No.

STUDY OF THE COOPERATION POSSIBILITY ON POWER DEVELOPMENT PHASE 2 IN NORTH SUMATRA, INDONESIA

FINAL REPORT

SUMMARY

November, 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

Commissioned firm

TOKYO ELECTRIC POWER SERVICES CO.,LTD.

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STUDY OF THE COOPERATION POSSIBILITY ON POWER DEVELOPMENT PHASE 2 IN NORTH SUMATRA, INDONESIA FINAL REPORT SUMARRY

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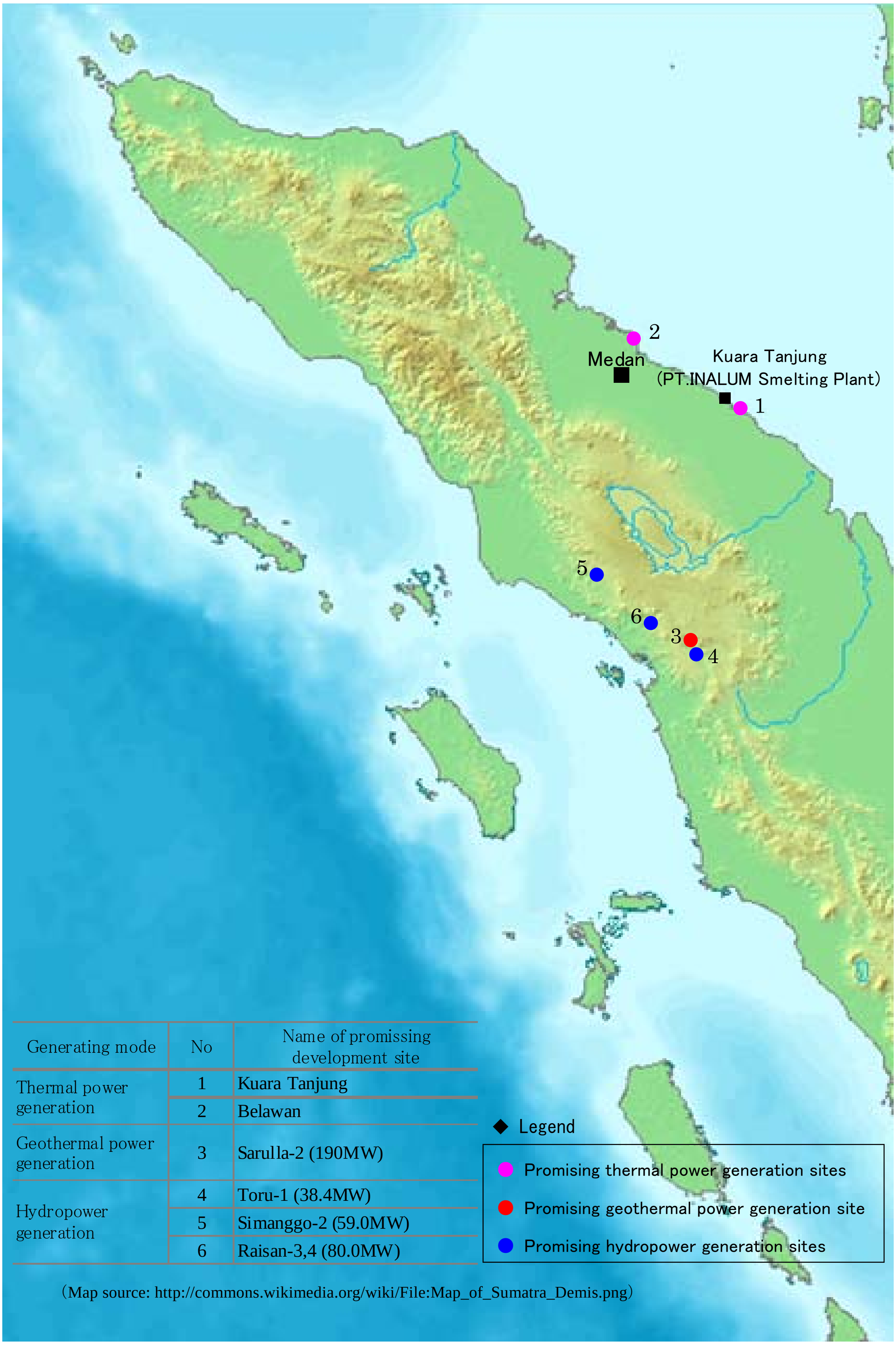


Generating mode	No	Name of promissing development site
Thermal power generation	1	Kuara Tanjung
	2	Belawan
Geothermal power generation	3	Sarulla-2 (190MW)
Hydropower generation	4	Toru-1 (38.4MW)
	5	Simanggo-2 (59.0MW)
	6	Raisan-3,4 (80.0MW)

(Map source: http://commons.wikimedia.org/wiki/File:Map_of_Sumatra_Demis.png)

<u>Map of the study target areas</u>

Chapter 1 Objectives and Background of the Study

This Study, intended to update the results of the JICA study (Phase 1) implemented between February-April 2009, has the objective of confirming the development potential of coal, gas, geothermal and hydropower as additional energy sources for Asahan Aluminum and presenting a viable potential plan for future development. The Study targets the North Sumatra Power Grid covering Aceh Province and North Sumatra Province.

In Phase 1, a preliminary study was conducted on numerous power resource options, and the various issues and problems were raised concerning the implementation system, economic and financial viability and project risk, etc. The study also stressed the need to develop electric power for supply of additional power in line with extension of the Asahan Aluminum business beyond 2013 and supply of public power use to satisfy the additional demand expected in line with promotion of industrial investment from now on. Concerning power development in North Sumatra, it is necessary to narrow down numerous power supply options into promising options that are financially sound and viable on the basis of development risk, business risk and the Indonesian side incentives, considering resource prices and social and environmental impacts, etc.

It is forecast that peak demand on the North Sumatra Grid will increase at an average rate of 8% per year up to 2018. However, the power supply backup rate until 2013 is expected to be less than 25% even when future development plans are taken into account. This grid is interconnected with Aceh Province, however, since power plants in this province suffered extensive damage in the Indian Ocean earthquake of December 2004, it is forecast that the reconstruction effort will lead to further demand. Even taking into consideration the hydropower plants that were introduced under yen loans in fiscal 2005 and 2006 (Asahan No.3: 154 MW and Pusangan No.1 & 2: 86 MW), it is necessary to develop further power resources. As of September 2010, planned power interruptions are implemented two or three times per week in areas around Medan, the capital city of North Sumatra Province.

Meanwhile, the Indonesian government and Japanese investors signed a master agreement concerning the development in 1975, and work was commenced on the Asahan Aluminum Smelter Project with the goals of constructing three dams and two power plants (with total capacity of 513 MW) on Asahan River as well as an aluminum smelter plant and incidental facilities, etc. on the coast facing the Malacca Straits roughly 80 km south of Medan. Following construction, production of aluminum was started in 1982.

Under the said agreement, a Japanese-Indonesian joint local aluminum producing corporation, PT Indonesia Asahan Aluminum (INALUM), was established and this has overseen the project construction and operation. Via INALUM, water use rights on Asahan River, various tax benefits and operating rights based on Indonesian foreign capital law have been granted for 30 years until October 2013. An important point pertaining to power development is that the operating rights can be extended on the premise of expanding the existing smelter providing that the Indonesian government and Japanese investors can reach an agreement by October 2010.

INALUM has plans to increase smelting plant capacity by 90,000 tons per year, and the securing of cheap and stable power supply is essential for this. Additional power supply of 200 MW is needed in order to boost aluminum production by 90,000 tons per year, however, since this would account for between 20~30% of the current capacity of the North Sumatra Grid, it will be necessary to carefully determine whether such a cheap and stable supply of electricity can be realized in the current demand and supply and future plans.

Against such a background, based on recognition of the supply and demand gap in the North Sumatra Grid, a study was implemented in order to confirm the timing and scale of increase in power demand arising from the large-scale development (INALUM expansion plan) and to determine the viability of conducting power resources development with a view to minimizing or eliminating impact on the supply and demand balance on the grid.

Chapter 2 Power Demand and Supply in North Sumatra

The North Sumatra Grid covers North Sumatra Province and Aceh Province and is linked by 150 kV transmission lines. PLN supplies power via the 150 kV North Sumatra Grid and other small independent power systems. These small independent power systems primarily supply power derived from diesel engine generation using relatively expensive fuel. On the other hand, the North Sumatra Grid supplies power from a diverse mix of hydropower, diesel power, steam power, gas turbines and combined cycle generation. In Aceh province, 70% of power is supplied from the North Sumatra Grid, while the remaining 30% comes from a 20 kV independent system (PLTD) using HSD as fuel. PLTD power supply via 20 kV systems based on HSD fuel is similarly conducted in limited parts of North Sumatra Province, however, this only accounts for 1% of overall grid capacity. Almost all power is obtained via the North Sumatra Grid.

When system interconnection between Southwest Sumatra Grid and North Sumatra Grid by 275 kV transmission line is realized and the transmission network on Sumatra Island is completed as planned in RUPTL 2010, the capacity of generating facilities will be approximately 6,200 MW, peak load will be approximately 4,500 MW and the network reserve margin will be around 38%. Furthermore, there are plans to connect the coal-fired thermal power plant intended for construction in Jambi Province via a 500 kV transmission line, and Sumatra will eventually be connected to the Java-Bali Grid via a 500 kV submarine transmission line under the Sunda Strait, thereby realizing even greater grid stability.

