The Republic of Indonesia
Ministry of Energy and Mineral Resources
PT PLN (Persero)

Project for the Master Plan Study of Hydropower Development in Indonesia

FINAL REPORT

VOL. III SUPPORTING REPORT (1) HYDROPOWER DEVELOPMENT MASTER PLAN

August 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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Part 1 Generation Development Plan in RUKN

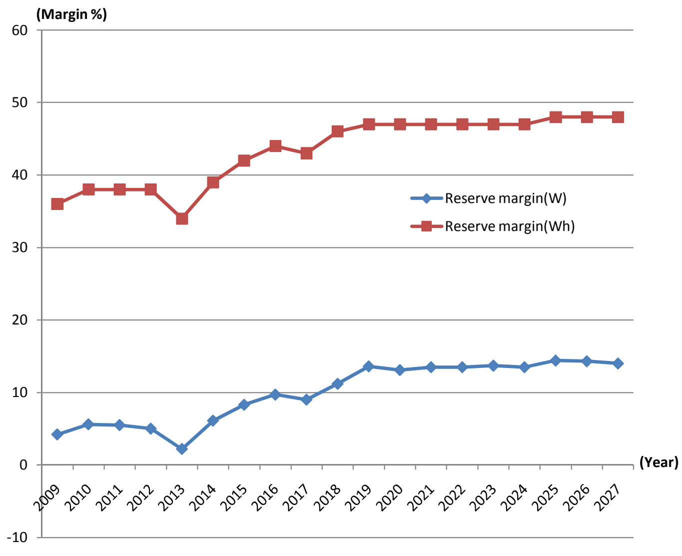
PART 1 GENERATION DEVELOPMENT PLAN IN RUKN

A check was made of reserve capability in the RUKN 2008 plan. The reserve capability figures in the chart in terms of electrical energy indicate the sending-end electrical energy in the case of operation of all power sources on line at rated output 24 hours a day, 365 days a year. It therefore must be noted that the figures are higher than would be obtained in actuality. It also may be noted that the reserve capability in terms of peak power is the total rated output when all power sources on line can be operated at rated output.

1. JAMALI

Reserve capability figures in RUKN indicate generation development targeting possession of a likelihood of 40 percent in terms of facility capacity.

In the chart noted below, the reserve capability for the peak power and that for electrical energy appear to be satisfactory, but the supply capacity is actually short due to facility failure and delayed development of new sources. Input of new sources through steady progress as shown in the chart is likely to become an important agendum. The drop in reserve capability in 2013 is due to the increase in abolished capacity. The plans envision the input of power sources sufficient to right the supply-demand balance beginning in 2019. For this reason, the margin takes a nearly constant value, and one can imagine a power system that is mature as regards the level of reserve capability for both peak power and electrical energy.



Source) Made by JICA Study Team based on RUKN 2008

Figure 1 Reserve capability in RUKN (Jamali)

2. SUMATRA

For the Sumatra system, the plans envision attainment of a sufficient reserve capability for peak load within the next few years. The ratio of reserve for electrical energy in the year in question is about 60 percent. At a discount of 50 percent, there would be ample margin with respect to electrical energy.

For reference purposes, the plan mentions the power source development plan for the Bangka Belitung and Batam systems. It may also be noted that the power source development plan for the Bable system is out of correlation because of the dramatic change between the time of RUKN formulation and that of RUPTL 20009-2018 formulation.

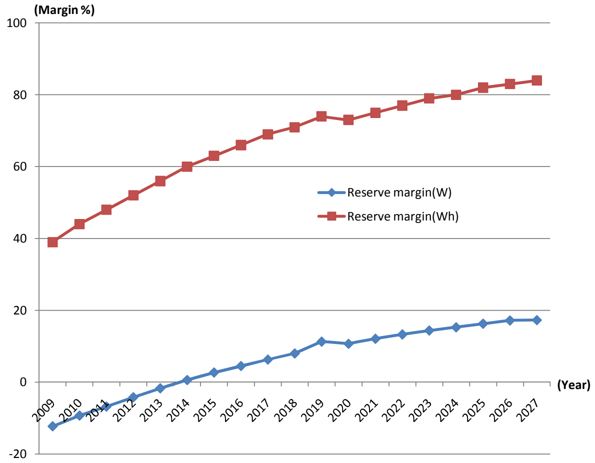


Figure 2 Reserve capability in RUKN (Sumatra)

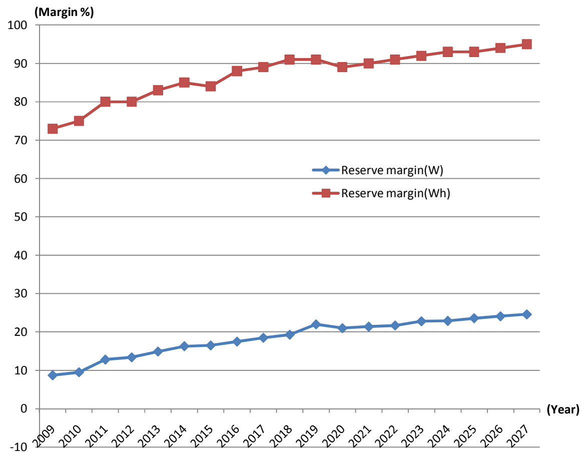


Figure 3 Reserve capability in RUKN (Babel)

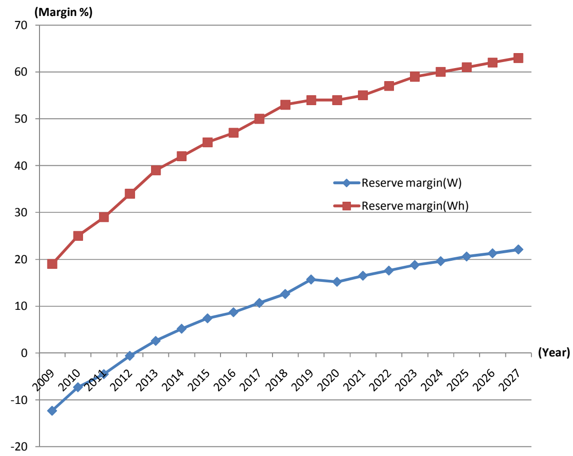
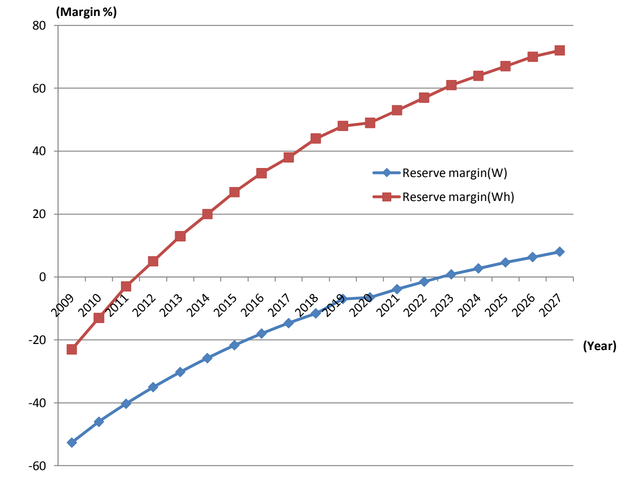


Figure 4 Reserve capability in RUKN (Batam)

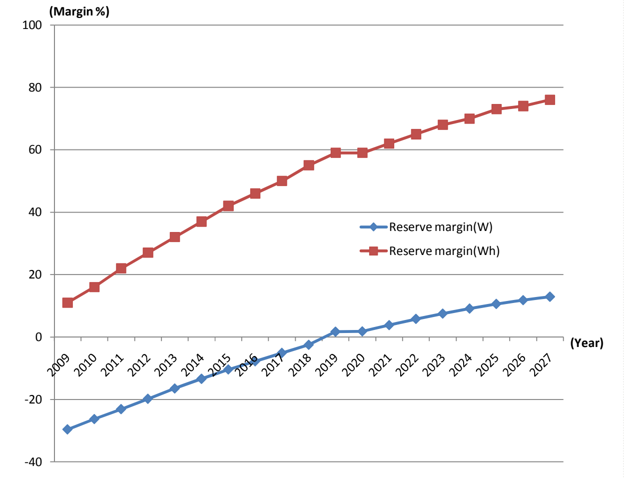
3. KALIMANTAN

A check of the reserve capability in RUKN 2008 reveals a shortage not only for peak power but also for electrical energy at present. As may be gathered from the aforementioned definition in this chart (See the Jamali part), the power system is fairly feeble. The situation in the Kalbar region is worse than those in the other two regions. In the year in which the reserve power in terms of electrical energy is scheduled to reach about 40 percent, the reserve power in terms of peak power will be minus 18, minus 10, and minus 10 percent at Kalbar, Kaselteng, and Kaltim, respectively. In terms of electrical power, these figures translate into a corresponding 70, 70, and 50 MW. In other words, the Kalbar system requires substantial peak power in spite of the small scale of its electrical energy demand. This points to the need for measures such as support of the supply capability through interconnection with other systems. As regards interconnection of the Kaselteng and Kaltim systems, it may be noted that both lack reserve capability terms of electric energy, and the level of reserve shortage relative to peak power suggests that system interconnection with input of large-scale sources would be preferable to development of medium-scale sources (on the order of 100 MW) in each system separately.



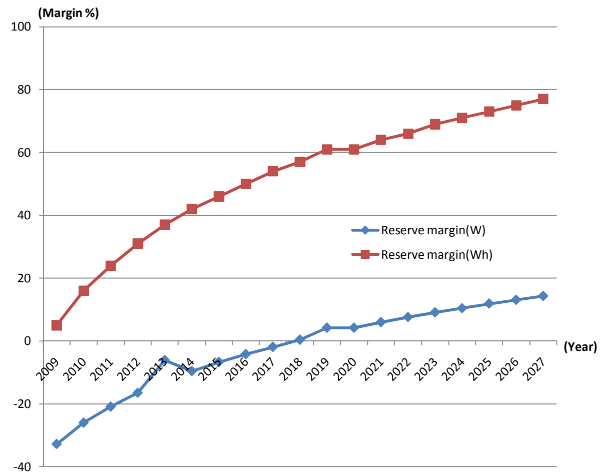
Source) Made by JICA Study Team based on RUKN 2008

Reserve capability in RUKN (Kalbar)



Source) Made by JICA Study Team based on RUKN 2008

Reserve capability in RUKN (Kalselteng)



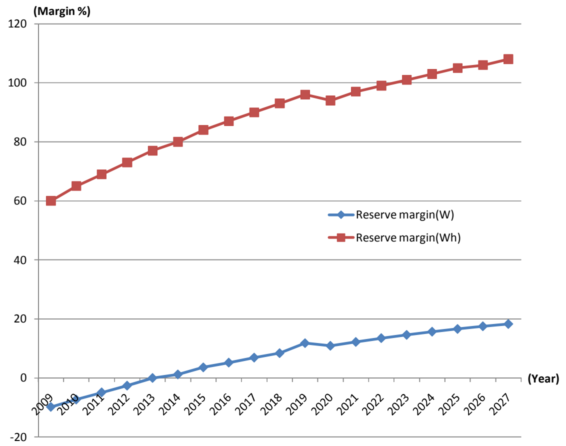
Source) Made by JICA Study Team based on RUKN 2008

Figure 5 Reserve capability in RUKN (Kaltim)

4. SULAWESI

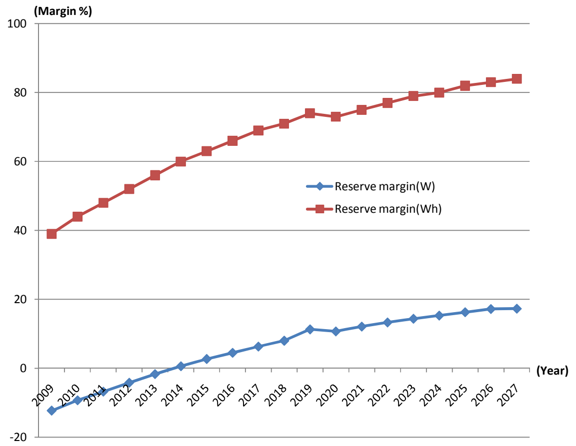
A check of the reserve capability in RUKN 2008 reveals that the system already retains a certain amount of margin in terms of electrical energy, but that there is a shortage for peak power, as shown in Figure 6 and 7.

The plans envision assurance of a sufficiient reserve for peak power in both the Suluttenggo[1] and Sulselra[2] wilayahs in 2014. If the power source development proceeds smoothly, the island could be equipped with power systems that are stable in terms of the supply-demand balance.



Source) Made by JICA Study Team based on RUKN 2008

Figure 6 Reserve capability in RUKN (Sulutenggo)



Source) Made by JICA Study Team based on RUKN 2008

Figure 7 Reserve capability in RUKN (Sulselra)

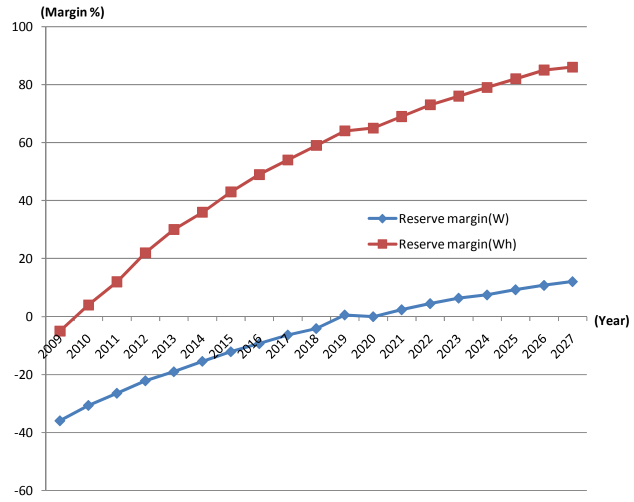
5. MALUKU

A check of the reserve capability in RUKN 2008 reveals that the reserve capability relative to peak power is slated to become positive in 2019, as shown in Figure 8. In the year when the reserve capability in terms of electrical energy is 40 percent, the value in terms of peak power will be minus 10 percent. In terms of electrical power, this is equivalent to 30 MW.

Because the load factor is estimated at about 60 percent, the shortage of electrical energy would be about (30 MW×400 hours)/2 = 6 GWh, or about 400 hours worth of peak power.

[1] The Sulut system includes the central Sulawesi (Tengah) and Gorontalo systems

[2] The Sulsel system includes the southeastern (Tenggara) system.



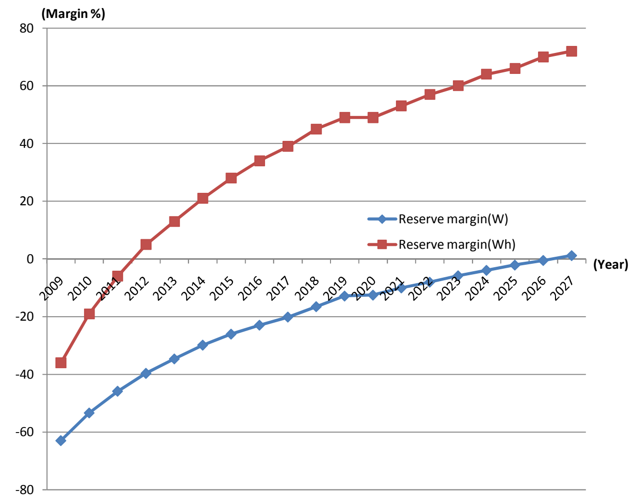
Source) Made by JICA Study Team based on RUKN 2008

Figure 8 Reserve capability in RUKN (Maluku)

6. PAPUA

A check of the reserve capability in RUKN 2008 reveals that the reserve capability relative to peak power will not become positive for another 20 years, as shown in Figure 9. This is to say that the system will continue to be one constantly requiring a peak-cutting operation. In the year when the reserve capability in terms of electrical energy is 40 percent, the value in terms of peak power will be minus 20 percent. In terms of electrical power, this is equivalent to 50 MW.

The reserve capability for peak power is therefore low as compared to the abundant one for electrical energy, and this situation derives from the poor load factor. This points to the need for measures to increase the load factor in promotion of power source development plans.



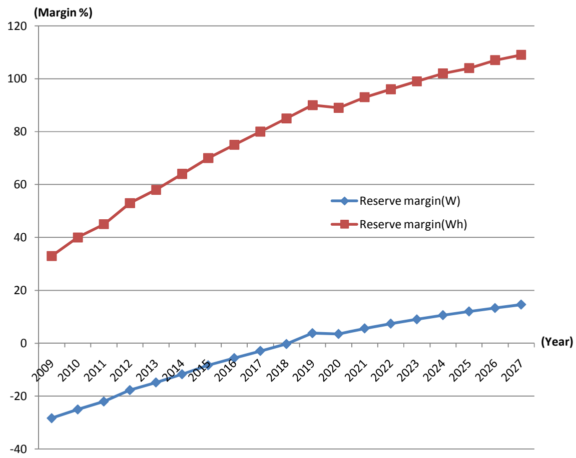
Source) Made by JICA Study Team based on RUKN 2008

Figure 9 Reserve capability in RUKN (Papua)

7. NTB・NTT

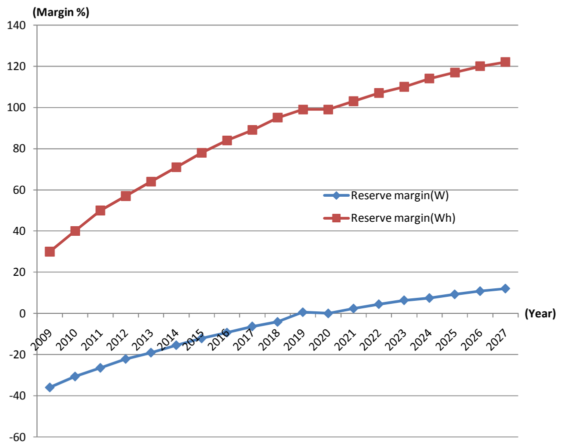
A check of the reserve capability in RUKN 2008 reveals that it is sufficient relative to electrical energy but will remain short relative to peak power until 2019, as shown in Figure 10 and Figure 11. In the year when the reserve capability in terms of electrical energy is 40 percent, the value in terms of peak power will be minus 20 percent for NTB and minus 20 percent for NTT. In terms of electrical power, these figures are equivalent to 40 and 30 MW, respectively.

The reserve capability for peak power is therefore low as compared to the abundant one in terms of the electrical energy, and this situation derives from the poor load factor. This points to the need for measures to increase the load factor in promotion of power source development plans.



Source) Made by JICA Study Team based on RUKN 2008

Figure 10 Reserve capability in RUKN (NTB)



Source) Made by JICA Study Team based on RUKN 2008

Figure 11 Reserve capability in RUKN (NTT)

Part 2 Transmission Development Plan in RUPTL

PART 2 TRANSMISSION DEVELOPMENT PLAN IN RUPTL

The table below profiles the plans for development of transmission lines, transformers, and power sources in the Jamali system.

From the table, it can be seen that emphasis in the Jamali system from now on will fall on active operation of the 500-kV trunk system and voltage upgrading (from 70 to 150 kV) in the load system.

Another table profiles the plans for development of transmission lines, transformers, and power sources in outer island systems.

From this table, it is estimated that the plans are suitable ones adapted to the system scale.

The following section presents a detailed description of the power transmission facility plans in the systems within each block, in line with the division of power supply blocks in RUPTL. The systems are as follows.

- Java – Madura – Bali (Jamali)
- Sumatra
- Kalimantan
- Sulawesi
- Maluku
- Papua

Nusa Tenggara

The following is a profile of the supply areas, PLN offices, and related power companies in each block.

- Jamali

  Java island plus the islands of Madura and Bali

  (All parts of the PLN distribution supply zone (West Java & Banten, DKI Jakarta & Tangerang, Central Java & DIY, East Java, and Bali); the area under the jurisdiction of P3B Java Bali; and the sources of PT Indonesia Power, PT PJB, and IPPs in the block assigned to generation.)

- Sumatra

  Sumatra island and peripheral islands

(All PLN wilayahs on the islands of Riau, Bangka, Belitung, and Nias (Nanggroe Aceh Darussalam (NAD), North Sumatra, West Sumatra, Riau, South Sumatra-Jambi-Bengkulu (S2JB), and Bangka-Belitung); the area under the jurisdiction of P3B Sumatra; the PLN North Sumatra Generating Section in charge of generation (PLN Pembangkitan Sumatra Bagian Utara); and the PLN South Sumatra Generating Section (PLN Pembangkitan Sumatra Bagian Selatan); and IPPs in the block.）[1]

- Kalimantan

  The island of Kalimantan

  (All PLN wilayahs (West Kalimantan, Central & South Kalimantan, and East Kalimantan)）[2]

- Sulawesi

  The island of Sulawesi

  (All PLN wilayahs (North-Central-Gorontalo and South-Southeast-West))

- Maluku

  The provinces of Maluku and North Maluku

  (PLN Wilayah(Maluku & North Maluku)）

- Papua

  The provinces of Papua and West Papua

  （PLN wilayah(Papua)）

- Nusa Tenggara(NTB, NTT)

  West Nusa Tenggara islands and East Nusa Tenggara islands

  （PLN wilayahs(West Nusa Tenggara and East Nusa Tenggara)）

[1] On the island of Batam, which has been designated as a special development area, PT PLN Batam, a subsidiary of PLN, is in charge of activities and formulating an original plan. For this reason, the island was not included in this plan(*).
[2] Footnote (*) also applies to the island of Tarakan (PT PLN Tarakan).

