construction cost equivalent to kWh		167.0 yen/kWh	132.1 yen/kWh	123.1 yen/kWh	122.1 yen/kWh	126.0 yen/kWh	23.6 yen/kWh



4-2-4. Review of main structures

4-2-4-1. Intake weir design

(1) Location and width of the Dam

As the plane view indicates, the dam is laid down in narrower part of river width, and it is easier to shut off river flow during construction and possible to reduce number of constructions. Therefore, design of dam is deemed to be appropriate approach.

Also, dam is designed to cover the full width of the river, thus, cross-section is fully satisfied in order to flow down design flood discharge (1,600 m^3/s).

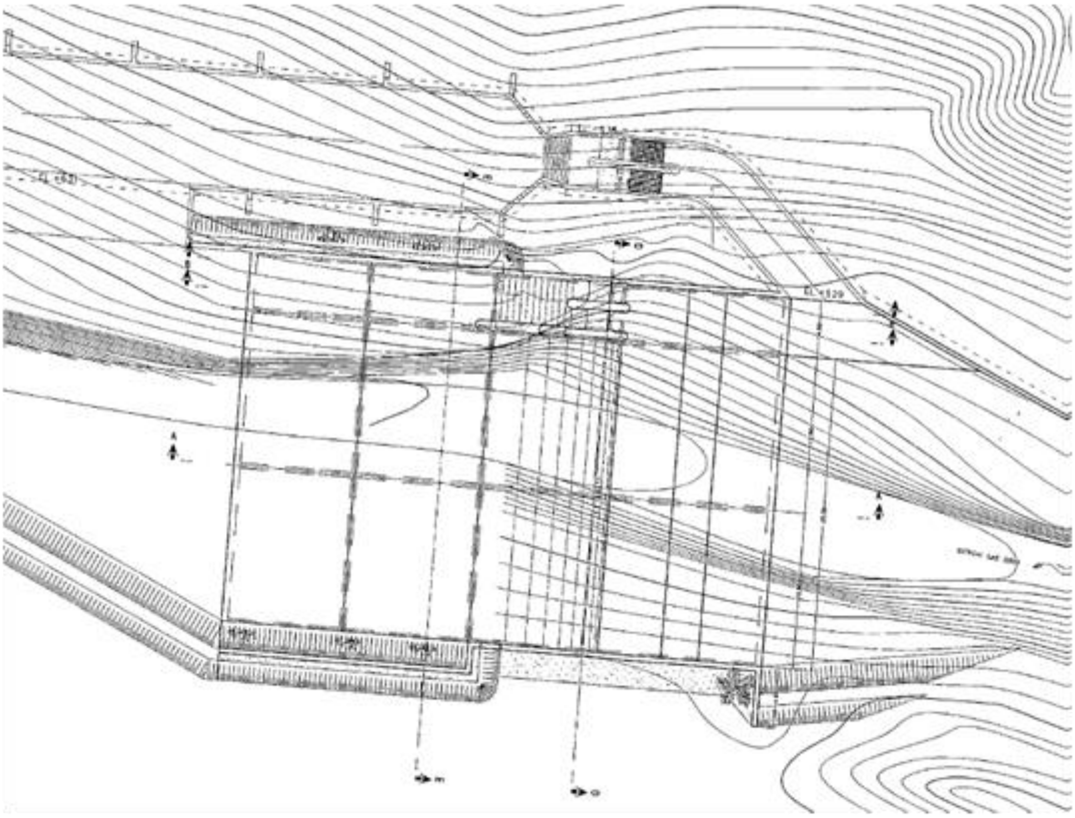


Figure 4-14 Intake weir design（Plane view）

(2) Dam height

The dam has a height - from the river bed to spillway crest - of 7.0m, which is a relatively large value for a weir, and the intake gate is elevated from river bed by 3.0m, allowing sufficient sediment storage capacity. The dam height allows intake depth as large as 2.0m, making the height design tobe considered appropriate.

A sand trap gate is incorporated in the river bank on one side of the intake enabling to discharge pebbles of the sizes up to around 10cm, which will prove to be an effective measure against difficulties in water intake.

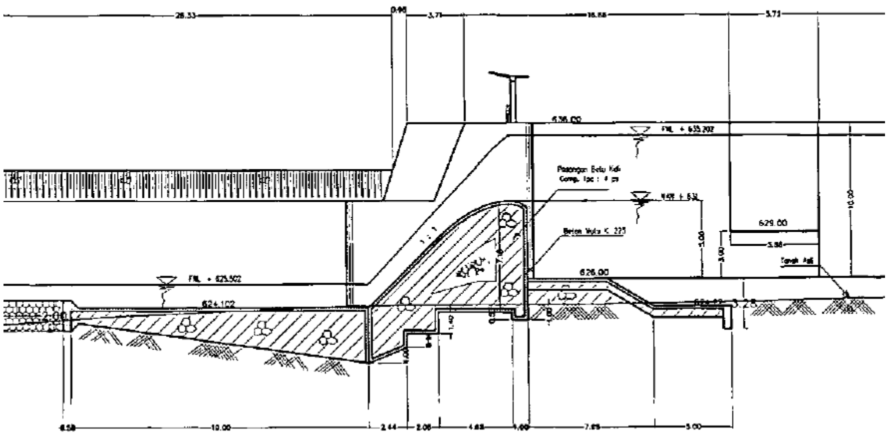


Figure 4-15 Intake weir design (longitudinal profile)

(3) Scouring in downstream river

As the longitudinal profile above shows, the front apron in downstream of the dam has sufficiently large depth of footing, also with sufficient extension, ensuring safety against scouring in the river bed and river banks.

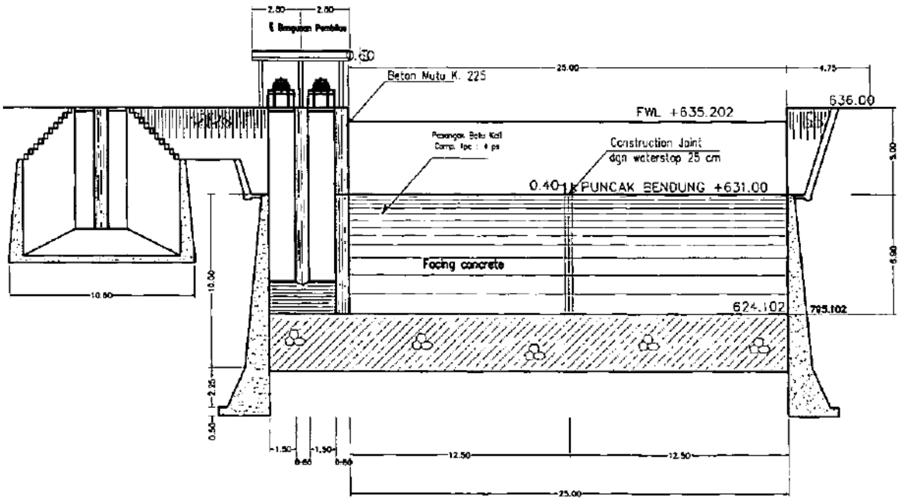


Figure 4-16 Intake weir design (front view)

4-2-4-2. Stability analysis of Intake weir

(1) Discussion

In the project site, an intake weir of concrete gravity dam us located upstream of the power plant. In this section, stability of intake weir – in term of sliding, overturning, bearing resistance – is analyzed based on the technology standards used in Japan.

Selection of the cross-sections used in the analysis and provisions for design were assigned based on the documents provided by Indonesian side (e.g. engineering drawings), and for unknown specifications, additional references were made to Japanese technology standards on an as-required basis.

In this section, the conditions applied to analysis, and the results are presented: for the specifics of calculations, see Appendix L4-3.

(2) Cross-section for analysis

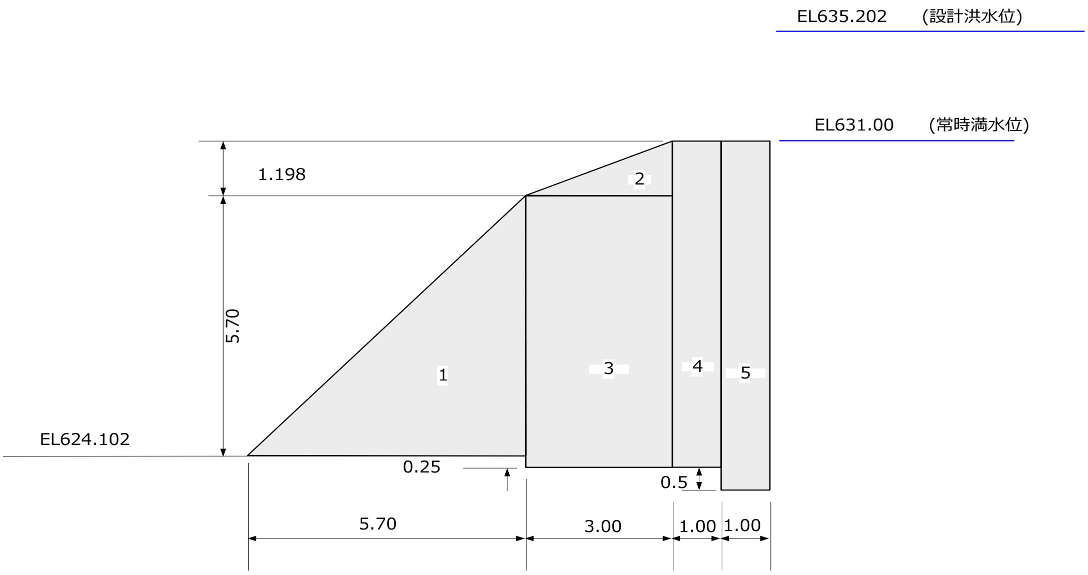


Figure 4-17 Intake Weir cross-section used for analysis (Lae Ordi II)

(3) Calculation condition

1) Reference and standard

Reference and standard to which design conforms, and the written materials to which the design made reference are listed in Table 4-38.

Table 4-38 Reference for Stability analysis of dam

No	Title	Issued year	Issuing organization
1	Design document from local company	2011	—
2	Technological standards for hydraulic power generating installations and applications to the government for installation	2011. March	Electric power civil engineering association
3	Cabinet order concerning structural standards for river management facilities	2000. January	Japan rivers association
4	Ministry of construction River errosion control technical standard	1997. October	Japan rivers association
5	Standard specifications for concrete Structures 'Structural performance verification'	2008. March	Japan society of civil engineer
6	The structural mechanics handbook	1986. June	Japan society of civil engineer
7	Specification for highway bridges （PartI.Common, PartⅥ.Substructure）	2012. March	Japan road association
8	Road earth work 'Retaining wall construction guideline'	2012. July	Japan road association

2) Material condition

Calculation conditions for each material are shown below.

(A) Concrete

Table4-39 Concrete Condition

Item	Symbol	Unit	Value	Reference No.
Unit weight (Concrete)	γ_c	kN/m³	24.0	1
Unit weight（Masonry block）	γ_b	kN/m³	22.0	1
Design strength	σ_{ck}	N/mm^2	—	—
Allowable bending compressive stress intensity	σ_{ca}	N/mm^2	—	—
Allowable shearing stress intensity	τ_a	N/mm^2	—	—

3) Natural condition

Basic information such as geographic condition for this construction is shown below.

(A) Soil condition（sedimentary soil）

Table4-40 Soil Condition

Item	Symbol	Unit	Value	Reference No.
Unit weight （wet）	γ_t	kN/㎥	17.65	4
Unit weight （underwater）	γ_s	kN/㎥	9.81	4
Unit weight of water （underwater）	γ_w	kN/㎥	9.81	4

(B) Foundation ground

Physical property values of foundation ground are referred and used from “River erosion control technical standard” (Ministry of construction). Geological feature on the location of intake weir is welded tuff according to “Design from local company”. In this review, it is evaluated “as hard rock with cracks” to verify the allowable bearing capacity while considering safety work.

Table 4-41 Foundation Ground Condition

Item	Symbol	Unit	Value	Reference No.
Compressive strength	qu	kN/㎡	9810	4
Allowable bearing capacity （At normal）	σ	kN/㎡	588	4
Allowable bearing capacity （During earthquake）	〃	kN/㎡	883	4

Table 4-42 Allowance Bearing Capacity and Friction Factor for Type of Geology

基礎地盤の種類		許容支持力度 (tf/m²) {kN/m²}		摩擦係数 場所打ちコンクリートの場合の堰等の底面の滑動安定計算に用いるすべり	備考	
		常時	地震時		qu (tf/m²) {kN/m²}	N 値
岩盤	亀裂の少ない均一な硬岩	100 {981}	150 {1470}	0.7	1 000 以上 {9 810 以上}	—
岩盤	亀裂の多い硬岩 Hard rock with cracks	60 {558}	90 {883}	0.7	1 000 以上 {9 810 以上}	—
岩盤	軟岩，土丹	30 {294}	45 {441}	0.7	100 以上 {981 以上}	—
礫層	密なもの	60 {588}	90 {883}	0.6	—	—
礫層	密でないもの	30 {294}	45 {441}	—	—	
砂質地震	密なもの	30 {294}	45 {441}	0.6	—	30～50
砂質地震	中位なもの	20 {196}	30 {294}	0.5	—	15～30
粘性土地盤	非常に堅いもの	20 {196}	30 {294}	0.5	20～40 {196～392}	15～30
粘性土地盤	堅いもの	10 {98.1}	15 {147}	0.45	10～ 20 {98.1～196}	8～15
粘性土地盤	中位なもの	5 {49}	7.5 {73.5}		5～ 10 {49～ 98.1}	4～ 8

4) Loading condition

(A) Dead load

Total weight of dam is considered as dead load.

(B) Soil and water weight

The weight of soil and water upstream of the dam need not be taken into account, because no construct, such as a dam fillet, exists upstream.

(C) Seismic inertia force

Seismic inertia force (P_f) is defined as dead load (W) multiplied by design horizontal seismic coefficient (K_h), and exertsforce in horizontal direction through center of gravity of dam.

Design horizontal seismic coefficient K_h is calculated by following equation. The coefficients, γ_1 and γ_2 should be determined in consideration of local information – normally the strength of earthquake and type of foundation. In this review, these values are set to be well on the safe side, because of the lack of the information on its foundation.

$Pf = K_h \times W$

$K_h = \gamma_1 \times \gamma_2 \times \gamma_3 \times K_0$

where,

K_h : Design seismic coefficient ($K_h = 1.0 \times 1.2 \times 1.0 \times 0.2 = 0.24$)

K_0 : Standard seismic coefficient ($K_0 = 0.2$)

γ_1 : Seismic zone factor ($\gamma_1 = 1.0$ from Table 4-43)

γ_2 : Ground condition factor ($\gamma_2 = 1.2$ from Table 4-44)

γ_3 : Importance factor ($\gamma_3 = 1.0$)

Table 4-43 Seismic zone factor

Earth quake zone	Strong	Medium	Weak
Factor γ_1	1.0	0.85	0.7

Table 4-44 Ground condition factor

Ground condition	Type Ⅰ	Type Ⅱ	Type Ⅲ
Factor γ_2	0.8	1.0	1.2

(D) Hydrostatic pressure

Hydrostatic pressure is defined as external and internal hydraulic pressure that works on the the walls, and calculated using the following equation. An assumption is made for the calculation – i.e. the following three forces do not act on the wall all at the same time: earthquake inertia force, hydrodynamic pressure during earthquake, and hydraulic pressure at design flood.

$P_w = (1/2) \times \gamma_w \times h^2$

where,

P_w : Total hydraulic pressure from surface to depth h (kN/m²)

γ_w : Unit volumetric weight of water ($\gamma w = 9.8$kN/m³)

h : Depth from surface

(E) Uplift pressure

Uplift pressure due to water level differences between upper and lower reach of the dam axis.

Uplift at upper reach : $\{(h_1 - h_2) \times \mu + h_2\} \times \gamma_w$

Uplift at lower reach : $h_2 \times \gamma_w$

where,

μ : Uplift coefficient (=1/3)

h_1 : Depth of upper reach

h_2 : Depth of lower reach

(F) Mud pressure

Horizontal pressure exerted by earth and sand accumulated on the base of the reservoir (mud pressure) can be calculated using the following equation.

$$Pe = (1/2) \times Ce \times \gamma_s \times d^2$$

where,

Pe : Total mud earth pressure in horizontal direction at the depth of d from sediment surface

Ce : Mud pressure coefficient (=0.5)

γ_s : Unit volumetric weight (underwater) of accumulated earth and sand

d : Depth from sediment surface

(G) Dynamic water pressure during earthquake

This value can be calculated using Westergaard's approximation formula.

$$Pd = (7/12) \times \gamma_w \times K_h \times H^{1/2} \times h^{3/2}$$

where,

Pd : Total dynamic water pressure from water surface to depth h (kN/m²)

γ_w : Unit volumetric weight of water

K_h : Design horizontal seismic coefficient

H : Depth from water surface to foundation ground

H : Depth from surface

(H) Wave pressure

Wave pressure is generally calculated using wave height caused by wind and earthquake. In this review, however, wave height caused by wind is ignored in reference to the directive contained in the dam standard. Wave height caused by an earthquake is calculated using the formula below.

$$h_e = (K_h \cdot \tau / \pi) \times \sqrt{(g \times H)}$$

where,

h_e : Total of wave height

K_h : Design seismic coefficient

τ : Earthquake frequency (normally 1 second)

H : Depth from design water level to bottom sill level

5) Stability condition

As a part of stability calculations, an examination is made regarding sliding, overturning, and bearing capacity.