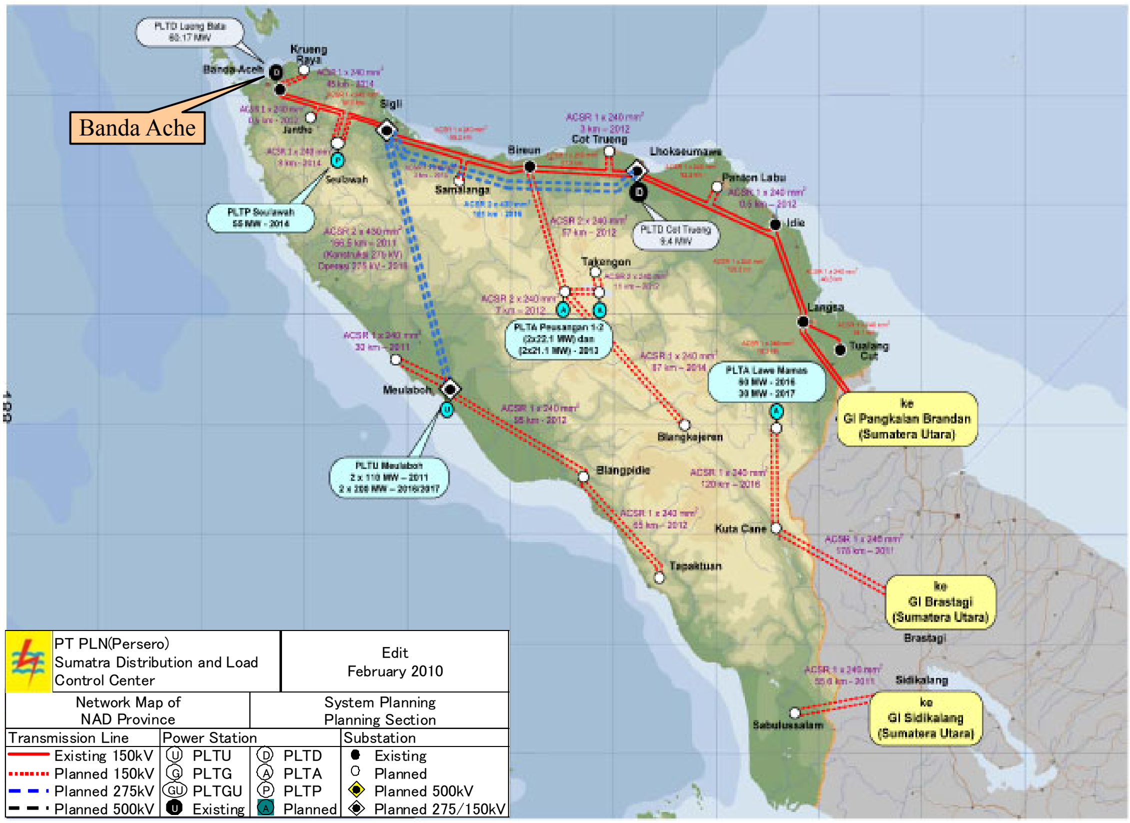
Currently the capacity of power generation facilities amounts to approximately 1,700 MW, that is 80 MW in Aceh Province and 1,620 MW in North Sumatra Province. However, many of these power plants were constructed in the 1970s and 1980s and suffer from declining efficiency caused by deterioration, and they only have enough capacity to generate roughly 80% of rated capacity on average. This deterioration of power generation facilities, combined with the increasing demand for power, is one of the causes behind the critical power supply situation. In response to these conditions, PLN has designated the North Sumatra Grid as a ‘critical area’ (designated area of power shortage) requiring immediate countermeasures, and the rehabilitation and renewal of such deteriorated facilities is deemed to require urgent attention.

According to demand forecast in Aceh Province and North Sumatra Province which was conducted by PLN, energy demand/ generated electric energy/ peak load in Aceh Province net system will increase from 1,470 GWh/ 1,591 GWh/ 293 MW in 2010 to 3,541 GWh/ 3,893 GWh/ 684 MW in

2019, representing an annual increase of 10.4%/ 9.8%/ 9.7%. Meanwhile, in North Sumatra Province, the same items will increase from 6,782 GWh/ 7,474 GWh/ 1,293 MW in 2010 to 15,042 GWh/ 16,262 GWh/ 2,821 MW in 2019, representing an increase of 8.5%/ 8.3%/ 7.9% respectively. Compared to the situation in Sumatra as a whole, the growth rates for generated electric energy and peak load are slightly lower, however, these growth rates are still at a high level.

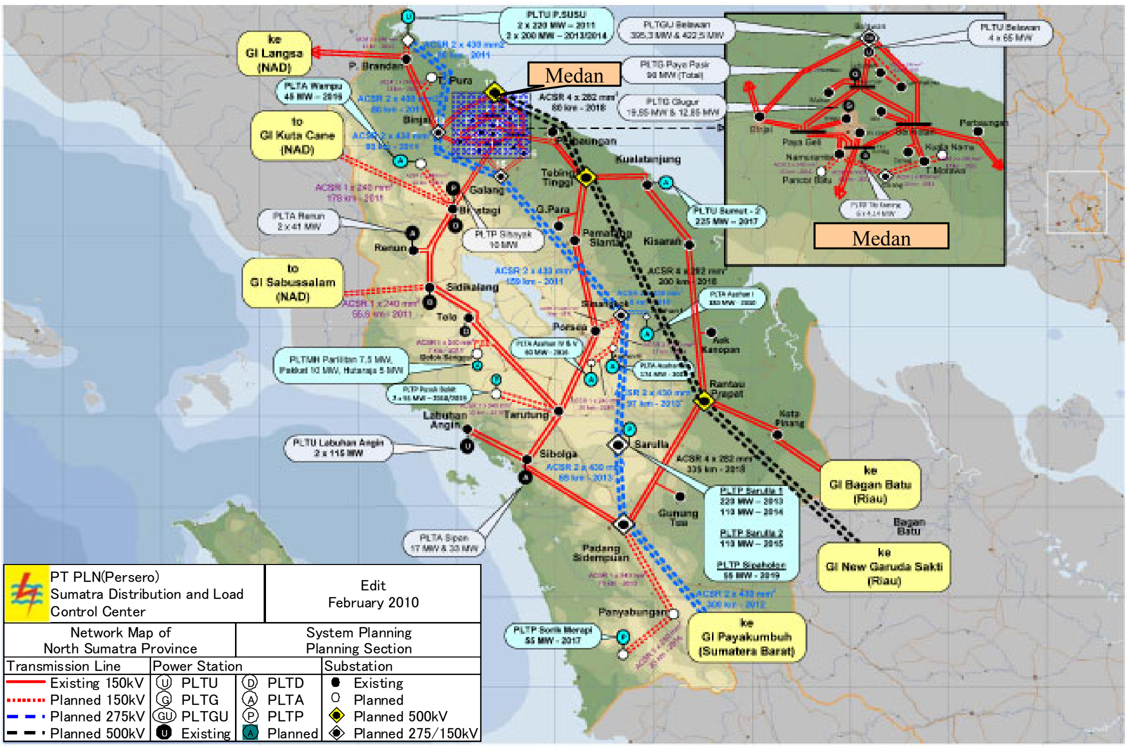
Looking to other power grids apart from North Sumatra, since existing power generation facilities are showing reduced output due to deterioration, while IPP projects tend to be unreliable, RUPTL 2010 sets the reserve margin in systems other than the Java-Bali Grid at around 40% upon considering the risk of not being able to secure the necessary power resources. If currently planned projects are finished and introduced to the North Sumatra Grid on schedule, it will be possible to secure a reserve margin of 43.3%, higher than the target figure of 40% by 2014.

Meanwhile, the power supply plans are based on the assumption that existing generating facilities will generate power at rated output, however, the generating facilities that were introduced in the 1970s and 1980s have not undergone appropriate maintenance and they suffer from seriously impaired output due to deterioration as mentioned above. When the potential generating output of facilities on the North Sumatra Grid is applied to the power supply plan, the actual generating output is less than demand in recent years. Accordingly, PLN is now responding to this power supply shortfall by conducting rolling blackouts and so on. However, the situation is expected to improve if PLTA Asahan-1 (180 MW) started commercial operation in October, 2010 as planned.



Source: RUPTL(2010-2019)

Figure 2-1 Transmission Networks in Aceh Province



Source: RUPTL(2010-2019)

Figure 2-2 Transmission Networks in North Sumatra Province

Table 2-1 Power Supply Plan on the North Sumatra Grid

Item	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1 Power Demand											
Energy	GWh	8,252	9,006	9,825	10,741	11,775	12,908	14,175	15,539	17,012	18,583
Peak Load	MW	1,586	1,748	1,907	2,085	2,275	2,478	2,707	2,954	3,218	3,505
Load Factor	%	59.4%	58.8%	58.8%	58.8%	59.1%	59.5%	59.8%	60.0%	60.3%	60.5%
Reserve Margin	%	3.9%	6.9%	21.0%	43.3%	54.6%	42.0%	43.4%	46.9%	36.5%	28.5%
2 Power Supply											
Total Supply	MW	1,703	1,923	2,363	3,043	3,573	3,573	3,938	4,393	4,448	4,558
Diesel/PLTD	MW	107	107	107	107	107	107	107	107	107	107
Gas Turbine/	MW	156	156	156	156	156	156	156	156	156	156
Combined Cycle/	MW	818	818	818	818	818	818	818	818	818	818
Steam Turbine/	MW	490	710	1,150	1,350	1,550	1,550	1,750	2,175	2,175	2,175
Hydro	MW	132	132	132	392	392	392	557	587	587	587
Geothermal/	MW	0	0	0	220	550	550	550	550	605	715

Chapter 3 Power Development Potential and Promising Sites

3.1 Coal-fired and Gas-fired Thermal Power Generation

Potential Sites

Usually when selecting sites for thermal power stations, providing that enough space to install major equipment, water treatment facilities and fuel storage facilities (depending on the fuel type) is available, and it is possible to acquire the essential water for plant operation and cooling water for steam, unlike geothermal and hydropower facilities, there are no restrictions on candidate sites. In the case of coal-fired thermal power plants, since it is necessary to install the regular boilers, turbines, generators, auxiliary units and attached equipment and to provide a yard or silo for storing coal, a large area have to be secured for the plant site. Meanwhile, in the case of gas-fired thermal power plants, since the fuel gas is stored as LNG in the facilities of a separate company, there is no need to install the fuel storage facilities inside the plant complex.

Coal-fired and gas-fired thermal power plants are often installed at sites that are close to consumer areas so that transmission distances can be reduced; however, coal-fired thermal power plants are sometimes constructed at the mine mouth in order to shorten the coal transportation distance, although the transmission distance to consumer areas becomes long in such cases.

Plant construction candidate sites are narrowed down upon examining which option is more appropriate in economical and technical terms. However, even assuming that the South and North Sumatra grids are interconnected, considering that there is more than 1,000 km of transmission distance between mines in South Sumatra Province and consumer areas in North Sumatra, it is better to construct power plants close to the demand centers.

Meanwhile, it is difficult to secure ample coal or natural gas from Aceh Province and North Sumatra Province to justify construction of thermal power plants in those provinces. Accordingly, there will be a choice between 1) using the newly constructed railway, etc. to transport coal from mines in South Sumatra Province that possess ample reserves through Tanjung-Api-Api Port facing the South China Sea, and from there transporting to North Sumatra, or 2) in the case of gas, installing a pipeline from the LNG loading point that is planned for completion off the coast of Medan in 2013 to candidate power plant sites in order to secure a supply of gas as fuel.

Promising Development Sites

Since the coal-fired thermal power plant will obtain coal supply from outside of North Sumatra, it is desirable to construct it on the coast, where it is possible to build coal unloading facilities suitable for coal transportation, in a site where the freshwater essential for plant operation and seawater necessary for cooling can be obtained. A site near Kuala Tanjung where the INALUM aluminum smelting plant is located is a candidate because the distance of the dedicated transmission line can be shortened. Since RUPTL 2010 also includes plans to construct an IPP power plant near Kuala Tanjung, this satisfies the above conditions.

In the case of a gas-fired thermal power plant, construction is conditional on the gas supply company installing the necessary gas pipeline. In this case, the options are to either 1) construct the power plant on the outskirts of Medan in order to minimize the length of pipeline and to install a dedicated overhead transmission line to the smelting plant, or 2) have a pipeline installed to the same proposed location as in the coal-fired case and shorten the distance of the dedicated transmission line. In either case, it is assumed that gas will be supplied from the offshore LNG loading point scheduled for completion in 2013, and since the supply capacity from the loading point is planned as roughly 40 MMcfd, it will be necessary to conduct detailed examination into whether or not a sufficient quantity of gas can be supplied to the new power resource in line with the LNG loading point expansion plans. Moreover, in the case of gas-fired thermal power, another option is to rehabilitate the existing Belawan thermal power plant owned by PLN, however, in this case it would be necessary for the aluminum smelting plant to receive power supply from the existing PLN grid via a dedicated transmission line.