Source: RUPTL2009-2018

Figure 1 Inspection area on transmission and generation development plans

Table 1 Development plan of transmission lines (Jamali system)

(kms)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
500kV AC		159	127	4	329	920	606	444	100	60	340	3089
500kV DC									350			350
150kV	564	3497	1403	1120	727	482	560	282	644	276	12	9567
70kV	14	80	10	22								126
Yearly total	578	3735	1541	1146	1056	1402	1166	726	1094	336	352	13132

Source) RUPTL2009-2018

Table 2 Consequence between transformer development plan and generation development plan (Jamali system)

		As of 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Peak demand (MW)		16,840	17,627	18,854	20,900	23,012	25,343	27,906	30,597	33,535	36,708	39,949	43,629
Gene. Capacity (MW)		22,236	22,296	25,146	30,061	32,505	36,340	39,715	43,540	47,730	52,012	56,834	62,279
Traf. Capacity ($\times 10^3$MVA)		4,640	4,644	4,654	4,655	4,661	4,666	4,674	4,681	4,687	4,689	4,694	4,697
	500/150kV(MVA)	$1,700\times 10^3$	1,666	4,666	3,000	2,000	1,000	4,000	3,500	3,000	6,000		1,000
	150/70kV(MVA)	361×10^3	160	490	160						350		
	150/20kV(MVA)	$2,579\times 10^3$	1,820	4,800	7,920	4,036	3,570	3,480	3,330	3,690	5,370	5,160	1,980
	70/20kV(MVA)	288×10^3	60	480	190	90	90	80	80	150	190	130	100

Note; Not considered assumption of retired transformers
Source) Made by JICAStudy Team based on RUPTL2009-2018

Table 3 Development plan of transmission lines (outer island systems)

(kms)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
500kV									1,040			1,040
275 kV			5,122				2,872		2,508			10,502
150kV	1,098	2,277	5,502	2,908	2,179	714	618	897	531	273	8	17,005
70kV	105		1,006	272	90		186	660	170	90		2,579
Yearly total	1,203	2,277	11,630	3,180	2,269	714	3,676	1,557	4,249	363	8	31,126

Source) RUPTL2009-2018

Table 4 Consequence between transformer development plan and generation development plan (outer island systems)

		As of 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gene. Capacity (MW)		6,969	7,344	7,661	10,987	13,631	16,753	18,291	19,508	20,042	21,584	22,842	23,460
Traf. Capacity (×10^3MVA)		7,916	9,742	13,452	20,122	21,302	22,742	23,792	26,132	27,702	31,822	32,888	33,398
	500/275kV(MVA)	0									1,000		
	275/150kV(MVA)	160		1,500	4,000				1,350		1,500		
	150/20kV(MVA)	6,693	1,746	2,100	2,280	1,050	1,360	1,050	890	1,410	1,500	1,006	450
	70/20kV(MVA)	1,063	80	110	390	130	80		100	160	120	60	60

Note; Not considered assumption of retired transformers

Source) Made by JICAStudy Team based on RUPTL2009-2018

(1) Jamali

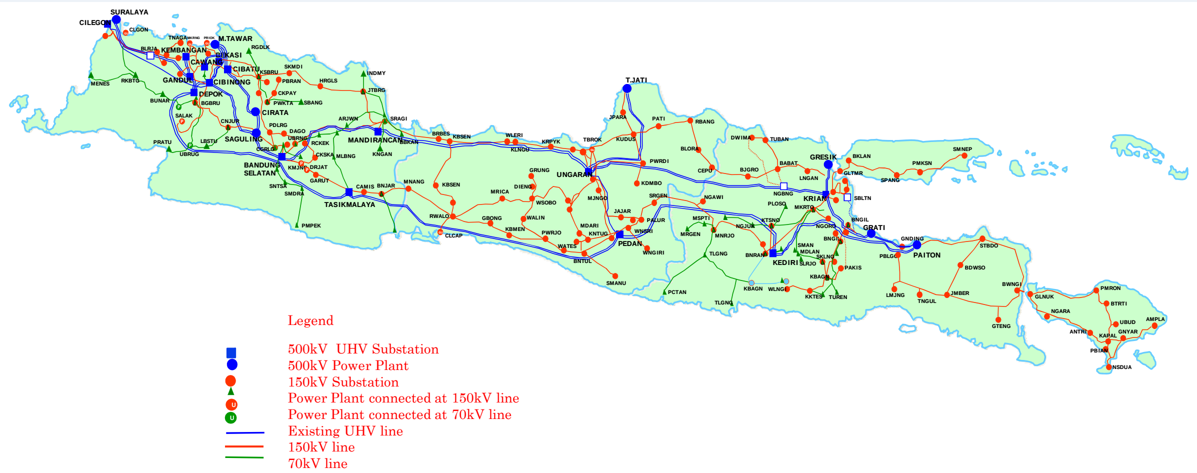
1) Condition and Prediction

In Jamali, the placement of the 500-kV transmission line southern route into service was accompanied by an increase in the system-level likelihood for the chronic power flow from east to west, and this temporarily alleviated worries about a transmission capacity shortage. Nevertheless, the development of new sources in Fast Track phases I and II in order to keep abreast of the increase in the burgeoning demand will probably make system reinforcement an urgent priority over the next few years, owing to the shortage of transmission capacity.

Table 5 Demand forecasting about Jamali system

Energy sales forecasting 2008 → 2018(TWh)		Peak Demand forecasting 2008 →2018 (MW)
100.9 → 250.9		17,627 → 43,629
Distribution Area	Energy sales forecasting 2008 → 2018(TWh)	Peak Demand forecasting 2008 →2018 (MW)
DKI and Tangerang	29.2 → 70.0	4483 → 10,416
West Java	34.7 → 83.3	5198 → 12,071
Central Java and DIY	14.2 → 36.7	2,656 → 6,521
East Java	20.5 → 45.2	3,681 → 7,842
Bali	2.5 → 7.9	469 → 1,271

Source: RUPTL2009-2018



Source: P3B Java Bali

Figure 2 Jamali system

2) Review

A check was made of RUPTL 2009 - 2018. The notable points are as follows.

The review of the transmission line development plan was made on the basis of the items noted in the results of the Jamali system power flow calculation in Supplement A.8 in RUPTL.

In 2010, the plan envisions reinforcement of power source lines via GI Balaraja accompanying expansion of the PLTU Suralaya, installation of load connection substations along with demand growth, and installation of new substations at GI Rancaekok and Rawalo to serve as access points for additional power sources in the future.

The notable elements of system plans over the years leading up to 2014 are as follows: a) provisional influx of power flow in the 500-kV southern route because the influx of the entire power flow into the 500-kV northern route as the nearest access point along with the start-up of PLTU Tanjung Jati B will result in imbalance on the southern route; b) installation of a new power source line in the direction of Japotabek for smooth delivery of the power flow related to Fast Track Phase I (added in Central Java) to the site of consumption; and c) construction of a new gas-fired power source and pumped storage hydropower plant (Upper Cisokan) in West Java and the vicinity for middle and peak load.

The notable elements of system plans over the years leading up to 2018 are as follows: a) assurance of supply capacity in the West Java direction by large-capacity DC transmission from Sumatra, which is slated to come on line in 2016; and b) input of pumped storage hydropower sources (Matenggeng and Grindulu) in Central Java and East Java to address the local power peak and absorb the coal-fired surplus power during the night.

In any year, the system does not appear to have any problems, according to the results of power flow calculations. In reality, however, in every year, there is a heavy power flow from east (or the central region, depending on the year) to west. It is vital to make studies of system stabiilty, and particularly voltage and transition stability, in each year (when large-capacity sources are brought on line). It may also be noted that the plan posits DC transmission from Sumatra, which is to come on line in 2016. It is important to make full studies on the frequency drop in the Jamali system and frequency rise in the Sumatra system in the event of failure of this facility, and to determine countermeasures for the same.

As shown in the table below, there are plans to reinforce the capacity of load 150-kV transmission lines by switching to thicker wire as the demand increases. If there is cause for apprehension about this move, it would be the mode of operation of the load transmission lines, i.e., whether they would be operated in a looped or radial system. The system is going to get more complex as the demand grows. For this reason, it is advisable to reconsider policy on load system operation taking account of matters such as early resumption of service after failure and ease of system recognition as well as the staffing requirement and balance with facilities.

As for power source lines related to hydropower sources in the Jamali system, there are plans for three pumped storage plants at Upper Cisokan, Matenggeng, and Grindulu in the 500-kV extra high voltage system. These sources are to come on line in 2014 (pi-feeder connection of Cibinon-Saguling), 2017 (GI Rawalo connection), and 2018 (GI Kegonagug connection). As part of system planning in the introduction of pumped storage hydropower stations, studies are being made of the system balance at peak power flow in RUPTL, but it is also necessary to consider the system balance during pumped storage operation at night.

In connection with new hydropower sources apart from those noted above, there are plans for installation of 150-kV power source lines for PLTA Rajamandala in 2016 and PLTA Jatigede in 2017.

There are no problems with the transmission line plans for either of these hydro sources.

Table 6 Transmission line development plan(DKI・Banten 500kVExtra high voltage system)

Term	Location	Remark
2009	Balaraja - Inc.(Slya-Gdl)	
2009	Suralaya New - Suralaya Old	1st circuit
2010	Bojanegara - New Suralaya	
2010	Bojanegara - Balaraja	
2012	Balaraja - Kembangan	Cable 500 kV
2012	Durikosambi - Inc. (Kmbng-Gndul))	
2014	Muarakarang - Durikosambi	
2014	Banten PLTU - Cilegon Baru	
2014	Lengkong - Inc. (Blrja-Gndul)	
2016	Bogor X - Tanjung Pucut	DC HVDC SUTT
2016	Tanjung Pucut - Ketapang	DC HVDC CABLE

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 7 Transmission line development plan (Java Barat 500kVExtra high voltage system)

Term	Location	Remark
2011	Ujungberung - Inc. (Mdcan-Bdsln)	
2013	Indramayu PLTU - Cibatu	Cap.3000 MW
2013	Mandirancan - Cibatu	
2013	Tambun - Inc. (Mtwar-Cibng-Cwang)	
2013	Tanjung Jati A PLTU - Mandirancan	Cap.3000 MW
2014	**Cisokan PS - Incomer (Cibng-Sglng)**	**Power line for Hydro**
2017	**Matenggeng PS - Rawalo**	**Power line for Hydro**
2018	Indramayu PLTU - Mandirancan	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 8 Transmission line development plan (DIY・Tengah 500kVExtra high voltage system)

Term	Location	Remark
2010	Cilacap PLTU - Rawalo	
2010	Rawalo - Inc. (Pedan-Tasik)	
2012	Tanjung Jati B PLTU - Ungaran 3,4	
2013	Pemalang - Inc. (Ungar-Mdcan)	Double Phi
2014	Ungaran - Mandirancan (Lanjutan T)	
2014	PLTU Jateng Inf. - Pemalang	Cap.3000 MW, Double Phi

Term	Location	Remark
2016	Cepu PLTGU - Inc. (Tj Jati-Mdcan)	Cap.3000 MW
2018	Tanjung Angin PLTU - Dbphi (Pedan-Rawalo)	Cap.3000 MW
2018	Bantul - Dbphi (Rawalo-T.Angin)	
2019	Muria - Cibatu	DC HVDC SUTT
2019	Muria - Tambun	DC HVDC SUTT

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 9 Transmission line development plan (Java Timur･Bali 500kVExtra high voltage system)

Term	Location	Remark
2009	Ngimbang - Inc. (Sbrat-Ungar)	
2009	Paiton New - Paiton Old	1 circuit
2009	Surabaya Selatan - Grati	
2012	Paiton - Grati 3rd	
2013	Grati - Kdiri 1st	
2014	Kebonagung - Inc. (Grati-Kediri) 1st	
2015	Kapal JB Crossing - Paiton	
2015	Ngoro - Inc. (Piton-Kdiri) 2nd	
2018	**Grindulu PS - Kebonagung**	**Power line for Hydro**
2019	Tanjung Pelang PLTU - Kediri	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 10 Transmission line development plan (DKI･Banten Load system)

Term	Grade.	Location	Remark
2008	150kV	AGP Mampang - Senayan	Reconfigration
2008	150kV	Depok III - Inc. (Gndul-Cmgis)	
2008	150kV	ITP - Semen Cibinong	2nd circuit
2008	150kV	Senayan Baru - Kembangan	
2008	150kV	Tambun - Poncol II	
2009	150kV	Angke - Ancol	Reconductoring
2009	150kV	Antasari/CSW II - Duren Tiga	
2009	500kV	Balaraja - Inc.(Slya-Gdl)	
2009	150kV	Balaraja - New Balaraja	
2009	150kV	Bintaro - Petukangan	Reconductoring
2009	150kV	Bintaro - Serpong	Reconductoring
2009	150kV	Bintaro II - Bintaro	
2009	150kV	Bogor Baru - Sentul	Reconductoring
2009	150kV	Bogor baru - Cibinong	Reconductoring
2009	150kV	Cawang - Duren Tiga	Reconductoring
2009	150kV	Cibinong - Sentul	Reconductoring
2009	150kV	Cikupa - Balaraja	Reconductoring
2009	150kV	Duren Tiga - Kemang	
2009	150kV	Durikosambi - Petukangan	Mkrng-rep(?)
2009	150kV	Gandul - Serpong	
2009	150kV	Jabar Selatan - PLTU Lembursitu II	
2009	150kV	Jabar Selatan - PLTU Cibadak Baru II	
2009	150kV	Labuan - PLTU Saketi II	Uprating
2009	150kV	Labuan - PLTU Menes II	
2009	150kV	Mangga Besar - Ketapang	

Term	Grade.	Location	Remark
2009	150kV	Manggarai - Gedungpola	
2009	150kV	Menes II - Asahimas	
2009	150kV	Miniatur 150 - Gandaria	Uprating
2009	150kV	Muaratawar - Inc. (Bkasi-Kdsapi)	
2009	150kV	Plumpang - Inc.(Piok-Pgsan)	Priok Rehabilitation
2009	150kV	Saketi II - Rangkasbitung II	Uprating
2009	150kV	Suralaya New - Suralaya Old	
2009	150kV	Taman Rasuna - Duren Tiga	
2009	150kV	Tangerang Baru - Cengkareng	Reconductoring
2009	150kV	Teluk Naga - PLTU Tangerang Baru	
2009	150kV	Teluk Naga - PLTU Teluk Naga	
2009	150kV	Ubrug II - Lambur Situ II	Uprating
2010	150kV	Bogor Kota (IPB) - Kedung Badak	
2010	150kV	Ciawi II - Cibadak Baru II	Uprating
2010	150kV	Ciawi II - Bogor Baru	Uprating
2010	150kV	Cibatu - Cileungsi	
2010	150kV	Depok II - Depok III	Uprating
2010	150kV	G.Sahari/Mangga Besar I - Kemayoran	
2010	150kV	Gambir Lama - Kebon Sirih	
2010	150kV	Gandaria 150 - Depok III	Uprating
2010	150kV	Gandul - Petukangan	Rekonduktoring
2010	150kV	Jatiwaringin - Inc. (Pdklp-Jtngn)	
2010	150kV	Kedung Badak II - Depok III	Uprating
2010	150kV	Kelapa Gading - Incomer (Priok-Plpng)	
2010	150kV	Lautan Steel - Inc. (Blrja-CHabitat)	
2010	150kV	Lembursitu II - Cianjur	Uprating
2010	150kV	Lippo/Curug - Inc. (Cldug-Ckupa)	
2010	150kV	Milenium - Inc. (Blrja-CHabitat)	
2010	150kV	Pelabuhan Ratu 150 - Ubrug 150	
2010	150kV	Pondok Indah - Gandul	
2010	150kV	Rangkasbitung II - Kopo	
2010	150kV	Tanah Tinggi - Inc. (Gmblm-Plmas)	
2011	150kV	Grogol II - Grogol	
2011	150kV	Kebon Sirih - Gambir Lama	
2011	150kV	Lengkong - Serpong	Reconductoring
2011	150kV	New Muarakarang - Durikosambi	Mkrng-rep
2011	150kV	Bogor II - Inc. (Bgbru-Cnjur)	
2011	150kV	Cibinong II - Cimanggis	
2011	150kV	Ciledug II - Ciledug	
2011	150kV	Dukuatas II - Taman Rasuna Said	
2011	150kV	Kebon Sirih II - Inc.(Angke-Karet)	
2011	150kV	Miniatur II - Jatirarangon	
2011	150kV	Puncak Ardi Mulya II - Inc.(Ckande-PAM)	
2011	70kV	Semen Sukabumi - Incomer (Cnjur-Lbstu)	
2011	150kV	Tangerang Barui II - Tangerang Baru	
2012	150kV	Serang - Cilegon	Reconductoring
2012	150kV	Bekasi II - Tambun	
2012	150kV	Cimanggis II - Cimanggis	

Term	Grade.	Location	Remark
2012	150kV	Cipinang II - Cipinang	
2012	150kV	Daanmogot/Durikosambi I - Inc.(Dksbi-Mkrng)	
2012	150kV	Duren Tiga II - Inc. (Gndul-Cwang)	
2012	150kV	Kemayoran II - Kemayoran	
2013	150kV	Muarakarang - Angke	Reconductoring
2013	150kV	Citra Habitat II - Citra Habitat	
2013	150kV	Kandang Sapi II - Kandang Sapi	
2013	150kV	Lengkong II - Lengkong	
2013	150kV	Penggilingan II - Pulogadung	
2013	150kV	Semanggi Barat - Inc. (Mpang-Karet)	
2013	150kV	Taman Rasuna Said II - Taman Rasuna Said	
2014	150kV	Lembursitu III - Lembursitu II	Uprating
2014	150kV	Lipokarawaci II - Lipokarawaci	Uprating
2014	150kV	Asahimas II - Asahimas	
2014	150kV	Cibadak Baru II - Inc. (Bgbru-Cbdak)	
2014	150kV	Danayasa II - Mapang	
2014	150kV	Jatiwaringin II - Jatiwaringin	
2014	150kV	Kelapa Gading - Kelapagading II	
2014	150kV	Mangga Besar III - Mangga Besar II	
2014	150kV	Manggarai II - Taman Rasuna Said	
2014	150kV	Muarakarang III - Muarakarang II	
2014	150kV	Pondok Indah II - Pondok Indah	
2014	150kV	Senayan Baru II - Senayan Baru	
2014	150kV	Sepatan II - Sepatan	
2014	150kV	Serang II - Inc. (Srang-Clbru)	
2014	150kV	Teluk Naga II - Teluk Naga	
2015	150kV	Gambir Lama II Kemayoran	
2015	150kV	Kandangsapi II Kandangsapi	
2015	150kV	Kebonsirih III Kebonsirih II	
2015	150kV	Kracak II Kedung Badak	
2015	150kV	Pengilingan III Marunda	
2015	150kV	Tangerang Barui III Tangerang Baru II	
2016	150kV	Batu Kuwung PLTP Menes	
2016	150kV	Bogor III Inc. (Bgbru-Sntul)	
2016	150kV	Cileungsi II Cibinong	
2016	150kV	Citaman PLTP Endut	
2016	150kV	Endut PLTP Serang	
2016	150kV	Gandaria II Gandaria	
2016	150kV	Gandul II (Inc.(Cwang-Gndul)	
2016	150kV	Grogol III Grogol II	
2016	150kV	Kandang Sapi III Kandang Sapi II	
2016	150kV	Legok II Legok	
2016	150kV	Pondok Indah III Bintaro	
2016	150kV	Taman Rasuna Said III Taman Rasuna Said II	
2016	150kV	Tanah Tinggi II Tanah Tinggi	
2016	150kV	Tigaraksa II Tigaraksa	
2017	150kV	Bogor Kota II Inc. (Bgbru-Ciawi)	
2017	150kV	Cipinang III Cipinang II	

Term	Grade.	Location	Remark
2017	150kV	Citra Habitat III Citra Habitat II	
2017	150kV	Durikosambi III New Durikosambi	
2017	150kV	Muarakarang IV Muarakarang III 150	
2017	150kV	Priok Timur II Priok Timur	
2017	150kV	Teluk Naga III Teluk Naga II	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 11 Transmission line development plan (Java Barat Load system)