In reference to "Ministry of construction River erosion control technical standard", stability condition of a concrete gravity dam is estimated as below :

① Sliding : Safety factor 1.5 is applied to Henny's formula

② Overturning : Resultant external force should fall within middle-third of horizontal section of the dam body

③ Bearing capacity : Stress acting on the rock surface and inside the dam body should not exceed its allowable limit.

Items and details to analyze are as follows.

(A) Stability against sliding

To maintain stability against sliding, the safety factor N, represented by Henny's equation, must ssatisfy the following inequality. ("Ministry of construction River erosion control technical standard")

$$N = \frac{\text{Resistant force against sliding}}{\text{Sliding force}} = \frac{f \cdot \Sigma V + \tau \cdot L}{\Sigma H} \geqq 4$$

where, ΣV : Total vertical load on dam base bottom (kN/m)

ΣH : Total horizontal load on dam base bottom (kN/m)

f : Friction factor between dam bottom and bearing ground

From the natural condition described above, $f = \tan \phi_B = 0.7$

ϕ_B : Friction angle between dam bottom and bearing ground(°)

τ : Shearing strength of rock mass(kN/m^2)

Since no experiment value is available, this review uses Coulomb's equation for estimation

$$\tau = C_B + \sigma \cdot \tan \phi_B$$

C_B : Cohesion between dam bottom and bearing ground(kN/m^2)

As natural condition mentioned above, $C_B = 196$(kN/m^2)

When there is no test result of Japan's domestic stability calculation example, internal friction angle and cohesion are not considered at same time, thus,

$C_B = 0$(kN/m^2)

σ : Generally interpreted as vertical stress acting on failure surface, but this review interpret it as the bearing capacity (see natural condition above)

Normal state $\sigma = 588$(kN/m^2)

During earthquake $\sigma = 882$(kN/m^2)

L : dam bottom width(m)

(B) Stability against overturning

Stability against overturning requires that the net force of external force (= resultant force R) should fall in middle-thirds- i.e. the displacement distance(e) between the resultant force R's working point and the center of the basal plate must satisfy the following relations.

Normal state : $|e| \leqq B/6$

During earthquake : $|e| \leqq B/3$

Displacement distance (e) – between the working point of R and center of basal plate – is represented by following equation.

$e = (L/2) - d$

where,

d : Distance between the working point of R and the toe of revetment basal plate (m)

$$d = \frac{\Sigma M_r - \Sigma M_0}{\Sigma V} = \frac{\Sigma V_i \cdot a_i - \Sigma H_j \cdot b_i}{\Sigma V_i}$$

ΣM_r : Resisting moment around toe of dam base(kN・m)

ΣM_o : Overturning moment around toe of dam base(kN・m)

V_i : Vertical component of load acting to the dam(kN/m)

a_i : Horizontal distance between the toe of dam base and the working point of V_i(m)

H_j : Horizontal component of load acting to dam(kN/m)

b_j : Vertical distance of the working point of H_j above the dam base(m)

L : In this design, L indicates the dam's basal plate width(m):see the drawing below

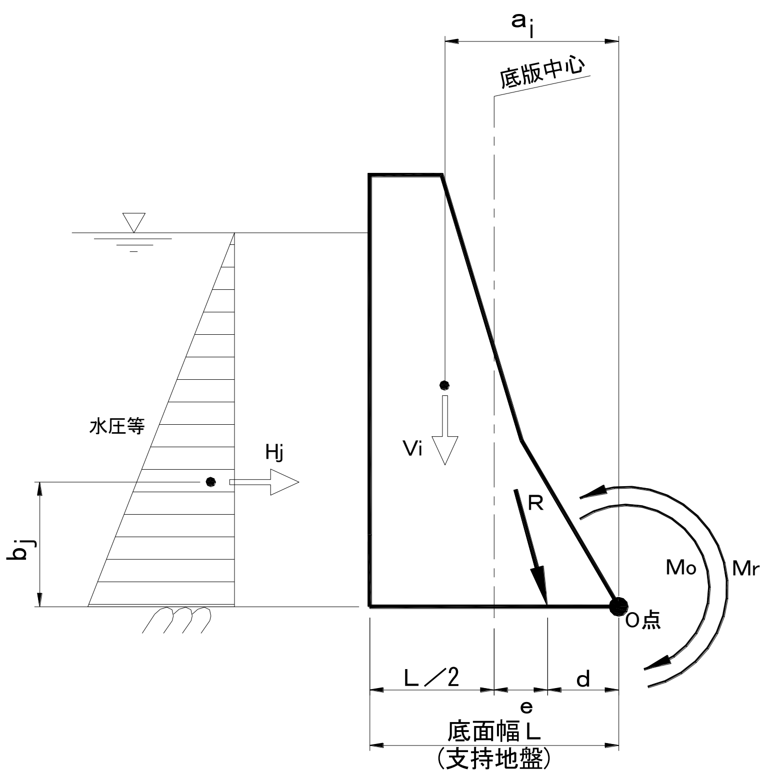


Figure 4-18 Working point of resultant force and the basal plate used for overturning resistance calculation

(C) Stability against bearing capacity of foundation ground

Stability against bearing power from supporting soil requires that the modulus of subgrade reaction(q_1, q_2) satisfies the following relations (see "Road earth work Retaining wall construction guideline").

$$\left.\begin{matrix} q_1 \\ q_2 \end{matrix}\right\} \leqq q_a$$

where,

q_a : Allowable bearing capacity of ground(kN/m^2)

In this design, these two parameters assume the following values – see the description in「3) Natural condition (B) Foundation ground」,

Normal state : 588 kN/m^2
During earthquake : 882 kN/m^2

Modulus of subgrade reaction q_1、q_2 are expressed using the following equations.

① Working point of the resultant force falls within middle-third of the basal plate width

$$q_1 = \frac{\Sigma V}{L} \cdot \left(1 + \frac{6e}{L}\right)$$

$$q_2 = \frac{\Sigma V}{L} \cdot \left(1 - \frac{6e}{L}\right)$$

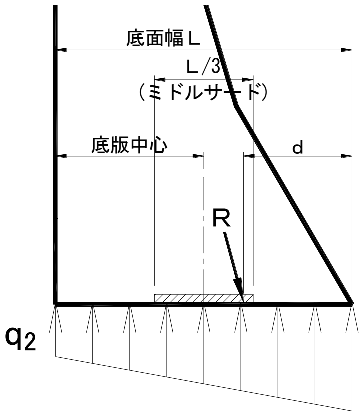


Figure 4-19 Modulus of Subgrade Reaction (trapezoidal distribution)

② Working point of the resultant force falls within a range between 1/3 -2/3 of basal plate width (and it falls outside of middle-third of basal plate width)

$$q_1 = \frac{2\Sigma V}{3d}$$

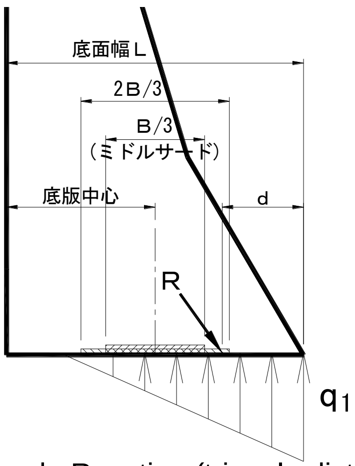


Figure 4-20 Modulus of subgrade Reaction (triangle distribution)

6) Possible cases

Loading condition described in previous section produces several combinations. These cases are listed in Table 4-45.

Table 4-45 Possible loading combinations in intake weir stability calculation (Lae Ordi II)

<table>
<tr><th colspan="2" rowspan="2">Condition</th><th>Sedimentation</th><th colspan="2">No sedimentation</th><th colspan="2">Fully sedimentation</th><th rowspan="2">Remark</th></tr>
<tr><th>Water level</th><th>High water level (during earthquake)</th><th>Design flood level (Normal)</th><th>High water level (during earthquake)</th><th>Design flood level (Normal)</th></tr>
<tr><td rowspan="9">Primary load</td><td colspan="2">Dead load</td><td>○</td><td>○</td><td>○</td><td>○</td><td>—</td></tr>
<tr><td rowspan="2">Mud pressure</td><td>Vertical</td><td>—</td><td>—</td><td>○</td><td>○</td><td>—</td></tr>
<tr><td>Horizontal</td><td>—</td><td>—</td><td>○</td><td>○</td><td>—</td></tr>
<tr><td colspan="2">Weight of water (upstream)</td><td>○</td><td>○</td><td>○</td><td>○</td><td>—</td></tr>
<tr><td rowspan="3">Static water pressure</td><td>Upstream</td><td>○</td><td>○</td><td>○</td><td>○</td><td>—</td></tr>
<tr><td>Downstream</td><td>—</td><td>—</td><td>—</td><td>—</td><td>Water level is set to 0.</td></tr>
<tr><td>Uplift force</td><td>○</td><td>○</td><td>○</td><td>○</td><td>—</td></tr>
<tr><td colspan="2">Vertical load</td><td>—</td><td>—</td><td>—</td><td>—</td><td>Vertical load acting upon levee crown is ignored.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td rowspan="3">Secondary load</td><td colspan="2">Seismic inertia force</td><td>○</td><td>—</td><td>○</td><td>—</td><td rowspan="3">Horizontal component must be taken into account.</td></tr>
<tr><td colspan="2">Seismic dynamic water pressure</td><td>○</td><td>—</td><td>○</td><td>—</td></tr>
<tr><td colspan="2">Seismic dynamic earth pressure</td><td>○</td><td>—</td><td>○</td><td>—</td></tr>
</table>

(4) Results

Results from stability calculation of intake weir are shown in Table 4-46 and Table 4-47. Under these conditions, all cases satisfied stability criteria.

Safety factor against sliding is high satisfying more than 10. However stability and strength will not be considered as critical element for low-height dam such as intake weir, and height, width and form are determined by hydraulic function (ensuring height of inlet of intake gate or intake depth).

However, because a part of physical properties of foundation soil used in the calculation is provisional (assumed values), additional soil test on site will be needed to make sure that these values are applicable.

Table 4-46 Result of stability calculation of intake weir (Lae Ordi II－No sedimentation)

cross section				At top water level	At design flood level
				During earthquake	Normal
Overflow section	Active force	Vertical force	(kN)	1,161.089	1,154.717
		Horizontal force	(kN)	637.684	517.821
		Resisting moment	(kN･m)	7,932.322	7,909.593
		Overturning moment	(kN･m)	1,727.466	1,223.746
	sliding	Safety factor		11.630	10.050
		Required safety factor		1.200	1.500
		Result		OK	OK
	Overturning	Eccentric throw	(m)	0.006	0.440
		Standard value	(m)	3.567	1.783
		Result		OK	OK
	Bearing capacity	Applied stress coefficient	(kN/m^2)	108.878	134.544
		Allowable bearing capacity	(kN/m^2)	882.000	588.000
		Result		OK	OK

Table 4-47 Result of stability calculation of intake weir (Lae Ordi－Fully sedimentation)

Cross section				At top water level	At design flood level
				During earthquake	Normal
Overflow section	Active force	Vertical force	(kN)	1,161.089	1,154.717
		Horizontal force	(kN)	754.380	599.877
		Resisting moment	(kN･m)	7,932.322	7,909.593
		Overturning moment	(kN･m)	1,995.750	1,412.393
	Sliding	Safety factor		9.830	8.680
		Required safety factor		1.200	1.500
		Result		OK	OK
	Overturning	Eccentric throw	(m)	0.237	0.277
		Standard value	(m)	3.567	1.783
		Result		OK	OK
	Bearing capacity	Applied stress coefficient	(kN/m^2)	122.934	124.680
		Allowable bearing capacity	(kN/m^2)	882.000	588.000
		Result		OK	OK

4-2-4-3. Intake gate

(1) Location and direction

Intake gate is built at proper location - upstream of far enough from intake weir – enabling to prevent earth and soil sedimentation effectively. The gate is also appropriately directed - facing to upstream against river flow - to prevent influx of earth, sand and floating objects.

(2) Design of intake gate

Width of inflow of intake gate is designed slightly narrower for the flow velocity at the maximum water intake (approx. 1.5 m/s). Site altitude of intake is designed to provide sufficient elevation – as high as 3.0m above the site altitude of intake weir, which is considered to give satisfactory protection against influx of earth and sand.

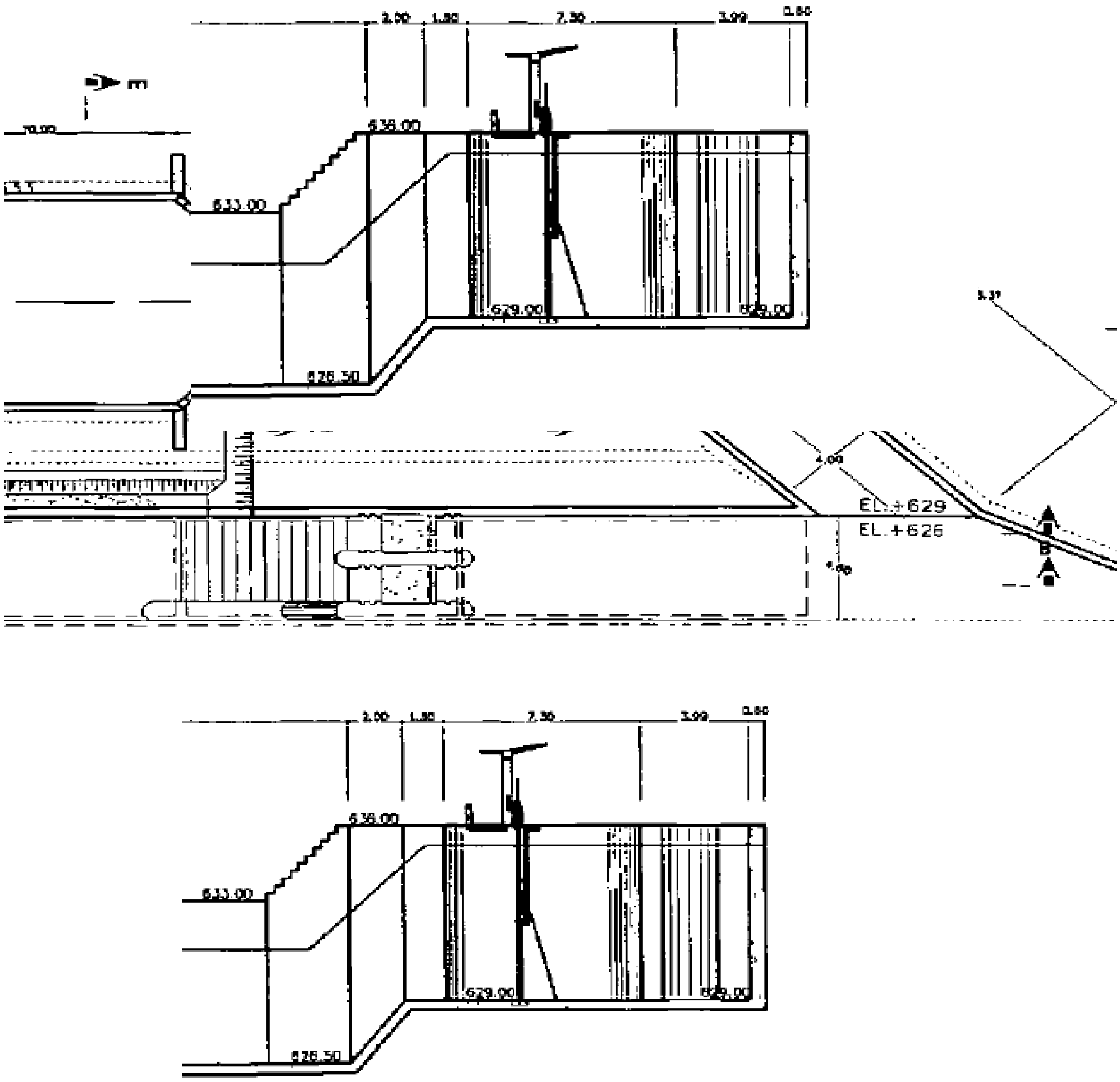


Figure 4-21 Intake gate (plane view and longitudinal section)

(3) Dust and waste filter

The drawings submitted from Indonesian side did not allow identification of such device in place: confirmation needed for its existence.

4-2-4-4. Settling basin

(1) Location

Settling basin is connected to intake gate and arrange in parallel with front apron of intake weir. Besides, since it is located close to the river where is reasonable location for flushing sediments and draining surplus water, it is enable to deposit and drain sediments right after water intake to effectively prevent wear of penstock. Thus, location of settling basin is deemed to be appropriate.

(2) Flow rate inside the settling basin

Flow velocity inside the settling basin is estimated to be around 0.4 m/s – flow volume Q = 11.9 m^3/s, flow section 30.6 m^2 (B: 9.0 m×H: 3.4 m). This is conventional value that allows earth and sand to settle in an appropriate period of time.

The length of channel of the settling basin is 56.2 m, and the design is deemed to be appropriate in that it secures enough length for inflow of earth and sand.