Power Development Scale

In the case of coal-fired or gas-fired thermal power, generating capacity can be set relatively freely so long as the necessary coal or gas supply can be secured. Here, examination is conducted on the following generating capacity scenarios: 1) 200 MW for INALUM plant expansion, 2) 400 MW comprising 200 MW for INALUM plant expansion + 200 MW for public use, and 3) 600 MW comprising 200 MW for INALUM plant expansion + 400 MW for public use. In the case of coal-fired thermal power, it is likely that provision of Japanese ODA will be conditional on the adoption of supercritical pressure or ultra supercritical pressure. Judging from past installation experience in Japan, it is technically feasible to construct facilities with unit capacity of 400 MW or 600 MW in either the supercritical pressure or ultra supercritical pressure case. However, assuming that the power resource for INALUM plant expansion will be introduced in 2015 following interconnection between the South and North Sumatra grids in 2012, according to RUPTL, load of 200 MW will be added to the peak load of 6,200 MW in 2015, meaning that peak load on the grid will rise to 6,400 MW.

If a facility with unit capacity of 400 MW or 600 MW is introduced in this situation, such facilities will account for approximately 6.3% and 9.4% of grid capacity respectively, figures which are higher than the recommended 4% or less for a single generating unit. Accordingly, in the event where the facility needs to be suddenly closed down due to equipment troubles, there is risk that this could destabilize the grid. Accordingly, it will be necessary to conduct system flow analysis in order to investigate the impact on the grid in detail. Incidentally, in the case of generating equipment with unit capacity of 200 MW, the share of grid capacity will be approximately 3.1% and, if this is installed after the South and North Sumatra grids are interconnected, the impact imparted on the grid will be mitigated.

In the event where a coal-fired thermal power plant with unit capacity of 400 MW or 600 MW is introduced, if a permanent civilian power supply of 200 MW or 400 MW can be supplied from coal-fired thermal power, it will be possible to use this as base power and conduct efficient operation in the high load zone irrespective of the system type; however, if this becomes the peak power supply, the system will only operate at partial load for supplying power to the INALUM aluminum smelting plant outside of peak times, meaning that plant operating efficiency will decline and the cost of power will become expensive.

Since such a trend is accentuated in supercritical or ultra-supercritical generating systems that require large initial investment, examination must be conducted on operating methods in combination with other power resources. Meanwhile, in the event where multiple generating units with 200 MW capacity are introduced, the above issue will be alleviated, however, in the case of a coal-fired system, since starting loss increases and it takes longer time to start and stop the system thus reducing load follow-up performance, it is better to adopt a combined cycle system, which has better starting characteristics and load follow-up performance, as the peak power resource.

Moreover, in the event where 200 MW is secured solely for the INALUM plant expansion, either a subcritical steam generating system or a combined cycle system can be introduced. However, because there would be no independent backup system in this case, it would be necessary to connect to the PLN grid and have power diverted from PLN during emergencies, and it would be necessary to examine the cost of this in advance. In this case, fixed power charges will arise irrespective of the said power coordination with PLN, while the specific charge will be levied according to the amount of power consumption. In either case, the tariff will be higher than conventional charges.

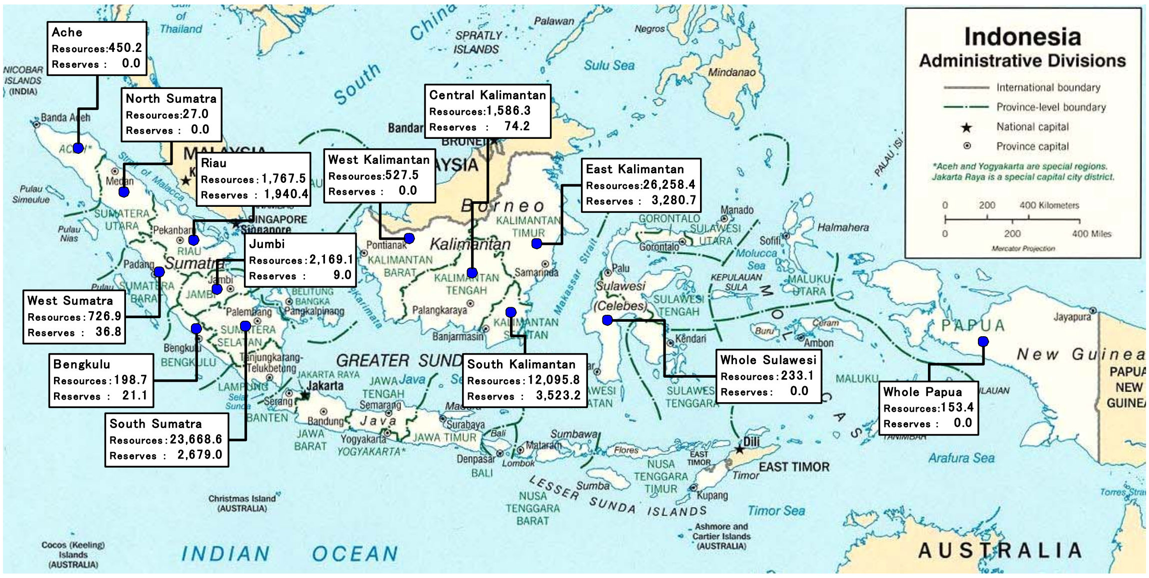
Construction Cost

In order to operate a coal-fired or gas-fired thermal power plant and conduct stable power supply, it is necessary to have a constant and ample supply of fuel. Considering that fuel prices have a major impact on earnings when operating a thermal power plant, fuel prices have been estimated while referring to other study reports and hearings. In the case of coal, the price was set assuming that low rank quality coal (4,500 kcal/ton) will be transported by railway or barge from mines in South Sumatra Province and discharged in the vicinity of Kuala Tanjung. Meanwhile, in the case of natural gas, price was set assuming that gas will be transported by LNG carrier from Kalimantan and Papua, consolidated at the LNG loading point off the coast of Medan and supplied via a pipeline constructed by the gas supply company.

The other major factor that impacts operating returns following the start of operation is the construction cost, which will be covered by loans. In the case of a coal-fired steam generating system based on subcritical pressure boilers, enterprises capable of building such systems exist in all countries, and the construction unit cost has been set at 800 USD/kWh, which is the mean value given to coal-fired thermal power in the Crash Program. In the case of a coal-fired steam generating system based on supercritical pressure boilers, since materials are more expensive than in the subcritical case and only limited enterprises have the capability to build such systems, the construction unit cost has been set at 1,300 USD/kWh. In the case of a gas-fired combined cycle system, based on recent projects in Indonesia, the construction unit cost has been set at 1,000 USD/kWh. This case assumes construction of a new combined cycle facility, however, the scenario of supercritical generating equipment is omitted because this would require the rehabilitation of Belawan thermal power plant and removal of existing facilities

Table 3-1 Estimates of Construction Cost and Operating Conditions of Thermal Power

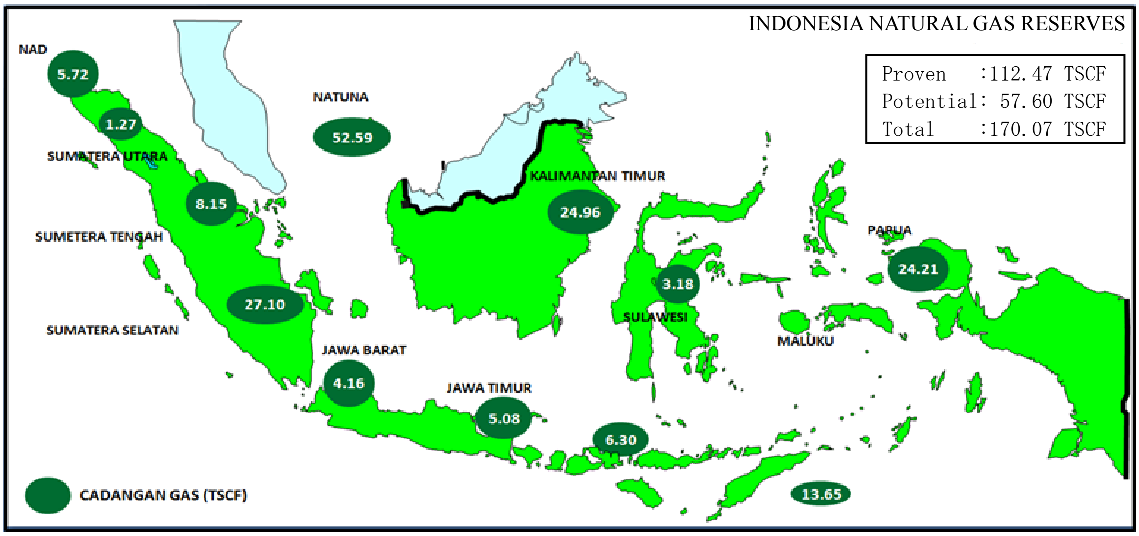
Capacity	Fuel	Type	Construction Cost (Million USD)	O&M Cost/Year (Million USD)	Fuel Cost	Thermal Efficiency	Load Factor
200MW	Coal	Subcritical	160	9.6	45USD/ton	39%	70%
400MW	Coal	Subcritical	320	19.2	45USD/ton	39%	70%
600MW	Coal	Subcritical	480	28.8	45USD/ton	39%	70%
400MW	Coal	Supercritical	520	31.2	45USD/ton	41%	70%
600MW	Coal	Supercritical	780	46.8	45USD/ton	41%	70%
200MW	Gas	Combined Cycle	216	10.8	7USD/MMbtu	45%	70%



(Unit: 100million ton)

Source: Map data from the University of Texas Libraries, combined with data from the Indonesian Coal Book 2008/2009

Figure 3-1 Coal Resources and Reserves in Indonesia



(Unit: Tscf)

Source: MEMR, Data Warehouse

Figure 3-2 Natural Gas Reserves in Indonesia

3.2 Geothermal Power Generation

Potential Sites

The following table shows the geothermal power sites where study or operation is currently being implemented. Specifically, Sibayak, Sarulla, Merapi, Sipaholon and Sinabung are expected to be promising potential sites in the future.

Table 3-2 Geothermal Potential Sites

	Area Name	Developer	Master Plan (2007) Total Capacity (MW)	Installed(2010) (MW)	RUPTL(2010-2019) (Operaion) (MW)	API NEWS(2010) Tender Status & Green Field List	Possible Additional Development (MW)
1	Sibayak	PGE	40	12	–	–	28
2	Sarulla 1	IPP	630	0	330 (2014)	–	–
	Sarulla 2	IPP		0	110 (2014)	–	190
3	Sorik-Merapi	IPP	100	0	55 (2014)	Tender	45
4	Sipaholon	IPP	50	0	55 (2019)	Tender	0
5	Sinabung	PGE	ND	0	–	–	(40)
6	Dolok Marawa	–	–	0	–	Green Field	–
7	Pusuk Bukit-Danau Toba	–	ND	0	–		–
8	Simbolon-Samosir	–	ND	0	–		–
9	Pagaran	–	–	0	–		–
10	Sibubuhan	–	–	0	–		–
	Total		820		550		273/(313)

・Sibayak

As was described in section 4.2, existence of geothermal fluid reservoir has been confirmed via well exploration in this area. The geothermal development potential here was estimated as 160 MW in the Geothermal Master Plan Study (2007), however, this is limited to 40 MW because of the site's location in THR. Bukit Barisan National Park. A 12 MW geothermal power plant went into operation in 2010, and it is estimated that a further 28 MW of development potential remains. Total expansion of the power plant up to 2014 is 19.5 MW (Surya et al., 2010). Incidentally, no development plans are stated in RUPTL 2010.