Term	Grade.	Location	Remark
2008	150kV	Bandung Selatan - Kamojang	Reconductoring
2008	150kV	Drajat - Garut	
2008	150kV	Garut - Tasikmalaya	
2008	150kV	Kamojang - Drajat	
2008	150kV	Poncol II - Miniatur 150	Uprating
2008	70kV	Wayang Windu - Sentosa	extension bongkaran
2008	150kV	Wayang Windu - Incomer	
2009	150kV	Cianjur - Cigereleng	Reconductoring
2009	150kV	Cikarang Lippo - Inc. (Gdmkr-Cbatul)	
2009	150kV	Cikedung - Inc. (Jtbrg - Hrgls)u	
2009	150kV	Cikijing - Mandirancan	
2009	150kV	Daeuhkolot/Cigereleng II - Inc. (Bdsln-Krcdg)	
2009	150kV	Jabar Utara PLTU - Kosambi Baru	
2009	150kV	Jabar Utara PLTU - Sukamandi	
2009	150kV	Jatiluhur - Padalarang	Reconductoring (T.1-56)
2009	150kV	Padalarang - Bandung Utara	Reconductoring (T.1-56)
2013	150kV	Patuha - Lagadar	
2009	150kV	Sukamandi 150 - Kosambi baru	Rekonduktoring
2009	70kV	Tanggeung - Cianjur	
2010	70kV	Aryawinangun - Palimanan	Reconductoring
2010	150kV	Bekasi Utara/Tarumaneg - Inc. (Bkasi-Ksbru)	
2010	150kV	Braga (GIS) - Cigereleng	
2010	150kV	Cibabat II - Inc. (Cbbat - Cbrem)	
2010	150kV	Cibabat III - Inc. (Pdlrgt - Lgdar)	
2010	150kV	Dago Pakar - Inc.(Bdutr-Ubrng)	
2010	150kV	Jatiluhur II - Inc. (Ksbru-Pdlrg)	
2010	150kV	Kadipaten 150 - Inc. (Rckek-Mdcan)	
2010	150kV	Kanci - Inc. (Sragi-Brbes)	
2010	150kV	Karang Nunggal - Tasikmalaya New	
2010	150kV	Kiaracondong II - Inc. (Krcdg-Ubrng)	
2010	150kV	Malangbong II - New Tasikmalaya	Uprating
2010	150kV	New Tasikmalaya - Ciamis	Reconductoring
2010	150kV	New Ujungberung - Bandung Utara	Reconductoring
2010	150kV	Sukamandi 150 - Pabuaran	Reconductoring
2010	150kV	Sukatani Gobel - Inc. (Bkasi-Ksbru)	
2010	150kV	Teluk Jambe - Cibatu	
2011	150kV	New Ujung Berung - Rancakasumba	
2011	150kV	New Ujung Berung - Ujung Berung	
2011	150kV	Bandung Timur II - Ujungberung	Uprating

Term	Grade.	Location	Remark
2011	150kV	Lagadar - Padalarang	Reconductoring
2011	150kV	Lagadar - Cigereleng	Reconductoring
2011	150kV	Mandirancan - Rancaekek	Reconductoring
2011	150kV	Rancaekek - Ujung Berung	Reconductoring
2011	150kV	Arjawinangun II - Sunyaragi	
2011	150kV	Cirebon (Kit) - Inc.(Sragi-Kbsen)	
2011	150kV	Tambun II - Tambun	
2011	150kV	Tambun III - Inc.(Pncol-Gdria)	
2012	150kV	Padalarang - Cibabat	Reconductoring
2012	150kV	Karaha Bodas PLTP - Garut	
2012	150kV	Cikumpay II - Cikumpay	
2012	150kV	Lagadar II - Incomer (Cnjur-Cgerlg)	
2012	150kV	Padalarang II - Padalarang	
2012	150kV	Rengasdengklok II - Kosambi baru	
2012	150kV	Subang II - Cikmpay	
2013	150kV	Cianjur II - Inc. (Cnjur-Cgrlg)	
2013	150kV	Jababeka II - Jababeka	
2013	150kV	New Lagadar - Lagadar	
2013	150kV	New Tambun - Tambun	
2013	150kV	Pinayungan II - Pinayungan	
2014	150kV	Cisolok PLTP - Pelabuhan Ratu	
2014	150kV	Tangkuban Parahu PLTP - Bandung Utara	
2014	150kV	Majalaya II - Rancakasumba	
2014	150kV	Panyadap II - Inc. (Kmjng-Ckska)	
2014	150kV	Rancaekek II - Rancaekek	
2015	150kV	Bengkok II - Dagopakar	Uprating
2015	150kV	Kosambi Baru II - Inc.(Bkasi-Ksbru)	
2015	150kV	Lembang - Dago	
2016	150kV	Rajamandala PLTA - Inc (Cgrlg-Cnjur)	
2016	150kV	Babakan II - Inc.(Kanci-Ubrng)	
2016	150kV	Dawuan II - Inc. (Ksbru - Jtlhr)	
2016	150kV	Garut II - Garut	
2016	150kV	Kiaracondong III - Kiaracondong II	
2016	150kV	Sumedang Baru - Ujungberung	
2017	150kV	Jatigede PLTA - Inc (Rckek-Sragi)	
2017	150kV	Cangkring II - Sunyaragi	
2017	150kV	Sukamandi II - Inc. (Ksbru-PLTUJabarut	
2017	150kV	Teluk Jambe II - Inc.(Tljbe-Cibatu)	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 12 Transmission line development plan (DIY･Java Tengah Load system)

Term	Grade.	Location	Remark
2008	150kV	Bumi Semarang Baru - Incomer	
2008	150kV	Masaran - Inc. (Palur-Srgen)	
2008	150kV	Mranggen - Inc.(Ungar-Pwddi)	
2008	150kV	Pedan - Kentungan	
2008	150kV	Purbalingga - Inc.(Rwalo-Mrica)	
2009	150kV	Brebes - Sunyaragi	
2009	150kV	Brebes - Kebasen	

Term	Grade.	Location	Remark
2009	150kV	Bumiayu - Kebasen	Reconductoring
2009	150kV	Bumiayu - Kalibakal	Reconductoring
2009	150kV	Jekulo - Kudus	Reconductoring
2009	150kV	Jekulo - Pati	Reconductoring
2009	150kV	Kebasen - Pemalang	Reconductoring
2009	150kV	Pati - Rembang	Reconductoring
2009	150kV	Pekalongan - Batang	Reconductoring
2009	150kV	Pemalang - Pekalongan	Reconductoring
2009	150kV	Rembang - Blora	Reconductoring
2009	150kV	Rembang PLTU - Rembang	
2009	150kV	Wleri - Batang	Reconductoring
2009	150kV	Wonogiri - Wonosar	Reconductoring
2009	150kV	Wonosari - Palur	Reconductoring
2009	150kV	Wonosari - Solo Baru	Reconductoring
2009	150kV	Wonosobo - Secang	Reconductoring
2010	150kV	Bala Pulang/Kebasen II - Inc. (Kbsen-Bmayu)	
2010	150kV	Kudus - Purwodadi	Reconductoring
2010	150kV	New Rawalo - Inc.(Rwalo-Lmnis)	
2010	150kV	New Rawalo - Rawalo Old	
2010	150kV	Purwodadi - Ungaran	Reconductoring
2010	150kV	Temanggung - Wonosobo	Reconductoring
2010	150kV	Ungaran - Krapyak_Weleri	
2010	150kV	Gedongrejo/Palur II - Inc.(Palur-Jajar)	
2010	150kV	New Rawalo - Gombong	
2011	150kV	Pedan - Wonosari	Reconductoring
2011	150kV	Purwodadi - Kudus	Reconductoring
2011	150kV	Wates - Purworejo	Reconductoring
2011	150kV	Tanjung Jati - Sayung	
2012	150kV	Pedan - Klaten	Reconductoring
2012	150kV	Pracimantoro/Muntoronad - Inc.(Pctan-Wngri)	
2013	150kV	Pekalongan II - Pekalongan	
2013	150kV	Pemalang New - Pemalang	
2014	150kV	Ungaran PLTP - Ungaran	
2014	150kV	Kalibakal II - Kalibakal	
2014	150kV	Tambaklorok II - Tambaklorok	
2015	150kV	Jajar II - Inc. (Jajar-Pedan)	
2015	150kV	Jepara II - Jepara	
2015	150kV	Pati II - Pati	
2015	150kV	Sanggrahan II - Sanggrahan	
2016	150kV	Mangunan PLTP - Mrica	
2016	150kV	Slamet PLTP - Rawalo	
2017	150kV	Pandeanlamper II - Pandeanlamper	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 13 Transmission line development plan (Java Timur･Bali Load system)

Term	Grade.	Location	Remark
2008	150kV	Gilimanuk - Pemaron	To be 2 circuit
2008	150kV	Sekarbungu - Kedinding	
2009	150kV	Babat - Tuban	Uprating

Term	Grade.	Location	Remark
2009	150kV	Bambe/Bringkang - Karangpilang	
2009	150kV	Banaran - Suryazigzag	Reconductoring
2009	150kV	Buduran II/Sedati - Inc.(Bngil-Waru)	
2009	150kV	Celukan Bawang PLTU - Incomer (Pmron-Glnuk)	
2009	150kV	Cerme - Inc. (Sgmdu-Lmgan)	
2009	150kV	Grati - Gondangwetan	Reconductoring
2009	150kV	Jatim Selatan PLTU - Pacitan II	
2009	150kV	Jatim Selatan PLTU - Wonogiri	
2009	150kV	Jombang - Jayakertas	
2009	150kV	Kabel Java Madura - Suramadu	
2009	150kV	Kalisari - Surabaya Selatan	
2009	150kV	Kapal - Padangsambian	Reconductoring
2009	150kV	Kedinding - Kalisari	
2009	150kV	Ketapang - Gilimanuk	Reconductoring
2009	150kV	Kraksaan - Probolinggo	Reconductoring
2009	150kV	New Ngimbang - Babat	
2009	150kV	New Ngimbang - Mliwang	
2009	150kV	Paciran/Brondong - Lamongan	
2009	150kV	Pacitan II - Ponorogo	Uprating
2009	150kV	Padangsambian - Pesanggaran	Reconductoring
2009	150kV	Paiton New - Paiton Old	Uprating
2009	150kV	Perak - Ujung	
2009	150kV	Sambi Kerep/Tandes II - Inc.(Waru-Gresik)	
2009	150kV	Simogunung/Gsari - Inc.(Swhan-Waru)	
2009	150kV	Tanjung Awar-awar PLTU - Tuban	
2009	150kV	Tulung Agung II - Kediri	
2009	150kV	Wlingi II - Kediri	
2010	150kV	Banyuwangi - Gilimanuk	To be 3 circuit
2010	150kV	Banyuwangi - Ketapang	Reconductoring
2010	150kV	Blimbing II - Inc. (Pier-Pakis)	
2010	150kV	Celukan Bawang PLTU - Kapal	
2010	150kV	Ponorogo II - Manisrejo	Uprating
2010	150kV	Purwosari/Sukorejo II - Inc. (Pier-Pakis)	
2010	150kV	Waru - Darmo Grand	Reconductoring
2010	150kV	Sidoarjo/Porong II - Bangil	
2011	70kV	Driyorejo - Miwon	Reconductoring
2011	150kV	Gianyar - Amplapura	Reconductoring
2011	150kV	Gilimanuk - Negara	Reconductoring
2011	150kV	Kapal - Gianyar	Reconductoring
2011	150kV	New Kapal - Inc.(Kapal-Antsri)	Reconductoring
2011	150kV	New Porong - Ngoro	
2012	150kV	Antosari - Kapal	Reconductoring
2012	150kV	Negara - Antosari	Reconductoring
2012	150kV	Bedugul - Baturiti	
2012	150kV	New Banyuwangi - Genteng	
2012	150kV	Ponorogo II - New Tulungagung	
2012	150kV	Bali Timur PLTU - Inc.(Gnyar-Ampla)	
2013	150kV	Pesanggaran - Sanur	Reconductoring

Term	Grade.	Location	Remark
2013	150kV	Sanur II - Inc.(Psgrn-Sanur)	
2013	150kV	Madura PLTU - Inc.(Spang-Pksan)	
2014	150kV	Ijen PLTP - Banyuwangi	
2014	150kV	Willis/Ngebel PLTP - Pacitan II	
2016	150kV	Kalikonto PLTA - Bumi Cokro	
2016	150kV	Arjuno PLTP - Mojokerto	
2016	150kV	Iyang Argopuro PLTP - Probolinggo	
2016	150kV	Iyang Argopuro PLTP - Probolinggo	
2017	150kV	Kesamben PLTA - Banaran	
2017	150kV	Turen II - Inc. (Kbagn-Pakis)	
2017	150kV	Turen II - Inc. (Kbagn-Pakis)	
2018	150kV	New Nusa Dua - Nusa Dua	
2018	150kV	New Nusa Dua - Nusa Dua	

Source: Made by JICA Study Team based on RUPTL2009-2018

(2) Sumatra

1) Condition and Prediction

The island of Sumatra is equipped with 150-kV interconnections in all regions, i.e., the 150-kV interconnection between Baganbatu and Rantauprapati, and that between Sumbagut and Sumbagselteng. However, problems have surfaced in the aspect of system stability, and the system is currently being operated with this latter section open. Full interconnection operation will become possible upon completion of the 275-kV transmission line between Payakumbuh and Padangsidempuan, which is slated for 2010.

The start of this 275-kV operation will provide the foundation for system development on Sumatra, because it will enable consolidation of as yet mutually isolated systems and the development of corresponding power sources.

As shown in the table below, all isolated systems on the island except for Kuala Enok in the province of Riau are to be interconnected by 2018. Kuala Enok, too, will probably be interconnected by extension of the system from GI Rangat, provided that the demand steadily expands.

Table 14 Power systems in Sumatra

Wlyh.	System	Remark	Peak Demand forecasting 2008 →2018 (MW)
NAD	Sabang	We island	3.1 → 5.6
	Biangpidie	Be interconnected in 2010	7.3* →
	Tapaktuan	Be interconnected in 2010	25.3* →
	Sinabang	Simeule island	2.6 → 4.7
	Kutacane	Be interconnected in 2010	8.2* →
	Blangkejeran		2.3 → 4.3
	Subulussalam	Be interconnected in 2009	9.2* →
	Takengon	Be interconnected in 2009	14.5* →
	Meulaboh	Be interconnected in 2010	14.3 →
Riau	Siak		7.5 → 20.2
	Rengat	Be interconnected in 2011	14.0* →
	Tembilahan	Be interconnected in 2012	8.6* →
	Kuala Enok		1.7 → 6.1
	Bagan Siapi-Api	Be interconnected in 2012	5.6* →
	Selat Panjang	Tebingtinggi island	7.7 → 21.2
	Bangkails	Bengkail island	8.8 → 27.2
	Tanjung Pinang	Bintan island, Be interconnected in 2010	42.3* →
	Tanjung Uban	Bintan island, Be interconnected in 2010	24.3* →
	Tanjung Balai Karimun	Kalimun island	17.8 → 53.8
	Tanjung Batu	Kundur island	4.8 → 14.7
Babel	Bangka	Bangka island, Be interconnected in the island	66.0 → 123.4
	Tanjung Pandan	Belitung island, Be interconnected in the island	17.1 → 29.1

Note; figure given in ( ) is summation of demand of each isolated system
Not considered diversity factor
N* means reference before interconnected
Source: RUPTL2009-2018

Source: RUPTL2009-2018

Figure 3 Power systems in Sumatra

2) Review

A check was made of RUPTL 2009 - 2018. The notable points are as follows.

The review of the transmission line development plan was made on the basis of the items noted in the results of the Sumatra system power flow calculation in Supplement B.1.8 in RUPTL.

Full interconnected operation will become possible with construction of the 275-kV transmission line between Payakumbuh and Padangsidempuan, which is slated for completion in 2010.

The basic direction of 275-kV power flow in the Sumatra system is from the sourth (Kalselteng) to the north (Sulut). Because of the long distance involved, there is a need for studies not only on the constraints deriving from transmission line thermal capacity but also the those associated with transmissible power flow as viewed from the perspective of stability.

In 2010, the plans call for a voltage increase to 275 kV on lines currently operated at 150 kV, specifically, Lahat-Lubuk Linggau-Bangko-Muara Bungo-Kiliranjao. They also stipulate addition of 275-kV transmission lines in the northern direction, in the Kiliranjao-Payakumbuh-Padang and Sidempuan-Sarulla-Simangkok-Galang-Binjai-PLTU Pangkalan Susu sections.

In this section, Asahan-1 (180MW) has been brought on line, and the system is characterized by adoption of the 275-kV voltage class for power source lines. There are no problems with the power source line plans.

In 2014, a 275-kV transmission line is to be added in the Musala Enim-Payakumuh section (eastern route) to form a looped system in response to the increased 275-kV power flow from south to north. The results of the power flow calculation in this year indicated no problems with the power flow on the eastern and western routes, where the maximum value would reach 460 MW (in the PLTU Bayung Lincir-Aur Duri section) and 361 MW (in the Kiliranjao-Payakumbuh section), respectively. Asahan-3 (174 MW in 2012) is to come on line by this year.

In 2018, the power flow will reach 472 MW in the eastern route (in the PLTU Bayung Lincir-Aur Duri section) and 550 MW in the western route (in the Bangko-Muara Bungo section), and would be from south to north (306 MW). The source to be brought on line in this year is the aforementioned PLTA Merangin (350 MW).

The 275-kV transmission line sections to be interconnected by this year are Pangkalan Susu-Sigli and PLTU Meulaboh-Sigli. The voltage represents an increase on lines currently operated at 150 kV.

PLTU Merangin is also to be brought on line by this year. A check of power source line construction indicated that it would be accessed by GI Bangko, the nearest extra high voltage substation. Nevertheless, it is also necessary to consider access in combination with PLTP Sungai Penuh (110 MW, 2013 and 2014). The plan is to first construct the transmission line for the PLTP facility coming on line in 2013 and 2014, and then to interconnect Merangin with this transmission line by feeder. The load in the PLTP Sungai Penuh-Bangko section consists solely of GI Sungai Penuh, and this substation will have a transformer capacity of 60 MVA in this year. Caution is required because of the risk that the transmission line will not be able to withstand full output from two substations unless the load is dropped to a certain extent at GI Sungai Penuh, considering the thermal capacity power flow constraints on this line.

Overall, in the Sumatra 275-kV system, the basic specification for transmission lines is ZEBRA x 2, and the upper limit for power flow is about 620 MVA due to the constraints on thermal capacity. The results of the power flow calculation seem to indicate that there are no problems, but it must be remembered that the transmission lines would run the length of Sumatra island. It would therefore be advisable to make in-depth studies on the power flow constraints in the interest of stability, in cases such as failure of a single circuit at peak power flow.

Another item of special note is the Sumatra-Java interconnection. The plan is to install two 500-kV circuits between Musi Rawas and Bangko Tengah (a distance of 120 km) and an HVDC circuit between Bangko Tengah and Kepatang (a distance of 400 km).

For reference purposes, the isolated systems on the Riau islands and the islands of Bangka and Belitung are taken up below.

The major systems on the Riau islands are the Tanjung Pinang system on Bintan island and the Tanjung Balai Karimun system on Kalimun island. The former has fallen into a state of power shortage, and there are plans to maintain the supply-demand balance until 2012 by introducing a rental PLTD (3 MW) and mobile PLTU (coal-fired, 30 MW). The medium-term plans envision interconnection with the Batam system by means of 150-kV undersea cable (two circuits, 130 MVA). The source of power supply by this system interconnection is to be PLTU (coal-fired) Tanjung Kasam (slated for introduction in the Batam system in 2010).

The plans envision interconnection between Batam and Bintan in advance of this interconnection and extension to the Tanjung Pinang system in 2018.

The Tanjung Balai Karimun system has similarly fallen into a state of power shortage, and PLTD sources (5 MW and 10 MW) are to be introduced over the short term. Over the medium and long terms, there are plans to introduce PLTU Tanjung Balai Karmum (2 x 7 MW, to be brought on line in 2010 as part of Fast Track Phase I), in order to maintain the power balance while aiming for the phase-out of oil-fired sources. Also on the schedule is the introduction of an IPP PLTU (2 x 2 MW) in 2010 and another PLTU (3 x 10 MW) in 2014.

As for the Bangka and Belitung systems, the Bangka system on Bangka island and the Tanjung Pandan system on Belitung island are not interconnected at present, and both are saddled with a power shortage.

In response, there is a plan to add capacity of 19.5 MW by rental PLTD for the Bangka system, as well as Air Anyer (2 x 25 MW) in 2010 as part of Fast Track Phase I. There are also plans for

IPP sources, each of which is to come on line in 2013.

The Tanjung Pandan system is also marked by a power shortage, and rental PLTD (4 MW) is being introduced. Over the medium and long terms, there are plans for introduction of the PLTU Beliktung Baru (30 MW) source as part of Fast Track Phase I. This, plus the introduction of a 26-MW IPP source, is scheduled to right the supply-demand balance.