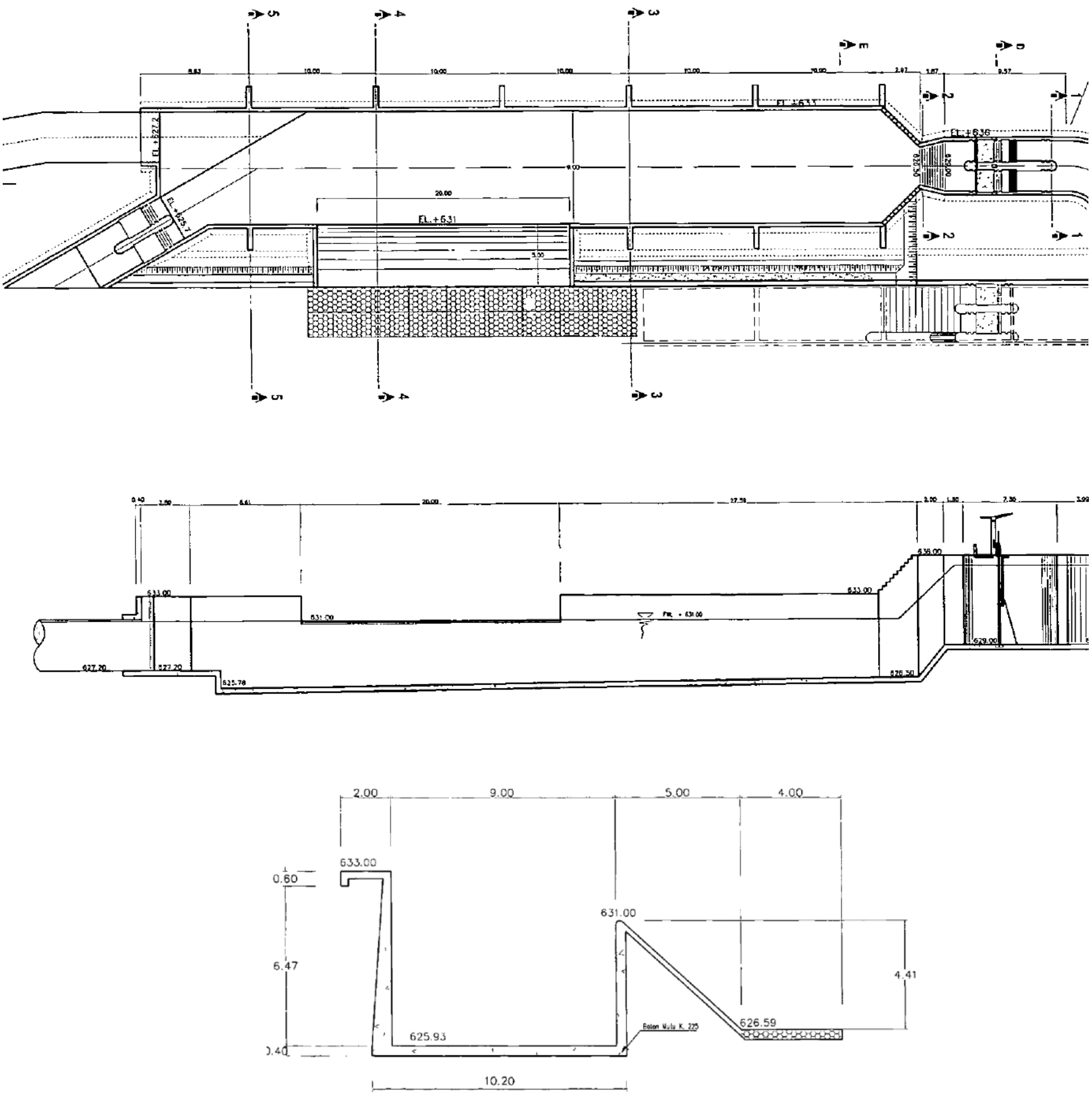


Figure 4-22 Settling basin design (plane view, longitudinal section, cross-section)

4-2-4-5. Headrace

(1) Analysis of local F/S plan

In reference to the general drawings, the structure and dimensions of the planned headrace is examined, through hydraulic calculations, especially in term of their water conduction capacity.

1) Elements of object headrace

According to the design drawing provided from local, the headrace is 2,426m length with 0.033％ sloping in the open channel and used circular waterway (steel pipe : D＝4.0m). Open construction method will be applied to construct headrace. Length and height of each section are shown in Table 4-48. Figure 4-23 shows cross-section of headrace.

Table 4-48 Length and Height of Each Section of Headrace

Name	Station point	Length of interval	Slope of headrace		Starting point sill height	End point sill height
	SP. m	m			EL. m	EL. m
Headrace	JS 10 ～ 140	2426. 37	3052. 04	0. 0328%	627. 200	626. 400

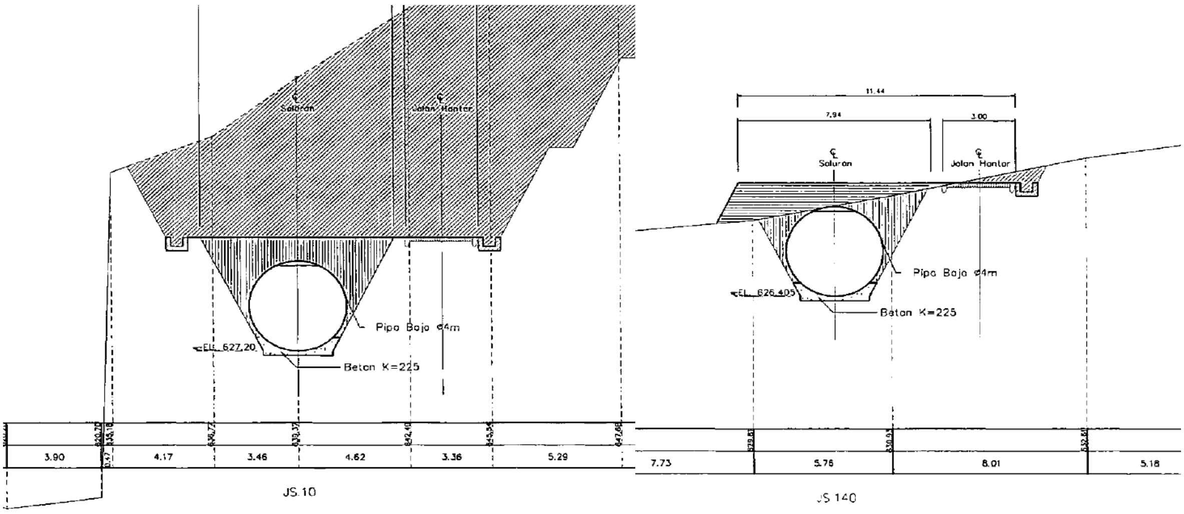


Figure 4-23 Cross-section of Headrace (Drawing Received in-site)

2) Calculation of uniform flow

Uniform flow depth was calculated using Manning equation. The calculation concluded uniform flow depth of 2.38m at maximum discharge, 11.63m^3/s, - i.e. approximately 60% depth to the height of the channel (4.0m). The result indicates that the channel has a sufficiently large capacity for water conduction in view of the projected amount of water to be used.

＜Uniform flow depth calculation using Manning equation＞

Uniform flow depth	:h_o		(m)
Plant discharge	:Q		(m^3/s)
Slope of headrace	:I=	0.0328%	
Manning roughness coefficient	:n=	0.013	
Width of headrace	:D=	4.000	(m)
Cross-sectional area of flow	:A		(m^2)
Wetted perimeter	:S		(m)
Hydraulic radius	:R=A/S		(m)

Item	Flow Q (m^3/s)	Right side $Q \cdot n/I^{0.5}$	Uniform flow depth h_0 (m)	Cross-sectional area of flow A (m^2)	Wetted perimeter S (m)	Hydraulic radius R (m)	Left side $AR^{2/3}$	(Left side)-(Right side)
MAX	11.630	8.353	2.383	7.807	7.055	1.107	8.353	0.000
Regular	5.710	4.101	1.572	4.585	5.421	0.846	4.101	0.000

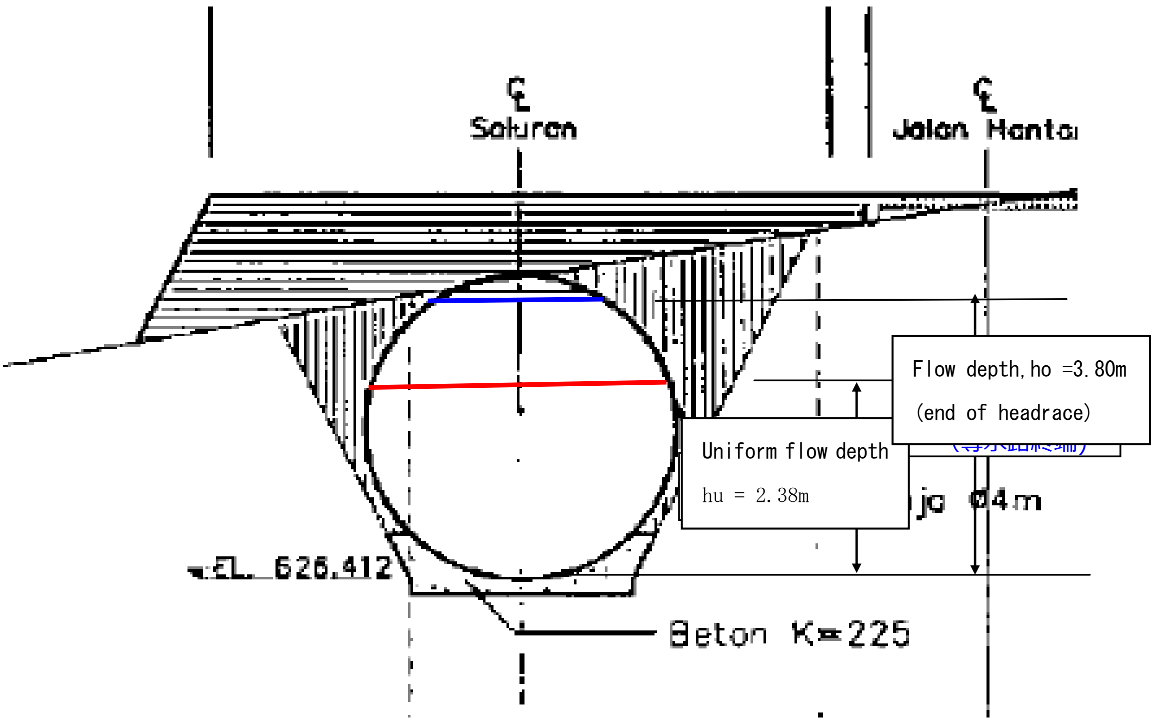


Figure4-24 Water conduction in Headrace

3) Calculation of non-uniform flow

Non-uniform flow is calculated using standard sequence method to estimate the water surface of raceway. Basic equation for calculating non-uniform flow is as below (set of hydraulic formula equation2.4). The following equation applies Manning equation and Bernoulli equation. This result is shown in Figure 4-25. Refer to the Appendix L4-1 for more detail.

Water surface profile shows afflux back water toward tank from upstream. Headrace end depth is 3.80m at the point of deeper water level of headrace, and there is about 0.20m redundant space for the raceway height 4.00m.

According to the results above, possibility of the raceway flow is deemed to be satisfied.

$$\left(\frac{\alpha_2 Q^2}{2gA_2^2}+h_2+z_2\right)-\left(\frac{\alpha_1 Q^2}{2gA_1^2}+h_1+z_1\right)=-\frac{1}{2}\left(\frac{Q^2}{K_1^2}+\frac{Q^2}{K_2^2}\right)(L_2-L_1)$$

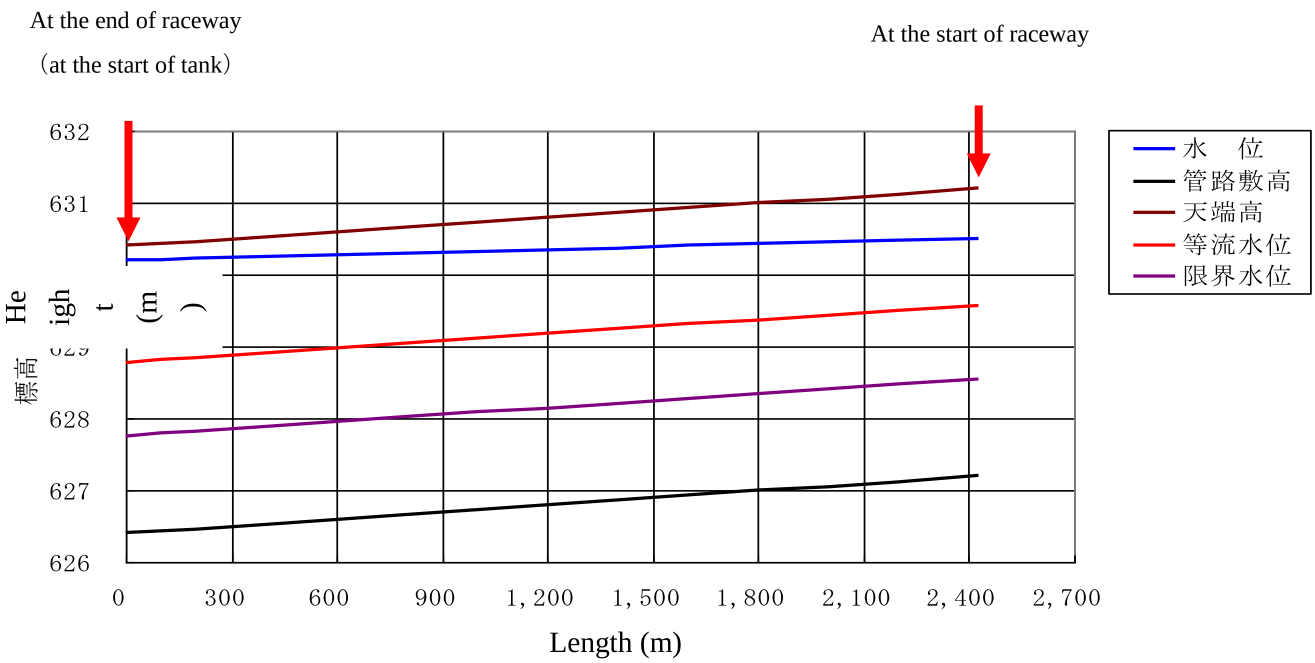


Figure 4-25 Water Surface Profile of Headrace

(2) Improvement plan

According to current design, water is conducted by headrace (length 2426.37m, slope 0.0328% (1/3052)) that is circular waterway (steel pipe : D=4.0m). Headrace is planning to construct using open method. However, since waterway slope is low-gradient and cross-section is large, large volume of excavation and steel pipe materials that have to be produced in a factory are required, and these raise the construction cost. Thus, to increase economic efficiency, changing the gradient of slope is suggested by minimizing cross-section of waterway in accordance with modifying cross-section shape.

1) Waterway cross-section

Current used circular pipe (steel) could change to trapezoid shape which is constructible in-site. Trapezoid waterway could be more economical for the waterway slope below.

2) Waterway slope

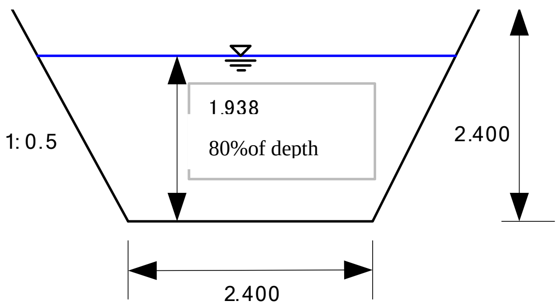
Current low-gradient slope of 0.0328% (1/3052) could change to Japanese general gradient of 0.1% (1/1000) .

3) Hydraulic accounting

Trapezoid waterway which is possible to flow 11.90 m^3/s of discharge with 0.1% (1/1000) sloping has 1.938m of uniform flow depth (about 80% water depth) under the condition of side wall slope1:0.5, waterway width B:2.4m, and waterway height H:2.4m. Refer to the Appendix L4-2 for more detail of calculation.

Uniform flow depth	:h_o		(m)
Plant discharge	:Q		(m^3/s)
Slope of headrace	:I=	0.001	
Manning roughness coefficient	:n=	0.017	
Width of headrace	:B=	2.400	(m)
Slope of sidewall	:m=	0.500	
Cross-sectional area	:A		(m^2)
Wetted perimeter	:S		(m)
Hydraulic radius	:$R=A/S$		(m)

Item	Flow Q (m^3/s)	Right side $Q \cdot n/I^{0.5}$	Uniform flow depth h_0 (m)	Cross-sectional area A (m^2)	Wetted perimeter S (m)	Hydraulic radius R (m)	Left side $AR^{2/3}$	(Left side)-(Right side)
Max	11.900	6.397	1.938	6.530	6.734	0.970	6.397	0.000
Regular	5.710	3.070	1.252	3.790	5.201	0.729	3.070	0.000



As the changes of headrace, head tank need to change as well. Also, as the tail water level heightens 5m, effective head will be reduced. Thus, improvement plan proposes that 11.90 m^3/s of discharge will be taken to generate 10,000kW (local capacity) by reduced effective head.

4) Evaluation

Head loss between intake and head tank will increase 3.5m by modifying slope of water channel from 1/3052 to 1/1000. Thus, cross-sectional area of waterway will minimize as approximately 2/3, and waterway width is also minimized from 4.0m to 2.4m. Therefore, excavation volume is expected to be minimized..