・Sarulla

Concerning Sarulla, a 330 MW development program has been compiled and the consortium signed a power purchase agreement with PLN in April 2010 for Sarulla-1 (Silangkitang, NIL). Currently 126 MW of steam is being obtained: 46 MW at NIL and 80 MW at Silangkitang (Surya et al, 2010). The consortium has the development concession for four working areas, and it will examine plans to develop 330 MW from now on. Concerning Sarulla-2, since

RUPTL 2010 already specifies 110 MW by IPP, while the consortium intends to sell power to PLN from developments after Sarulla-1, this will be used as a power source for public use. However, considering that the Geothermal Master Plan (2007) estimated that Sarulla has total energy reserves of 630 MW, this means that the area still has potential for the development of 190 MW not stated in RUPTL 2010. The actual development plans are more delayed than RUPTUL 2010 and it is expected that development of Sarulla-1 (330 MW) will not take place until 2015 at the earliest and that development of Sarulla-2 will happen after that. Moreover, since development of this area will be preceded step by step, it is possible that the actual development will be even slower than this.

・Merapi

According to the Geothermal Master Plan Study (2007), detailed surface survey has been conducted in this area and the temperature of the geothermal fluid reservoir is estimated to be 290℃ higher than the geochemical temperature, however, so far no deep exploratory well has been excavated. This area is thought to contain a large geothermal fluid reservoir with geothermal development potential of 500 MW; however, this is limited to 100 MW because of the site's location in a national park. Tender for geothermal development working areas (Sorik, Marapi, Roburan) is currently being conducted in this area, and a development plan of 55 MW has been included in RUPTL 2010. It will be difficult to commence operation by the planned date of 2014. Judging from the Geothermal Master Plan Study (2007), this area still has development potential for 45 MW not mentioned in RUPTL 2010.

・Sipaholon

According to the Geothermal Master Plan Study (2007), the geothermal development potential is estimated as 50 MW. Tender for geothermal development working areas is currently being conducted in this area. RUPTL 2010 contains development plans for 55 MW (2019).

・Sinabung

This area located next to Sibayak is scheduled to undergo development in the next phase. Surface investigation was being carried out, however, this was suspended due to volcanic eruption in the area. It is planned to implement detailed investigation and well investigation in the future. Judging from the surface survey, development potential here is estimated as 40 MW, the same as at Sibayak. Development of this area is not mentioned in RUPTL 2010, and it will take time for a geothermal power plant to be actually constructed.

・Other Areas

Other areas comprise Dolok Marawa, Pusk Bukit-Danau Toba, Simbolon- Samosir, Pagaran and Sibubuhan, however, survey work has only just begun and it will take some time before actual development can begin.

Promising Development Sites

Concerning development of Sarulla (330 MW) including Sarulla-2 as outlined above, a power purchase agreement has been signed with PLN, and power from subsequent developments will also be sold to PLN. Since Sarulla-2 is already indicated as a 110 MW IPP power resource in RUPTL 2010, this will be utilized as a public use power resource. However, judging from the Geothermal Master Plan (2007), it is estimated that Sarulla still has potential for the development of 190 MW not stated in RUPTL. Plans not stated in RUPTL include expansion of Sibayak and Sinabung. Of these sites, the Sibayak expansion (28 MW) can be definitely viewed as a power resource for INALUM, while Sinabung is still under development. Surface survey is still being implemented at Sinabung and potential reserves are still only estimate values. In consideration of the above points, Sarulla-2 (190 MW) is selected as a promising site assuming 100 MW scale of power generation development.

Construction Cost

The construction cost of the Sarulla-2 geothermal power plant (190 MW) is roughly estimated among the promising development sites. In conducting the calculation, consideration was given to the cost of excavating the number of wells deemed necessary according to the geothermal fluid reservoir characteristics estimated in the Geothermal Master Plan Study (2007) and Phase 1 study (2009) and the cost of plant construction, while adding new information (see Table 3-3). Moreover, as was pointed out in the Phase 1 study (2009), construction cost is impacted by the capacity (output) of production wells. Accordingly, the construction cost was estimated while using the average production well capacity (8 MW/well).

Table 3-3 Estimate of Construction Cost of a Promising Potential Site

No.	Development area	Generating capacity	Production well capacity	Excavation cost	Initial investment cost	Civil engineering cost	Transmission line	Total construction cast	Annual generated energy
		(MW)	(MW)	(Million USD)	(Million USD)	(Million USD)	(Million USD)	(Million USD)	(GWh)
1	Sarulla-2	190	8	275	553	28	6	586	1332

1: Lau Debuk-Debuk/ Sibayak, 2: Sarulla-1/ Sarulla-2, 3: S. Merapi, 4: Sipaholon, 5: Sinabung, 6: Dolok Marawa, 7: Pusuk Bukit-Danau Toba, 8: Simbolon-Samosir, 9: Pagaran, 10: Sibubuhan

Figure 3-3 Geothermal Potential Areas

3.3 Hydropower Generation

Potential and Promising Sites

The two potential sites of Tampur-1 and Jambu Aye, which were identified as promising sites in the Phase 1 Study 2009, will be omitted from the selection of promising sites since both sites have large-scale reservoirs covering an area of 10~100 km^2 and the impacts on the social and natural environment will be huge. Even PT. PLN believes that it will be difficult to resolve these problems and conduct development. Tampur-1 is also situated in a conservation area, consequently it will be difficult to achieve early development whereas Jambu Aye is a multipurpose dam, it will take time to coordinate and reach agreement with the related ministries and agencies in order to realize the project.

Meanwhile, Aceh Province has been in conflict with the central government for many years and it is forecast that coordinating and reaching consensus over power development will be difficult. PT PLN also believes that development in Aceh will require time-consuming coordination due to the strong autonomy and political conflict in that province. Accordingly, potential sites in Aceh Province shall be omitted from the selection of promising potential sites.

Usually, development of hydropower plants begins with establishing concept; the detailed development plan is settled upon conducting a series of studies including feasibility study and detailed design; the construction contractor is decided by tender, and then the construction work begins. It is not unusual for this implementation process from the study phase to construction to take more than 20 years; particularly in cases of projects that have large-scale dams and reservoirs, it is essential to give consideration to the social and natural environment.

Meanwhile, it will be necessary to develop the potential sites identified in this Study at the same time as or soon after the plant expansion works at INALUM. Accordingly, the Study will target potential sites where run-of-river or regulating reservoir type plants can be developed relatively quickly and where the map study has already been completed in the study stage.

However, since the power supply of the run-of-river or regulating reservoir type power plant will fluctuate according to the river flow, such systems are not suited to power supply for the aluminum smelting which requires a stable power supply. Accordingly, such potential hydropower will be considered as power resources for public use.

Table 3-4 Promising Hydropower Potential Sites

Site	Install capacity (MW)	Annual generated energy (GWh)	Plant factor (%)	Type of generation	Study level
Toru-1	38.4	308.1	91.6	Run-of-river	Pre-FS
Simanggo-2	59.0	367.0	71.0	Run-of-river	MP
Wampu	45.0	209.7	53.2	Run-of-river	FS
Raisan-3,4	80.0	295.0	42.1	Pondage	RS
Total	222.4	1,179.8			

The planning particulars for each promising development site are estimated as follows.

・Toru-1

The project particulars for this development site are taken from the Hydro Inventory and Pre-Feasibility Study implemented in 1999. As for the construction costs indicated in Table 3-5, escalation of 30% is added to the construction cost that was estimated in 1999.

・Simanggo-2

This site has been identified in the interim study stage of the Master Plan Study for Hydropower Development in Indonesia that is currently being implemented by JICA, and it is scheduled to implement a Pre-F/S in its final study stage. Because surveys are still being implemented, it wasn't possible to obtain detailed information in this Study, therefore, the Working group materials of the JICA Advisory Committee on Environmental and Social Consideration have been adopted. It will be necessary to once more confirm the project particulars after completion of the Master Plan.

・Wampu

When JICA feasibility study was conducted in 1992, power potential of 84.0 MW was estimated. However, development was subsequently delayed when it was found that the transmission line and access road would cross a conservation forest area. Currently, in RUPTL, the development scale has been reduced to 45 MW and operation is scheduled to begin by an IPP in 2016. In this Study, because the detailed plans are still unclear, project particulars were prepared based on the 1992 F/S while assuming the plan for 45 MW capacity. As for the construction cost, based on reference to the escalation of 9% from the F/S report to the Hydro Inventory and Pre-Feasibility Study and the escalation of 30% from the Hydro Inventory and Pre-Feasibility Study to the Hydropower Master Plan, an increase of 40% has been assumed here.

・Raisan-3&4

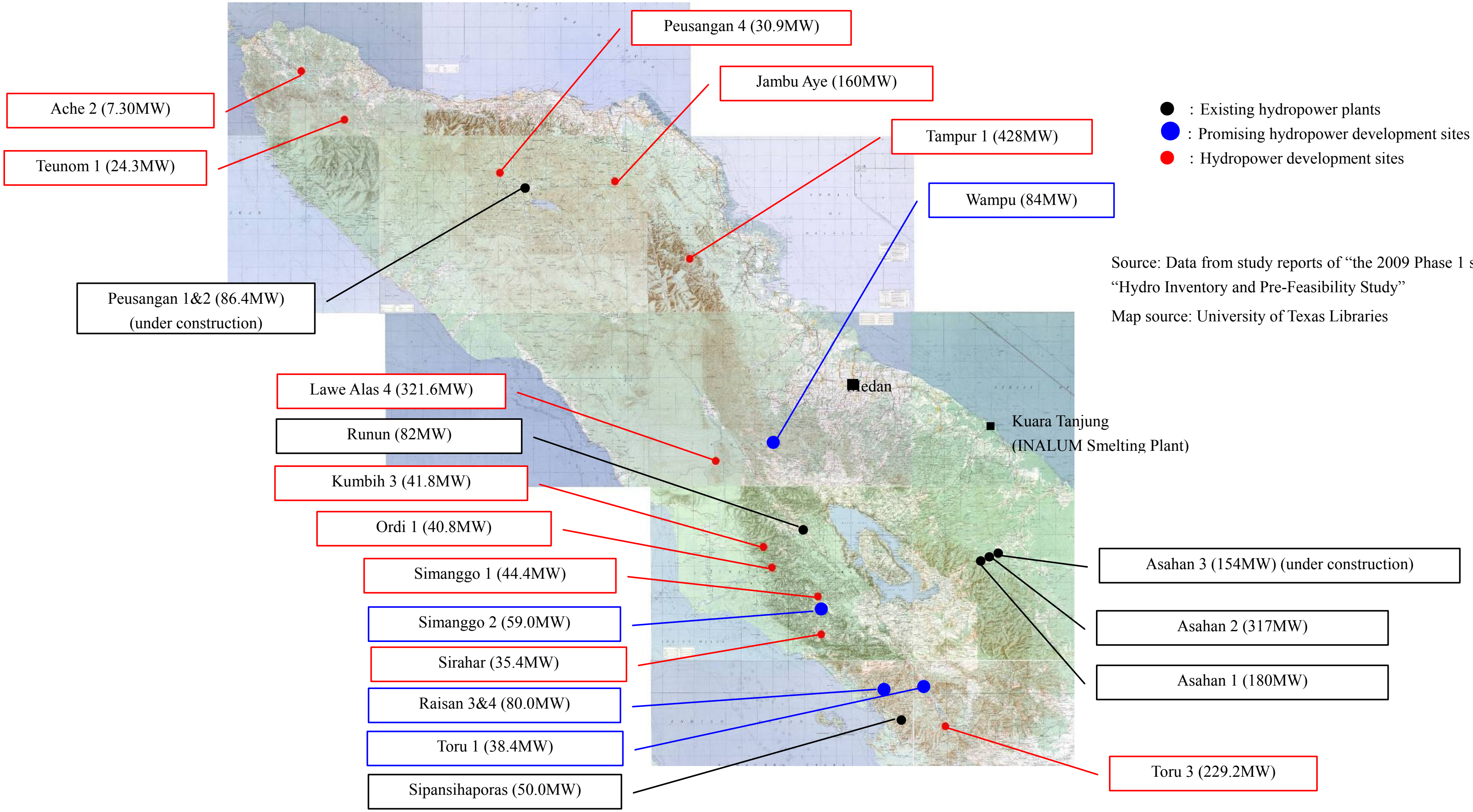
The project particulars for this site have been adopted based on the Reconnaissance Study implemented by PLN and TEPSCO in 2004. Concerning the construction cost, based on reference to the escalation of 30% from the Hydro Inventory and Pre-Feasibility Study to the Hydropower Master Plan, an increase of 15% has been assumed here.