Table 15 Transmission line development plan (Sumatra 500kVExtra high voltage system)

Area	Term	Location	Remark
Sumsel	2016	Musi Rawas - Bangko Tengah	
Lampung	2016	Bangko Tengah – Ketapang	HVDC

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 16 Transmission line development plan (Sumatra 275kVExtra high voltage system)

Area	Term	Location	Remark
Sumbar	2010	Kiliranjao – Payakumbuh	
Sumut	2010	Padang Sidempuan – Payakumbuh	
Sumut	2010	Padang Sidempuan - PLTP Sarulla	
Sumut	2010	PLTP Sarulla – Simangkok	
Sumut	**2010**	**PLTA Asahan 1 - Simangkok**	**Power line for Hydro**
Sumut	2010	Simangkok - Galang	
Sumut	2010	Galang – Binjai	
Sumut	2010	Binjai - PLTU Pangkalan Susu	
Riau	2010	Garuda Sakti – Payakumbuh	
S2JB	2014	Betung - Aur Duri	
S2JB	2014	PLTU Sumsel-5 (B.Lencir) - Incomer 2 PI	
S2JB	2014	Aur Duri – Rengat	
Riau	2014	Rengat - Garuda Sakti	
S2JB	2016	Lahat – Gumawang	
S2JB	2016	Bangko Tengah - Incomer (Lahat - Gumawang)	
S2JB	2016	Bangko Tengah – Betung	
NAD	2016	Pangkalan Susu – Sigi	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 17 Transmission line development plan (NAD Load system)

Term	Grade.	Location	Remark
2009	150kV	Panton Labu - Incomer (Idi -Lhok Seumawe)	
2009	150kV	Takengon - PLTA Peusangan	
2009	**150kV**	**PLTA Peusangan 1 - PLTA Peusangan 2**	**Power line for Hydro**
2009	**150kV**	**PLTA Peusangan 2 - Bireun**	**Power line for Hydro**
2009	150kV	Sidikalang - Subulussalam	
2010	150kV	Meulaboh - Sigli	Construced with 275kV design
2010	150kV	PLTU Meulaboh - Meulaboh	
2010	150kV	Meulaboh - Blang Pidie	
2010	150kV	Brastagi - Kuta Cane	
2010	150kV	Jantho - Incomer (Sigli -Banda Aceh)	
2010	150kV	Blang Pidie - Tapak Tuan	
2012	150kV	Cot Trueng - Incomer (Bireun - Lhokseumawe)	
2012	**150kV**	**Takengon - PLTA Peusangan 1**	**Power line for Hydro**
2012	150kV	PLTP Seulawah - 2pi Incomer (Sigli - Banda Aceh)	

Term	Grade.	Location	Remark
2014	150kV	Banda Aceh - Krueng Raya	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 18 Transmission line development plan (Sumut Load system)

Term	Grade.	Location	Remark
2008	150kV	PLTU Labuhan Angin - Sibolga	
2009	150kV	Dolok Sanggul - Incomer (Tele - Tarutung)	
2009	150kV	Tanjung Marowa - Kuala Namu	
2010	150kV	Galang - Namurambe	
2010	150kV	Galang - Tanj. Marowa	
2010	150kV	P. Sidempuan - Panyabungan	
2010	150kV	Lima Puluh - Incomer (K.Tanjung -Kisaran)	
2010	150kV	Kuala Namu - Incomer (Sei Rotan - Perbaungan)	
2010	150kV	Porsea - Simangkok	
2010	150kV	PLTU Kuala Tanjung - Kuala Tanjung	
2010	**150kV**	**PLTA Asahan3 - Simangkok**	**Power line for Hydro**
2012	150kV	Tanjung Pura - Incomer (Binjai - P.Brandan)	
2012	150kV	KIM - KIM 2	
2012	150kV	KIM - Medan Pancing	
2012	150kV	KIM 2 - Medan Selayang	
2012	150kV	PLTU Sumut Infrastructure - *am*otma	
2015	150kV	Lamhotma - Labuhan(uprating to 1x240mm2)	1cct, Related PLTU Sumut
2015	150kV	Labuhan - Belawan(uprating to 1x240mm2)	1st circuit, Related PLTU Sumut
2015	150kV	Lamhotma - Belawan	2nd circuit, Related PLTU Sumut
2015	150kV	PLTU Paluh Merbau - Belawan PLTGU	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 19 Transmission line development plan (Sumbar Load system)

Term	Grade.	Location	Remark
2008	150kV	Sumbar Indarung – Bungus	
2008	150kV	Maninjau - Simpang Empat	
2010	150kV	Maninjau - Padang Luar	
2010	150kV	Padang - Luar Payakumbuh	
2010	**150kV**	**Bangko - Sungai Penuh**	**Power line for Hydro(Merangin)**
2010	150kV	PLTU Sumbar Pesel - Bungus	
2011	150kV	PLTP Sungai Penuh - Sungai Penuh	
2011	150kV	Bungus - Kambang	
2011	150kV	Pariaman - Incomer (L.Alung - Maninjau)	
2011	150kV	Kiliranjao - Teluk Kuantan	2nd circuit
2011	150kV	PLTP Kerinci - Incomer (Bangko - Sungai Penuh)	
2017	150kV	PLTP Gunung - Talang Solok	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 20 Transmission line development plan (Riau Load system)

Term	Grade.	Location	Remark
2008	150kV	Duri - Bagan Batu	2nd circiut
2009	150kV	Garuda Sakti - Kulim/Pasir Putih	
2010	150kV	Bangkinang - Pasir Pangaraian	
2010	150kV	Garuda Sakti - New Garuda Sakti	
2010	150kV	Dumai - KID Dumai/New Dumai	
2010	150kV	Tanjung Kasang - Tanjung Sauh	Undersea cable (Batam-Bintan)

Term	Grade.	Location	Remark
2010	150kV	Tanjung Sauh - Pulau Ngenang	Batam - Bintan
2010	150kV	Pulau Ngenang - Tanjung Taluk	Undersea cable (Batam-Bintan)
2010	150kV	Tanjung Taluk - Sribintan	Bintan island
2010	150kV	Sribintan - Air Raja	Bintan island
2011	150kV	Teluk Kuantan - Rengat	
2012	150kV	Dumai - Bagan Siapi-api	
2012	150kV	Kulim/Pasir Putih - Perawang	
2012	150kV	Kulim/Pasir Putih - Pangkalan Kerinci	
2012	150kV	Rengat - Tembilahan	
2012	150kV	Pangkalan Kerinci - Rengat	
2016	150kV	PLTU Cirenti - Incomer(Teluk Kuantan - Rengat)	4circuits

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 21 Transmission line development plan (S2JB Load system)

Term	Grade.	Location	Remark
2008	150kV	Borang – Mariana	
2008	150kV	Muara Bulian - Incomer (M.Bungo - Aur Duri)	
2008	150kV	PLTG Sengeti - Incomer (Aur Duri - Payo Selincah)	
2008	70kV	Pekalongan 70 - Sukamerindu 70 (Uprating)	Uprating to TACSR 185 mm2
2008	150kV	Bukit Asam - Lahat	Uprating to 1 x 240 mm2
2009	150kV	Tanjung Api api - Borang	
2009	150kV	Pagar Alam - Manna	1st circuit
2009	150kV	Lahat - Pagar Alam	
2010	150kV	Betung - Sekayu	1st circuit
2010	150kV	Talang Kelapa - Betung	2nd circuit
2010	150kV	Sarolangun - Bangko	1st circuit
2010	150kV	Kambang - Mukomuko	1st circuit
2010	150kV	Mariana - Kayu Agung	1st circuit
2010	150kV	Jaka Baring - Incomer (Keramasan - Mariana)	
2010	150kV	Pekalongan/Curup - Pulo Baai	
2011	150kV	Betung - Aur Duri	Constructed with 275kV design
2011	150kV	PLTP Lumut - Balai Lahat	
2011	150kV	PLTU Sumsel-4 (S. Belimbing) - Lahat	
2011	150kV	PLTU Sumsel-1 (Banjarsari) - Incomer (PLTU S.Belimbing - Lahat)	
2012	150kV	PLTP Hulu Lais - Pekalongan	
2012	150kV	Baturaja - Muara Dua	1st circuit
2012	150kV	PLTU Sumsel-2 (Baturaja) - Baturaja	
2013	150kV	Lubuk Linggau - Muara Rupit	1st circuit
2017	150kV	PLTU Sumsel-3 (Banyuasin) Betung	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 22 Transmission line development plan (Lampung Load system)

Term	Grade.	Location	Remark
2008	150kV	Menggala - Gumawang	1circuit
2008	150kV	Sukarame - Incomer (Sutami - Natar)	
2008	150kV	Blambangan Umpu - Incomer (Baturaja - B.Kemuning)	
2009	150kV	Sribawono - Seputih Banyak	
2009	150kV	Bukit Kemuning - Kotabumi	Uprating
2010	150kV	PLTU Tarahan - Baru Incomer (New Tarahan - Kalianda)	
2010	150kV	Pagelaran - Kota Agung	

Term	Grade.	Location	Remark
2010	150kV	Liwa - Incomer (B.Kemuning - Besai)	
2011	150kV	PLTP Ulu Belu - pi Incomer (Pagelaran-Batutegi)	
2012	150kV	Gumawang - Menggala	2nd circuit
2012	150kV	Menggala - Seputih Banyak	
2012	150kV	Natar - Gedong Tataan	1circuit
2012	150kV	PLTP Rajabasa - Kalianda	
2013	150kV	Teluk Betung - Teluk Ratai	
2014	150kV	Kalianda - Bakauheni	
2014	150kV	PLTP Wai Ratai - Teluk Ratai	
2015	150kV	Menggala - Simpang Pematang	1circuit
2016	150kV	Pakuan Ratu - Incomer (Gumawang - Menggala)	
2017	150kV	Sukadana - Incomer (S.Banyak - Sribawono)	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 23 Transmission line development plan (Babel Load system)

Area	Term	Grade.	Location	Remark
Bangka	2009	150kV	Air Anyir - Pangkal Pinang	
Bangka	2009	150kV	Air Anyir - Sungai Liat	
Belitung	2009	70kV	Suge - Tanjung Pandan/Dukong	
Bangka	2010	150kV	Pangkal Pinang - Kelapa	
Bangka	2010	150kV	Pangkal Pinang - Air Gegas	

Source: Made by JICA Study Team based on RUPTL2009-2018

(3) Kalimantan

1) Condition and Prediction

The major systems on the island of Kalimantan are the Khatulistiwa system centered around West Kalimantan Pontianak; the Kalselteng system centered around Central Kalimantan Palangkaraya and South Kalimantan Banjarmasin; and the Kaltim system centered around East Kalimantan Samarinda and Balikpapan. In addition to these systems on tthe coast, there are several isolated systems in the interior.

On Tarakan island, the system is operated by PT Pelayanan Listrik Nasional Tarakan, a PLN affiliate.

Table 24 Power systems in Kalimmantan

Wlyh.	System	Remark	Peak Demand forecasting 2008 →2018 (MW)
Kalibar	Khatulistiwa		(317) → 562
	Sanggau	Be interconnected within Khatulistiwa system in 2011	45.1* →
	Sintang	Be interconnected within Khatulistiwa system in 2014	82.5* →
	Putussibau		4.1 → 11.5
	Ketapang	Be interconnected within Khatulistiwa system in 2016	18.3* →
Kalselteng	Kota Baru	Laut island	6.9 → 19.3
	Batulicin	Be interconnected within Kalselteng-Tim distribution system in 2010	8.2 →
	Buntok	Be interconnected within Kalselteng-Tim distribution system in 2011	5.1* →
	Muara Teweh	Be interconnected within Kalselteng-Tim system in 2012	4.7* →
	Kuala Pambuang		1.8 → 4.0
	Sampit	Be interconnected within Kalselteng-Tim distribution system in 2010	17.2* →
	Pangkalan Bun	Be interconnected within Kalselteng-Tim distribution system in 2012	15.5* →
	Kasongan	Be interconnected within Kalselteng-Tim distribution system in 2011	6.23* →
	Kalselteng-Tim	Be interconnected in 2009	(562) → 1486

Kaltim	Bontang	Be interconnected with Kalselteng-Tim system in 2011	15.6 →
	Sangata	Be interconnected with Kalselteng-Tim system in 2011	9.1 →
	Kota Bangun		1.7 → 4.5
	Melak		4.7 → 12.5
	Tanah Grogot	Be interconnected with Kalselteng-Tim system in 2009	6.8* →
	Petung	Be interconnected within Kalselteng-Tim system in 2010	7.2* →
	Nunukan	Nunukan island	5.1 → 13.9
	Berau		9.4 → 22.6
	Tanjung Selor		5.2 → 13.7
	Malinau		3.0 → 8.2

Note; figure given in ( ) is summation of demand of each isolated system
Not considered diversity factor
N* means reference before interconnected
Source: RUPTL2009-2018

Source: Made by JICA Study Team based on RUPTL2009-2018

Figure 4　Location of Power systems in Kalimantan

2)　Review

A check was made of RUPTL 2009 - 2018.　The notable points are as follows.

The key components of the plan for reinforcement of the system on Kalimantan are interconnection of the Kalselteng and Kaltim systems in 2014, and interconnection for international power interchange[3] between the Kalbar system and the system of the Sarawak power company in Malaysia, by means of 275-kV transmission lines.

[3] Power is to be imported (purchased) from the Bakun hydropower plant. The issue is whether to make the power interchange in advance, to hedge the risk of delay in input of the PLTU (IPP) applying LRC in the Kalbar system.
The Bakun hydropower plant is expected to serve as a source for interconnection (Sarawak-Tenaga) between Kalimantan and the Malay peninsula

There are no particular indications to make about the Kalselten-Kaltim interconnection.

Regarding the Kalbar system, the plans call for construction of a 275-kV trunk transmission line between Sarawak and Bengkawang, and supply of power to Pontianak and Singkawang, the major points in the system. In addition, there are plans to extend 150-kV transmission lines for interconnection of isolated systems in the interior. Also under study is installation of reactors at the substations on the end of the extension to compensate for reactive power due to the long-distance transmission. The extensions will have an extended length of 300 km, and there are no power sources en route. As such, careful checks must be made of stability in the event of failures on one circuit.

There are plans for development of PLTA Kusan in the Kalselteng system in 2015. The transmission line development plans include a two-circuit line toward Batulicin and another toward Barkin for the rated capacity of 65 MW. With an extended length of some 400 km, this line will entail a heavy load of construction work. It may also be observed that the plan is excessive for the level of rated capacity.

Table 25 Transmission line development plan (Kalbar)

Term	Grade.	Location	Remark
2008	150kV	Parit Baru - Kota Baru	
2009	150kV	Singkawang - Sambas	
2009	150kV	Sei Raya - Kota Baru	
2010	150kV	PLTU Singkawang (Perpres)/Kura2 - Incomer 2 phi	
2010	150kV	Siantan - Tayan	
2011	150kV	PLTU Gambut Pontianak (IPP) - Mempawah	
2011	150kV	Tayan - Sanggau	
2011	150kV	PLTU Parit Baru (IPP) - Parit Baru	
2012	150kV	Singkawang - Bengkayang	
2013	150kV	Bengkayang - Ngabang	
2013	150kV	Sanggau - Sekadau	
2013	150kV	Ngabang - Tayan	
2014	150kV	Sintang - Sekadau	
2014	275kV	Singkawang - Mambong	Interconnection to Sarawak
2015	150kV	Sintang - Naga Pinoh	
2016	150kV	Pangkalan Bun Ketapang	
2017	150kV	Ketapang - Sukadana	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 26 Transmission line development plan (Kalselteng)

Term	Grade.	Location	Remark
2009	150kV	Barikin - Tanjung	Intrc. to Kaltim, 2006 in RUPTL2006
2009	150kV	Tanjung - Perbatasan	Intrc. to Kaltim, 2006 in RUPTL2006
2009	150kV	Barikin - Amuntai	
2009	150kV	Seberang Barito - Kayutagi	Kayutagi-Trisakti
2010	150kV	Asam-asam - Batu licin	2008 in RUPTL2006
2010	150kV	Palangkaraya - Sampit	2010 in RUPTL2006
2010	150kV	PLTU Asam-asam (Perpres) - Mantuil	
2010	150kV	PLTU P.Pisau (Perpres)/Selat - Incomer 2 phi	2006 in RUPTL2006

Term	Grade.	Location	Remark
2011	150kV	Kasongan (Sampit - Praya) - Incomer phi	
2011	150kV	Tanjung - Buntok	
2011	150kV	PLTU M. Tambang Kalsel-1(IPP) - Rantau	
2011	150kV	PLTGU Muara Teweh - Buntok	
2012	150kV	Sampit - Pangkalan Bun	2012 in RUPTL2006
2012	150kV	Rantau (Barikin - Cempaka) - Incomer 2 phi	
2015	150kV	PLTU M. Tambang Kalsel-2(IPP) - Tanjung	
2015	**150kV**	**PLTA Kusan - Batu Licin**	**Power line for Hydro**
2015	**150kV**	**PLTA Kusan - Barikin**	**Power line for Hydro**

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 27 Transmission line development plan (Kaltim)

Term	Grade.	Location	Remark
2008	150kV	Bukuan - Sambutan	
2009	150kV	Harapan Baru - Bukuan	Uprating
2009	150kV	Karang Joang - Kuaro	Interconnecting to Kalselteng
2009	150kV	Kuaro - Perbatasan	Interconnecting to Kalselteng
2009	150kV	Muara Java - Incomer 2 phi	
2010	150kV	Bontang - Sambutan	
2010	150kV	Petung - Incomer 2 phi	
2010	150kV	PLTG Senipah (IPP) - Muara Java	
2011	150kV	Bontang - Sangata	
2011	150kV	PLTU Kaltim/Kemitraan (IPP) - Muara Java	
2011	150kV	PLTU Muara Java (Perpres) - Muara Java	
2012	150kV	Berau - Tanjung Selor	
2013	150kV	PLTU New Kaltim (Perpres) - Muara Java/Senipah	
2013	150kV	Industri - New Industri	
2014	150kV	Muara Java - Industri Baru	
2014	150kV	Sembera - Embalut(Tanjung Batu)	

Source: Made by JICA Study Team based on RUPTL2009-2018

(4) Sulawesi

1) Condition and Prediction

The major systems on the island of Sulawesi are the South Sulawesi (Sumatra Selatan: Sulsel) system, whose major center of consumption is Makassar, and the North Sulawesi (Sulawesi Utara: Sulut) system, whose major city is Manado. These systems are situated at the northern and southern tips of the island, respectively, and are not interconnected. In addition, there are some isolated systems.

Table 28 Power systems in Sulawesi

Wlyh.	System	Remark	Peak Demand forecasting 2008 →2018 (MW)
Sulselra	Sulsel	Southern	(716.8) → 1520
	Kendari	Southeastern, around Kendari Be interconnected within Sulsel system in 2012	195.6* →
	Kolaka	Southeastern, around Kolaka Be interconnected within Sulsel system in 2012	10.2* →
	Selayar	Selayar island	11.4 → 31.8
	Raha	Muna island	5.3 → 15.7
	Bau-Bau	Buton island	11.4 → 32.5

	Wangi-Wangi	Wangiwangi island	1.3 → 4.3
Sulutteng	Sulut	Northern	140 → 392
	Gorontalo	Norethern, around Gorontalo Be interconnected with Marisa and Buroko system in 2010	28.9* →
	Palu	Central, around Palu Be interconnected with Parigi and Poso system in 2010	50* →
	Molibagu	Northern	19 → 5.3
	Tafuna	Sangihe Besar island	5.7 → 15.7
	Luwuk	Central, around Luwuk	10.8 → 30.4
	Toli-Toli	Northern, around Tolitoli	6.4 → 18.1
	Loek	Northern, east of Tolitoli	3.3 → 9.3
	Moutong	Northern, south of Tolitoli	4.8 → 13.6
	Kolonedale	Central	2.1 → 5.7

Note; figure given in ( ) is summation of demand of each isolated system
Not considered diversity factor
N* means reference before interconnected
Source: RUPTL2009-2018

Source: Made by JICA Study Team based on RUPTL2009-2018

Figure 5 Location of Power systems in Sulawesi

2) Review

A check was made of RUPTL 2009 - 2018. The notable points are as follows

As noted in the existing JICA study[4], the plans for reinforcement of the system in Sulawesi rest on system interconnection (consolidation) in the northern as well as southern halves.

The studies concerning interconnection of the Sulut and Gorontalo systems in North Sulawesi have been properly executed.

4 Planning Study for Optimal Power Source Development on the Island of Sulawesi, Indonesia (2008)

It is thought that caution is required in handling the results of the study concerning system interconnection in South Sulawesi, and specifically interconnection of the Sulsel and Kolaka-Kendari systems. The plans target interconnection in 2011, but are based on installation of a 150-kV line. If so, there would be a 150-kV system stretching for a distance of more than 1,000 km, from Makassar to Kendari.

A particular focus is the 250-km leg between Malili and Kolaka. Although a balance is maintained in normal operation due to the light power flow, problems of system stability could result if a single circuit is tripped on the long-distance transmission line. Points such as these require in-depth study[5].

The existing JICA study also contains mention of a plan for construction of a 275-kV transmission line linking Palopo, Wutu, and Poso. Examinations of this study likewise adopt a 275-kV transmission line for the interconnection between the Sulsei and Kolaka-Kendari systems.

As for other points, it may be noted that, in the results of the peak power flow calculation in each year in the plans, the power factor is basically about 0.87 at each major substation. The plans for systems, and particularly for facilities related to regulation of reactive power, ought to target a power factor of about 0.90.