Waterway cross-section

Current : circular $2 \times 2 \times \pi = 12.566 m^2$

Suggestion : trapezoid $(2.4+0.5 \times 2.4) \times 2.4 = 8.64 \ m^2$

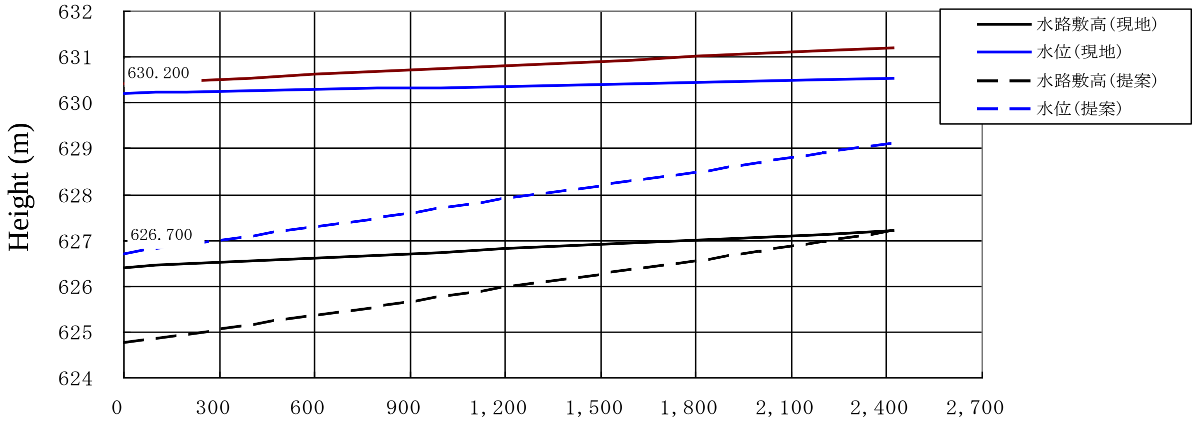


Figure 4-26 Comparison of Water Surface Profile between Local Design and Suggested Design

In the improvement plan, upside width of waterway is suggested as 4.80m which is smaller compared to 6.00m of original plan. It is possible to reduce excavation volume where required cutting slope.

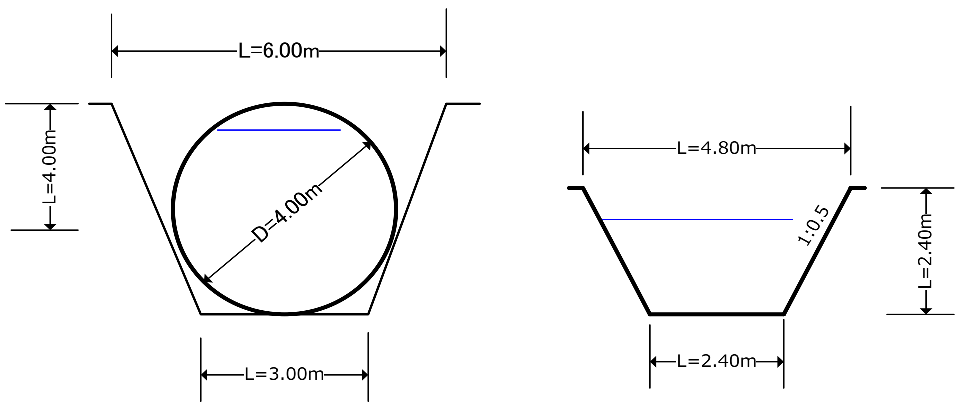


Figure 4-27 Comparison of Cross-section between Local Plan and Improvement Plan

4-2-4-6. Head tank

(1) Verification of the design

Many of the existing head tanks used in power stations are designed capable to store, on an empirical basis, an amount of water capable to sustain 2 to 3 minutes of operation at maximum discharge (120Qmax ~ 180Qmax). Their configuration conventionally place emphasis on hydrological safety. Looked at from another perspective, optimized design of a head tank may lead to a reduction of its size. In this section, the design is verified, in reference to guiding principles commonly practiced in Japan (Small and medium hydropower guidebook", New Energy Foundation), if it meets hydrological requirements.

Requirements that determine the scale of head tank :

・ Water surface area large enough to prevent hunting action to occur in the level regulator
・ Capacity that allows “try-on” required for startup and normal operation.
・ Capacity for drawdown detection – allowance to be placed before emergency stop after a detection of abnormally low water level – and the capacity for emergency stop

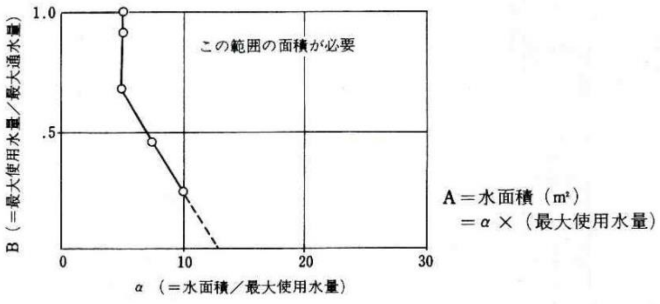
Generally accepted water surface area required to prevent a level regulator entering into a hunting action – based on the simulations performed with consideration given to hydrological behavior of water channel system and hydraulic equipment – lies anywhere between 5~10Qmax. This review assume its maximum value (i.e. 10Qmax) for the following verification procedures.

Therefore, the required surface area (A) of the head tank measures is 116.3 m^2.

Required area $A \geqq 10Q_{max}$

Required area $A \geqq 10 \times 11.63 = 116.3\ m^2$

Where, Qmax：maximum discharge＝11.63m^3/s



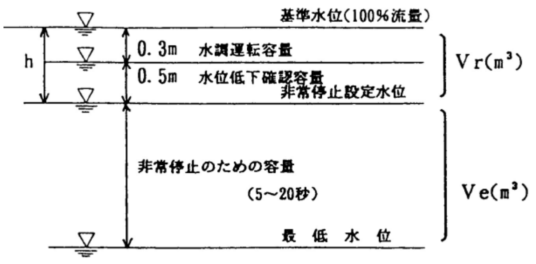
Breakdown of the head tank ‘s required volume (V) is shown in below.

・ Capacity for priming operation
・ Capacity for low level detection
・ Capacity for successful completion of emergency stop

In view of these factors, it is decided to secure capacity of 11Qmax, which translates into the required capacity of 126.5m^3

$V \geqq V_r + V_e$

$\geqq 11Q_{max} \geqq 11 \times 11.63 = 127.93 m^3$



水 調 方 式	ヘッドタンク容量
垂下率水調	11Qmax
定水位水調	7 Qmax

ヘッドタンク容量

V＝Vr＋Ve

＝11Q 又は 7Q(m³)

ヘッドタンク容量の条件

Dimensions of the head tank are put into review, with due consideration given to the required conditions above, and design conditions regarding the lowest level. Based on the drawings submitted from Indonesian side, dimensions of the head tank are listed in Table 4-49.

Table 4-49 Head Tank dimensions (based on the drawings submitted from Indonesian side)

Item	Unit	Local plan	Remark
Effective length	m	73.50	Distance from end of enlargement area to overflow weir
Width of tank	m	12.00	
Tank level	m	630.20	
Lowest level	m	626.00	Considered air entrained for penstock(D:diameter) 626.0m ＞ 625.34m ＝ Height of penstock 623.34m ＋ 1D:2.0m
Effective depth	m	4.20	Tank level 630.2m－ Lowest level 626.00m
Water area	m^2	882.00	＞10Qmax＝116.30m^2
Effective strage capacity	m^3	3,704.40	＞11Qmax＝127.93m^3

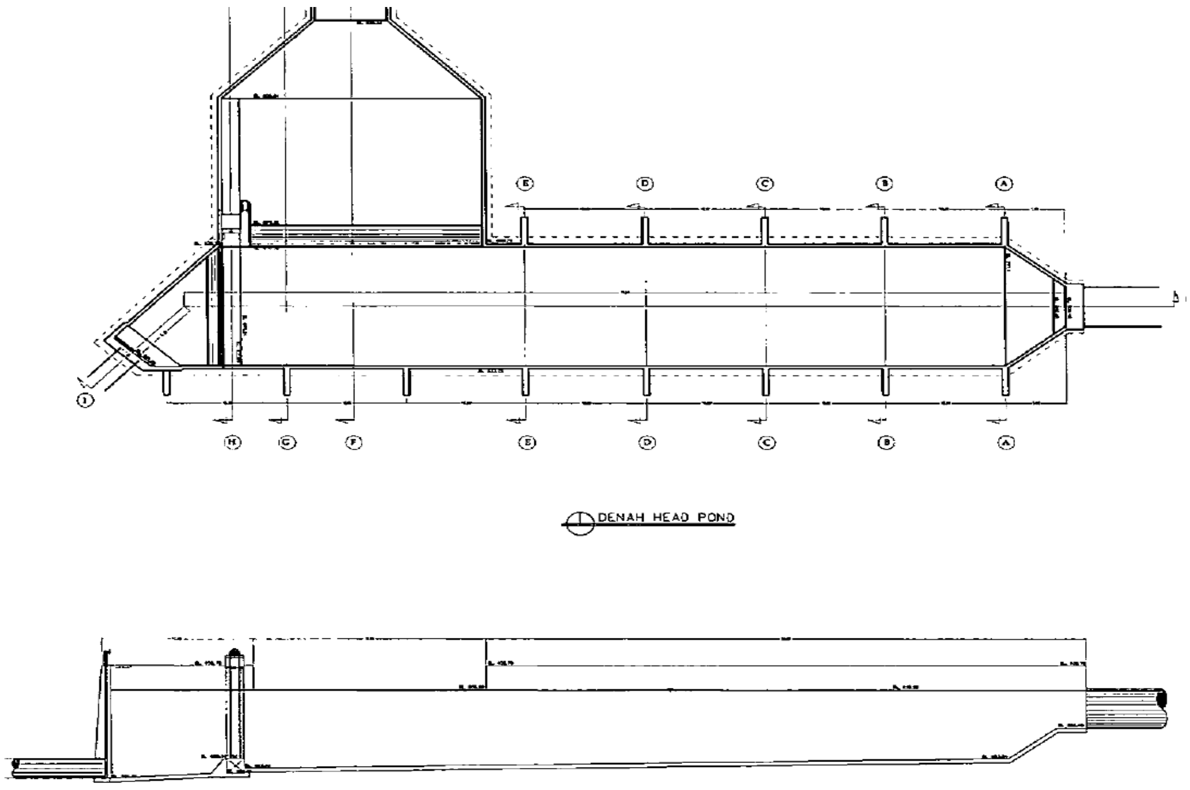


Figure4-28 Head tank design（Plane view, cross-section）

Source: local design

From the discussion above, the water surface area and effective capacity are set to 75.8Qmax and 318.5Qmax (see the calculations below). These values clearly surpass conventional ones (2 to 3 minutes equivalent of water at max. discharge), while satisfying required conditions with comfortable margin.

①Water surface area＝tank width×effective length＝12.0×73.5＝882.0 m^2 （≒75.84Qmax≧10Qmax

②Effective capacity＝water surface area×tank depth＝882.0×4.20＝3704.4 m^3 （≒318.52Qmax）≧11Qmax

(2) Improvement plan of Head tank

Current design of head tank is large size with 75.0m length, 12.0m waterway width, and 4.5m of effective depth. Following to the improvement plan of headrace, head tank could miniaturize its size.

Specifically, headrace length will extend 25m, and tank length will shorten to 48.5m. Tank water level could adjust to EL626.70 same as uniform flow level at headrace end of improvement plan. Since water level is set low, it is necessary to set low for the lowest level to ensure effective depth considering sill height and actual depth of penstock. Thus, effective capacity is analyzed.

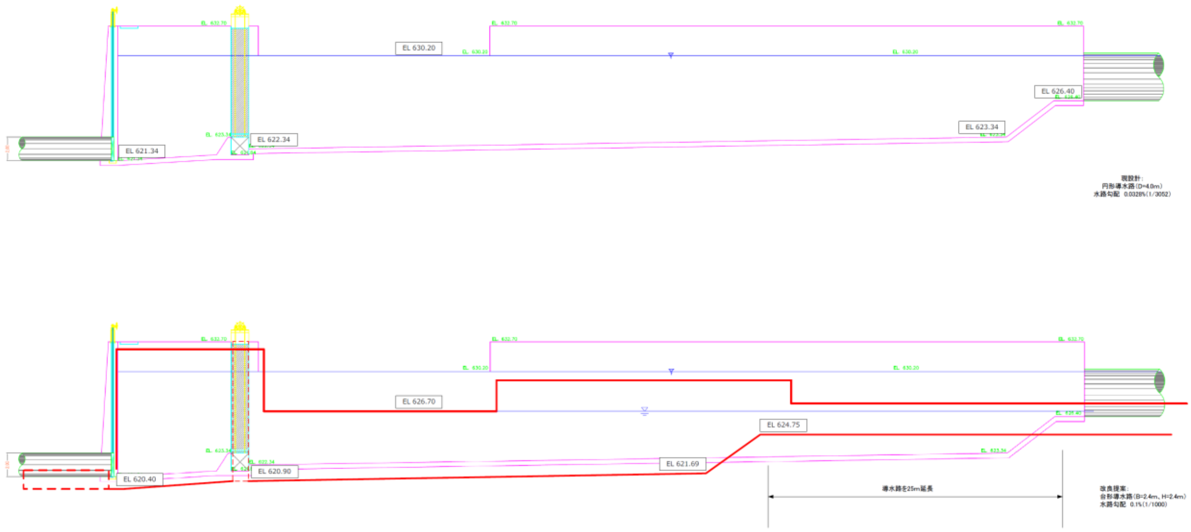


Figure 4-29 Rationalization plan of head tank (above：original, below：improvement plan)

Table 4-50 Analysis of Tank Capacity of Improvement Plan

Item	unit	Local plan	Remark
ffective lengt	m	48. 50	Distance from end of enlargement and overflow weir
Width of tank	m	12. 00	
Tank level	m	626. 70	
Lowest level	m	624. 50	considered air entrained for penstock(D : diameter) 624. 5m＞624. 4m＝Height of penstock622. 40m+1D : 2. 0m
Effective deptl	m	2. 20	Tank level626. 70m－Lowest level624. 50m
Water area	㎡	582. 00	＞10Qmax＝116. 30m^2
Effictive storage capacity	㎥	1, 280. 40	＞11Qmax＝127. 93m^3

Table 4-50 shows water area and capacity of the miniaturized tank with the same lowest level as current plan. Water area and capacity are both miniaturized from 75.8Qmax, 318.5Qmax to 50.4Qmax, 110.1Qmax. It is possible to downsize the capacity by 2 to 3 minutes of the maximum discharge while maintaining the conditions required to ensure the necessary space.

① Water surface area＝tank width×effective length＝12.0×48.5 ＝582.0 ㎡（≒50.4Qmax≧10Qmax

② Effective capacity＝water surface area×tank depth＝582×2.20 ＝1280.40 ㎥（≒110.1Qmax）≧11Qmax

4-2-4-7. Penstock and power plant

(1) Analysis of local F/S plan

1) Strength of penstock

To confirm safety of the penstock system design submitted from Indonesian side, an examination is made by performing critical calculations – intra-penstock pressure, structural verification of the pipes, and so on - based on the instructions contained in Japanese guideline ("Technical standards of water gate iron pipes" Japan hydraulic gate & penstock association).

In this section, focus is placed on the conditions applied to analysis, and results derived from the analysis: for specifics of calculation procedures, see Appendix L4-4.

(A) Design detail

Type	:	Exposed penstock and concrete revetted embedded penstock
Number of pipe	:	1 waterway
Inner diameter size	:	2.000 m
Pipe thickness	:	10～24 mm
Pipe length	:	310.000 m (Curve length from start of penstock to branch pipe)
Maximum static head	:	110.850 m (Head from tank water level WL 630.20m to center of inlet valve EL 519.35 m)
Maximum water hammer pressure head	:	33.000 m (Center of inlet valve)
Attack wave head	:	0.000 m
Maximum design head	:	143.850 m (Center of inlet valve)
Maximum discharge	:	11.63 m^3/s
Turbin closing time	:	4 sec
Corrosion allowance	:	1.5 mm
Safety factor against external pressure	:	1.5 over
Temperature change	:	20 ℃
Type of material Allowble stress	:	(see table below)

Material	Thickness (mm)	Tensile stress (N/mm^2)	Compressive stress (N/mm^2)	Shearing stress (N/mm^2)	Bearing stress (N/mm^2)
ISO E275 A-D	t ≦16	150	150	85	255
	16＜ t ≦40	145	145	80	245
	40＜ t ≦63	140	140	80	235

Elastic modules of steel	:	206 kN/mm^2
Linear expansion coefficient of steel	:	1.2×10^{-5} /℃
Poisson's ratio of steel	:	0.3
Weld efficiency	:	Plant 0.85 Site 0.80

(B) Results

The results from stress analysis of penstock are shown in Table 4-51. The analysis revealed that the planned wall thickness (10mm) was not enough in some part of the downstream sections of the penstock channel.