Project Features and Construction Cost

The following table summarizes the general particulars of the promising sites including project cost.

Table3-5　Project Features and Cost Estimates of Promising Hydropower Potential Sites

Site			Toru-1	Simanggo-2	Wampu	Raisan-3	Raisan-4
Power Generation Outline	Province		North Sumatra Province				
	River		Bantang Toru	Aek Simanggo	Sie Wampu	Raisan	
	Catchment area (km^2)		1,013	480	959	204	259
	Generation mode		Run-of-river	Run-of-river	Run-of-river	Pondage	Run-of-river
	Install capacity (MW)		38.4	59.0	45.0	37.0	43.0
	Plant discharge (m^3/s)		-	38.1	35.6	40.0	40.0
	Total head (m)		-	187.4	114.0	113.0	129.0
	Annual generated energy (GWh)		308.1	366.9	209.7	135.0	160.0
	Operating factor (%)		91.6	71.0	53.2	42.1	
Plant Facilities Outline	Dam	Dam type	Concrete	Gate weir	Concrete	Concrete	Concrete
		Dam height (m)	-	15.0	4.5	40.0	15.0
	Headrace	Type	Pressure tunnel	Non-pressure tunnel	Non-pressure tunnel	Pressure tunnel	Non-pressure tunnel
		Length (km)	3.47	4.75	8.0	3.70	4.00
		Inner diameter (m)	2.9	4.1	4.2	4.5	4.5
	Penstock	Type	Ground	Tunnel	Ground	Ground	
	Power house	Type	Ground	Ground	Ground	Ground	
Economy	Construction cost (million USD)		82.2	118.0	148.3	161.0	
	Cost per kW　(USD/kW)		2,140	2,000	3,296	2,013	
	Cost per kWh (USD/kWh)		0.267	0.322	0.707	0.546	
	Study level		Pre-F/S	M/P	F/S	R/S	



Source: Data from study reports of "the 2009 Phase 1 study" and "Hydro Inventory and Pre-Feasibility Study"

Map source: University of Texas Libraries

Figure 3-4 Hydropower Potential and Promising Sites in Ache Province and North Sumatra Province

3.4 Construction and Operation Schedule for Potential Options

The construction and operation schedule of promising potential options was examined. Until operation can start at each option site, it is necessary to decide the implementation plan, consisting of studies, design, fund procurement, tender and construction, and it was assumed that this series of processes will start from 2011 following completion of the Study. However, concerning hydropower site Simanggo-2, since the current JICA Hydropower Development Master Plan will finish in July 2011, it is assumed that the above processes will begin immediately after that. These processes differ according to the project implementation body, however, leaving aside Sarulla-2 geothermal site for which IPP development has been decided, it is assumed that the project will be implemented upon obtaining public funding.

In cases where a site plan contains multiple generators, the start of operation is assumed to the point at which the first generator goes into operation. In the case of coal-fired thermal power generation utilizing supercritical or ultra-supercritical boilers, it is structurally more advantageous to adopt single units. Meanwhile, in the case of geothermal power generation, phased development is conducted while confirming the state of geothermal fluid reservoirs by means of well surveys, and the entire development may require a few years. Sarulla-2 (the target of this Study) is at the Pre-F/S stage of development, and the development stage won't begin until the F/S including well investigation is finished. The F/S for Sarulla-2 (110 MW) will begin during construction of Sarulla-1, while the development study for Sarulla-2 (190 MW), which is targeted in the Study, will commence following completion of the F/S for Sarulla-2 (110 MW).

Taking these conditions into account, the following table indicates the years of operation commencement for each potential site. According to this, gas-fired power generation, which entails relatively fast study, design and construction work, will commence in 2016, followed by coal-fired thermal power generation in 2017 and hydropower generation in 2017~2018. Meanwhile, geothermal power generation will commence in 2020, following the development of the already scheduled Sarulla-1 (330MW) and Sarulla-2 (110MW). However, this Study assumes the earliest possible operation start times in the case where all processes advance smoothly, and it is possible that schedules will change according to the type of business operator, incentives and adjustment policies concerning power resource development by the central government and local governments, and other factors.

Table 3-6 Start of Operation of Promising Potential Options

Plan		Capacity	Purpose of Use	Start of Operation
Geothermal	Sarulla-2	190MW	Civilian / (INALUM expansion)	2020
Coal-fired thermal	Kuala Tanjung outskirts	200/400/600 MW (subcritical)	INALUM expansion / Civilian	2016
	Kuala Tanjung outskirts	>450 MW (ultra / supercritical)	INALUM expansion / Civilian	2016
	New	200/400/600 MW (subcritical)	Civilian	2016
	New	>450 MW (ultra / supercritical)	Civilian	2016
Gas-fired thermal	Kuala Tanjung outskirts	200/400/600 MW	INALUM expansion / Civilian	2016
	Belawan Rehabilitation	520 MW	Civilian	2016
	New	200/400/600 MW	Civilian	2016
Hydro	Toru-1	38.4 MW	Civilian	2017
	Simanggo-2	59.0 MW	Civilian	2018
	Raisan-3 & 4	80.0 MW	Civilian	2017

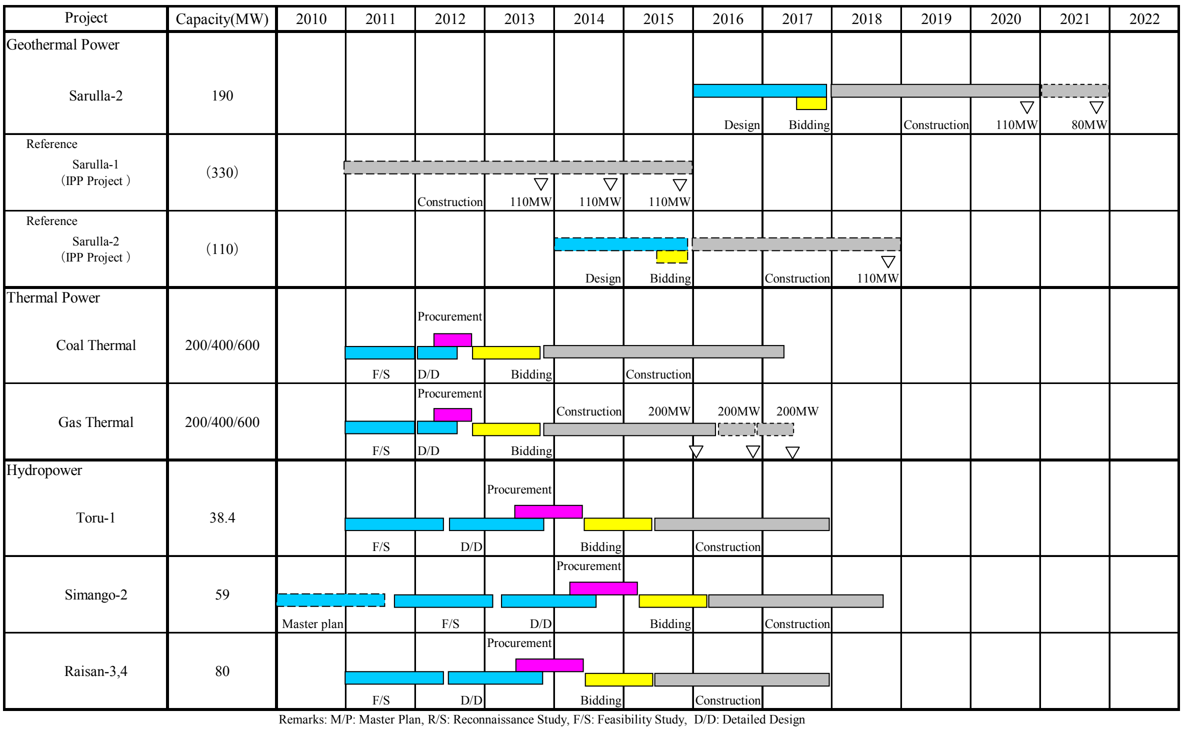
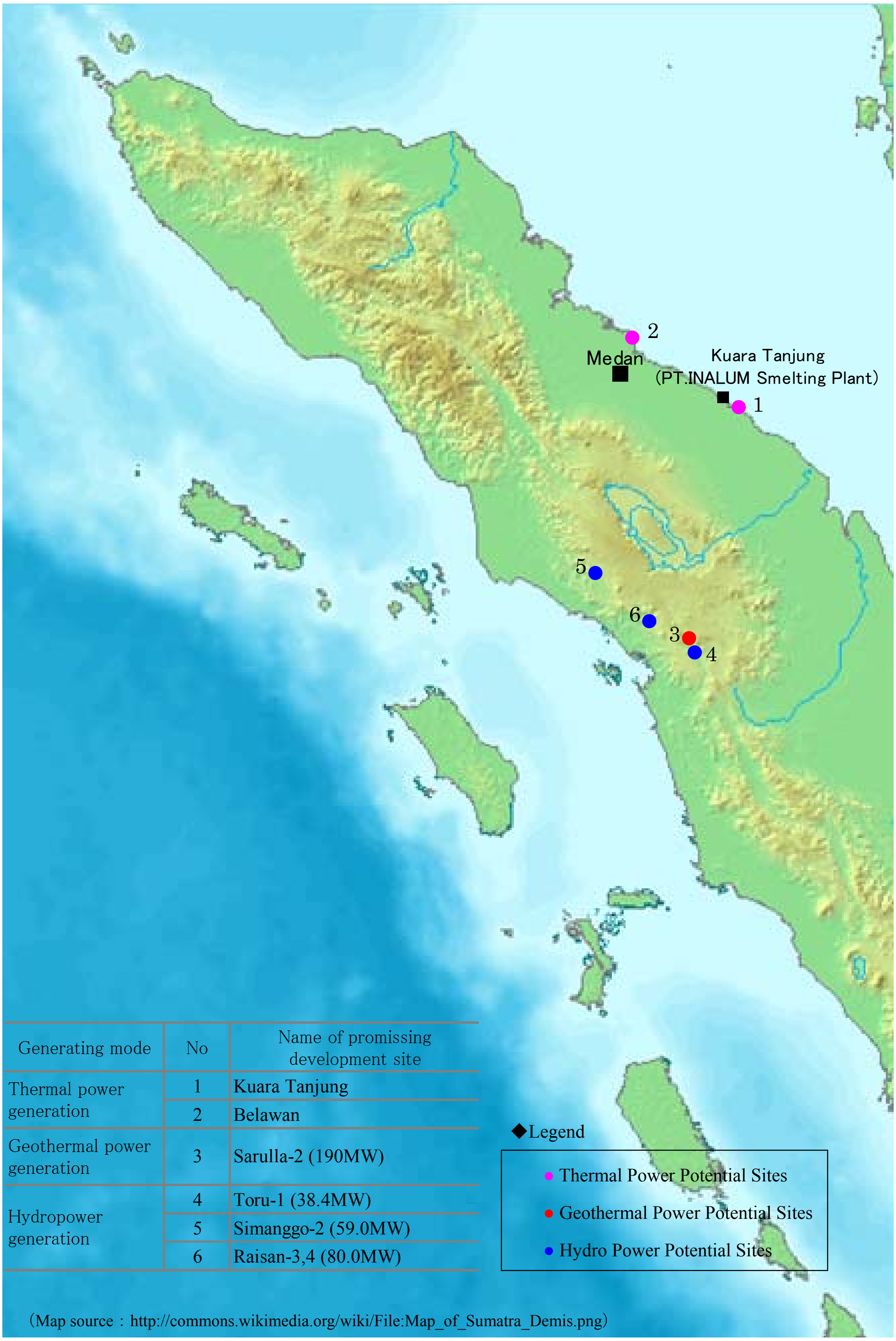