The plans for development of hydropower sources in the Central Sulawesi-Palu system envision input of PLTA Poso in 2011 and PLTA Malea, Bakaru-2, Bonto Batu, and Poko-2 in 2013 and succeeding years. There are no particular problems with the design for these plants. However, there is no indication of plans for construction of power source lines for PLTA Solewana 1, 2, and 3 (with a combined capacity of 54 MW) and PLTA Palu (30 MW) in the Palu system in Central Sulawesi. Improvement is required in this respect.

PLTA Mobuya[6], which is on the list in the plan for power source development in the Sulutenggo system, is not in this table because the interconnection will be a 20-kV line.

There are no plans for interconnection of the Palu and Sulsel systems up to and including 2018.

Table 29 Transmission line development plan (Sulutenggo)

Term	Grade.	Location	Remark
2008	150kV	Lopana - Kotamubagu/Otam	
2008	70kV	PLTU PJPP – Parigi	
2008	70kV	Parigi – Talise	
2009	70kV	Lopana - telling	150kV designed
2009	150kV	PLTU Gorontalo Energi(IPP) – Botupingge	
2009	150kV	Isimu – Botuppingge	
2010	150kV	Isimu – marissa	

5 RUPTL 2006 - 2015 merely notes the construction of a 150-kV line (2 circuits, 2HAWK, 400 km) between Malili and Lasusua-Kolaka in 2011. It does not contain any detailed specifications for construction of 275-kV transmission lines.
6 One of the cascade power stations in the Poigar river basin, It was brought on line as an IPP source and is managed as a PLTM.

Term	Grade.	Location	Remark
2010	150kV	PLTU Gtalo(Perpres)/Kwandang – Incomer	
2010	150kV	Isimu – Buroko	
2010	150kV	PLTU2 Sulut(Perpres) – Lopana	
2010	150kV	Ranomut Baru 150kV(Paniki) - Bitung Baru 150kV (Kema)	
2010	150kV	Kotamobagu/Otam - Lolak(New)	
2010	150kV	Talise - Pasang Kayu	
2011	**150kV**	**PLTA Poso – Parigi**	
2011	150kV	Lolak – Buroko	
2011	150kV	Bintauna – Tapping	
2011	150kV	PLTU Palu(Kemitraan) - Incomer(Talise - Pasang Kayu)	
2011	150kV	PLTP Kotamobagu - Kotamobagu/Otam	
2011	70kV	PLTU Infrastructure(IPP) - Incomer(Bitung - Sawangan)	
2014	150kV	PLTU Sulut(IPP) - PLTU2 Sulut(Perpres)	
2018	150kV	New PLTU - PLTU2 Sulut(IPP)	

Source: Made by JICA Study Team based on RUPTL2009-2018

Table 30 Transmission line development plan (Sulselra)

Term	Grade.	Location	Remark
2008	150kV	Majere - Mamuju	
2009	150kV	Sidrap - Maros(New)	
2009	150kV	Maros(New) - Sugguminasa	
2009	150kV	Tanjungbunga - Bontoala	Cable
2010	150kV	Sengkang - Siwa/Kera(New)	
2010	150kV	Siwa/Kera(New) - Palopo	
2010	150kV	Sengkang - Sidrap	
2010	150kV	Tallo Lama - Bontoala	Cable
2010	150kV	PLTU Sulsel (Perpres)/Baru - Incomer 2 phi	
2010	150kV	PLTU NII Tasana - Kendari	
2011	150kV	Mamuju - Pasang Kayu	
2011	150kV	Kendari - Unahaa(New)	
2011	150kV	PLTU Kolaka(Perpres tambahan) - Kolaka	
2011	150kV	PLTU Takalar(Prepres 2) - Tip. 157	
2011	150kV	PLTU Takalar(Prepres 2) - Tip. 158	
2012	150kV	Palopo - Wotu(New)	
2012	150kV	Wotu(New) - Malili(New)	
2012	150kV	Unahaa - Kolaka(New)	
2013	150kV	PLTU Jeneponto(IPP-Bosowa) - PLTU Takalar(Perpres2)	
2013	**150kV**	**PLTA Malea - Makale**	**Power line for Hydro**
2015	**150kV**	**PLTA Bakaru-2 - Sidrap**	**Ditto,**
2016	**150kV**	**PLTA Bonto Batu - Makale**	**Ditto.**
2016	**150kV**	**PLTA Poko - PLTA Bakaru2**	**Ditto,**
2017	150kV	PLTU Lakatong(IPP) - Takalar	
2017	150kV	New PLTU - Takalar	

Source: Made by JICA Study Team based on RUPTL2009-2018

(5) Maluku

1) Condition and Prediction

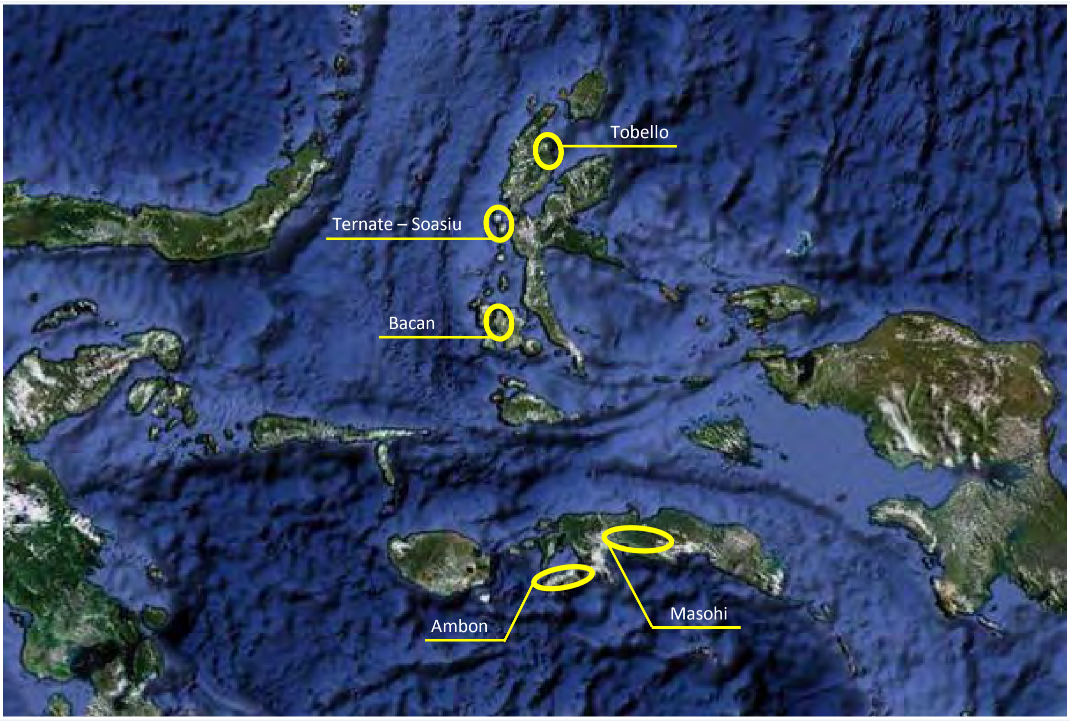
The systems in Wilayah Maluku, which has jurisdiction over Maluku and North Maluku provinces, are scattered isolated ones given the geographical configuration of the islands.

The biggest demand belongs to the Ambon system. The other systems all have small demands on about the same scale. Ternate and Tidore systems, which distance between them is around 3km, are interconnected with a 20-kV distribution line.

Table 31 Power systems in Maluku

Wlyh.	System	Remark	Peak Demand forecasting 2008 →2018 (MW)
Maluku	Ambon	Ambon island, Maluku	35.9 → 87.9
	Ternate – Soasiu	Ternate – Tidore islands, North Maluku	(19.3) → 45.7
	Tual	Kai Kecil island, Maluku	5.4 → 9.5
	Tobello	Halmahera island, North Maluku	4.0 → 8.7
	Masohi	Seram island, Maluku	5.2 → 13.6
	Bacan	Bacan island, North Maluku	1.9 → 5.6

Note; figure given in ( ) is summation of demand of each isolated system
Not considered diversity factor
Source: RUPTL2009-2018



Source: Made by JICA Study Team based on RUPTL2009-2018 leveraged google

Figure 6 Location of Power systems in Maluku

2) Review

A check was made of RUPTL 2009 - 2018. The notable points are as follows.

The plan for system reinforcement in Maluku is being implemented for the Ambon system. The key components are the formation of a looped system with the PLTU Waai power source line (one circuit) and installation of the PLTA Isal-2 power source line (two circuits). There are no particular problems with the plan for transmission line development.

Table 32 Transmission line development plan (Maluku)

Term	Grade.	Location	Remark
2010	70kV	PLTU Waai - Sirimao	Ambon system (Ambon island), 1st circuit
2010	70kV	PLTU Waai - Passo	Ambon system (Ambon island) 1st circuit
2010	70kV	Passo – Sirimao	Ambon system (Ambon island) 1st circuit
2011	70kV	Masohi – Kairatu	Ambon system (Ambon island) 2nd circuit
2014	**70kV**	**PLTA Isal-2 – Masohi**	**Masohi system (Seram island), Power line for Hydro**

Source: Made by JICA Study Team based on RUPTL2009-2018

(6) Papua (Irian Jaya)

1) Condition and Prediction

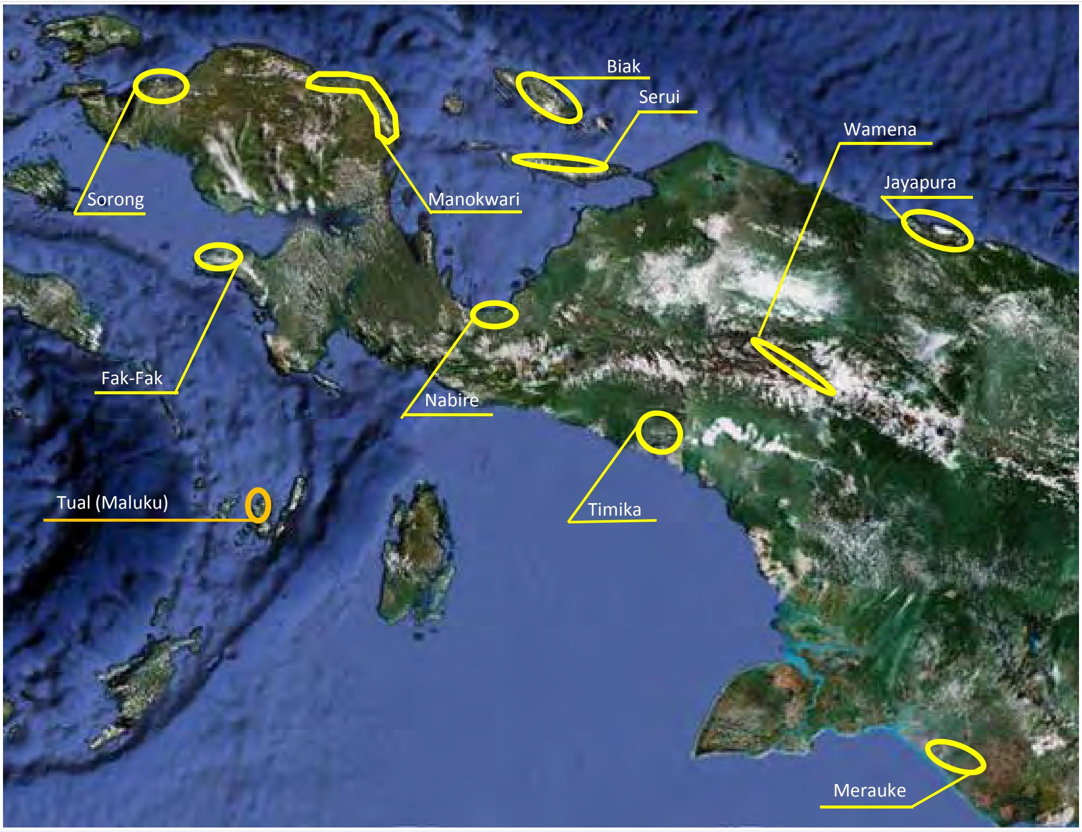
The systems in Wilayah Papua, which has jurisdiction over Papua and West Papua provinces, do not have any large-scale interconnections. There are only isolated systems, as noted below.

The biggest demand belongs to the Jayapura system. The other systems all have small demands on about the same scale (with the exception of remote islands), and present long interconnection distances of at least 200 km.

Table 33 Power system in Papua

Wlyh.	System	Remark	Peak Demand forecasting 2008 →2018 (MW)
Papua	Jayapura		37.0 → 79.1
	Biak	Biak island	7.6 → 16.3
	Serui	Yapen island	3.3 → 7.0
	Sorong		18.8 → 40.2
	Wamena		2.0 → 4.3
	Merauke		8.4 → 17.9
	Manokwari		8.0 → 17.2
	Nabire		5.3 → 11.3
	Fak-Fak		2.6 → 5.6
	Timika		7.9 → 17.0

Source: RUPTL2009-2018



Source: Made by JICA Study Team based on RUPTL2009-2018 leveraged google

Figure 7 Location of Power systems in Papua

2) Review

A check was made of RUPTL 2009 - 2018. The notable points are as follows.

The system that ought to be developed is Jayapura, which has a large demand. There are plans for construction of a power source line for this system. A check of these plans did not find any particular problems. PLTA Geyem (20 MW) is connected by a two-circuit line as far as Wamena, and has an extended length of 165 km.

Table 34 Transmission line development plan (Papua)

Term	Grade.	Location	Remark
2010	70kV	PLTU Hautekamp – Yarmokh	Jayapura system
2011	**70kV**	**PLTA Genyem – Waena**	**Jayapura system, Power line for Hydro**
2011	70kV	PLTU Pomako - Timika	Timika system

Source: Made by JICA Study Team based on RUPTL2009-2018

(7) NTB・NTT

1) Condition and Predicction

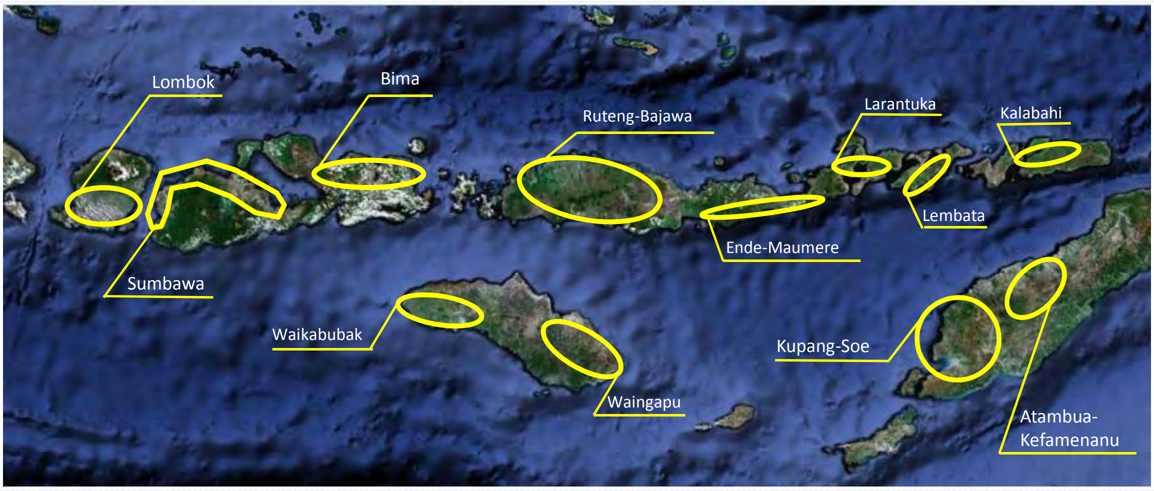
Wilayah Nusa Tengara Barat (NTB) covers Lombok, Sumbawa, and neighboring islands, and Wilayah Nusa Tenggara Timur (NTT), the islands east of Komodo, up to the western half of Timur. In this area, the Lombok system has the biggest demand because the major industry is tourism, as in Bali. The demand forecast for it is much higher than those for other systems.

Noted below are the power systems in the NTB and NTT areas, with the 2018 demand forecast in RUPTL for each system.

Table 35 Power systems in NTB・NTT

Wlyh.	System	Remark	Peak Demand forecasting 2008 →2018 (MW)
NTB	Lombok	Lombok island	504.5 → 1365.9
	Sumbawa	Sumbawa island	105.0 → 2842.
	Bima	Sumbawa island	99.8 → 270.3
NTT	Kupang-Soe	Timor island	(167.9) → 524.7
	Atambua-Kefamenanu	Timor island	(30.6) → 164.0
	Kalabahi	Alor island	10.4 → 27.6
	Waingapu	Sumba island	13.5 → 35.6
	Waikabubak	Sumba island	12.1 → 25.3
	Ruteng-BaJava	Flores island	(29.8) → 92.1
	Ende-Maumere	Flores island	(56.3) → 92.1
	Larantuka	Flores island	11.8 → 49.1
	Lembata	Lembata island	4.3 → 10.6

Note; figure given in ( ) is summation of demand of each isolated system
Not considered diversity factor
Source: RUPTL2009-2018



Source: Made by JICA Study Team based on RUPTL2009-2018 leveraged google

Figure 8 Location of Power systems in NTB・NTT

2) Review

A check was made of RUPTL 2009 - 2018. The notable points are as follows.

The system on Lombok is the only one with a radial pattern of 150-kV lines; those on other islands have a radial pattern of 70-kV lines. Plans are aimed at increased efficiency in system operation by consolidating supply power through interconnections between the Kupang and Soe systems and the Atambua and Kefamenanu systems on Timor island, and the Ruteng and BaJava systems and the Ende and Maumere systems on Flores island.

One point requiring caution in the transmission line development plans in RUPTL is the construction of a 70-kV line between Dompu and Labuhan, which is slated for 2015. The completion of this line (with two circuits and a length of 360 km) will mean connection of the entire system on Sumbawa island with 70-kV lines. This system will have a total length of 300 km. Failure of a single circuit on the Dompu-Labuhan line could make interconnected operation of the whole system impossible, depending on conditions as regards voltage drop and other items. This prospect, together with the supply-demand balance, requires close examination.

As for hydropower development projects and the connection with transmission line plans, the hydropower plants contained in the plans are of the PLTM type, and the interconnections will probably be mainly with 20-kV distribution lines.

Table 36 Transmission line development plan (NTB)

Term	Grade.	Location	Remark
2010	150kV	Ampenan – Jeranjang	Lombok system (Lombok island)
2010	150kV	Jeranjang – Sengkol	Lombok system (Lombok island)
2010	150kV	Sengkol – Selong	Lombok system (Lombok island)
2010	150kV	Sengkol – Kuta	Lombok system (Lombok island)
2010	70kV	PLTU Bonto - Ni'u/Bima	Bima system (Sumbawa island)
2010	70kV	Ni'u/Bima – Dompu	Bima system (Sumbawa island)
2010	70kV	PLTU Badas - Incomer(Labuhan - Tano)	Sumbawa system (Sumbawa island)
2010	70kV	Labuhan – Tano	Sumbawa system (Sumbawa island)
2011	150kV	PLTU IPP - Selong	Lombok system (Lombok island)
2011	150kV	Ampenan - Tanjung	Lombok system (Lombok island)
2011	150kV	Selong - Pringgabaya	Lombok system (Lombok island)
2012	70kV	PLTP Hu'u – Dompu	Bima system (Sumbawa island)
2013	150kV	PLTP Sembalun - Pringgabaya	Lombok system (Lombok island)
2015	70kV	Dompu – Labuhan	Interconnect
2017	70kV	PLTP Maronge - Labuhan	Interconnect

Source: Made by JICA Study Team based on RUPTL2009-2018

Source: Made by JICA Study Team based on RUPTL2009-2018 leveraged google

Figure 9 Plan of Lombok 150-kV system

Table 37 Transmission line development plan (NTT)

Term	Grade.	Location	Remark
2010	70kV	PLTU Bolok/Kupang Baru - Maulafa	Kupang-Soe system (Timor island)
2010	70kV	Maulafa - Nailbonat	Kupang-Soe system (Timor island)
2010	70kV	Naibonat - Nonohamis/Soe	Kupang-Soe system (Timor island)
2010	70kV	Kefamenanu - Atambua	Kupang-Soe system (Timor island)
2010	70kV	PLTU Ropa - Incomer (Ende - Maumere)	Ende-Maumere system (Flores island)
2010	70kV	Ende - Maumere	Ende-Maumere system (Flores island)
2015	70kV	BaJava - Ruteng(PLTP Ulumbu)	Ruteng-BaJava system (Flores island)
2015	70kV	BaJava - Ende	Ruteng-BaJava system (Flores island)
2015	70kV	Nonohamis/Soe - Maulafa	Kupang-Soe system (Timor island)
2016	70kV	Ruteng(PLTP Ulumbu) - Labuhan Bajo	Ruteng-BaJava system (Flores island)

Source: Made by JICA Study Team based on RUPTL2009-2018

Part 3 List of Referred Geological Data and Information

PART 3 LIST OF REFERRED GEOLOGICAL DATA AND INFORMATION

1. Geological Base Map used in HPPS2 (soft copy), from Pusat Penelitian dan Pengembangan Geologi (P3G) (Department of Mines and Energy, Directorate General of Geology and Mineral Resources, Geological Research and Development Centre), scale 1/250,000.
2. Geological Map of Indonesia (1965): published by Agency for International Development, United States Department of State, scale 1/2,000,000.
3. Geological Map of the Banda Aceh Quadrangle, Sumatera (1981), published by Geological Research and Development Centre (GRDC), scale 1/250,000.
4. Geological Map of the Tapaktuan Quadrangle, Sumatera (1982), published by GRDC, scale 1/250,000.
5. Geological Map of the Takengon Quadrangle, Sumatera (1983), published by GRDC, scale 1/250,000.
6. Geological Map of the Lhoksumawe Quadrangle, Sumatera (1981), published by GRDC, scale 1/250,000.
7. Geological Map of the Sidikalang Quadrangle, Sumatera (1983), published by GRDC, scale 1/250,000.
8. Geological Map of the Medan Quadrangle, Sumatera (1982), published by GRDC, scale 1/250,000.
9. Geological Map of the Langsa Quadrangle, Sumatera (1981), published by GRDC, scale 1/250,000.
10. Geological Map of the Padang Quadrangle, Sumatera (1996), published by GRDC, scale 1/250,000.
11. Geological Map of the Pemantangsiantar Quadrangle, Sumatera (1982), published by GRDC, scale 1/250,000.
12. Geological Map of the Tebingtinggi Quadrangle, Sumatera (1981), published by GRDC, scale 1/250,000.
13. Geological Map of the Sungaipemuh dan Ketaun Quadrangle, Sumatera (1992), published by GRDC, scale 1/250,000.
13\. Geological Map of the Painan & bagian Timur Quadrangle, Sumatera (1996), published by GRDC, scale 1/250,000.