Table 4-51 Results from Stress Analysis of Penstock (Lae Ordi II)

No.	Inner diameter	Pipe thickness	Pipe length	Pipe wall thickness			Inner pressure		
				Design head	Allowable head	Result	Circumferential	Allowable stress	Result
	D_0	t_0	Ln	H	Ha		σ 1	η・σ a	
	(mm)	(mm)	(m)	(m)	(m)		(N/mm²)	(N/mm²)	
1	2000	10	32.670	17.78	104.00	OK	20.50	120.00	OK
2	2000	10	99.450	58.37	104.00	OK	67.30	120.00	OK
3	2000	10	89.220	97.86	104.00	OK	112.80	120.00	OK
4	2000	10	77.320	142.64	104.00	NG★	164.50	120.00	NG★
5	2000	10	11.340	143.85	104.00	NG★	165.90	120.00	NG★

No.	Inner diameter	Pipe thickness	Pipe length	Axial stress			
				Equivalent stress		Allowable stress	Result
	D_0	t_0	Ln	σ eq	σ eq'	σ a	
	(mm)	(mm)	(m)	(N/mm²)	(N/mm²)	(N/mm²)	
1	2000	10	32.670	42.00	63.85	120	OK
2	2000	10	99.450	78.40	74.80	120	OK
3	2000	10	89.220	116.50	104.06	120	OK
4	2000	10	77.320	161.60	144.33	120	NG★
5	2000	10	11.340	163.00	145.41	120	NG★

2) Route of penstock and power plant

In the local F/S plan, penstock and power plant are planning to place as shown below. Open cut method will be applied for construction, and excavation depth at joint part of penstock and power plant is expected as deeper than 50m. From the view of number and cost of construction, this design is considered to arise some issues.

Therefore, examination of route of penstock and location of power plant which enable to reduce number of construction was made. Further details are described below.

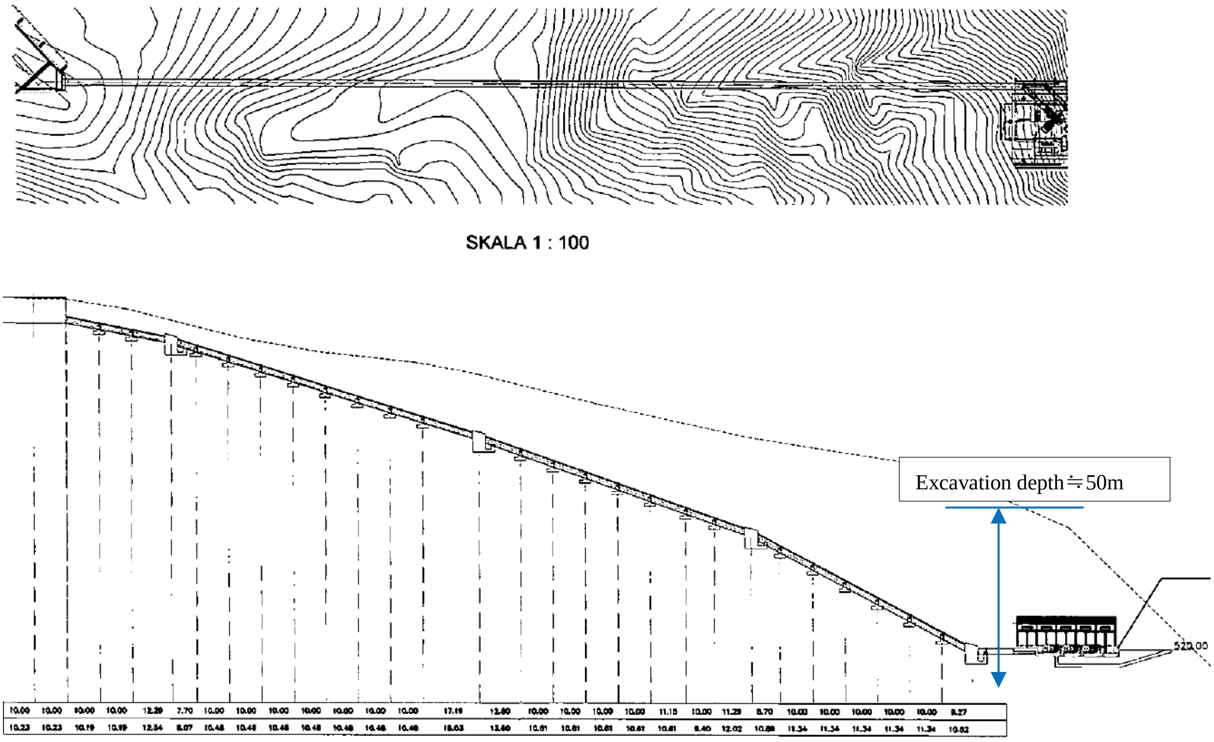


Figure 4-30 Route of penstock – power plant (plane view, longitudinal view)

3) Layout of turbine and generator

Current layout of turbines is shown in Figure 4-31. In the current design, turbines are located diagonally against buildings. To install turbines, overhead traveling crane will be used, and crane moves toward direction of building or vertical direction against buildings. Therefore, turbine could place in axial direction of building in order to facilitate installation of generator and turbine runner. Detail of improved design will be explained further on.

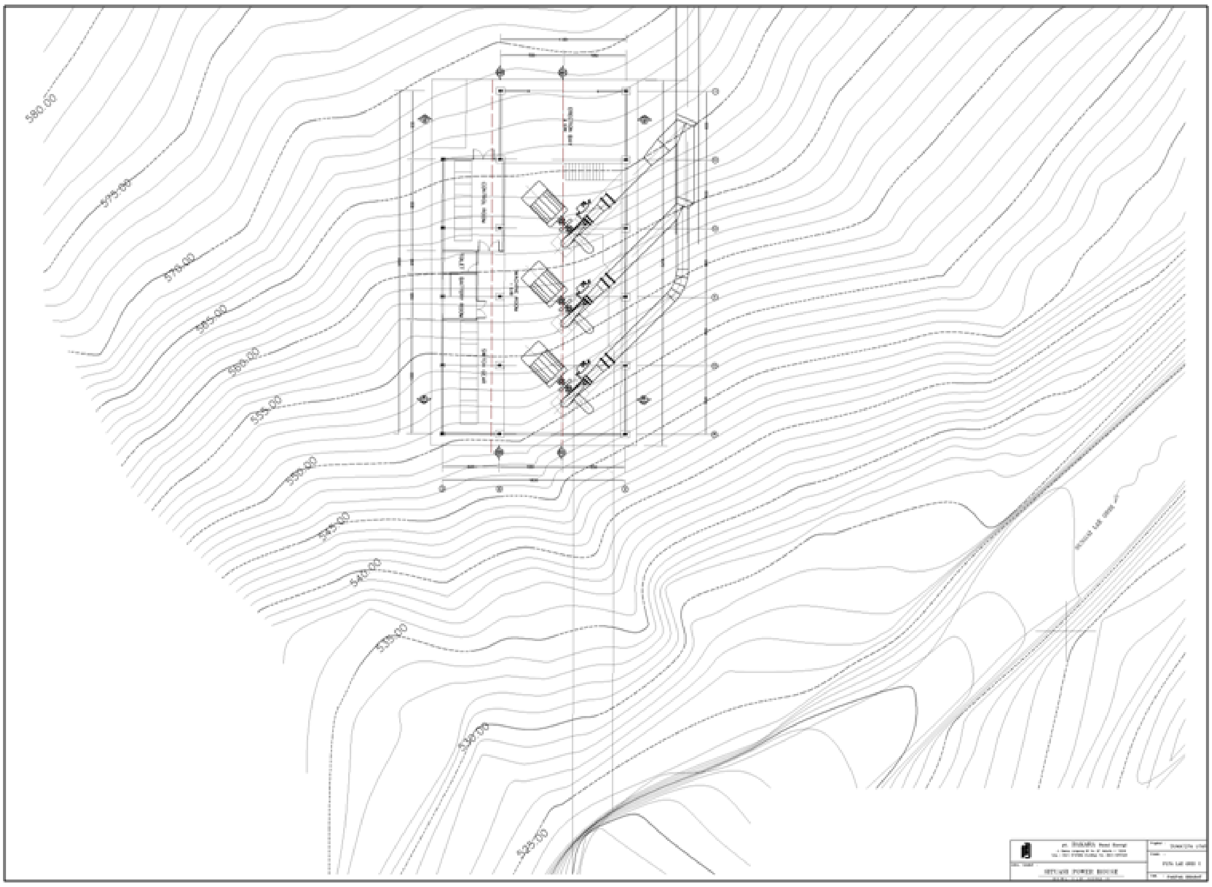


Figure 4-31 Layout of Water Turbine

(2) Improvement plan of locations of penstock and power plant

1) Location of improvement plan

Sill level of power plant is 50m deeper than ground surface, and large volume of excavation is required. Thus, location of power plant could change considering construction carry out. As Figure4-32 shows, power plant could locate closer to river to build as semi-underground type. Besides, penstock could be exposed in half way to minimize construction for tunnel and reduce the volume of excavation. Power plant could locate where the river bank does not necessary to dig deeper to set the tail water level at 525m. Thus, head between river water level and tail water level means loss head.

2) Direction to install turbines

Direction to install turbines could change from diagonally to parallel way adjusting to axial direction of building. To install turbines, overhead traveling crane will be used, and crane moves toward direction of building or vertical direction against buildings. Therefore, turbine could place in axial direction of building in order to facilitate installation of generator and turbine runner.

However, if turbines are placed in parallel way, it occupies more space and raises the construction cost. On the other hand, direction of building is almost in parallel way to a contour, and volume of excavation will be reduced. Thus, it is necessary to examine the layout considering construction cost.

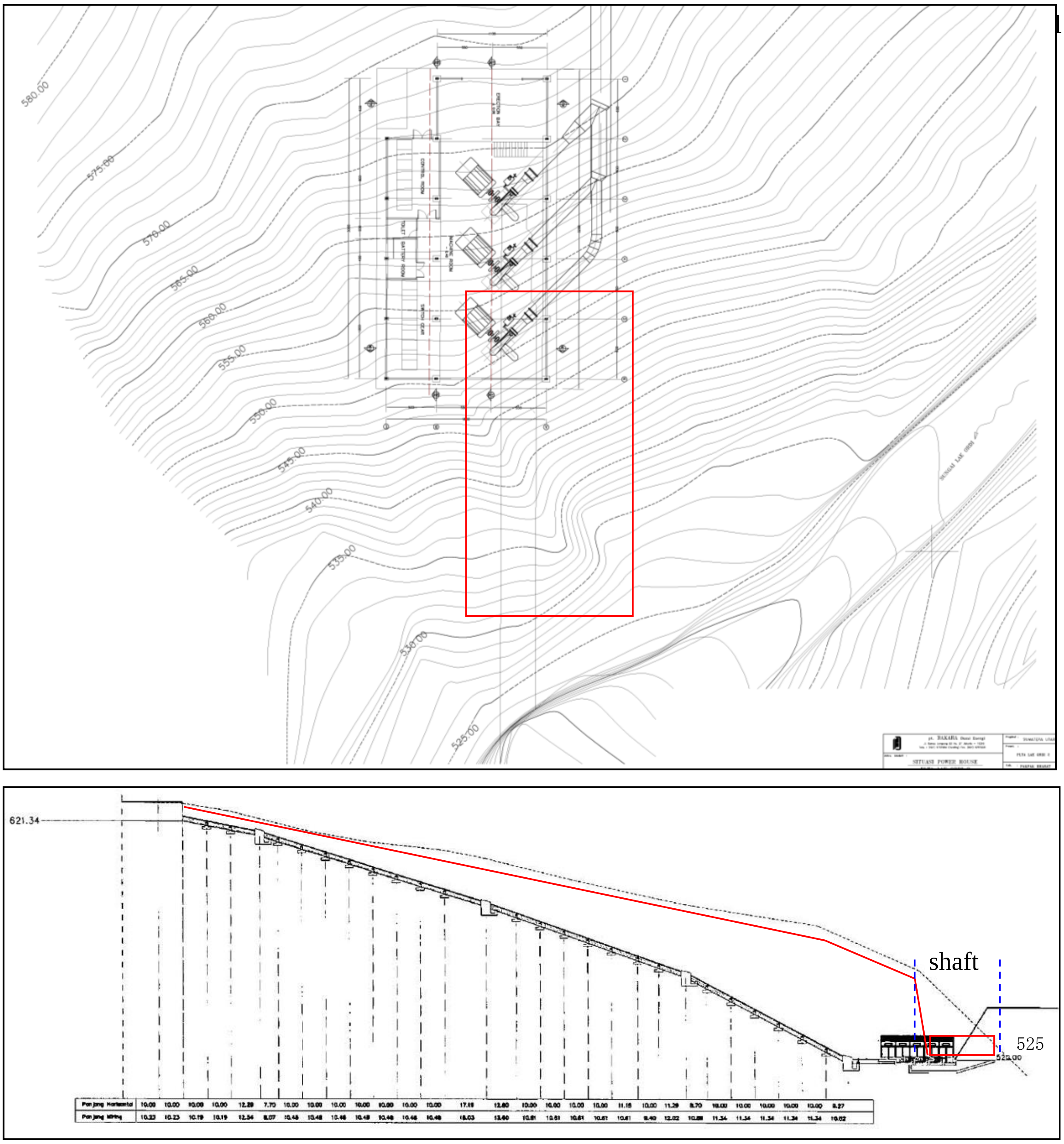


Figure4-32 Turbines and Power plant Location of Improvement Plan
(above：plan drawing, below：cross-section drawing)

3) Estimated cost of improvement plan

To reduce the excavation volume, penstock will be exposed in half way and construct tunnel the rest.

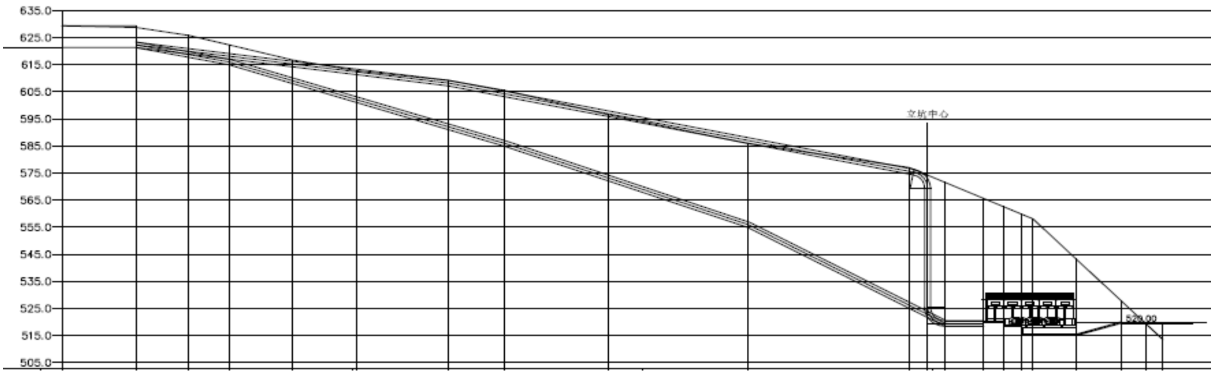


Figure 4-33 Penstock Installation of Improvement Plan

Cost of penstock construction is estimated and compared original and improvement plan. Improvement plan shows its possibility to construct with 1/2 cost of original plan.
Construction cost and numbers show in Table 4-52.

Table 4-52 Comparison of Penstock Construction Cost (improvement plan/local plan)

Content	Unit	Unit price	Original plan		Improvement plan		Refference
			Quantity	Amount	Quantity	Amount	
1. Cutting	m^3	5,400	210,271	1,135,463,400	74,638	403,045,200	
2. Shaft excavation	m^3	58,000	0	0	360	20,880,000	
3. Level drift excavation	m^3	58,000	0	0	155	8,990,000	
4. Penstock Laying(Exposed pipe)	m	410,000	312	127,920,000	281	115,210,000	
4. Penstock Laying(Tunnel embede	m	650,000	0	0	80	52,000,000	
5. Filling concrete	m^3	36,000	0	0	295	10,620,000	
Total				1,263,383,400		610,745,200	
Ratio				1.00		0.48	

※(Power plant－Trailway－Outlet) these construction cost is not included.

4) Pipe thickness for improvement plan

Based on Japanese technical standard, safety of penstock was analyzed using structural calculation of penstock pressure and the steel pipe. As a result, pipe thickness on downstream section of penstock on the local plan was not sufficient.

Besides, since stress is smaller on upstream section of penstock, it is possible to make pipe thickness thinner. The result of calculated the most appropriate pipe thickness is shown in Table 4-53 . Refer to Appendix L4-5 for more detail of calculation.

Table 4-53 Pipe Thickness for Improvement Plan (Lae Ordi II)

No.	Inner diameter	Thickness	Length	Pipe thickness			Inner pressure		
				Design head	Allowable head	Result	Circumferential stress	Allowable stress	Result
	D_0	t_0	Ln	H	Ha		σ 1	η・σ a	
	(mm)	(mm)	(m)	(m)	(m)		(N/mm^2)	(N/mm^2)	
1	2000	10	32.670	17.67	104.00	OK	20.40	120.00	OK
2	2000	10	99.450	57.94	104.00	OK	66.80	120.00	OK
3	2000	10	89.220	97.15	104.00	OK	112.00	120.00	OK
4	2000	14	77.320	141.68	152.95	OK	111.10	120.00	OK
5	2000	14	11.340	142.85	152.95	OK	112.00	120.00	OK

No.	Inner diameter	Thickness	Length	axial stress			
				Equivalent stress		allowable stress	Result
	D_0	t_0	Ln	σ eq	σ eq’	σ a	
	(mm)	(mm)	(m)	(N/mm^2)	(N/mm^2)	(N/mm^2)	
1	2000	10	32.670	41.90	63.85	120	OK
2	2000	10	99.450	78.00	74.52	120	OK
3	2000	10	89.220	115.80	103.47	120	OK
4	2000	14	77.320	117.40	101.36	120	OK
5	2000	14	11.340	118.40	101.92	120	OK

5) Comparison of number of generator

Number of turbine and generator is examined to reduce construction cost of major equipments.