Figure 3-5 Implementation and Construction Schedule of Promising Potential Sites

*Concerning geothermal development sites, IPP development has already been decided for Sarulla-1 (330 MW) and Sarulla-2 (110 MW) and they are not targeted by the Study, however, they are shown here for reference.



Generating mode	No	Name of promissing development site
Thermal power generation	1	Kuara Tanjung
	2	Belawan
Geothermal power generation	3	Sarulla-2 (190MW)
Hydropower generation	4	Toru-1 (38.4MW)
	5	Simanggo-2 (59.0MW)
	6	Raisan-3,4 (80.0MW)

(Map source：http://commons.wikimedia.org/wiki/File:Map_of_Sumatra_Demis.png)

Figure 3-6　Promising Potential Sites

Chapter 4 Promising Options for Power Supply

The Study examines three options in total: namely the basic 200 MW supply option to supply the power required for INALUM plant expansion, plus the 400 MW and 600 MW options for supplying the INALUM power and an additional 200 MW and 400 MW respectively for public use purposes. Concerning the supply resources, supply options that can cover 400 MW and 600 MW supply are proposed by combining the power resources extracted in Promising Potential Sites. All the power resources are scheduled to go into operation after 2013, when the INALUM plant expansion plan is realized.

Numerous cases can be considered for the power supply options depending on the purpose of power supply for INALUM or for public uses and the scale of development 200 MW / 400 MW / 600 MW. Concerning the business models, these can be arranged as shown in Table 4-1 according to each power mode and purpose of use for the following reasons.

- There is a limit to the supply capacity of each selected hydropower and geothermal power resource (each source is less than 200 MW).
- The construction cost for coal-fired/thermal power development does not change according to the scale of development.
- The business model is almost uniquely set according to the power resource mode and purpose of use of electric power. (Example: hydropower and geothermal energy→IPP, power for INALUM→SPC, etc.)

In Table 4-1, the business model in the cases of ‘Public use only’ and ‘Public use priority’ are PLN, IPP or PPP consisting of PLN with IPP, so INALUM will purchase power from PLN. In the case of ‘INALUM priority + public use,’ the business operator is an SPC or INALUM. In cases where the scale of development is 200 MW, INALUM needs to also consider binding a backup contract with PLN (synchronized connection: currently under examination by PLN). In this case, it is necessary to pay a basic charge (normal tariff + additional charge) whether or not there is use, while the metered charge is levied according to the level of power consumption (including additional charge). There are no clear specifications concerning the additional charge.

Out of the ‘INALUM priority + public use’ cases, if the scale of development exceeds 200 MW, it is possible that the sale to PLN will be treated as excess power. In this case, only a low sale price covering operation costs, the fuel cost and personnel expenses, etc. can be expected.

Table 4-1 Business Model in the Power Supply Options

<table>
<tr><th rowspan="2">Generating mode</th><th rowspan="2">Project</th><th rowspan="2" colspan="2">Generating Capacity (MW)</th><th colspan="5">Business Model</th></tr>
<tr><th>PLN</th><th>IPP</th><th>SPC (CP)</th><th>PPP</th><th>INALUM</th></tr>
<tr><td rowspan="4">Coal</td><td>Close to the smelting plant</td><td colspan="2">200/400/600 (subcritical)</td><td colspan="2" rowspan="2">Not applicable</td><td>INALUM priority + civil use</td><td rowspan="2">Not applicable</td><td>INALUM priority + civil use</td></tr>
<tr><td>Close to the smelting plant</td><td colspan="2">Unit capacity: 450or more (supercritical / ultra-supercritical)</td><td>INALUM priority + civil use</td><td>INALUM priority + civil use</td></tr>
<tr><td>Within the range of the PLN grid</td><td colspan="2">200/400/600 (subcritical)</td><td>Civil use priority</td><td>Civil use priority</td><td rowspan="2">Not applicable</td><td>Civil use priority</td><td rowspan="2">Not applicable</td></tr>
<tr><td>Within the range of the PLN grid</td><td colspan="2">Unit capacity: 450or more (supercritical / ultra-supercritical)</td><td>Civil use priority</td><td>Civil use priority</td><td>Civil use priority</td></tr>
<tr><td rowspan="3">Gas</td><td>Close to the smelting plant</td><td colspan="2">200/400/600</td><td colspan="2">Not applicable</td><td>INALUM priority + civil use</td><td>Not applicable</td><td>INALUM priority + civil use</td></tr>
<tr><td>Belawan rehabilitation</td><td colspan="2">520</td><td>Civil use priority</td><td colspan="4">Not applicable</td></tr>
<tr><td>Inside the PLN grid range</td><td colspan="2">200/400/600</td><td>Civil use priority</td><td>Civil use priority</td><td></td><td>Civil use priority</td><td>Civil use priority</td></tr>
<tr><td>Geothermal</td><td>Sarulla-2</td><td colspan="2">190</td><td>Not applicable</td><td>Civil use priority</td><td>※</td><td colspan="2">Not applicable</td></tr>
<tr><td rowspan="3">Hydro</td><td>Toru-1</td><td>38.4</td><td rowspan="3">177.4</td><td>Civil use only</td><td>Civil use only</td><td colspan="3" rowspan="3">Not applicable</td></tr>
<tr><td>Simanggo-2</td><td>59.0</td><td>Civil use only</td><td>Civil use only</td></tr>
<tr><td>Raisan-3,4</td><td>80.0</td><td>Civil use only</td><td>Civil use only</td></tr>
</table>

※: Sarulla-2 is planned as a civil use power resource in RUPTL 2010 and there is deemed to be little possibility of this plant directly supplying power to INALUM. For reference, Chapter 8 Addendum 1 shows the economic and financial analysis for the case where Sarulla-2 is used as a dedicated supply resource for INALUM.

Chapter 5 Economic and Financial Analysis

Operating System and Fund Procurement

JICA and JBIC have a variety of financing schemes regarding project implementation bodies and model of investment and loans. The application of such schemes has a major bearing on the economic viability of the project. The followings are JBIC and JICA investment schemes and the interest levels they entail.

JBIC Finance Schemes; The standard loan terms offered by JBIC differ according to the type of finance, and financing models are applicable to the power generation options here. Finance categories are import, investment and project development, etc. for resources and international competitiveness, which will be applied in this case. Interest rate for yen-based loans will be 1.10% and for foreign currency (USD) base will be a spread interest rate based on the LIBOR (London Inter-Bank Offered Rate). Meanwhile, the upper limit 70% for overseas loans in the resources field shall be adopted with repayment period over 12 years following the start of operation.

ODA Loan Scheme；JICA applies low interest financing in the shape of three schemes, namely the general terms scheme, the preferential terms scheme, and the climate change scheme. For financing in the general terms scheme, Indonesia is a medium income country, then the interest rate is given as 1.40% with the condition of repayment period of 25 years, grace period of seven years and untied procurement. For application of preferential terms, the interest rate is given as 0.65% with repayment period of 40 years, grace period of 10 years and untied procurement. For Yen loan of the climate change, the interest rate is given as 0.30% with repayment period of 40 years, grace period of 10 years and untied procurement.

Financing Terms and Interest Scenarios; It is assumed that sublease financing cost will not arise for the JBIC financing but that the sublease financing rate will be between 0.5~1.0% for JICA ODA loans. Taking into account the sublease financing ratio, the JICA ODA interest rate scenarios here will be 1.5%, 2.0%, 2.5% and 3.0%. Also, assuming that 15% of the total investment is derived from own capital in line with Japan’s ODA financing terms, the financing ratio will be 85%.

Financial Viability Assessment

Financial viability assessment was conducted using the return on equity (ROE) and the internal rate of return (IRR). The ROE varies according to the interest rate on loans but it tends to increase in projects where funds are obtained at low interest rates. Usually in projects of a highly public nature, the ROE is calculated in order to indicate profitability to project owners and stakeholders, while the IRR is calculated in order to assess project feasibility for the recipient government and international financial agencies and to provide a comparison with other projects.

Considering the current conditions of investors and financing institutions in Indonesia, since ROE in the range of 15~20% is expected, power tariffs should be set to realize this. The anticipated ROE is 18% in private sector projects conducted by JBIC syndicates, while the ROE of project owners in JICA ODA financing is 15%. Within a power tariff system that satisfies the above ROE levels, the long-term interest rate in JBIC syndicate loans is estimated at between 4~7% for private sector projects, the IRR criterion is deemed to be between 8~14% (twice the interest rate). Meanwhile, since the interest rate is in the range of 1~3% in ODA projects, the judgment criterion for IRR in state-owned or public project operators is deemed to be in the range of 2~6%.

Until now the effective interest rate in emerging nations and developing countries has usually been around 7%, while in advanced countries with smaller demand for funds, it has been around 5%. However, the present effective interest rate in Indonesia is between 9~10%, so it isn't necessarily low. Accordingly, 10% shall be used as the discount rate in the Study too.