14. Geological Map of the Solok Quadrangle, Sumatera (1996), published by GRDC, scale 1/250,000.

15. Geological Map of the Manna & Enggano Quadrangle, Sumatera (1993), published by GRDC, scale 1/250,000.

16. Geological Map of the Bengkulu Quadrangle, Sumatera (1992), published by GRDC, scale 1/250,000.

17. Geological Map of the Rengat Quadrangle, Sumatera (1994), published by GRDC, scale 1/250,000.

18. Geological Map of the Tanjungpinang & Siaksriinrdrapura Quadrangle, Sumatera (1982), published by GRDC, scale 1/250,000.

19. Geological Map of the Bengkalis Quadrangle, Sumatera (1982), published by GRDC, scale 1/250,000.

20. Geological Map of the Kotaagung Quadrangle, Sumatera (1993), published by GRDC, scale 1/250,000.

21. Geological Map of the Baturaja Quadrangle, Sumatera (1993), published by GRDC, scale 1/250,000.

22. Geological Map of the Leuwidamar Quadrangle, Jawa (1991), published by GRDC, scale 1/100,000.

23. Geological Map of the Jampang & Balekambang Quadrangle, Jawa (1975), published by GRDC, scale 1/100,000.

24. Geological Map of the Bogor (Edisi 2) Quadrangle, Jawa (1998), published by GRDC, scale 1/100,000.

25. Geological Map of the Sindang Barang & Bandarwaru (Edisi 2) Quadrangle, Jawa (1996), published by GRDC, scale 1/100,000.

26. Geological Map of the Cianjur (Edisi 2) Quadrangle, Jawa (1994), published by GRDC, scale 1/100,000.

27. Geological Map of the Garut & Pameungpeuk Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

28. Geological Map of the Arjawinangun Quadrangle, Jawa (1995), published by GRDC, scale 1/100,000.

29. Geological Map of the Pangandaran Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

30. Geological Map of the Majenang (Edisi 2) Quadrangle, Jawa (1996), published by GRDC, scale 1/100,000.

31. Geological Map of the Banyumas Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

32. Geological Map of the Purwokerto & Tegal (Cetakan 2) Quadrangle, Jawa (1996), published by GRDC, scale 1/100,000.

33. Geological Map of the Kebumen Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

34. Geological Map of the Banjarnegara & Pekalongan (Edisi 2) Quadrangle, Jawa (1996), published by GRDC, scale 1/100,000.

35. Geological Map of the Yogyakarta Quadrangle, Jawa (1995), published by GRDC, scale 1/100,000.

36. Geological Map of the Magelang & Semarang (Cetakan 2) Quadrangle, Jawa (1996), published by GRDC, scale 1/100,000.

37. Geological Map of the Surakarta & Giritontro Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

38. Geological Map of the Salatiga Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

39. Geological Map of the Pacitan Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

40. Geological Map of the Ngawi Quadrangle, Jawa (1996), published by GRDC, scale 1/100,000.

41. Geological Map of the Tulungagung Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

42. Geological Map of the Blitar Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

43. Geological Map of the Kediri Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

44. Geological Map of the Mojokerto Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

45. Geological Map of the Turen Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

46. Geological Map of the Malang Quadrangle, Jawa (1992), published by GRDC, scale 1/100,000.

47. Geological Map of the Besuki (Edisi 2) Quadrangle, Jawa (1997), published by GRDC, scale 1/100,000.

48. Geological Map of the Singkawang Quadrangle, Kalimantan (1993), published by GRDC, scale 1/250,000.

49. Geological Map of the Nangataman Quadrangle, Kalimantan (1993), published by GRDC, scale 1/250,000.

50. Geological Map of the Longpahangai Quadrangle, Kalimantan (1993), published by GRDC, scale 1/250,000.

51. Geological Map of the Longnawan Quadrangle, Kalimantan (1993), published by GRDC, scale 1/250,000.

52. Geological Map of the Muarawahau Quadrangle, Kalimantan (1995), published by GRDC, scale 1/250,000.

53. Geological Map of the Napaku dan Longbia Quadrangle, Kalimantan (1995), published by GRDC, scale 1/250,000.

54. Geological Map of the Malinau Quadrangle, Kalimantan (1995), published by GRDC, scale 1/250,000.

55. Geological Map of the Apobayan Quadrangle, Kalimantan (1995), published by GRDC, scale 1/250,000.

56. Geological Map of the Pangkajene Quadrangle, Sulawesi (1982), published by GRDC, scale 1/250,000.

57. Geological Map of the Majene dan Palopo Quadrangle, Sulawesi (1996), published by GRDC, scale 1/250,000.

58. Geological Map of the Palu Quadrangle, Sulawesi (1996), published by GRDC, scale 1/250,000.

59. Geological Map of the Toli-toli Quadrangle, Sulawesi (1976), published by GRDC, scale 1/250,000.

60. Geological Map of the Kotamubago (Edisi 2) Quadrangle, Sulawesi (1997), published by GRDC, scale 1/250,000.

61. Geological Map of the Sangihe dan Siau Quadrangle, Sulawesi (1994), published by GRDC, scale 1/250,000.

62. Departemen Pekerjaan Umum Badan Penelitian dan Pengembangan, Pusat Penelitian dan Pengembangan Sumber Daya Air (2005): Peta Zona Gempa Indonesia, Sebagai Acuan Dasar Perencana dan Perancangan Bangunan, Peta Zona Gempa Indonesia, scale 1/10,000,000.

Part 4 Preliminary Geological Evaluation Result

Part 4 GEOLOGICAL AND SEISMIC INVENTORY EVALUATION OF POTENTIAL CONVENTIONAL HYDROPOWER PROJECT SITES (1 / 6)

No.	Project ID	Scheme Name	Preliminary Geological Evaluation								Seismic Assesment	
			Geological zone	Project Facility						Geological Class	Seismic Zone	Seismic Coefficient
				Damsite	Headrace	Surgetank	Penstock	Tailrace	Quarry			
1	01-190-13	Mamas-2	C	3	3	2	3	2	2	Acceptable	E	0.20
2	01-192-04	Jambo Papeun-3	A	1	2	2	2	1	2	Very Good	E	0.20
3	01-204-05	Woyla-2	C	3	3	2	3	2	2	Acceptable	E	0.20
4	01-190-11	Ketambe-2	C	3	3	2	3	2	2	Acceptable	E	0.20
5	01-205-09	Teunom-2	C	3	3	2	3	2	2	Acceptable	E	0.20
6	01-192-03	Kluet-1	A	1	2	2	2	1	2	Very Good	E	0.20
7	01-202-06	Meulaboh-5	C	3	3	2	3	2	2	Acceptable	E	0.20
8	01-192-07	Kluet-3	A	1	2	2	2	1	2	Very Good	E	0.20
9	01-027-14	Ramasan-1	C	3	3	2	3	2	2	Acceptable	D	0.20
10	01-192-08	Sibubung-1	A	1	2	2	2	1	2	Very Good	E	0.20
11	01-201-03	Seunangan-3	A	1	2	2	2	1	2	Very Good	E	0.20
12	01-198-05	Teripa-4	A	1	2	2	2	1	2	Very Good	E	0.20
13	01-205-10	Teunom-3	C	3	3	2	3	2	2	Acceptable	E	0.20
14	01-202-02	Meulaboh-2	C	3	3	2	3	2	2	Acceptable	E	0.20
15	01-192-10	Sibubung-3	C	2	3	2	3	1	2	Acceptable	E	0.20
16	01-186-01	Sirahar	B	2	3	2	3	1	2	Good	E	0.20
17	01-190-33	Ordi-1	B	2	3	2	3	1	2	Good	E	0.20
18	01-190-40	Simanggo-1	B	2	3	2	3	1	2	Good	E	0.20
19	01-190-21	Renun-3	C	3	3	2	3	2	2	Acceptable	E	0.20
20	01-190-32	Kumbih-3	B	2	3	2	3	1	2	Good	E	0.20
21	01-190-41	Simanggo-2	B	2	3	2	3	1	2	Good	E	0.20
22	01-183-01	Raisan-1	A	1	2	2	2	1	2	Very Good	E	0.20
23	01-190-26	Gunung-2	B	2	3	2	3	1	2	Good	E	0.20
24	01-178-03	Toru-2	C	3	3	2	3	2	2	Acceptable	E	0.20
25	01-190-24	Renun-6	C	3	3	2	3	2	2	Acceptable	E	0.20
26	01-184-05	Sibundong-4	B	2	3	2	3	1	2	Good	E	0.20
27	01-190-34	Ordi-2	B	2	3	2	3	1	2	Good	E	0.20
28	01-190-37	Ordi-5	B	2	3	2	3	1	2	Good	E	0.20
29	01-055-02	Bila-2	B	2	3	2	3	1	2	Good	D	0.20
30	01-190-35	Ordi-3	B	2	3	2	3	1	2	Good	E	0.20
31	01-053-01	Silau-1	B	2	3	2	3	1	2	Good	C	0.15
32	01-190-22	Renun-4	C	3	3	2	3	2	2	Acceptable	E	0.20
33	01-190-38	Siria	B	2	3	2	3	1	2	Good	E	0.20
34	01-178-07	Toru-3	B	2	3	2	3	1	2	Good	E	0.20
35	01-071-12	Sangir	B	2	3	2	3	1	2	Good	D	0.20
36	01-066-03	Sinamar-2	A	1	2	2	2	1	2	Very Good	E	0.20
37	01-147-03	Air Tuik	B	2	3	2	3	1	2	Good	D	0.20
38	01-145-01	Sirantih-1	B	2	3	2	3	1	2	Good	D	0.20
39	01-071-11	Batang Hari-4	A	1	2	2	2	1	2	Very Good	D	0.20
40	01-147-01	Taratak Tumpatih-	B	2	3	2	3	1	2	Good	D	0.20
41	01-066-02	Sinamar-1	B	2	3	2	3	1	2	Good	E	0.20
42	01-163-02	Masang-2	B	2	3	2	3	1	2	Good	E	0.20
43	01-071-01	Gumanti-1	A	1	2	2	2	1	2	Very Good	D	0.20
44	01-155-01	Anai-1	C	3	3	2	3	2	2	Acceptable	F	0.25
45	01-163-03	Masang-3	A	1	2	2	2	1	2	Very Good	E	0.20
46	01-066-16	Kuatan-2	A	1	2	2	2	1	2	Very Good	C	0.15
47	01-058-08	Rokan Kiri	B	2	3	2	3	1	2	Good	D	0.20
48	01-115-01	Mauna-1	B	2	3	2	3	1	2	Good	F	0.25
49	01-136-02	Langkup-2	C	3	3	2	3	2	2	Acceptable	D	0.20
50	01-071-33	Merangin-4	A	1	2	2	2	1	2	Very Good	D	0.20
51	01-113-02	Padang Guci-2	B	2	3	2	3	1	2	Good	F	0.25
52	01-074-17	Endikat-2	B	2	3	2	3	1	2	Good	E	0.20
53	01-082-07	Semung-3	B	2	3	2	3	1	2	Good	F	0.25
54	01-106-02	Menula-2	B	2	3	2	3	1	2	Good	F	0.25

Part 4 GEOLOGICAL AND SEISMIC INVENTORY EVALUATION OF POTENTIAL CONVENTIONAL HYDROPOWER PROJECT SITES (2 / 6)

No.	Project ID	Scheme Name	Preliminary Geological Evaluation								Seismic Assesment	
			Geological zone	Project Facility						Geological Class	Seismic Zone	Seismic Coefficient
				Damsite	Headrace	Surgetank	Penstock	Tailrace	Quarry			
55	01-071-17	Tebo-2	B	2	3	2	3	1	2	Good	D	0.20
56	03-043-52	Melawi-9	B	2	3	2	3	1	2	Good	A	0.10
57	03-043-20	Mandai-5	B	2	3	2	3	1	2	Good	A	0.10
58	03-014-06	Boh-2	A	1	2	2	2	1	2	Very Good	A	0.10
59	03-010-01	Kelai-1	A	1	2	2	2	1	2	Very Good	B	0.10
60	03-004-20	Sesayap-20	A	1	2	2	2	1	2	Very Good	B	0.10
61	03-004-11	Sesayap-11	A	1	2	2	2	1	2	Very Good	A	0.10
62	03-003-03	Sembakung-3	A	1	2	2	2	1	2	Very Good	A	0.10
63	03-004-15	Sesayap-15	A	1	2	2	2	1	2	Very Good	A	0.10
64	03-014-13	Telen	A	1	2	2	2	1	2	Very Good	A	0.10
65	04-026-03	Poso-2	B	2	3	2	3	1	2	Good	D	0.20
66	04-026-02	Poso-1	C	3	3	2	3	2	2	Acceptable	D	0.20
67	04-106-07	Lariang-7	B	2	3	2	3	1	2	Good	D	0.20
68	04-106-06	Lariang-6	B	2	3	2	3	1	2	Good	D	0.20
69	04-003-04	Bone-3	A	1	2	2	2	1	2	Very Good	D	0.20
70	04-030-02	Bongka-2	B	2	3	2	3	1	2	Good	D	0.20
71	04-038-01	Solato-1	B	2	3	2	3	1	2	Good	D	0.20
72	04-106-08	Lariang-8	C	3	3	2	3	2	2	Acceptable	D	0.20
73	04-100-03	Karama-2	B	2	3	2	3	1	2	Good	E	0.20
74	04-055-01	Tamboli	A	1	2	2	2	1	2	Very Good	D	0.20
75	04-100-01	Karama-1	A	1	2	2	2	1	2	Very Good	E	0.20
76	04-095-06	Masuni	A	1	2	2	2	1	2	Very Good	E	0.20
77	04-073-04	Mong	C	3	3	2	3	2	2	Acceptable	D	0.20
78	04-093-13	Bonto Batu	C	3	3	2	3	2	2	Acceptable	D	0.20
79	04-056-01	Watunohu-1	C	3	3	2	3	2	2	Acceptable	D	0.20
80	04-047-01	Lalindu-1	C	3	3	2	3	2	2	Acceptable	D	0.20
81	04-057-03	Pongkeru-3	A	1	2	2	2	1	2	Very Good	D	0.20
82	14-002-02	Mala-2	A	1	2	2	2	1	2	Very Good	D	0.20
83	14-002-01	Mala-1	A	1	2	2	2	1	2	Very Good	D	0.20
84	14-012-01	Tala	A	1	2	2	2	1	2	Very Good	D	0.20
85	13-004-01	Tina	A	1	2	2	2	1	2	Very Good	E	0.20
86	05-042-02	Warasai	C	3	3	2	3	2	2	Acceptable	E	0.20
87	05-013-06	Jawee-4	C	3	3	2	3	2	2	Acceptable	E	0.20
88	05-043-07	Derewo-7	B	2	3	2	3	1	2	Good	E	0.20
89	05-013-05	Jawee-3	C	3	3	2	3	2	2	Acceptable	E	0.20
90	05-013-07	Endere-1	C	3	3	2	3	2	2	Acceptable	E	0.20
91	05-013-08	Endere-2	C	3	3	2	3	2	2	Acceptable	D	0.20
92	05-043-06	Derewo-6	B	2	3	2	3	1	2	Good	E	0.20
93	05-013-04	Jawee-2	C	3	3	2	3	2	2	Acceptable	E	0.20
94	05-006-08	Baliem-7	A	1	2	2	2	1	2	Very Good	D	0.20
95	05-006-06	Baliem-5	C	3	3	2	3	2	2	Acceptable	D	0.20
96	05-036-12	Waryori-4	A	1	2	2	2	1	2	Very Good	F	0.25
97	05-042-01	Ulawa	B	2	3	2	3	1	2	Good	D	0.20
98	05-037-91	Gita/Ransiki-1	A	1	2	2	2	1	2	Very Good	F	0.25
99	05-006-07	Baliem-6	C	3	3	2	3	2	2	Acceptable	D	0.20
100	05-032-03	Kladuk-2	C	3	3	2	3	2	2	Acceptable	C	0.15
101	05-015-05	Titinima-3	C	3	3	2	3	2	2	Acceptable	D	0.20
102	05-020-01	Maredrer	C	3	3	2	3	2	2	Acceptable	D	0.20
103	05-026-01	Muturi-1	B	2	3	2	3	1	2	Good	F	0.25
104	05-043-09	Siewa-1	B	2	3	2	3	1	2	Good	E	0.20
105	05-006-09	Baliem-8	B	2	3	2	3	1	2	Good	D	0.20
106	09-011-01	Parainglala	C	3	3	2	3	2	2	Acceptable	D	0.20
107	11-012-01	Be Lulic-1	A	1	2	2	2	1	2	Very Good	D	0.20
108	09-012-01	Watupanggantu	C	3	3	2	3	2	2	Acceptable	D	0.20

Part 4 GEOLOGICAL AND SEISMIC INVENTORY EVALUATION OF POTENTIAL CONVENTIONAL HYDROPOWER PROJECT SITES (3 / 6)