Table 4-54 Comparison of Number of turbine and generator (case of 3 unit /2 unit)

		3 unit	Remark	2 unit	Remark
Available discharge	m3/s	11.90		11.90	
Intake Level	EL m	631.00		631.00	
Tailwater level	EL m	525.00	for reduce cost	525.00	
Gross head	m	106.00		106.00	
Head Loss	m	5.70		5.70	
Effective head	m	100.30		100.30	
Theoretical water power	kW	3,899	per 1 unit	5,848	per 1 unit
Combined efficiency		0.851		0.851	
Power output	kW	10,000	3333kW x 3 unit	10,000	5,000kW x 2unit
L5 output	kW	8,196		8,228	
Annually electricity generation	MWh	80,993		81,257	
River utilization rate	%	60.2%		60.2%	
Plant utilization factor	%	92.5%		92.8%	

Improvement of generation efficiency is deemed to be improved by changing to number of turbine and generator from 3 to 2 units. Output and generation energy will increase for same amount of discharge water, and generation energy in 2 units plan will be 81,257MWh which is 264 MWh more than 3 units plan of 80,993MWh.

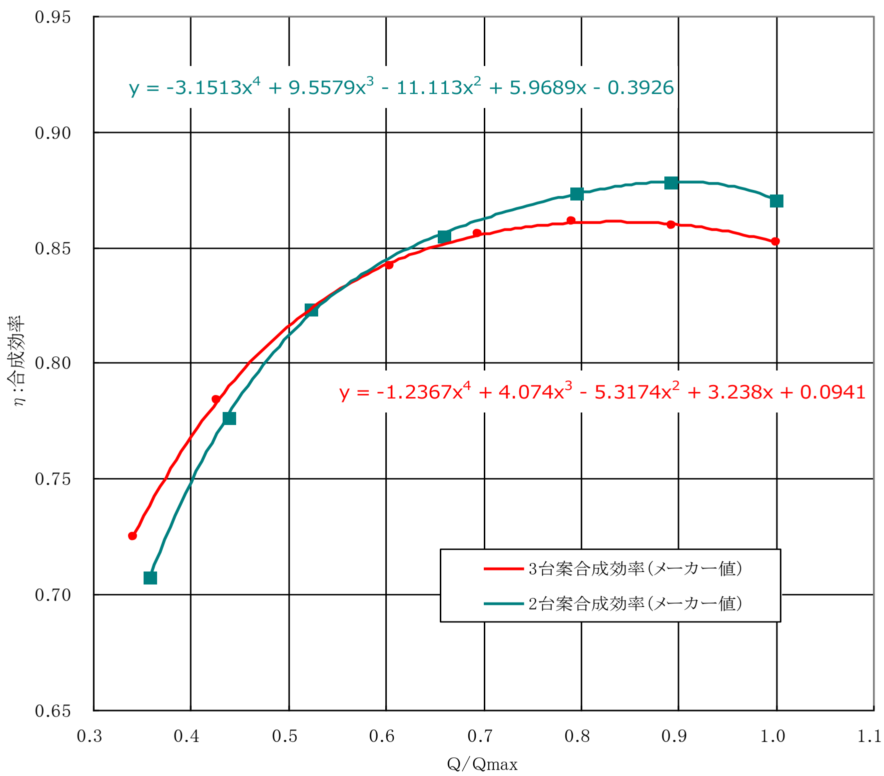


Figure 4-34 Combined Efficiency of Turbine and Generator (case of 3 unit /2 unit)

4-2-4-8. Power generating plan of improvement plan

In the power generating plan of improvement plan, maximum discharge (11.90m^3/s) is withdrew through the intake weir, and the water is conducted from intake weir into head tank in 2.4km downstream from the weir through the headrace of the open or subterranean. Then it runs through penstock (347.4m) to the power plant, and generates maximum generation energy of10,000 kW gaining effective head of 100.3m. Then finally the water joins Lae Ordi River again.

Table 4-55 shows comparison of power generation plan. (Improvement plan/local plan)

Table 4-55 Comparison of Power Generation Plan (Improvement plan/ local plan)

		suggestion	Summary	Original	Summary
Available discharge	m^3/s	11.90		11.63	
Intake Level	EL.m	631.00		631.00	
Tailwater Level	EL.m	525.00	for reduce cost	520.00	
Gross head	m	106.00		111.00	
Head loss	m	5.70		4.60	
Effective head	m	100.30		106.40	
Theoretical water power	kW	3,899	per 1 unit	4,042	per 1 unit
Combined efficiency		0.851		0.840	
Power output	kW	10,000	3333kW× 3unit	10,000	4042kW× 3unit
L5 output	kW	8,196		8,482	※
Annually electricity generation	MWh	80,993		82,107	
River utilization rate	%	60.2%		57.8%	
Plant utilization factor	%	92.5%		93.7%	

Power generation plan of improvement plan

- Tail water level change to 525.0 m
- Head tank level lower to 626.7 m

Provided these change, effective head also change to 100.30 m by reducing about 6m. Therefore, 11.9 m^3/s of discharge will be required to produce 10000 kW of generation energy. Electric power generation will be 80,993MWh reduced by 1114MWh (－1.5％) compare to local plan, and it is possible to generate almost same volume as local plan. Table 4-56 shows comparison of improvement plan and local plan.

Table 4-56 Comparison of Waterway Structure (improvement plan, local plan)

				suggestion	summary	original	summary
Headrace	Length		m	2451.37		2426.37	
	Type			Open (Trapezoid)	start EL627.20	Closed (circular)	start EL627.20
	Width		m	2.40	end EL624.75	4.00	end EL626.40
	Height		m	2.40		4.00	
	Slope		%	0.1000%	1/1000.00	0.0328%	1/3052.04
Head tank	Type			Non-pressure		Non-pressure	
	Feature	width	m	12.00		12.00	
		Length	m	48.50		73.50	
		height	m	7.50		9.50	
	waterLevel		EL.m	626.70		630.20	
Penstock	Type			Iron		Iron	
		Length	m	347.40	for reduce cost	310.00	fromupdated
		diameter	m	2.00		2.00	plan
Power house	Type			steel construction		steel construction	
	Size	Length	m	15.00		15.00	
		width	m	32.00		32.00	
		height	m	9.87		9.87	
	Turbin center		EL.m	795.45		790.45	

4-2-5. Discussion of domestic technique and possible implementation of specific know-how

4-2-5-1. Supply of generating equipment – tools by Japanese enterprises

It is necessary to examine products and technique of Japanese companies that can be supplied to the local projects.

(1) Compound auxiliary engine

So far, oil pressure have been used for the operation of turbine's guide vane, however electric auxiliary engine was used in Japan to find environmental-friendly solutions to avoid oil spills in the generating station,. However, electric auxiliary engine has problems in maintenance of spindle damage or the replacement of regular lubricants. These problems are solved by using compound auxiliary engine combining the strengths of operation by oil pressure and electricity. This method is already applied for turbines with capacity of 10,000 kW, and this technique is fully capable of application in accordance with this station.

The characteristics of this system are listed below.

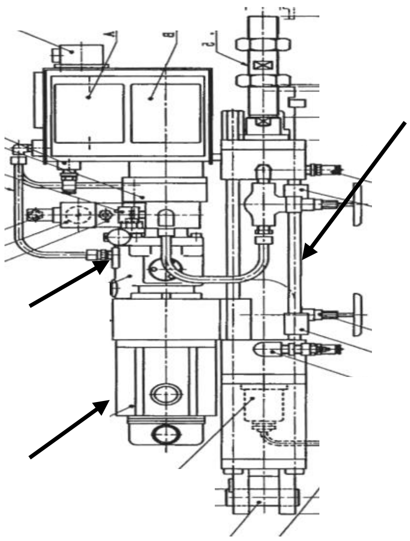
① It is a uniform and simple device, so it is easy to install with the existing equipment. There is also no additional pipe.

② With a compact design using oil pressure 10Mpa, it minimizes the installation space.

③ Because it requires a small amount of oil during operation, it is easy to maintain.

Below is an example of installation of Francis horizontal shaft turbine with the same size and general structure.

<General Structure>



<Example of Application>

Figure 4-35 Compound Auxiliary Engine

(2) Integrated control panel

So far, the device is always composed of many separate control panels such as the main panel, engine speed governor, AVR[19] to improve the performance of PLC[20], the number of control panels is reduced by putting all these features together into a single PLC in Japan. This technique can fully apply to the generating station of the project.

The characteristics of this system are listed below.

① Reducing the number of control panels

② Reducing the cost of installing cable systems by decreasing the number of cables

Here is the design of integrated control panel.

Figure 4-36 Design of Integrated Control Panel

4-2-5-2. Research related to efficiency and sophistication of operation and maintenance

(1) Background

Hydropower plants in Japan except the special generating stations are not managed by people. With regard to maintenance of generating station, a large-scale maintenance system which manages several generating stations by responsible offices being is in operation. Besides, in recent years, based on data that are continuously stored by machines automatically, we perform effective operating maintenance such as prompt recovery in case of problems, as well as measured life extension and large-scale dismantling and checking cycle of equipment relying on aging diagnosis, etc.

On the other hand, in Indonesia, almost all hydropower plants have maintenance personnel and operators. For equipment maintenance, the replacement timing and maintenance period are judged mainly based on the period after installation. In comparison with the planned maintenance scheme by analyzing the machine conditions, those tasks such as overhauling, checking and repairing hydraulic generator machinery is being done in a shorter cycle in Indonesia

(2) Component of remote monitoring system

Based on the system that is being used by HEPCO, chart below shows the recommended demonstration system and establishment of positive system.

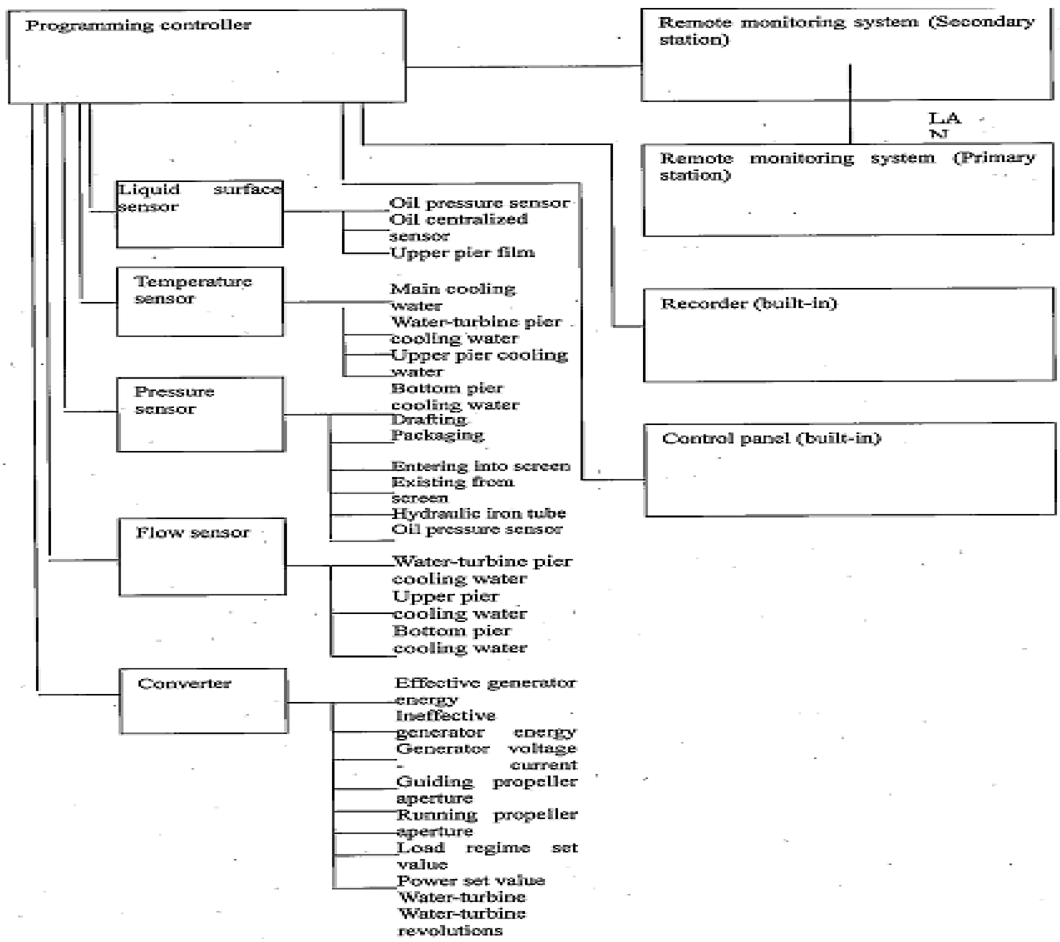


Figure 4-37 Components of Remote Monitoring System

(3) Analysis of maintenance data

Before trying to implement a wide-area maintenance framework, detailed review and examination on how well the ongoing system is functioning in such terms of: maintenance and management, method of operation and maintenance, and maintenance criteria. Expected effects gained by the system introduction, and the sets of information required for the preliminary evaluation on them, are as follows.

① Maintenance criteria

Required frequency of types of inspection - cruise (visual) inspection, regular inspection, and overhaul - should be reviewed. This may enable, by leveraging systematic data management, elongation of the intervals and saving in labor.

② Update cycle of equipment

Status management of equipment using the data gained from the system enables to determine optimum updating cycle of the equipment - e.g. runner, electric, and control elements.

③Intervals of regular inspection and overhaul

Implementation of the maintenance flow shown below is of great utility for enhancing maintenance efficiency.

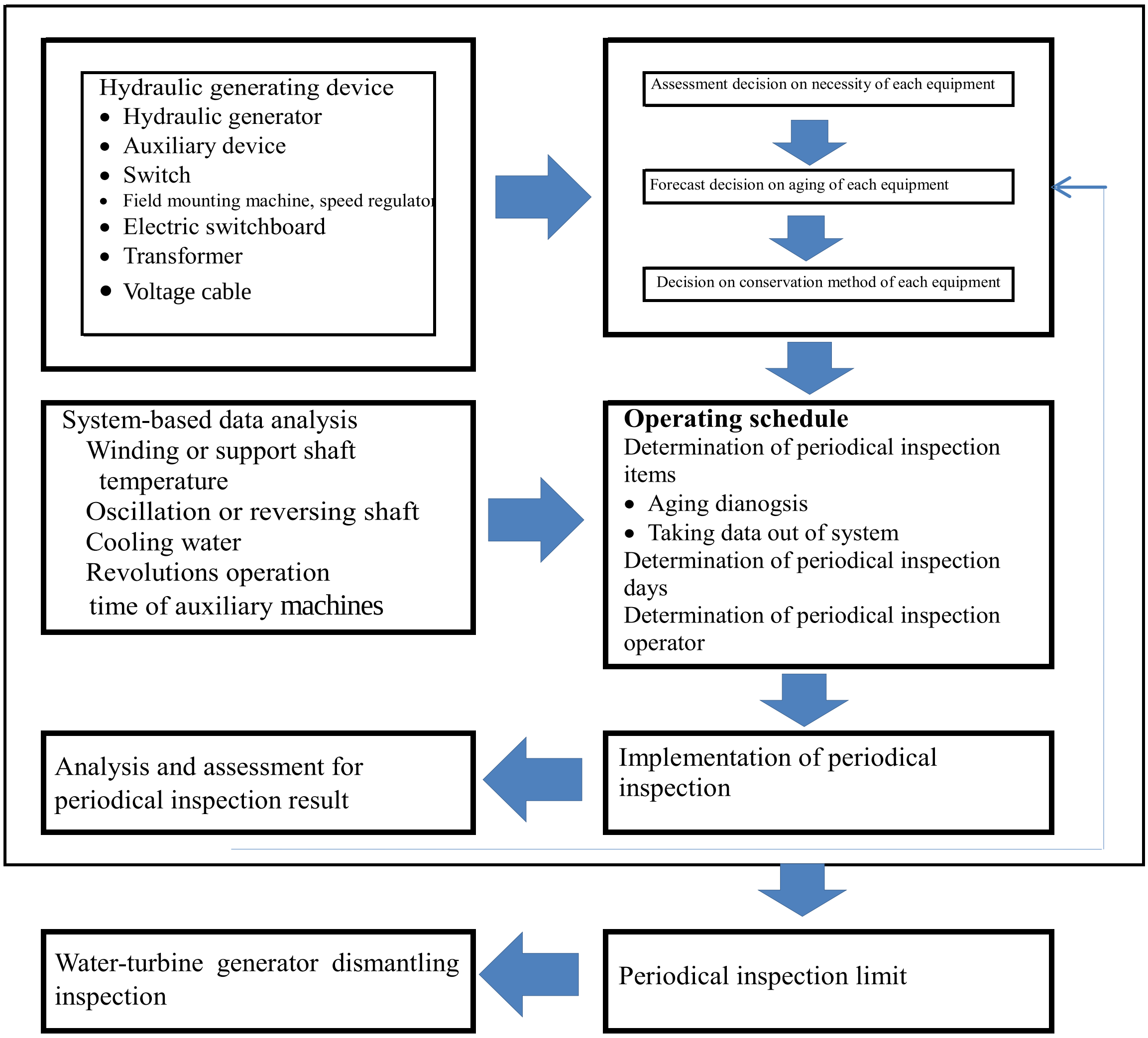


Figure 4-38 Flow of Maintenance

(4) Introduction of wide-area maintenance framework to the newly developed hydro power plant

Assignment of maintenance personnel becomes more efficient, and much higher level of maintenance works will become available if a small hydro power plant is developed under a precondition that it is operated as an integral part of a wide-area maintenance framework. To construct a wide-area maintenance framework that consistently monitors and controls multiple of hydro power plants that are located along the same river system, the hub station that preside over the maintenance works should be selected first, and construction of communication network and allocation of remote monitoring systems should be incorporated from the beginning of the power station design.