Financial Calculation Conditions and Considerations

In this analysis, inflationary elements based on domestic conditions in Indonesia will basically not be taken into consideration. Looking at global economic trends, it is expected that energy prices and prices for food and mineral resources, etc. will increase from now on. Such elements will be incorporated into the accounting as 'inflation in actual prices. Meanwhile, in the short term, energy prices rise and fall according to respective conditions, however, in the long run, coal and natural gas prices display the same trends as crude oil prices. Accordingly, it is assumed that coal and gas prices will increase at a similar rate to the price of crude oil in the Study.

The financial assessment term has been set as 30 years in consideration of the average service life of equipment and the duration of business concessions in Indonesia. Construction costs are included not for transmission lines but only generating facilities, since assuming the project site will be located near smelting plant or will be connected to nearest PLN Grid. As O/M costs, thermal fuel costs, personnel costs, supplies expenses and repair costs, etc., are included. Considering the equipment deterioration term in coal-fired thermal power, gas-fired thermal power and geothermal power generation, the depreciation period of target equipment is set at 25 years, while the depreciation period in hydropower generation has been set at 30 years to coincide with the economic accounting period. Under the revised tax law of October 2008, in the case of geothermal power generation, 5% of pretax profits will be deducted from taxable income for six years from the start of operation.

Calculation Cases and Results of Power Generating Cost

・Subcritical coal-fired thermal power and gas-fired thermal power; there is no disparity in economic and financial analysis apart from the economic scale between the 200 MW, 400 MW and 600 MW cases. Accordingly, the 200 MW option is analyzed in this examination.

・Supercritical/ Ultra supercritical coal-fired thermal power; there are technically subject to constraints on scale, the minimum scale possible for construction is set without adhering to the 200, 400 or 600 MW classifications. Here, a scale of 450 MW has been set. The climate change loans are applicable when applying for ODA financing.

・Geothermal power generation; since the generated amount of steam varies according to the well, it is set in the range of 6~10 MW. Here, a figure of 8 MW/well is assessed. The climate change loans are applied when applying for ODA financing for geothermal power generation.

・Reconstruction of existing facilities; the upgrading of Belawan gas-fired thermal power plant and new capacity will be combined with existing capacity to give the following: 520 MW with 400 MW new installation and 120 MW existing plant.

The following table sums up the power generating costs and power tariffs in each of the examined cases according to the power generating mode, project business model and type of operator.

Table 5-1 Power Generating Cost for Power Generating Mode and Type of Operator (1)

<table>
<tr><th rowspan="4">Generating Mode</th><th rowspan="4">Project Name</th><th rowspan="4">Capacity</th><th colspan="5">Project Operator</th><th rowspan="4">Issues</th></tr>
<tr><th>PLN</th><th>IPP</th><th>SPC</th><th>PPP</th><th>INALUM</th></tr>
<tr><th>ODA</th><th>JBIC</th><th>JBIC</th><th>ODA</th><th>ODA</th></tr>
<tr><th>ROE=15%</th><th>ROE=18%</th><th>ROE=18%</th><th>ROE=15%</th><th>ROE=15%</th></tr>
<tr><td rowspan="4">Coal</td><td>Near to the smelting plant</td><td>200/400/600MW Subcritical</td><td></td><td></td><td>C_SPC_
Near
4.3/5.9</td><td></td><td>C_INA_
Near
4.3/5.6</td><td rowspan="2">(1) In the case of INALUM, costs and tariffs rise because it is necessary to prepare a backup power resource.
(2) The INALUM power purchase price differs depending on whether the power plant is made a separate operating body or is incorporated into INALUM.</td></tr>
<tr><td>Near to the smelting plant</td><td>450MW or higher Supercritical / Ultra-supercritical</td><td></td><td></td><td>C_SPC_
NU450
5.1/7.6</td><td></td><td>C_INA_
NU450
5.0/5.2</td></tr>
<tr><td>Unspecified location</td><td>200/400/600MW Subcritical</td><td>C_PLN_
Any
4.3/5.6</td><td>C_IPP_
Any
4.3/5.9</td><td></td><td>C_PPP_
Any
4.3/5.6</td><td></td><td rowspan="2">(3) A power purchasing contract for 200 MW is required between PLN and INALUM, however, under the current social situation of power shortages, negotiations could drag on.
(4) An issue is whether or not PLN will implement tariff steps with respect to a large-scale consumer.
(5) In the case of an IPP, it is necessary to conduct negotiations between the IPP, PLN and INALUM.</td></tr>
<tr><td>Unspecified location</td><td>450MW or higher Supercritical / Ultra-supercritical</td><td>C_PLN_
AU450
5.0/5.2</td><td>C_IPP_
AU450
5.1/7.6</td><td></td><td>C_PPP_
AU450
5.0/5.2</td><td></td></tr>
<tr><td rowspan="3">LNG</td><td>Near to the smelting plant</td><td>200/400/600MW</td><td></td><td></td><td>L_SPC_
Near
8.6/10.8</td><td></td><td>L_PPP_
Near
8.7/8.9</td><td>(6) This issue is the same as in (1); moreover, cost feasibility is low because LNG is used.</td></tr>
<tr><td>Belawan upgrading</td><td>520MW</td><td>L_PLN_
Belaw
8.3/8.5</td><td></td><td></td><td></td><td></td><td>(7) This case depends on internal conditions in PLN. It is possible LNG power generation will be conducted in North Sumatra as an example of domestic market priority (DMO).</td></tr>
<tr><td>Unspecified location</td><td>200/400/600MW</td><td>L_PLN_
Any
8.7/8.9</td><td>L_IPP_
Any
8.6/10.8</td><td></td><td>L_PPP_
Any
8.7/8.9</td><td></td><td>(8) In the case of an IPP, cost feasibility is low because LNG is used. PLN may conduct LNG power generation as an example of DMO.</td></tr>
</table>

Figures on the left indicate the power generating unit cost (¢/kWh), while figures on the right indicate the power sale tariff (c/kWh).

Table 5-1 Power Generating Cost for Power Generating Mode and Type of Operator (2)

Generating Mode	Project Name	Capacity	Project Operator					Issues
			PLN	IPP	SPC	PPP	INALUM	
			ODA	JBIC	JBIC	ODA	ODA	
			ROE=15%	ROE=18%	ROE=18%	ROE=15%	ROE=15%	
Geothermal	Sarulla-2	190MW		S_IPP Sarul 4.5/9.2				(1) Current regulations require that an IPP sells power to PLN, however, examine the possibility of consigning transmission from IPP to INALUM.
Hydropower	Total	177.4MW	H_PLN_ Total 2.6/3.5	H_IPP_ Total 2.6/7.6				(2) For hydropower generation, the power tariff greatly differs between the case of using ODA funds and the case of IPP base (with JBIC syndicate). This is due to the difference in the interest burden, making it less likely for hydropower generation by an IPP. (3) Rather than INALUM purchasing hydroelectric power from an IPP (generating charge + transmission cost), it may be cheaper to conduct routine power purchase from PLN.
	Toru-1	38.4MW	H_PLN_ Touru 1.8/2.4	H_IPP_ Touru 1.8/5.3				
	Simanggo-2	59.0MW	H_PLN_ Simang 2.2/2.9	H_IPP_ Simang 2.2/6.4				
	Raisan-3,4	80.0MW	H_PLN_ Raisan 3.8/4.9	H_IPP_ Raisan 3.7/10.8				

Figures on the left indicate the power generating unit cost (¢/kWh), while figures on the right indicate the power sale tariff (c/kWh).

Chapter 6 Recommended Power Supply Options

As a result of assessing each option's viability from the viewpoints of certainty of realization in the near future, issues in development and power generating cost in each mode, the following power supply options have high viability and are recommended in the Study. In the supply options that assume power purchase from PLN, INALUM purchases power according to the PLN tariff scheme at a uniform rate irrespective of the supply scale and generating mode. Consequently, all of the options that are based on power purchasing from PLN have low feasibility and cannot be recommended.

(1) First recommended option: Development of a 200 MW coal-fired thermal power plant for INALUM by an SPC or INALUM;

Since the SPC or INALUM can independently conduct planning and development, this has the fewest uncertain elements of all the power generation options. Technical confirmation of coal price trends, coal supply stability and location conditions, etc. is required. Moreover, authorization as a specific power supplier/private power generator is required. In view of the power generating cost and certainty of development, coal-fired thermal power generation (subcritical 200 MW) is the most feasible option. In this case, it is necessary to secure backup in the event of plant failure, however, assuming that RUPTL 2010 progresses smoothly, the backup tariff can fall in line with increase in reserve capacity.

Project Operator	Power Generating Cost (¢/kWh)	Power Sale Price (¢/kWh)
SPC	4.3	5.9
INALUM	4.3	5.6

Note: Transmission costs and power access facility costs are not included.

(2) Second recommended option: Development of a 200 MW coal-fired thermal power plant for INALUM by an SPC or INALUM, combined with 200 MW of hydropower plant for public use;

Since the SPC or INALUM can independently conduct planning and development of the dedicated coal-fired thermal power plant for INALUM plant expansion, this option has relatively few uncertain elements regarding development. Technical confirmation of coal price trends, coal supply stability and location conditions, etc. is required. Moreover, authorization as a specific power supplier/private power generator is required. There is uncertainty on the timing of hydropower development. Concerning hydropower development, it is necessary to conduct technical confirmation of the development potential and location conditions, etc. and to coordinate between the project implementation bodies. Among the 400 MW supply options, the case where an SPC or INALUM develop a dedicated power resource is the most feasible in terms of the power generating cost and certainty of development. This option also entails conducting hydropower development for public use purposes, and hydropower can make the greatest contribution to PLN finances because it entails the least expensive power generating cost.

Generating Mode	Project Operator	Power Generating Cost (¢/kWh)	Power Sale Price (¢/kWh)
Coal-fired thermal power for INALUM (subcritical 200 MW)	SPC	4.3	5.9
	INALUM	4.3	5.6
Hydropower for civilian purposes (177.4MW)	IPP	2.6	7.6
	PLN	2.6	3.5

Note: Transmission costs and power access facility costs are not included.

(3) <u>Third recommended option: Development of a 200 MW coal-fired thermal power plant for INALUM by an SPC or INALUM, combined with 200 MW of geothermal power plant for public use purposes;</u>

Since the SPC or INALUM can independently conduct planning and development of the dedicated coal-fired thermal power plant for INALUM plant expansion, this option has relatively few uncertain elements regarding development. It is uncertain whether or not the geothermal power development can be timed to coincide with the expansion of the INALUM aluminum smelting plant. Concerning the coal-fired thermal power development, the same issues as in the first and second recommended options apply. This option entails conducting geothermal power development for public use purposes at Sarulla-2 in tandem with coal-fired thermal power development for INALUM. The development concession for Sarulla-2 has already been obtained and, apart from the timing of development, feasibility is high.

Generating Mode	Project Operator	Power Generating Cost (¢/kWh)	Power Sale Price (¢/kWh)
Coal-fired thermal power for INALUM (subcritical 200 MW)	SPC	4.3	5.9
	INALUM	4.3	5.6
Geothermal power for civilian purposes (190MW)	IPP	4.5	9.2

Note: Transmission costs and power access facility costs are not included.