No.	Project ID	Scheme Name	Preliminary Geological Evaluation								Seismic Assesment	
			Geological zone	Project Facility						Geological Class	Seismic Zone	Seismic Coefficient
				Damsite	Headrace	Surgetank	Penstock	Tailrace	Quarry			
109	09-001-01	Karendi-1	C	3	3	2	3	2	2	Acceptable	D	0.20
110	07-015-01	Teldewaja	B	2	3	2	3	1	2	Good	E	0.20
111	09-005-02	Kambera-2	B	2	3	2	3	1	2	Good	D	0.20
112	10-003-02	Wai Ranjang (Wai	C	3	3	2	3	2	2	Acceptable	D	0.20
113	02-057-17	Kesamben	C	3	3	2	3	2	2	Acceptable	E	0.20
114	02-050-01	Rowopening	B	2	3	2	3	1	2	Good	C	0.15
115	02-108-01	Cibareno-1	A	1	2	2	2	1	2	Very Good	D	0.20
116	02-107-01	Cimandiri-1	B	2	3	2	3	1	2	Good	D	0.20
117	01-019-05	Baleg	A	1	2	2	2	1	2	Very Good	E	0.20
118	01-190-04	Pantan Dadalu-1	C	3	3	2	3	2	2	Acceptable	E	0.20
119	01-027-01	Jambuaye-1	A	1	2	2	2	1	2	Very Good	E	0.20
120	01-190-29	Pungu	A	1	2	2	2	1	2	Very Good	E	0.20
121	01-190-25	Gunung-1	B	2	3	2	3	1	2	Good	E	0.20
122	01-184-01	Sibundong-1	B	2	3	2	3	1	2	Good	E	0.20
123	01-184-02	Sibundong-2	B	2	3	2	3	1	2	Good	E	0.20
124	01-040-09	Berkail-2	C	3	3	2	3	2	2	Acceptable	D	0.20
125	01-066-15	Kuantan-1	C	3	3	2	3	2	2	Acceptable	D	0.20
126	01-066-08	Lawas-Suo	A	1	2	2	2	1	2	Very Good	E	0.20
127	01-168-01	Bangis	B	2	3	2	3	1	2	Good	D	0.20
128	01-077-03	Besai-2	B	2	3	2	3	1	2	Good	E	0.20
129	01-125-02	Nokan-2	A	1	2	2	2	1	2	Very Good	E	0.20
130	01-111-04	Mantai	B	2	3	2	3	1	2	Good	F	0.25
131	01-109-01	Sanbat Kiri	B	2	3	2	3	1	2	Good	F	0.25
132	02-057-04	Tambak Sari	B	2	3	2	3	1	2	Good	D	0.20
133	02-057-06	Blobo	B	2	3	2	3	1	2	Good	D	0.20
134	02-059-01	Baung	B	2	3	2	3	1	2	Good	D	0.20
135	02-057-05	Lumbang Sari	B	2	3	2	3	1	2	Good	D	0.20
136	02-065-01	Wanasari	C	3	3	2	3	2	2	Acceptable	C	0.15
137	02-057-25	Upper Konto-2	B	2	3	2	3	1	2	Good	D	0.20
138	02-057-10	Lesti-3	C	3	3	2	3	2	2	Acceptable	D	0.20
139	02-044-01	Curug Sewu-1	B	2	3	2	3	1	2	Good	C	0.15
140	02-083-03	Bogowonto-2	A	1	2	2	2	1	2	Very Good	C	0.15
141	02-083-04	Bogowonto-3	A	1	2	2	2	1	2	Very Good	C	0.15
142	02-106-01	Ciletuh	A	1	2	2	2	1	2	Very Good	D	0.20
143	02-104-01	Cikaso-1	A	1	2	2	2	1	2	Very Good	D	0.20
144	02-103-02	Cibuni-2	A	1	2	2	2	1	2	Very Good	D	0.20
145	04-040-01	Sumara	A	1	2	2	2	1	2	Very Good	D	0.20
146	04-128-04	Sawangan	B	2	3	2	3	1	2	Good	D	0.20
147	04-125-02	Poigar-1	B	2	3	2	3	1	2	Good	D	0.20
148	04-093-11	Mataalo-1	A	1	2	2	2	1	2	Very Good	D	0.20
149	07-009-02	Daya-2	B	2	3	2	3	1	2	Good	E	0.20
150	01-071-30	Merangin-2	B	2	3	2	3	1	2	Good	D	0.20
151	01-035-10	Tampur-1	A	1	2	2	2	1	2	Very Good	D	0.20
152	01-027-91	Jambu Aye-8	A	1	2	2	2	1	2	Very Good	D	0.20
153	01-040-91	Wampu	C	3	3	2	3	2	2	Acceptable	E	0.20
154	01-129-01	Ketaun-1	B	2	3	2	3	1	2	Good	E	0.20
155	01-074-01	Ranau	B	2	3	2	3	1	2	Good	F	0.25
156	01-205-03	Teunom-1	C	3	3	2	3	2	2	Acceptable	E	0.20
157	01-001-02	Aceh-2	A	1	2	2	2	1	2	Very Good	E	0.20
158	01-019-06	Peusangan-4	A	1	2	2	2	1	2	Very Good	E	0.20
159	01-190-15	Lawe Alas-4	C	3	3	2	3	2	2	Acceptable	E	0.20
160	01-178-02	Toru-1	A	1	2	2	2	1	2	Very Good	E	0.20
161	01-071-34	Merangin-5	A	1	2	2	2	1	2	Very Good	C	0.15
162	01-149-01	Bayang-1	A	1	2	2	2	1	2	Very Good	E	0.20

Part 4 GEOLOGICAL AND SEISMIC INVENTORY EVALUATION OF POTENTIAL CONVENTIONAL HYDROPOWER PROJECT SITES (4 / 6)

No.	Project ID	Scheme Name	Preliminary Geological Evaluation								Seismic Assesment	
			Geological zone	Project Facility						Geological Class	Seismic Zone	Seismic Coefficient
				Damsite	Headrace	Surgetank	Penstock	Tailrace	Quarry			
163	01-149-02	Bayang-2	A	1	2	2	2	1	2	Very Good	E	0.20
164	01-074-21	Lamatang-4	A	1	2	2	2	1	2	Very Good	D	0.20
165	04-093-53	Bakaru (2nd)	A	1	2	2	2	1	2	Very Good	E	0.20
166	04-047-06	Lasolo-4	A	1	2	2	2	1	2	Very Good	D	0.20
167	04-112-03	Palu-3	C	3	3	2	3	2	2	Acceptable	D	0.20
168	04-093-08	Poko	A	1	2	2	2	1	2	Very Good	E	0.20
169	04-093-01	Malea	A	1	2	2	2	1	2	Very Good	E	0.20
170	04-048-11	Konaweha-3	A	1	2	2	2	1	2	Very Good	D	0.20
171	04-125-04	Poigar-3	A	1	2	2	2	1	2	Very Good	D	0.20
172	04-093-02	Batu	A	1	2	2	2	1	2	Very Good	E	0.20
173	02-090-04	Maung	A	1	2	2	2	1	2	Very Good	C	0.15
174	02-016-04	Rajamandala	B	2	3	2	3	1	2	Good	D	0.20
175	02-026-08	Jatigede	A	1	2	2	2	1	2	Very Good	D	0.20
176	02-103-03	Cibuni-3	A	1	2	2	2	1	2	Very Good	D	0.20
177	02-026-06	Cipasang	B	2	3	2	3	1	2	Good	D	0.20
178	02-107-03	Cimandiri-3	A	1	2	2	2	1	2	Very Good	D	0.20
179	02-090-10	Gintung	C	3	3	2	3	2	2	Acceptable	C	0.15
180	02-090-13	Rawalo-1	A	1	2	2	2	1	2	Very Good	D	0.20
181	02-103-04	Cibuni-4	A	1	2	2	2	1	2	Very Good	D	0.20
182	02-104-03	Cikaso-3	A	1	2	2	2	1	2	Very Good	D	0.20
183	02-080-02	Grindulu-2	A	1	2	2	2	1	2	Very Good	E	0.20
184	03-026-03	Riam Kiwa	C	3	3	2	3	2	2	Acceptable	A	0.10
185	03-023-03	Kusan-3	C	3	3	2	3	2	2	Acceptable	A	0.10
186	03-044-05	Pade Kembayung	A	2	3	2	3	1	2	Very Good	A	0.10
187	03-010-03	Kelai-2	B	2	3	2	3	1	2	Good	B	0.10
188	03-027-16	Amandit-2	B	2	3	2	3	1	2	Good	A	0.10
189	03-008-04	Kayan-2	B	2	3	2	3	1	2	Good	C	0.15
190	03-043-69	Pinoh	A	1	2	2	2	1	2	Very Good	A	0.10
191	03-043-43	Silat	C	3	3	2	3	2	2	Acceptable	A	0.10
192	07-022-01	Ayung-1 (Sidan)	B	2	3	2	3	1	2	Good	E	0.20
193	07-022-02	Ayung-2 (Selat)	B	2	3	2	3	1	2	Good	E	0.20
194	07-022-03	Ayung-3 (Buangga	B	2	3	2	3	1	2	Good	E	0.20
195	08-007-01	Beburung	B	2	3	2	3	1	2	Good	D	0.20
196	08-007-02	Putih-1	B	2	3	2	3	1	2	Good	D	0.20
197	08-007-03	Putih-2	B	2	3	2	3	1	2	Good	D	0.20
198	08-007-04	Putih-3	B	2	3	2	3	1	2	Good	D	0.20
199	14-005-02	Isal-2	A	1	2	2	2	1	2	Very Good	D	0.20
200	15-005-02	Lamo-1	C	3	3	2	3	2	2	Acceptable	E	0.20
201	05-034-02	Warsamson	C	3	3	2	3	2	2	Acceptable	D	0.20
202	01-019-01	Peusangan-1	C	3	3	2	3	2	2	Acceptable	E	0.20
203	01-019-02	Peusangan-2	B	2	3	2	3	1	2	Good	E	0.20
204	01-053-04	Asahan-1	B	2	3	2	3	1	2	Good	D	0.20
205	01-053-05	Asahan-3	B	2	3	2	3	1	2	Good	D	0.20
206	04-125-03	Poigar-2	A	1	2	2	2	1	2	Very Good	D	0.20
207	05-051-05	Genyem	C	3	3	2	3	2	2	Acceptable	E	0.20
208	01-053-51	Tangga	B	2	3	2	3	1	2	Good	D	0.20
209	01-053-52	Siguragura	B	2	3	2	3	1	2	Good	D	0.20
210	01-066-52	Batang Agam	A	1	2	2	2	1	2	Very Good	E	0.20
211	01-162-51	Maninjau-1	B	2	3	2	3	1	2	Good	E	0.20
212	01-129-51	Tes-1	A	1	2	2	2	1	2	Very Good	E	0.20
213	01-190-19	Renun-1	B	2	3	2	3	1	2	Good	E	0.20
214	01-066-21	Singkarak	B	2	3	2	3	1	2	Good	F	0.25
215	01-062-51	Kotapanjan	A	1	2	2	2	1	2	Very Good	D	0.20
216	01-074-53	Musi-1	B	2	3	2	3	1	2	Good	F	0.25

Part 4 GEOLOGICAL AND SEISMIC INVENTORY EVALUATION OF POTENTIAL CONVENTIONAL HYDROPOWER PROJECT SITES (5 / 6)

No.	Project ID	Scheme Name	Preliminary Geological Evaluation								Seismic Assesment	
			Geological zone	Project Facility						Geological Class	Seismic Zone	Seismic Coefficient
				Damsite	Headrace	Surgetank	Penstock	Tailrace	Quarry			
217	01-077-02	Besai-1	B	2	3	2	3	1	2	Good	E	0.20
218	01-080-01	Batu Tegi	A	1	2	2	2	1	2	Very Good	F	0.25
219	01-181-01	Sipansihaporas-1	A	1	2	2	2	1	2	Very Good	E	0.20
220	01-181-02	Sipansihaporas-2	A	1	2	2	2	1	2	Very Good	E	0.20
221	04-128-52	Tonsea Lama	A	1	2	2	2	1	2	Very Good	D	0.20
222	04-128-51	Tanggari-1	A	1	2	2	2	1	2	Very Good	D	0.20
223	04-093-52	Bakaru (1st)	A	1	2	2	2	1	2	Very Good	E	0.20
224	04-057-51	Larona	C	3	3	2	3	2	2	Acceptable	D	0.20
225	04-128-03	Tanggari-2	A	1	2	2	2	1	2	Very Good	D	0.20
226	04-085-02	Bili-Bili	C	3	3	2	3	2	2	Acceptable	B	0.10
227	02-050-51	Jelok	C	3	3	2	3	2	2	Acceptable	C	0.15
228	02-039-51	Ketenger	B	2	3	2	3	1	2	Good	C	0.15
229	02-050-52	Timo	C	3	3	2	3	2	2	Acceptable	C	0.15
230	02-090-52	Garung	B	2	3	2	3	1	2	Good	C	0.15
231	02-055-51	Wonogiri	A	1	2	2	2	1	2	Very Good	D	0.20
232	02-090-51	Mrica	B	2	3	2	3	1	2	Good	C	0.15
233	02-051-51	Kedungombo	A	1	2	2	2	1	2	Very Good	C	0.15
234	02-085-51	Wadaslintang	A	1	2	2	2	1	2	Very Good	C	0.15
235	02-016-54	Plengan	B	2	3	2	3	1	2	Good	D	0.20
236	02-016-58	Ubrug	B	2	3	2	3	1	2	Good	D	0.20
237	02-016-55	Lamajan	B	2	3	2	3	1	2	Good	D	0.20
238	02-016-57	Kracak	C	3	3	2	3	2	2	Acceptable	D	0.20
239	02-026-51	Parakan Kondang	C	3	3	2	3	2	2	Acceptable	D	0.20
240	02-016-56	Cikalong	B	2	3	2	3	1	2	Good	D	0.20
241	02-016-51	Jatiluhur	C	3	3	2	3	2	2	Acceptable	D	0.20
242	02-016-53	Saguling	C	3	3	2	3	2	2	Acceptable	D	0.20
243	02-016-52	Cirata 1st	A	1	2	2	2	1	2	Very Good	D	0.20
244	02-016-52	Cirata 2nd	A	1	2	2	2	1	2	Very Good	D	0.20
245	02-057-56	Mandalan	B	2	3	2	3	1	2	Good	D	0.20
246	02-057-55	Siman	B	2	3	2	3	1	2	Good	D	0.20
247	02-057-53	Karangkates	B	2	3	2	3	1	2	Good	D	0.20
248	02-057-52	Wlingi	B	2	3	2	3	1	2	Good	E	0.20
249	02-057-51	Lodoyo	B	2	3	2	3	1	2	Good	E	0.20
250	02-057-54	Sengguruh	B	2	3	2	3	1	2	Good	D	0.20
251	02-057-59	Tulung Agung	C	3	3	2	3	2	2	Acceptable	E	0.20
252	02-057-57	Selorejo	B	2	3	2	3	1	2	Good	D	0.20
253	02-057-58	Wonorejo	A	1	2	2	2	1	2	Very Good	E	0.20
254	03-026-51	Riam Kanan	A	1	2	2	2	1	2	Very Good	A	0.10

Part 4 GEOLOGICAL AND SEISMIC EVALUATION OF POTENTIAL PUMPED STORAGE HYDROPOWER PROJECT SITES (6/6)

No.	Project ID	Scheme Name	Status	Preliminary Geological Evaluation								Seismic Assesment	
				Geological zone	Project Facility						Geological Class	Seismic Zone	Seismic Coefficient
					U-	L-	Headrace	Penstock	Tailrace	Quarry			
1	02-092-72-11	Cijulang-PS-2	PreFS	A	1	1	2	2	1	2	Very Good	D	0.20
2	02-103-71-11	Cibuni-PS-1	Inventory	B	2	2	3	3	2	2	Good	D	0.20
3	02-016-72-11	Upper Cisokan-PS	DD	B	2	2	3	3	2	2	Good	D	0.20
4	02-108-72-11	Cibareno-PS-2	Inventory	B	1	1	2	2	1	2	Very Good	D	0.20
5	02-107-71-11	Cikalong-PS	Inventory	A	1	1	2	2	1	2	Very Good	D	0.20
6	02-050-71-11	Klegung-PS	Inventory	B	2	2	3	3	2	2	Good	C	0.15
7	02-090-76-11	Dolok-PS	Inventory	B	2	2	3	3	2	2	Good	C	0.15
8	02-090-71-11	Laban-PS	Inventory	A	1	1	2	2	1	2	Very Good	C	0.15
9	02-080-73-11	Grindulu-PS-3	Inventory	A	1	1	2	2	1	2	Very Good	E	0.20
10	02-057-71-12	K. Konto-PS	Inventory	B	2	2	3	3	2	2	Good	D	0.20

Part 5 Regional Geology

PART 5 REGIONAL GEOLOGY OF INDONESIA

General geology of Indonesia has been summarized below, by editing and compiling the following references.

1) P.T. PLN, Hydro Inventory and Pre-Feasibility Studies, 1999.
2) Indonesian Government, http://www.iagi.or.id/indonesia_geology/
3) Darman, H. & Sidi, H., An Outline of the Geology of Indonesia, Indonesian Geologists Association publication, 2000.
4) Bemmelen, R. W. van, The Geology of Indonesia The Hague, Govt. Printing Office, 1949.
5) William H. Frederick, et. al., General Geology, U.S. Library of Congress, 1993.

Indonesia is a huge archipelagic country extending 5,000 kilometers from east to west and 1,800 kilometers from north to south. It encompasses 14,000 islands, only 6,000 of which are inhabited. There are five main islands (Sumatra, Java, Kalimantan, Sulawesi, and Irian Jaya), two major archipelagos (Nusa Tenggara and the Maluku Islands), and sixty smaller archipelagos.

Irian Jaya is the world's second largest island, where as Kalimantan is the third and Sumatra is the sixth. Indonesia's total land area is some 1,900,000 square kilometers. Indonesia's total territory includes another 93,000 square kilometers of inlands seas (straits, bays, and other bodies of water).

The tectonics of Indonesia is very complex as it is a meeting point of several tectonic plates. Indonesia is located between two continental plates: the Sunda Shelf (Eurasian Plate) and Sahul Shelf (Australian Plate); Sumatra, Java, Kalimantan lie on the Sunda Shelf; -an extension of the Malay Peninsula and the Southeast Asian mainland, and between two oceanic plates: the Indian Plate and Pacific Plates; Irian Jaya lies on the extension of the Australian Plate.

The Indian oceanic plate subducts beneath the Eurasian continental plate which creates deep submarine trench (Sunda trench) along the islands. The rate of subdution is some centimeters per year (ex. 6.0cm per year in west Java trench -10.7cm per year in New Guinea). In the eastern portion of Indonesia another subduction of Pacific plate moves southwesterly under the Eurasian plate. This subduction creates the formation of volcanoes in the North Sulawesi, Sangihe and Halmahera.

It creates one of the most active tectonic zones on earth. The subduction movement results in the oblique convergence of the Sunda trench, partitioned by thrust-faulting hundreds kilometers in parallel to the east of the trench. It is the region of one of the most seismically active zones of the earth, most of the earthquake concentrates in this subduction zone.

This subduction also formed the volcanic arc in western Indonesia, chain of active volcano arc, 3,000km long along the Sunda arc. As a result the country has numerous mountains and some 400 volcanoes, of which approximately 100 are active. Between 1972 and 1991 alone, 29 volcanic eruptions were recorded, mostly on Java. The most violent volcanic eruptions in modern times occurred in Indonesia. In 1815 a volcano at Gunung Tambora, Nusa Tenggara, in 1883 Krakatau in the Sunda Strait erupted. Mountains ranging between 3,000 and 3,800 meters above sea level can be found on the islands of Suda arc, Sulawesi, and Seram. However the tallest mountains was Puncak Jaya of 5,039 meters in Irian Jaya.

One of the most outstanding features among the major structures formed by the tectonic processes in Indonesia is the Great Sumatra Fault (Semangko Fault), a dextral strike-slip fault along Sumatra Island. This fault zone is formed as right lateral strike-slip fault due to the subduction movement in the west of Sumatra.

Palu-Koro fault is another major structural feature formed in the central part of Indonesia. This fault has similar orientation as the Great Sumatra fault, extend from Koro in central part of Sulawesi to Palu in the west coast of Sulawesi and extend across the Makassar strait to East Kalimantan.

Reflecting the tectonics, the stratigraphy of of Indonesia in general is such that constitutes relatively young, ranging in age from Paleogene to Quarternary layers in the western part, and eastern Indonesia has older stratigraphy compared to the western part. The stratigraphy ranges from Triassic to Tertiary. The brief description of each island is as follows.

1. SUMATRA ISLAND

SUMATRA Island is the northwest of the country, lied on the western edge of Sunda arc, a southern extension of the Eurasian Continental Plate. The Sumatra Island has an area of about 473,606 km2, measuring 1,650 km length and 100-350km in the width.

The most prominent topographic element of the island is the Barisan Range, running 1,650 km long across the whole western side of the island and about 100 km wide. The axis of the Barisan Range has the same northwesterly direction as that of the island and has many peaks of elevation over 2,000 meters, and a few peaks even higher than 3,000 meters. The island is largely divided into two drainage areas, i.e. the area of northeastward drainage to Strait of Malaka and the area of southwestward drainage to the Indian Ocean, by the cordillera of Barisan Range.

Sumatra is situated in a tectonically active zone along the western edge of the stabilised craton of Sunda Shelf. Located at approximately 200 km off-shore the west coast of Sumatra is the subduction zone of the Indian Ocean plate that is moving north or northeast and sinking below the Sumatra island arc. The Barisan Range forms the volcanic inner arc in the Quaternary tectonics, with many young volcanoes formed on the Pre-Tertiary meta-sedimentary basement rock.

In the other hand, the non-volcanic outer arc in the recent orogenesis is represented by the line of festoon islands of Simeulue and Nias to Enggano located between the west coast and the subduction zone.

An outstanding geological structure reflecting the recent tectonic activity is the Great Sumatra Fault (GSF) Zone (or Semangko Fault Zone), a chain of faults at the northwesterly orientation. Faults of this zone have been recognised to be currently active with dextral strike-slip movements associated with the subduction movement of the Indian Plate.

The GSF Zone develops through all the length of the Barisan Range from Semangko Bay up to Banda Aceh at the northwestern tip of the island. It passes almost the center of the Barisan Range, making lineament of valleys along it. Also formed are crater lakes and calderas near this fault zone including the lakes of Toba, Maninjau, Singkarak, Krinci, Ranau, etc. It is also recorded in the last hundred years that shallow earthquakes of high magnitude were generated at varied parts on this fault zone to cause public damages, as well as dislocations on fault planes. Most devastating earthquake occurred in 2004 releasing energy beyond M9 in the areas of North Sumatra through Andaman Archipelago, with displacement of longer than 1,000km.

Therefore, it is to be avoided to place big and important structures, especially large dams, on major fault lines within the GSF Zone.

To northeast of the Barisan Range develops an extensive foothill zone, composed of the Pre-Tertiary basement rock and Tertiary deposits overlying it, and a wide alluvial plane on the east coast.

On the opposite side of the Barisan Range, its southwestern slope descends to the west coast within 50 km of distance, where narrow coastal plains develop intermittently.