The development of small hydro power projects is generally a less profitable endeavor that makes private sector businesses hesitant to invest. However, if the scheme includes mechanisms that guarantee highly efficient operation and maintenance for a long period of time after its construction, it would work as incentives for promoting development. This is especially the case with the small hydro power development if it is financed by yen loan or other schemes, where, in addition to financial support for design, procurement and construction, value added operational supports, such as the followings, might be worth considering for the success of the project: operational know-how for running a remote monitoring system in a wide-area maintenance framework and technical support for data analysis methodology.

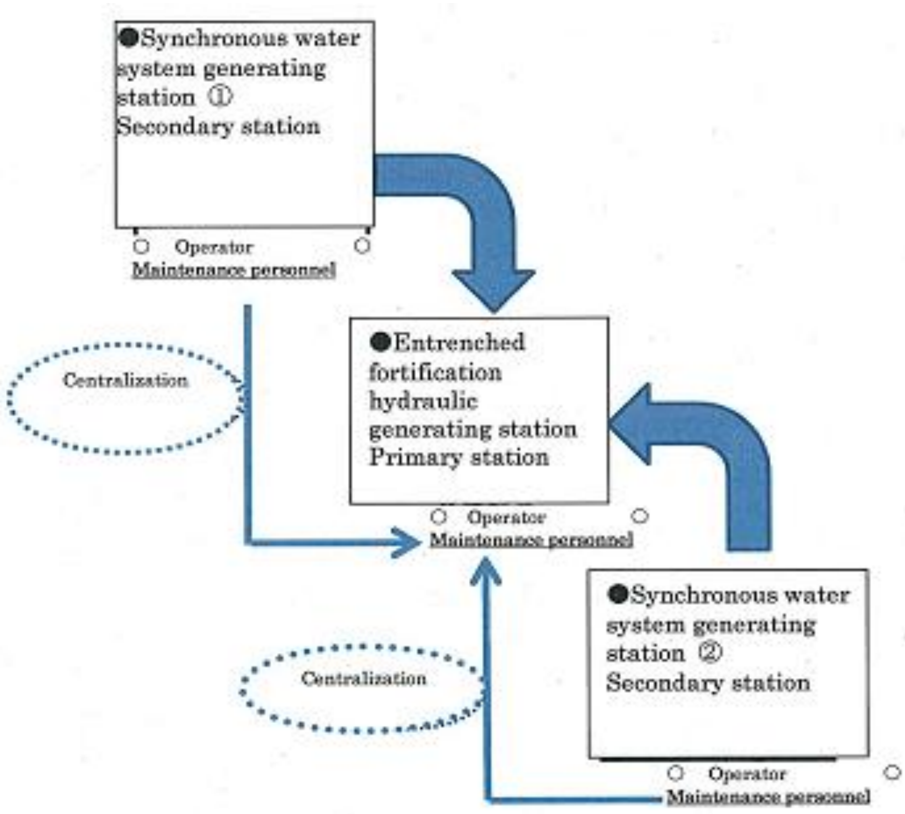


Figure 4-39 Image of Wide Area Maintenance System

(5) Effects in prospect

1) Direct effects

(A) Construction of efficient maintenance framework

- A smaller number of personnel is required for the maintenance and operation of a number of power plants efficiently
- Maintenance personnel shortage can be avoided in the face of rapid growth in the number of hydro power plants.
- Easier establishment of maintenance framework even in sparsely-populated remote/mountainous locations
-

(B) Preventive maintenance through correct understanding of equipment status

- Optimum interval settings for regular inspections, overhauls, and parts replacement
- Lower cost for running the power plant
- Long-term stability in the power plant operation

2) Indirect effects

- Increase in electric energy output due to enhanced utilization of the hydro power plant facilities
- Promotion of small hydro power development
- Expanded opportunities for Japanese corporations in IT sector to enter into the market
- Provision of added values
- Higher competitive edge gained by total solution delivery, including long-term stable operation and lower running cost.

4-2-6. Scheme of execution

A scheme of execution is a comprehensive implementation planning to bring the construction to perfection economically and safety within the prescribed work period, and without compromising desired quality nor damaging the environment. It requires multifaceted considerations over labor service, construction materials, power source, utilities, building and transportation and others. In this section, the construction planning method and important notes implemented in Japan and all the processes in this project will be discussed.

4-2-6-1. Possible issues on the scheme of execution

(1) Work volume and period

Work volume is roughly represented by the following formula below. Once the work period is defined, year-by-year schedule should be worked out so that work volume out so that work volume variations are as small as possible, and breaking it down into available months in a year and available days in a month, with due consideration given to climate and work conditions.

・(Work volume) = (Unit work volume) x (work period)
・(Daily work volume) = (work volume / hour) x (Work hours / day)

Daily and hourly work volume heavily depends on the on-site conditions: performance of machinery, processing condition, availability factor, and work shift schedule. Table 4-57 shows a list of Important points of concern for setting up a well-balanced schedule.

Table 4-57 Points of concern for setting up work volume and period

Construction equipments	Consider parameters (type, performance, on-site conditions) in a comprehensive way, and select the most efficient combination
Availability	A ratio of real operating time vs. total clock hours. Availability is susceptible to such factors as: initial work setup, maintenance, and driver’s skill. Meticulous management required to maintain high availability.
Working hour/day	Determined by organization/ grouping of workers. Working hours should be optimized reflecting the shift scheme (1,2,3 shifts/day)

(2) Construction method and cost

Construction cost is largely classified into two categories: the variable cost which varies depending on the work volume, and fixed cost which solely depends on the work period. Variable cost and fixed cost are essential elements for the analysis of prime cost and selection of work technique, because they can vary depending on the scale of construction, work technique used, and work capacity of the machines.

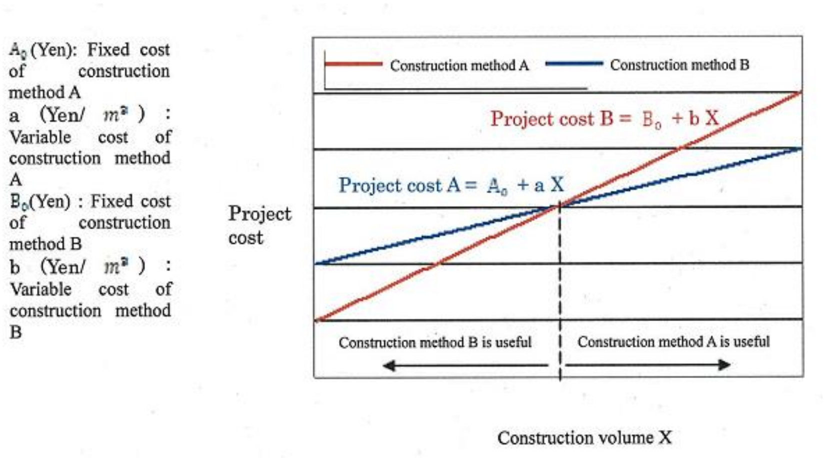


Figure 4-40 Comparing construction method A and B (Foundation excavation)

4-2-6-2. Points of concern for selecting the construction method

(1) Balance between economical speed and construction details

The fund for power plant construction is naturally accompanied by a substantial amount of interest. Therefore, in general term, the shorter the work period the more economically advantageous in term of interest, as well as in terms of administrative and miscellaneous expenditures. However, the effort for cutting back the work period has its own limit. An excessive cut back on the work period can incur a blown-up investment on temporally facilities and construction machines, as well as redundant labor expenditure, leading to an unexpected increase in construction cost.

One of the characteristics pertinent to power plant construction is that it requires types of long-term constructions such as a large-scale dam and long tunnels, which often determines the total period of construction works. If this is the case, the first thing to do is to streamline the long-term construction economically, and then to make up the overall schedule with due considerations given to balancing the multitude of work types. (Comparison of project stages, Table 4-58 and Figure 4-41)

Table 4-58 Comparison of Project Stages

(Based on medium and small hydroelectric power manual)

Plan 1	・ Considering each stage of work independently and arranging to have the same completion time in a most economical way. ・ Because a large portion of total quantity of the project work concentrates at the end of project period, it looks as if it is a most economical way from the aspect of interest payment. However, the peak of some stages of work is duplicated; therefore, it is expected to have large work volume of work during certain periods. ・ Therefore, to accommodate such large volume of work, required lodging for workers, collecting, transportation, other temporary facilities and machinery is expected to be increase accordingly, thus losing economy.
Plan 2	・ By moving the operation period of work of the tunnel, it can reduce the maximum total workload significantly and becomes more economical than plan 1.
Plan 3	・ Squeezing the work period of dam A which requires the maximum period and adjusting the work stage of dam B and tunnel along the work of dam A, it balances and streamlines the temporary facilities and usage of machines.
Plan 4	・ Taking a comprehensive view over 3 stages of work and without thinking of the completion stage of dam A, by extending total work period, the total economic benefits can be obtained.

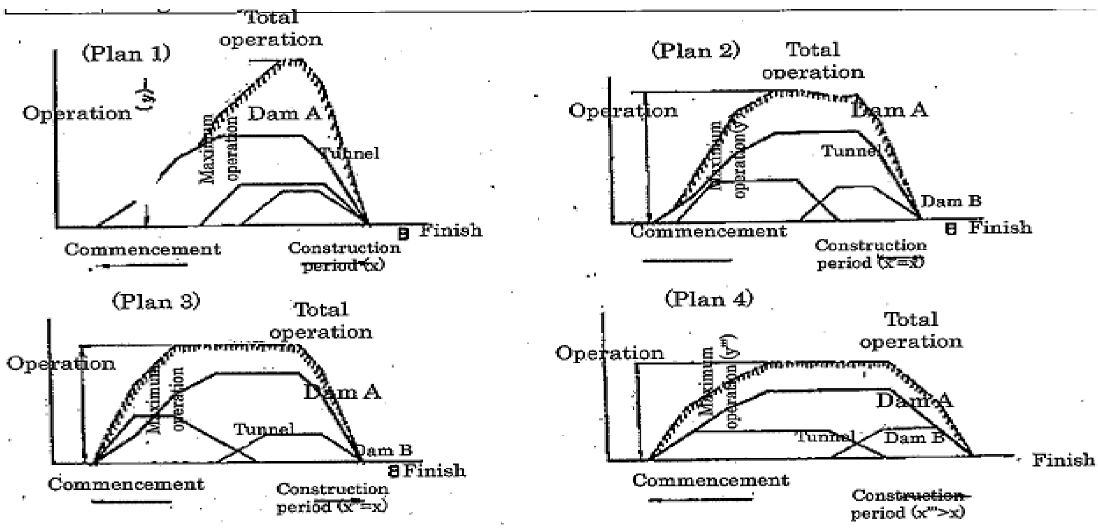


Figure 4-41 Comparison of a Construction Process

(2) Facilities and equipment

Construction work requires a variety of facilities and machines. The work schedule must take ability/capacity of these into account, with a view to achieve a balance among them.

In general, larger work facilities enable shorter work period. However, excessive enlargement of facilities can level off, or even damage the achievement of shortening efforts. Economy of a type of work is generally gets better as the scale of facility becomes larger (i.e. reduction of unit work cost), and normally starts to decrease as the scale of surpasses a certain level (i.e. cecrease in unit work cost). The turning point occurs at relatively small facility scale when the scale of the work is small, and at relatively large facility if the work scale is greater.

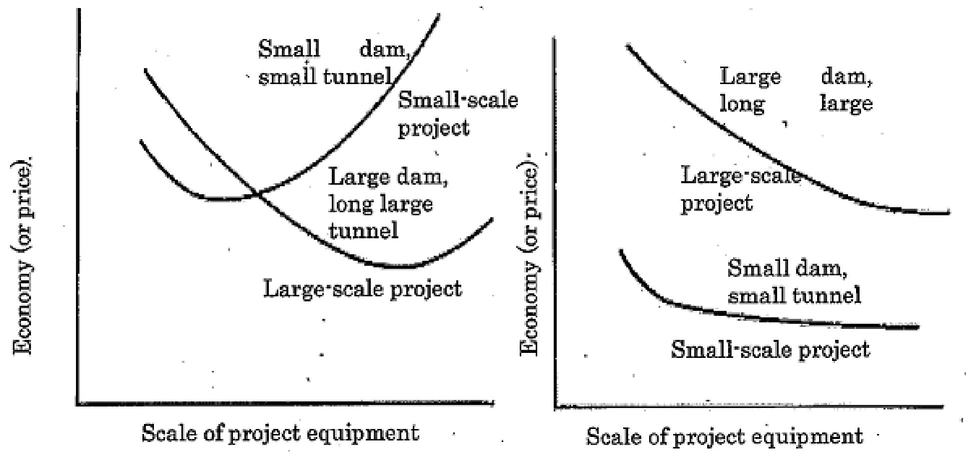


Figure 4-42 Scale of facility, economy, and work period

Source: Guidebook for small hydropower project

(3) Hydro-meteorological condition: Timing of groundbreaking and work period

Hydro-meteorological conditions such as temperature, rainfall, heavy snow and flood and others have significant effects on construction processes. Therefore, these conditions must be taken into account for the optimum period selection for groundbreaking and construction work.

(4) Allocation of workload

In reference to work schedule plan, important items such as monthly wage, number of workers, quantity of construction materials, and major machines employed should be put into review. A significantly biased allocation, if any, should be passed into review.

(5) Schedule allowance

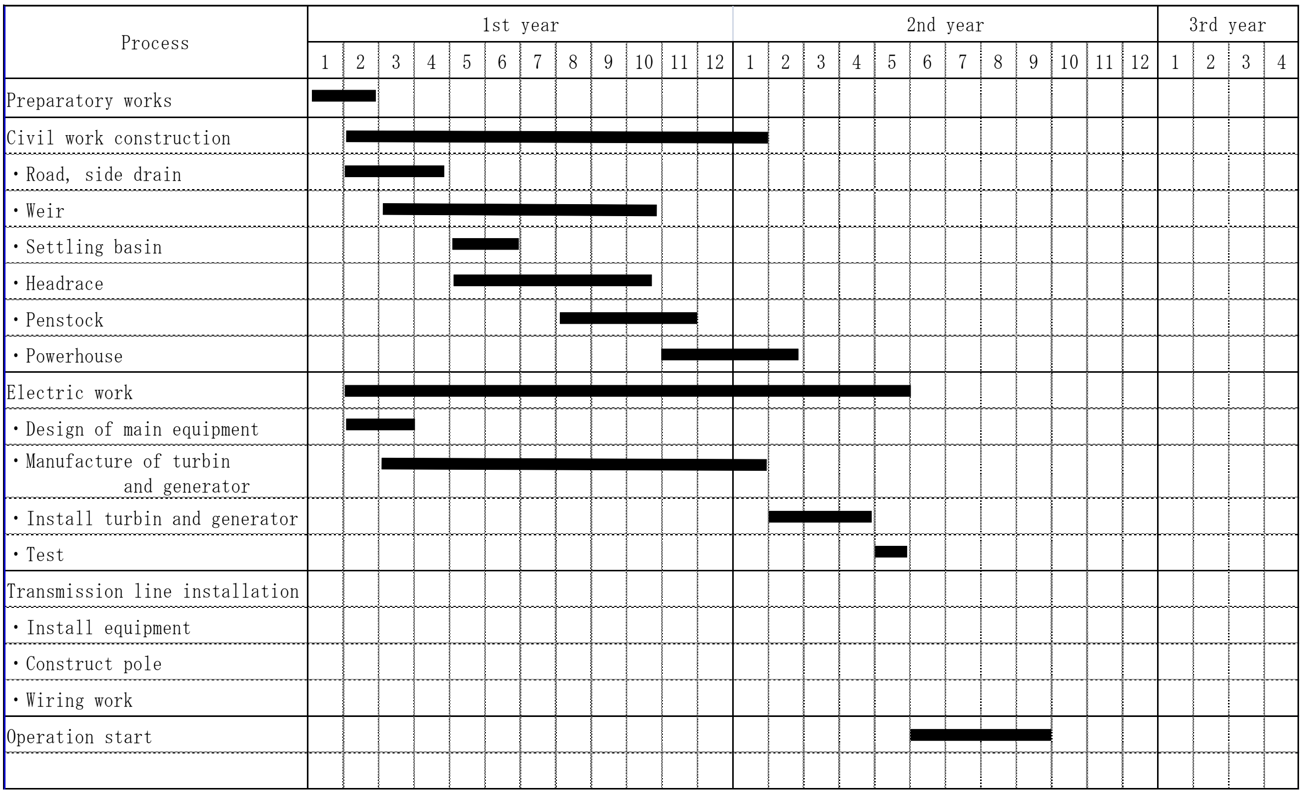
As the construction progresses, the project may be faced with an unexpected incidence such as a large influx of spring water inside the tunnel, abnormal flood of a river, and so on. If the impediment is serious and large in scale, all the steps and organization of the schedule may have to be reviewed. However, the schedule should be set up from the start in such a manner that it allows each step of the construction work to have an adequate margin to absorb small delay caused by a minor accident and variation of work volume.