(4) Fourth recommended option: Development of a 400 MW coal-fired thermal power plant by an SPC or INALUM, and 200 MW for INALUM and 200 MW for public use purposes;

Since the SPC or INALUM can independently conduct planning and development, this option has relatively few uncertain elements regarding development. Issues are the same as in the first recommended option, i.e. technical confirmation of coal price trends, coal supply stability and location conditions, etc. is required, and it is necessary to secure authorization as a specific power supplier/private power generator. Concerning backup in the event of plant failure, this option is better than the first three recommended options, however, excess power for civilian purposes is likely to be sold at a low price.

Project Operator	Power Generating Cost (¢/kWh)	Power Sale Price (¢/kWh)
SPC	4.3	5.9
INALUM	4.3	5.6

Note: Transmission costs and power access facility costs are not included.

(5) Fifth recommended option: Development of a 600 MW coal-fired thermal power plant by an SPC or INALUM, and 200 MW for INALUM and 400 MW for public use purposes;

Since the SPC or INALUM can independently conduct planning and development, this option has relatively few uncertain elements regarding development. Issues are the same as in the first recommended option, i.e. technical confirmation of coal price trends, coal supply stability and location conditions, etc. is required, and it is necessary to secure authorization as a specific power supplier/private power generator. In the event where INALUM is nationalized, ODA would become applicable to supercritical or ultra-supercritical coal-fired thermal power and the power sale price would be lower than in the case of subcritical generation ; however, since the plant cost would be expensive, the generating unit cost would conversely increase. The 600 MW supply option entails supplying 400 MW for public use purposes, however, if the plans of RUPTL 2010 advance smoothly, there is a risk of creating excess supply. Thus there is little likelihood that 400 MW will be needed for public use purposes. Moreover, since more power will be sold at low prices as excess power, the resulting loss will be greater than in the 400 MW option. Therefore, the 600 MW supply option is less feasible than the 200 MW and 400 MW options.

Project Operator	Power Generating Cost (¢/kWh)	Power Sale Price (¢/kWh)
SPC	5.1	7.6
INALUM (state-owned)	5.0	5.3

Note: Transmission costs and power access facility costs are not included.

Chapter 7 Study Results and Issues for the Future

Coal-fired thermal power

Sources of coal supply to North Sumatra are limited to sites in the three provinces of South Sumatra, East Kalimantan and South Kalimantan, where there are abundant reserves. East Kalimantan and South Kalimantan Provinces have abundant reserves of medium quality coal for supply to the domestic and oversea market. Meanwhile, coal from South Sumatra province is largely the low quality type suited to consumption in Indonesia. As for the provinces of North Sumatra, Riau is thought to have some coal reserves, however, unlike the three provinces mentioned above, it does not have the potential to provide a stable supply into the future. Accordingly, there is little expectations of developing a power plant in and around the north of Sumatra; rather, it is more appropriate to transfer coal to North Sumatra Province from sites in South Sumatra, East Kalimantan or South Kalimantan. Judging from the transfer distances and state of transportation infrastructure, the best option is thought to utilize coal from South Sumatra Province.

So long as the necessary quantity of coal can be secured, there are no particular constraints concerning the power plant site rather than the other power sources. The required conditions for sites are that water supply can be secured, major equipment can be installed and there is enough land to store coal. Concerning economic and financial efficiency, for example, in the case where an SPC (special purpose company) is established near the INALUM aluminum smelting plant, a power plant and transmission lines are constructed using a JBIC loan and 200 MW subcritical coal-fired thermal power generation is conducted, the estimated power generating cost is 4.3 ¢/kWh, the power tariff is 5.9 ¢/kWh, FIRR is 12.1% and ROE is 18%.

Meanwhile, judging from the experience of Japanese thermal power plants that have adopted supercritical pressure or ultra supercritical pressure boilers with excellent thermal efficiency, the minimum unit capacity is generally around 400 MW. Since North Sumatra Grid has a combined generating capacity of approximately 1,700 MW as of 2010, 400 MW would account for roughly 23% of total capacity, which would be far higher than the 4% or less that is recommended for new power resources. Even in the event where power plants scheduled in the Crash Program are completed and commence operation, thereby bringing grid capacity up to approximately 3,500 MW by 2015, a 400 MW unit would still account for 11% of the grid capacity. In either case, it would be necessary to choose suitable supply capacity upon conducting system flow analysis.

In the event where 200 MW of generating capacity is reserved exclusively for INALUM, subcritical steam power generation would be adopted; however since the system would have no backup, it would be necessary to connect to the PLN grid and secure power in the event of emergency. Similar backup measures would also be needed when introducing 400 MW and 600 MW coal-fired thermal power generation.

Gas-fired thermal power

The areas having the greatest natural gas potential are Natuna, South Sumatra Province, East Kalimantan Province and West Papua Province. The gas fields around Natuna located close to North Sumatra have the largest reserves however, these reserves have CO_2 content of 70% and their viability cannot be judged from the amount of reserves alone. Sumatra also has gas fields in Aceh Province and North Sumatra Province, however, reserves here are limited and production has been declining in recent years. Concerning natural gas produced in South Sumatra, since priority is given to supply to Java and it would be necessary to transport it more than 1,000 km by tank lorry, it is not feasible to use this.

Moreover, concerning natural gas procurement via pipeline, a pipeline has been installed and is being used between Grissiki in South Sumatra Province and Duri in Riau Province, however, since the remaining section of more than 500 km to Medan is only in the planning stage and so far no specific construction schedule has been set, no date has been set for supply via this route. Meanwhile, it is scheduled to construct a marine LNG terminal off the coast of Medan in 2013 and this will primarily supply gas to the existing thermal power plant at Belawan (combined cycle plant). Possible options are either to procure gas from East Kalimantan Province and West Papua Province and construct a combined cycle power plant, or to rehabilitate the deteriorated steam generating facilities at the existing Belawan thermal power plant and thereby boost the power resources.

So long as the necessary quantity of natural gas can be secured, there are no particular constraints concerning the power plant site. The required conditions for sites are that water supply can be secured and there is enough land to install major equipment. Concerning economic and financial efficiency, for example, in the case where an SPC (special purpose company) is established near the INALUM aluminum smelting plant, a power plant and transmission lines are constructed using a JBIC loan and 200 MW subcritical coal-fired thermal power generation is conducted, the estimated power generating unit cost is 8.6 ¢/kWh, the power tariff is 8.8 ¢/kWh, FIRR is 3.1% and ROE is 18%.

Since it is initially planned for the offshore LNG terminal to supply around 40 MMcfd, it would be necessary to examine in detail whether enough gas for the new power resources can be supplied in line with the expansion plans of the LNG terminal. In the case where a power plant is constructed around Kuala Tanjung near the INALUM plant, it would be necessary to examine, among other things, whether the gas supplier or the consumer invests in the pipeline leading from the existing gas pipeline system around Medan to the power plant. In the case where 200 MW of supply capacity is secured only for the INALUM plant expansion, as in the case of coal-fired thermal power, it is necessary to secure the backup power source.

Geothermal power

Promising potential areas where operation or survey work is currently being undertaken are Sibayak, Sarulla, Merapi, Sipaholon and Sinabung. Among the promising areas, only Sarulla-2 has the potential to generate 200 MW of power. However, concerning development of Sarulla with the whole capacity of 330MW including Sarulla-2, a power purchase agreement has been signed with PLN the developed power will be sold to PLN. It would thus be difficult for ILUNAM to directly obtain power supply from Sarulla.

Meanwhile, according to the Geothermal Master Plan (2007), it is estimated that Sarulla-2 has development potential for 300 MW, of which 110 MW is planned in RUPTL. Accordingly, this Study targeted the remaining 190 MW of potential not stated in RUPTL. However, there are a number of obstacles to developing Sarulla-2 for INALUM, including the issue of the development concession. Concerning economic and financial efficiency, for example, in the case where an IPP is established, a power plant and transmission lines are constructed using a JBIC loan and 200 MW geothermal power generation is conducted, the estimated power generating cost is 4.5 ¢/kWh, the power tariff is 9.2 ¢/kWh, FIRR is 11.6% and ROE is 18%.

Sarulla covers a wide area spanning four sections, however, these are regarded as one working area and the development concession covers all of it. Accordingly, in the case where this area is targeted for development, it would be necessary to conduct discussions and negotiations with the existing stakeholders. Moreover, since development of Sarulla-2 will take place after development of Sarulla-1, it would be necessary to expedite the work on Sarulla-1 if Sarulla-2 is targeted. For this purpose, it would be essential to support the project with government funds for the drilling and power plant construction.

Meanwhile, it is estimated that Sarulla-2 has development potential of around 300 MW, however, since this figure was based on the study findings from the Pre-F/S, it would be necessary to conduct a more detailed assessment of reserves through a geothermal development study that includes a well investigation.

Hydropower

In Phase 1, Tampur-1 and Jambu Aye were identified as promising sites since both would possess large reservoirs and be capable of supplying stable power to INALUM; however, since both these sites are located in nature protection areas, development would be difficult in terms of the environmental impacts. Moreover, since both sites are located in Aceh Province, which has been in conflict with the central government for many years, it would be difficult to conduct development in the long term.

Accordingly, these sites were omitted from the list of promising development sites in the Study. As alternatives, four sites: Toru-1, Simanggo-2, Wampu and Raisan-3,4, were newly proposed as sites with the potential to supply 200 MW. Apart from Wampu, none of these sites is mentioned in RUPTL. Since all four sites are middle-scale regulating reservoir or run-of-river schemes, they would entail few environmental problems and are viable. Concerning economic and financial efficiency, for example, in the case where an IPP is established, a power plant and transmission lines are constructed using a JBIC loan and 200 MW hydropower generation is conducted at four sites, the estimated power generating cost is 2.6 ¢/kWh, the power tariff is 7.6 ¢/kWh, FIRR is 12.2% and ROE is 18%.

In this Study, promising sites were selected on condition that projects features are relatively accurate, however, all the plans have only reached the initial study phase. Moreover, since a number of years have passed since studies were finished, it is necessary to implement renewed studies. Accordingly, it would be necessary to immediately raise the study accuracy and smoothly advance the work to the design and construction stages to realize development plans. Even though the run-of-river and regulating reservoir type plants proposed entail smaller environmental impacts than storage reservoir type plants, it would still be necessary to conduct adequate surveys and examinations.

Meanwhile, in line with the advance of decentralization in Indonesia, provincial governments have the authority to grant development concessions for hydropower development. It is also believed that the authority to utilize natural energy resources for hydropower and geothermal development should be held by the areas where those resources are located. Accordingly, it would be necessary to commence advance coordination with provincial governments in each development case.

Legal systems

The New Electric Power Law was enacted in September 2009, however related government ordinances, etc. have not yet been revised in line with this. For example, provisions concerning the leasing of transmission lines have been stipulated in Government Regulations No.3/2005 and No.26/2006, however, detailed provisions have not yet been established. In order to formulate such detailed provisions on the leasing of transmission lines, it would be necessary to conduct examination giving consideration to grid stability and trends in power resources development and demand, however, unless the needs for leasing increase, there is a strong possibility that work on preparing such provisions won't even begin.

Accordingly, in the Study, it was decided that the leasing of transmission lines would be difficult in the current situation. However, since this factor has the greatest impact on securing a power resource for INALUM plant expansion, it will be necessary to pay close attention to work on detailed provisions.