As is proved by many projects completed or contemplated so far, the Barisan Range is the zone specifically suitable for major hydropower projects in Sumatra, mainly because of its topographic feature that easily allows to take high water head. From geological and geotechnical points of view the Barisan Range can be divided into two zones as follows:

(1) The Pre-Tertiary rock zone, where the hard Pre-Tertiary bedrock is exposed or encountered within reasonable depths for project structures. The Pre-Tertiary rock can be regarded essentially well cemented, hard and strong if it is in the intact condition, neither weathered nor fractured. Projects with high dams or underground powerhouses are viable in this zone, even if some of them might require deep foundation excavation to remove thick weathered rock or heavy supports for underground cavern in schists or slaty rocks.

(2) The young volcanic zone, where the basement rock is covered by very thick Quaternary volcanic products; especially by young pyroclastic rocks, e.g., poorly cemented tuff or volcanic breccia or lahar. Rocks of this zone, except for volcanic rocks such as andesite or basalt, are not suitable for foundation to undergo high stress. Andesite and basalt are sufficiently hard, though their

occurrence is often localized in limited areas. Dams (weirs) and tunnels of medium diameter have been constructed in this zone.

2. JAVA ISLAND

The island of JAVA has an area of 127,000 km2, with the length of approximately 1,000 km in the east-to-west direction and the width varying from 60 km to 200 km. It is situated on the southern edge of the cratonic mass of Pre-Tertiary Sunda Shelf overriding the oceanic Indian plate, thus forms volcanic arc that is tectonically active in Quaternary age.

The main geological structure of Java is the geo-anticline occupying the southern half area of the island, as represented by east-to-west stretching belts of Southern Mountains and Central Depression Zone associated with a row of Quaternary volcanoes. These zones correspond with a volcanic inner arc on the south rim of the Sunda continental crust, like the Barisan Range of Sumatra on its west rim. The difference from the Barisan Range is that the bedrock is mostly Tertiary or younger, with only very localized occurrence of Pre-Tertiary rocks.

The outer arc of the Java tectonics is located about 100 km off-shore the south coast in the form of submarine ridges, and the subduction zone of the Indian Ocean Plate is located further 100 km south.

The Southern Mountains consist of interbedding Miocene volcano-sedimentary rocks and calcareous beds. The volcanic rocks, such as andesite and basalt, are sufficiently strong and most of pyroclastic rocks are generally compact and solid. The calcareous rocks are mainly limestone and marl. The Tertiary limestone is hard, though it is often lightly karstified and considerably pervious. The problem of high permeability is involved also in Quaternary coral limestone in the Southern Mountains zone.

The Central Depression Zone was a part of the mountain range, together with the Southern Mountains. The mountains of this zone have subsided and been broken, and are presently covered by volcanic products of the young volcanoes. While the Quaternary volcanic deposits are poorly cemented and weak, the Tertiary pyroclastic rocks, e.g., tuffs, tuff breccias and volcanic breccias, are duly strong and often exposed in valleys.

Other Tertiary sediments develop north of the Central Depression Zone, which are the deposits in the foreland basin between the continental crust of Sunda Land and the inner arc in South Java.

A number of hydropower projects with high embankment dams have been effectuated in the terrain of Tertiary volcano-sedimentary rocks, especially in the Central Depression Zone. The Tertiary pyroclastic rocks are not very hard but sufficiently strong, and manageable to support high embankment dams and accommodate tunnels of medium diameter.

The limestones of both Tertiary and Quaternary in the Southern Mountains are more or less pervious with wide open fissures or fractures.

3. KALIMANTAN ISLAND

KALIMANTAN is the second largest island in the Indonesian archipelago with a total area of 736,000 km2. The Indonesian part of the island covers 539,500 km2. The island has a roughly triangular outline. It lies upon the southeastern margin of the Eurasian plate, and is bounded to the north by the South China Sea marginal oceanic basin, to the east by the Philippine Sea Plate and to the south by the Sunda arc. It is essentially of Paleozoic and Mesozoic continental crust of the Malay Peninsula.

It has extensive hill and mountainous relief which, however, in most localities does not exceed 1,500 meters a.s.l. A broad mountain system traverses the island from the Kinabalu Range in the north (with Mt. Kinabalu, El. 4,175 m) to the Schwaner Range in the southwest (with Bukit Raya, El.2,278 m), forming a main divide of the island. There is also an isolated range of Meratus with north-south trend in the southeastern part. The Lower Kapuas Mountains on the Malaysian border is a western branch of the main divide. One of the eastward branches is the complex system of Sambaliung Mountains stretching to Cape Mangkalihat on the east coast.

The island can be divided into three major geomorphologic units as follows:

(1) Continental basement and platform sediments

The continental basement rock and platform sediments are developed in the Schwaner Range in the southwestern part of Kalimantan and in the mountain area between Singkawang and Balaisebut at the western edge of the island. The oldest rock of the continental basement is Palaeozoic metamorphic rock including slate, hornfels, phyllite, quartzite, schist, gneiss, migmatite, etc.. Triassic to Cretaceous sedimentary rocks are also parts of the basement, but its major part is occupied by Cretaceous granitic rock and, partly, gabbro.

Sediments covering platforms in the outer zone of the continental crust are Plio-Pleistocene to Quaternary deposits which are extensively developed over almost one half part of Kalimantan Tengah and wide coastal plain of Kalimantan Barat.

(2) Oceanic basement and overlying sediments

The oceanic basement rock is represented by Jurassic ultramafic rock and Cretaceous meta-sedimentary rock which form the main mountain range along the Upper Kapuas mountains and the Iban Mountains on the Malaysian border. The ultramafic rock includes serpentinite, peridotite, gabbro, basalt and diorite, and the meta-sedimentary rock consists of clastic rocks ranging from conglomerate to claystone, shale, slate, greywacke, crystalline limestone, chert, spillite and pyroclastic rock. The basement rock in the main range is associated by Mio-Pliocene volcanic products of lava, breccia and tuff of andesitic- basaltic composition, which indicates that this mountain range was a volcanic inner arc in the Miocene age.

The same kind of Jurassic-Cretaceous rock, along with the granitic rock, makes the core of the Meratus Mountains near the southeastern edge of Kalimantan.

Overlying sediments are Quaternary deposits.

(3) Foreland sediments

Foreland sediments are formed by deposits in the shallow sea between the continental mass and the arc and sometimes around the arc. The sediments consist of Oligocene and Miocene lithic sandstone or quartz sandstone, tuffaceous sandstone, mudstone, shale, conglomerate, limestone and other soft or moderately hard sedimentary rock. These sedimentary beds develop in the west-to-east trending belt between the Schwaner Mountains (the continental craton) and the Kapuas Mountains (the arc), and on both sides of the Meratus Mountains (the other arc). Calcareous rock is predominant around the Meratus Mountains and its north up to Tanjungredeb.

From tectonic point of view, Kalimantan has the geological structure of two old arcs, which have already been stabilised, along the north and the east edges of a continental craton. The thick mountain range of Kapuas to Iban on the northern arc shows a curve concave to the north, and all main faults and fold axes are nearly parallel with this curve. It also has a group of faults right angle to the curve. The eastern mountain range of Meratus shows a general trend of north-northeast to south-southwest, and the same trend appears in faults and fold axes.

4. SULAWESI ISLAND

SULAWESI is an island of complicated form like the capital “K” with an area of 172,000 km2, surrounded by deep seas over 2,500 meters in depth. The island is mountainous at large, with many peaks higher than 2,000 meters a.s.l. and only limited development of coastal plains at places.

Tectonically, Sulawesi island is placed among the northward-moving Australian plate, the westward-moving Pacific plate, and the south-southeast-moving Eurasia plate. Sulawesi appears to be a fragment of the Sunda Land which has been moving away from Kalimantan to the east-southeast by separation of the oceanic crust under the Makassar Strait. To the north of the island is the North Sulawesi Trench formed by the subduction of oceanic crust from the Sulawesi Sea. To the southeast convergence has occurred between the Southeast Arm and the northern part of the Banda Sea along the Tolo Thrust (Silver et al., 1983a, b). Both major structures (the North Sulawesi Trench and Tolo Thrust) are linked by the Palu-Koro Fault system.

Due to this movement, a long stretched fault zone with sinistral strike slip, named Palu-Koro Fault, is developed in the direction of north-northwest to south-southeast through a 200 km wide mountain zone from the Palu Bay to the Bone Bay. This fault zone has been recognized as active by the presence of earthquake centers and many hot springs along it. The Palu-Koro Fault Zone is located nearly in the central part of Sulawesi, dividing the island into two parts of east and west.

The east part of Sulawesi consists of Minahasa Peninsula in the north and two peninsulas of so-called East Arms in the Central Sulawesi and the Southeast Sulawesi. The Minahasa Peninsula is a 40 to 60 km wide and 600 km long sinuous land string located at the farthest northern part. The western part of this peninsula is composed of Mesozoic to Paleogene basement rocks, including Triassic metamorphic rock and Cretaceous to Oligocene volcano-sedimentary rock. The eastern part is largely covered by Neogene to Quaternary sediments and Quaternary volcanic products, and has structural connection to Mindanao, the Philippines, through festoon islands in between.

The East Arms are characterised by extensive exposure of the Pre-Tertiary basement rock that includes schist of unknown age, Mesozoic limestone and other sedimentary rocks, and basic intrusive rock. Tertiary sediments are developed in the central part and Tertiary limestone also occurs in the southern end of the East Arm.

South Sulawesi and a part of Central Sulawesi on the west side of the Palu-Koro Fault are composed of Tertiary to Quaternary sediments, volcanic products and intrusive rocks. Intrusive granite/diorite rock occupies large areas around the Palu-Koro Fault and Mt. Gandadiwata (El. 3,074 m) to the south. Cretaceous basement rock is exposed only around Mt. Rantemario (El. 3,440 m) and on the western slope of Mt. Malawa (El. 1,696 m) near the west coast. Paleogene rocks are developed around those basement exposures and also between the Palu-Koro Fault and the west coast. Other areas are occupied by Neogene and Quaternary sediments. The Quaternary occupies only low lands.

5. IRIAN JAYA ISLAND

IRIAN JAYA has an area of 394,000 km2 and forms the western half of the world second largest island of New Guinea. The island consists of the WNW-ESE trending main trunk and a peninsula with the form of a bird’s head on the western end. The Tectonically Irian Jaya is complex, involving interaction between two plates; the Australian and Pacific plates. Most of the Cenozoic tectonic evolution of New Guinea is the result of oblique convergence between the Australian and Pacific plates. and an active oceanic island arc and continent collision. The Central Range is a 1,300 km long, 150 km-wide belt with numerous peaks over 3,000 m in elevation. Most of the range is composed of folded and faulted Mesozoic and Cenozoic strata deposited on the Australian passive continental margin.

The southern half part of the main trunk and the most part of the bird’s head is situated on the northern rim of the Australian continental crust, while the northern half of the main trunk is on the oceanic crust. Fold mountain ranges are developed in the transition zone between those two crusts, with igneous rock intrusions of the Miocene to Pliocene ages and rather weak volcanic activities.

In the peninsula of the bird’s head, the fold mountains are developed on its northern half part, divided into two ranges stretching west to east by a depression of the same trend in between. Those ranges are composed of Paleogene sediments, Miocene volcanic rocks and coral limestone in the north and of

Jurassic to Cretaceous and Tertiary sediments in the south. The sedimentary rock is often calcareous in the southern mountains.

At the eastern end of the bird's head, the axis of the fold mountain ranges turns southward and, after a stretch of 200 km to south, it turns again to the west-to-east direction, thereby making a form of a bird's neck. The peninsula is separated from the rest of the island by a shallow sea of Bintuni Bay on its south side, connected to the main trunk of Irian Jaya only by a narrow isthmus, 30 km wide, in a part of the neck.

In the main trunk, a west-to-east trending fold mountain range is developed through the central part of the island. It is composed of Mesozoic sedimentary beds, Tertiary deep marine sediments and shallow sea limestone. In the northern flank occur Triassic ultra-basic rocks, Tertiary meta-sediments, Pliocene intrusive rocks and Alluvial plain. Clastic sediments of Miocene to Pliocene are formed on the south side of the mountain range.

The central mountain range of Mesozoic and Tertiary rocks has the width of 150 km on the north-south section right angle to its axis. On its north side develops an extensive alluvial plain with swamps, which has the maximum width of 70 km and the west-to-east length of more than 300 km. The alluvial plain is bordered on the north by another mountain range of Mio-Pliocene sediments, including siltstone, lithic sandstone, limestone and marl, which is also associated by local exposures of Neogene volcanics, Pre-Tertiary meta-sedimentary rock and ultra-basic basement rock. This northern mountain range has the highest peak of El. 2,272 meters, though it is generally lower than the central range.

An extensive alluvial plain spreads over 300 km of distance to the south of the central range.

6. NUSA TENGGARA ISLAND

NUSA TENGERA are series of islands from less than 300 km2 of Pantar to 32,000 km2 of Timor. The total area of the larger islands is over 75,000 km2. The maximum altitude ranges from 20 to 3,726 meters (Mt. Rinjani at Lombok).

NUSA TENGERA consists of two strings of islands stretching eastward from Bali toward South Maluk, up until Irian Jaya. The inner arc of Nusa Tenggara is a continuation of the chain of mountains and volcanoes extending from Sumatra through Java, Bali, and Flores, and trailing off in the Banda Islands. The outer arc of Nusa Tenggara is a geological extension of the chain of islands west of Sumatra that includes Nias, Mentawai, and Enggano. This chain resurfaces in Nusa Tenggara in the ruggedly mountainous islands of Sumba and Timor.

The western part of the inner arc of Bali, Lombok and Sumbawa is closely related with the volcanic belt of Java and virtually on its geomorphological extension. The row of Holocene volcanoes in the east-west trending Central Depression Zone of Java continues east up to the central part of Sumbawa

Island, together with the Tertiary sediments and limestone of the Southern Mountains. The eastern part of the arc consists of islands of a little older volcanic activity of the Plio-Pleistocene age, ranging from Flores eastward to Romang, which represents the volcanic inner arc of the Timor Orogenesis. The whole inner volcanic arc has the basement of Miocene volcano-sedimentary rocks covered by Early Quaternary andesitic-basaltic lavas and pyroclastic rocks, intercalating shallow-water sediments of tuffaceous rocks and limestones with globigerina fossils. At many places the marine volcanic rocks are overlain by intermediate and basaltic volcanic products of Young Quaternary.

The outer and non-volcanic arc comprises the islands of Timor, Semau, Roti, Sawu, Raijua and Dana, which are composed of the basement meta-sedimentary complex of ages from Permian to Cretaceous and the overlying Oligocene to Early Quaternary volcano-sedimentary rocks. Quaternary coral limestones are found at various levels.

From tectonic point of view the area has undergone a series of complicated structural evolution, including the Holocene tectonic activity as indicated by the current seismicity and the long-term ground movement.

BALI is composed of products from the volcanic activities in the Plio-Pleistocene age and the Pleistocene to Holocene age. The products in those two activities are similarly andesitic and basaltic lavas, tuffs and other pyroclastic rocks. The Plio-Pleistocene volcanic products are wide-spread in the western part of the island and in the vicinity of crater lakes of main volcanoes to the east. The Quaternary volcanic rock and sediments are developed extensively in the central and eastern parts. The southern end is an extension of the Southern Mountains of Java, composed of limestone and other calcareous sediments.

LOMBOK, as the extension of Java, is covered by Quaternary volcanic products in the north and Oligo-Miocene volcanic deposits and limestone in the Southern Mountains.

SUMBAWA is an island, in the west of similar geological setting as the Southern Mountains of Java with Oligocene-Miocene volcanics and Miocene limestone which are further flanked on the north by Miocene sediments, in the northwest with Plio-Pleistocene volcanic products.

FLORES is composed of Miocene volcano-sedimentary beds and Plio-Pleistocene volcanic products. The Miocene consists of alternatingly developed limestone beds and volcanic beds and is covered by younger lavas, tuffs and breccias of the Plio-Pleistocene volcanism in the southern part of the island. The Miocene rocks are developed in the northern half of the eastern block of Flores and in the middle part of the island. The Plio-Pleistocene volcanic activity is one step older than the Quaternary rocks in Java, Bali and Lombok. Quaternary volcanoes are also located in Flores but sporadically on the south coast.

TIMOR is a part of the non-volcanic outer arc. The eastern part of the island is largely occupied by Late Palaeozoic to Mesozoic rocks which includes Pre-Permian schist, gneiss and granulite, Permian sandstone and shale, Triassic phyllite, slate and calcareous rock, and Triassic-Jurassic clastic sediments. The southwestern half of Timor has a complex geological setting with many small patches of Pre-Tertiary rock exposures including limestone, among the wide-spread Neogene bedrock. The Neogene rock is a large mass of melange bed in which scaly clay forms a matrix with exotic blocks derived from older rock. Quaternary deposits and limestone are widely developed in the central belt stretching nearly parallel with the axis of the island.

SUMBA is also located on the same submarine ridge as Timor. The geological setting of Sumba, however, has no similarity with Timor. The island is dominated by Neogene clastic sedimentary rocks such as the alternation of sandstone, marl and tuff with intercalation of limestones. The other major members are the wide-spread Neogene carbonates or limestone, with marl and tuff; and the uplifted Quaternary coral limestone. The carbonate rocks could be pervious because of karstification in varied degrees. Older volcanic products and sedimentary rocks of Paleogene are located in limited parts of the island.

7. MALUKU ISLAND

The Maluku Islands are geologically among the most complex of the Indonesian islands bounded by the Philippines and Pacific ocean to the north (Pacific & Philippine plate), Irian Jaya (Australian craton) to the east, and Nusa Tenggara to the south, Sulawesi and Kalimantan (Sunda Shelf) to the west. The largest of these islands include Halmahera, Seram, and Buru, all of which rise steeply out of very deep seas. This abrupt relief pattern from sea to high mountains means that there are very few level coastal plains. It has the Inner Banda Arc, the Outer Banda Arc and the West Halmahera-Obi arc.

SERAM is situated on the Outer Banda Arc as against the line of Ambon, Haruku, Saparua and Banda Islands on the Inner Banda Arc, accompanied by three small islands of Boano, Kelang and Manipa. The southwestern part of Seram is composed of Pre-Tertiary metamorphic rocks, including schist, gneiss, amphibolite of the Palaeozoic age and phyllite, slate, meta-sandstone and crystalline limestone of the Mesozoic. The central part of middle Seram is occupied by Triassic low-grade metamorphic rocks as phyllite and slate, overlain by Triassic sandy limestone. Mesozoic to Cenozoic shales, marls and calcilutites overlie the Mesozoic metamorphic rock in the central part of the island. The calcareous rock can be well cemented and hard, while it may have problem in water-tightness for karstification. The rest of the island is composed of Jurassic to Miocene sedimentary rocks and mélange, and Quaternary coral limestone on the north and east coasts. The melange contains large blocks of igneous, sedimentary and metamorphic rocks in the matrix of scaly clay.

BURU is west of the Seram. The bedrock of the island is for the most part Pre-Tertiary meta-sediments except for very small patches of Mio-Pliocene sedimentary rock at the northwestern tip and a part of the south coast. Alluvial deposit is developed in the northeastern valley and on parts of the north coast. Palaeozoic metamorphic rocks of schist, quartzite and marble occupy the eastern half of the island. And on its southwest side develops Permian phyllite, slate, meta-greywacke and marble. Further southwest adjacent to the Permian exposed are Triassic sediments including limestone, which is followed by Cretaceous sediments including calcilutite, marl, chert and conglomerate.

8. HALMAHERA ISLAND

HALMAHERA is characterized by its complex form like the capital "K".

The western trunk of Halmahera Island is on the West Halmahera-Obi Arc, along with the islands of Kasiruta, Bacan, Obi arranged on the north-south direction. The west coast of the southern half of West Halmahera is studded by Oligocene to Miocene volcanic breccia and lava, associated by clastic sediments. The same formation develops in the northern end of the West Halmahera and in the island of Morotai to the north. The other part of West Halmahera is composed of Neogene pyroclastic rocks and clastic sedimentary rocks, e.g., tuff, breccia, lava, sandstone, shale, conglomerate, etc..

Two arms (small peninsulas), namely the northeast arm and the southeast arm, have different geological composition and is characterized by broad exposure of basic intrusive rock of unknown age, including peridotite, norite, dunnite, serpentinite, gabbro, diabase and basalt. Jurassic-Cretaceous carbonates, consisting of limestone with calcareous sandstone and marl, are located sporadically in the middle part of the northeast arm. Exposed in this part is also a minor patch of Cretaceous volcano-sedimentary rocks that is alternation of pyroclastic rocks and clastic sedimentary rocks. The same volcano-sedimentary rocks appear at the eastern tip of the southeast arm. These Mesozoic rocks make the basement of this area.

Tertiary rocks in the northeast arm are mainly of Paleogene, including Paleocene to Eocene limestone and mudstone, alternating sandstone and claystone, volcanic breccia and lava. Neogene clastic sediments and limestone are minority in this peninsula.

In the southeast arm, Neogene limestone and calcareous sedimentary rocks are predominant. Paleogene sandstone and conglomerate occupy only a small cape at the east end of this arm.