Optimum margin depends on several factors – planning condition, type of work, and previous knowledge of the nature of the work -, thus, a study of track records in the past may help establish an adequate value.

4-2-6-3. Grand schedule of Lae Ordi II project

Grand schedule, including every steps involved of Lae Ordi Ⅱ is shown in Table4-59.

Table4-59 Construction schedule (Lae Ordi II)



4-2-6-4. Notes on constructing facilities in Lae Ordi Ⅱ hydropower project

(1) Intake weir, intake gate, and settling basin

Dam body construction includes a temporary shutoff operation, the timing of which must be carefully selected taking climate conditions into account, and during the period when river flow is a minimum. Constructions of intake gate and settling basin will carry out about same time, and shutoff operation must be implemented securing lands for materials and equipments.

Also, construction site is in mountainous area, construction roads maintenance is necessary to provide materials and equipments.

(2) Headrace

In the improvement plan, cross-sections of opened and culvert conduits are suggested to use. However, since large scale of cutting slope and banking works are required because of the geography, construction must be carefully implemented considering stability and protection of slope during and after construction.

(3) Penstock and power plant

In the improvement plan, penstock route and power plant location to reduce number of cutting work are suggested. Wide range of slope must be created same as headrace, construction must be carefully implemented considering stability and protection of slope during and after construction.

4-2-7. Management, operation, and maintenance

4-2-7-1. General

In hydropower generation facilities, such as the one constructed in this project, a large portion of operating cost is occupied by labor cost: every effort should be made to attain unattended management/operation in as wide as possible extent. Establishment of a wide-area maintenance framework – personnel in one office administrates plural of power plants – can be a solution for efficient management and maintenance.

Focus should be placed on the efficiency of operation and maintenance that enables full-fledged use of the planned effect continuously and uninterruptedly. This strategy should include diligent performance of such routine tasks as continuous monitoring and analysis of maintenance data. Such effort will have an effect on rapid recovery from failures, and easier diagnostics of system degradation, leading to longer life of facilities and extended interval between large-scale overhauls.

4-2-7-2. Specifics of management system

The business entities in Indonesia are lacking in specific information not only to perform activities in an orchestrated and organized manner, but also track record for operation and maintenance of hydropower stations. In this context, F/S report does not provide specific descriptions on maintenance/management planning that will become necessary after completion of the construction.

In this section, description is made on the system and planning of operation, maintenance, and management based on the directives in place in Japan (Electricity Business Act). It is highly advisable that a similar management system be organized in Indonesia for enhanced operation and maintenance of the electricity generating facilities.

(1) Obligations prescribed by Electricity Business Act

1) Appointment of chief engineer

For effective implementation of operational management on hydropower facilities, Electricity Business Act dictates appointment of chief engineers and establishment of safety regulation based on which operation and management of the facility should be performed. At least two chief engineers must be appointed: a licensed electric engineer in charge of electric facilities (turbine, generator, transformer, and distribution board) and a hydraulic chief engineer in charge of hydraulic facilities (intake, water channels, and spillway.

Safety regulations have a requirement that they define such variety of rules as: organization and duties of administrators, maintenance education, inspection tour for maintenance, check/inspection items, operation/manipulation of power generation facilities, maintenance during a long downtime, measures to be taken at the time of emergency, record keeping of operation and maintenance, and maintenance items related to maintenance and operation of power generating facilities. The business entity responsible for the operation and maintenance of the facility must abide by the safety regulations.

2) Report and contact

The operator of a private power generation plant with output capacity greater than 1,000kW must submit an operation report once in every six months to the Minister of Economy, Trade and Industry. When an accident occurs, the chief engineer in charge of the facility, irrespective of its output capacity, must submit a quick report without delay, followed by detailed description of the accident.

3) Operation and maintenance of hydropower facility

As an accident in a hydropower facility can have a huge impact on the local society, diligent performance of maintenance activities of the facility – extraordinary inspection at the time of emergency as well as regular maintenance – is of utmost importance.

Hydraulic facilities (intake gate, water channels, and spillway) are susceptible to damages caused by natural force, and, once an accident occurs, it can have a huge impact on the local society. If an abnormal incident occurs, or any sign of it is detected, an extraordinary inspection should be given.

For hydraulic facilities, normal frequency of tours of inspection is as follows.

①Two or three times a month: in search of any sign of abnormality

②Once in every six month: detailed external inspection

③Once in every two to five years: internal inspection with the water drained out (the frequency depends on the structure of the facility, years of use, and natural conditions)

An extraordinary inspection must be given after an earthquake, flooding, and heavy rain, for early detection of cracks, damages and inflow of earth and sand. Immediate measure should be taken if the situation calls for.

Internal inspection of water channels, with the water drained out, requires special safety measures: in addition to set up a detailed plan beforehand, close contact and cooperation with relevant departments is essential to avoid unexpected accident –e.g. influx of water while the inspection is underway.

4) Operation and maintenance of electric facility

In most cases, totally unattended operation is a common practice in power generation plants. Therefore, regular tour of inspection, as well as an extraordinary inspection when an accident occurs, should be an integral part of electric facility maintenance.

Although the power plant include sources of potential danger – high-voltage electric equipment, and running heavy machines - the number of unmanned plants is on the increase owing to advance in technology. For this reason, multiple safety measures should be in place such as the safety barrier (lockable) and the device to detect intrusion of an alien.

For electric equipment (turbine, generator, transformer, distribution panel), normal frequency of tours of inspection is as follows.

①Two times a month: monitor the occurrence of abnormality

②Two or three times a year: detailed inspection of the turbine (water drained out) and electric equipment

③Once in every five to ten years: overhaul of power generating equipment

5) Operation and maintenance of power transmission/distribution facility

Power transmission and distribution facilities are classified into two categories (aerial and underground) and details of maintenance procedures differ accordingly. However, regular tour of inspection and extraordinary inspection in case of abnormal incidence should be given to both of these categories.

Aerial system is subject to damage such as: typhoon damage, salt damage, transmission tower collapse due to earth slide, mud slide, and avalanche, lightning strike, and, damage caused by wind and overgrowth of weed. Underground system is subject to such damages as: landslide and mud slide, and damages caused by small animals.

To cope with this variety of damages, regular tour of inspection, as well as an additional extraordinary inspection at the occurrence of abnormal situation, should be an integral part of the maintenance system.

4-2-8. Summary, future issues

4-2-8-1. Summary, future issues, and measures

Major conclusions derived from this review, and future issues and remedial measures are listed in Table 4-60.

(1) Discussion of power generation plan

1) Major results of the review, and future issues

① Flow data was estimated using NRECA model from the precipitation data collected at Sidikalang observatory from 1993 to 2008. Precision of NRECA model needs to be examined. Because scarcely any flow rate data was available from the rivers in the neighborhood of the project site, the flow rate data contained in the Indonesian plan was used for review.

② Effective head which is determined after calculating the loss head based on local design is consistent with estimated value of the plan. However, waterway is designed as gentle gradient (1/3052) on larger cross section due to minimize loss head at headrace. Therefore, gradient of headrace is extremely gentle and cross section of waterway is large compared to general slope of headrace (1/1000-1/1500) in Japan.

③ Assuming the same maximum discharge as put forward by Indonesian plan, power output was found to be lower, 10,300kW as compared to Indonesian plan, 10,000kW. This is because generating efficiency of this survey is used the value provided from domestic manufacturers, which is high efficiency.

④ Electric energy output reported in this review showed nearly the same level as that contained in Indonesian document with a margin around 760MWh (Note that the two calculations used different conditions such as: setting methods for generator output, power generation efficiency, and maintenance flow)

⑤ Construction cost evaluated using Japanese standards procedure showed approximately 5-6 times higher price than that contained in Indonesian document. The large margin can be attributed to the difference in labor and material cost between the two countries.

⑥ The cost from the local materials is roughly estimated based on the other similar projects in Indonesia by local consulting company. Although it does not show big difference, the cost estimated from the local materials is little higher. It is necessary to consider design of the structure and construction schedule for more accuracy of estimation.

⑦ Power generation capacity was evaluated based on the unit cost comparison (per kWh). In case the fixed purchase price limits at 10000kW, the most appropriate capacity using method used in Japan is 10,000kW (maximum output) with 11.20m^3/s of discharge, which result is almost same as the local plan.

2) Possible solution and remedial measure

① Flow rate data: It is to be desired to implement simplified flow rate measurement at the project site, for 1 year or around, to confirm accuracy of flow rate data – including reliability evaluation of data, and validity assessment of NRECA model.

② Effective head: It is possible to improve economical efficiency by designing appropriate headrace considering efficiency of construction and economical.

③ Electric energy output: It is necessary to verify accuracy of electric energy calculation considering necessity of maintenance discharge and setting efficiency.

④ Economic evaluation: Evaluation of the construction cost remains to be worked out for the future, wherein an extensive review of the structural design and implementation planning should be take into consideration.

(2) Safety of major civil engineering structure

1) Major results of the review, and future issues

① Stability of intake weir: Calculation based on Japanese standard proved that intake weir is sufficiently stable.

② Dust and waste filter: The drawings submitted from Indonesian side did not allow identification of such device in place, thus confirmation needed for its existence.

③ Water conduction capacity of headrace: Hydraulic calculation proved that the system provides sufficient water conduction capacity. However, since the headrace is designed gentle gradient (1/3052) and larger cross-section due to reduce loss head, large volume of excavation is required and steel pipes materials have to be manufacture in a factory. These raise the construction cost, and it is needed to verify from the view of economic efficiency.

④ Head tank capacity: Current design is confirmed to provide sufficient capacity.

⑤ Wall thickness of penstock: Examination based on Japanese standard concludes 10mm thickness of penstock that is applied on local document is not sufficient in some section of the downstream.

⑥ Location of turbine: In the current design, turbines are located diagonally against buildings. To install turbines, overhead traveling crane will be used, and crane moves toward direction of building or vertical direction against buildings. Therefore, turbine could place in axial direction of building in order to facilitate installation of generator and turbine runner.

⑦ Number of turbine and generator: 3 units of turbines and generators are planned to be used in local plan. Although stream regime is stable relatively, it will need more space to install if they are placed separately. Thus, it is necessary to verify considering economical efficiency.

⑧ Location of power plant: Since sill level of power plant is 50m deeper than ground surface, it requires large volume of excavation including installation of penstock. Thus, it is needed to verify considering economic term.

2) Possible solution and remedial measure

① Intake weir: Although judged stable, the examination used expected values (e.g. physical property of foundation) in a part of the calculations. Recalculation is highly desirable using measured/experimental values (this requires implementation of soil test).

② Headrace: It is expected reducing construction cost and improve economic efficiency by changing cross-section shape considered construction efficiency and gradient to be more steeply in order to minimize cross-section for water conduction.

③ Head tank: It is possible to miniaturize head tank by shorten tank length accordance with improvement of headrace design. Thus, it is necessary to consider location and capacity of tank.

④ Location of Turbine: Direction to install turbines could change from diagonally to parallel way adjusting to axial direction of building. However, space of building and excavation volume will change, and it is necessary to examine the layout considering construction cost.

⑤ Wall thickness of penstock: 10mm of pipe thickness in downstream is not sufficient for the pressure, and it is required to have more thickness. Since the pressure in upstream is lower, increasing the size of thickness gradually by some section toward the downstream could be more economical. Besides, according to the change of location of power plant, waterway route could be change as well to reduce the loading and improve safety.

⑥ Number of turbine and generator:
It is possible to reduce building cost of equipment and save the installation space by changing number of turbine and generator 3 to 2. Thus, it is necessary to verify economic efficiency specifically. Note that energy generation is same amount with either 2 or 3 turbines and generators.

⑦ Location of power plant: As the change of penstock route, power plant could construct at higher elevation. Therefore, excavation for construction of penstock and power plant will reduce drastically. It is expected improvement of economic efficiency and necessary to verify for more detail.

Table 4-60 Major Results, future Issues and remedial measures

		Major results, future issues	remedial measures
Generating plan	Flow rate data	Flow data was estimated using NRECA model from the precipitation data collected at Sidikalang observatory from 1993 to 2008. Precision of NRECA model needs to be examined.	It is to be desired to implement simplified flow rate measurement at the project site, for 1 year or around, to confirm accuracy of flow rate data - including reliability evaluation of data, and validity assessment of NRECA model.
		In Japan, in case no water-gauging facility is available in the immediate or moderate neighborhood of the project site, a simplified precipitation measurement should be taken for a year to figure out the flow rate. Based on the measured flow rate and the data obtained from the water-gauging facilities along the neighboring rivers, correlation favor of mutually complementary use of these set of data, flow rate is forecast using regression analysis for the period of ten years. Since major flow data is not available from the neighborhood of the project site, this review uses the flow rate data available from the on-site planning document (converted from precipitation data using NRECA model) for analysis.	
	Effective head	Effective head which is determined after calculating the loss head based on local design is consistent with estimated value of the plan. However, waterway is designed as gentle gradient (1/3052) on larger cross section due to minimize loss head at headrace. Therefore, gradient of headrace is extremely gentle and cross section of waterway is large compared to general slope of headrace (1/1000-1/1500) in Japan.	It is possible to improve economical efficiency by designing appropriate headrace considering efficiency of construction and economical.
	Output	Assuming the same maximum discharge as put forward by Indonesian plan, power output was found to be lower, 10,300kW as compared to Indonesian plan, 10,000kW. This is because generating efficiency of this survey is used the value provided from domestic manufacturers, which is high efficiency.	
	Electric generation	Electric energy output reported in this review showed nearly the same level as that contained in Indonesian document with a margin around 760MWh	It is necessary to verify accuracy of electric energy calculation considering necessity of maintenance discharge and setting efficiency.
	Estimated cost	Construction cost evaluated using Japanese standards procedure showed approximately 5-6 times higher price than that contained in Indonesian document. The large margin can be attributed to the difference in labor and material cost between the two countries.	Evaluation of the construction cost remains to be worked out for the future, wherein an extensive review of the structural design and implementation planning should be take into consideration.
		Comparing construction cost of this project and similar project in Indonesia, it does not show big difference, however, the cost estimated from the local materials is little higher.	
	Power Generation capacity	Power generation capacity was evaluated based on the unit cost comparison (per kWh). In case the fixed purchase price limits at 10000kW, the most appropriate capacity using method used in Japan is 10,000kW (maximum output) with 11.20m3/s of discharge, which result is almost same as the local plan.	It is examined appropriate capacity with capacity of local plan, still it is necessary to confirm selecting method for the most appropriate capacity.
Safety issues of main structures	Intake weir	Calculation based on Japanese standard proved that intake weir is sufficiently stable.	Although judged stable, the examination used expected values (e.g. physical property of foundation) in a part of the calculations. Recalculation is highly desirable using measured/experimental values.
	Dust and waste filter	The drawings submitted from Indonesian side did not allow identification of such device in place, thus confirmation needed for its existence.	—
	Headrace	Hydraulic calculation proved that the system provides sufficient water conduction capacity. However, since the headrace is designed gentle gradient (1/3052) and larger cross-section due to reduce loss head, large volume of excavation is required and steel pipes materials have to be manufacture in a factory. These raise the construction cost, and it is needed to verify from the view of economic efficiency.	It is expected reducing construction cost and improve economic efficiency by changing cross-section shape considered construction efficiency and gradient to be more steeply in order to minimize cross-section for water conduction.
	Head tank	Current design is confirmed to provide sufficient capacity.	It is possible to miniaturize head tank by shorten tank length accordance with improvement of headrace design. Thus, it is necessary to consider location and capacity of tank.
	Penstock	Examination based on Japanese standard concludes 10mm thickness of penstock that is applied on local document is not sufficient in some section of the downstream.	10mm of pipe thickness in downstream is not sufficient for the pressure, and it is required to have more thickness. Since the pressure in upstream is lower, increasing the size of thickness gradually by some section toward the downstream could be more economical.
	Turbin, Generator	In the current design, turbines are located diagonally against buildings. To install turbines, overhead traveling crane will be used, and crane moves toward direction of building or vertical direction against buildings. Therefore, turbine could place in axial direction of building in order to facilitate installation of generator and turbine runner.	Direction to install turbines could change from diagonally to parallel way adjusting to axial direction of building. However, space of building and excavation volume will change, and it is necessary to examine the layout considering construction cost.
		3 units of turbines and generators are planned to be used in local plan. Although stream regime is stable relatively, it will need more space to install if they are placed separately. Thus, it is necessary to verify considering economical efficiency.	It is possible to reduce building cost of equipment and save the installation space by changing number of turbine and generator 3 to 2. Thus, it is necessary to verify economic efficiency specifically.
	Power plant	Since sill level of power plant is 50m deeper than ground surface, it requires large volume of excavation including installation of penstock. Thus, it is needed to verify considering economic term.	As the change of penstock route, power plant could construct at higher elevation. Therefore, excavation for construction of penstock and power plant will reduce drastically. It is expected improvement of economic efficiency and necessary to verify for more detail.