Chapter 2

Electric Power Supply in EAS Countries

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CHAPTER 2

ELECTRIC POWER SUPPLY IN EAS COUNTRIES

This chapter sets out the data for each individual country used in the simulation model (in Chapter 3).

The simulation model covers a total of 12 East Asian countries, namely, Brunei Darussalam, Cambodia, China (Yunnan Province), India (northeast region), Indonesia, Lao People's Democratic Republic (PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The following abbreviations are used in this report to represent the names of these countries.

Table 2.1: List of country names and abbreviations

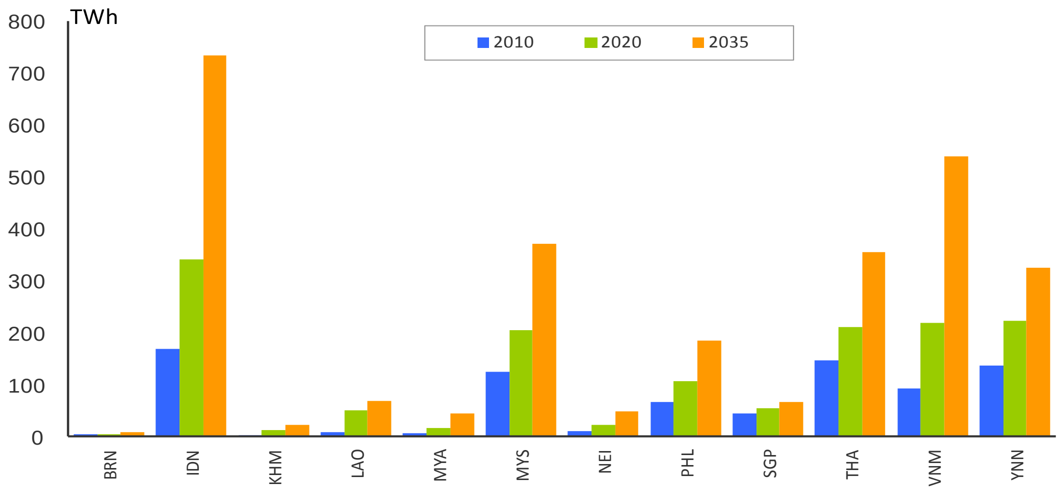
Country	3-letter codes	Country	3-letter codes
Brunei Darussalam	BRN	Malaysia	MYS
Cambodia	KHM	Myanmar	MYA
China (Yunnan province)	YNN	Philippines	PHL
India (North-East region)	NEI	Singapore	SGP
Indonesia	IDN	Thailand	THA
Lao PDR	LAO	Vietnam	VNM

2.1. Projected electric power demand

The projected power demand for each country was assumed on the basis of the power generation output (TWh) for each country in the business as usual (BAU) scenario discussed in the ERIA Research Project Report 2012, No. 19 titled "Analysis on Energy Saving Potential in East Asia".

However, the projected power demand figures for India (northeast region) and China (Yunnan Province) were calculated by taking the power generation output (TWh) of the entire country to which each of the regions belongs, and calculating a share of this output proportional to the region's actual performance in the regional breakdown of the country's generation output.

Figure 2.1: Projected electric power demand (TWh)



	TWh						AAGR		
	2010	2015	2020	2025	2030	2035	2010-2020	2020-2035	2010-2035
BRN	3.87	4.47	5.22	5.96	6.77	7.67	3.0%	2.6%	2.8%
IDN	169.79	252.38	341.64	448.07	576.05	733.09	7.2%	5.2%	6.0%
KHM	0.99	6.15	12.33	17.67	19.58	22.15	28.6%	4.0%	13.2%
LAO	8.45	22.54	51.35	65.44	67.13	68.82	19.8%	2.0%	8.8%
MYA	7.54	11.42	16.44	23.15	32.24	44.59	8.1%	6.9%	7.4%
MYS	124.10	161.20	205.10	254.00	309.10	371.80	5.2%	4.0%	4.5%
NEI	11.44	15.68	22.18	29.52	38.34	49.28	6.8%	5.5%	6.0%
PHL	67.74	84.63	106.79	130.51	156.00	185.93	4.7%	3.8%	4.1%
SGP	45.38	51.19	55.60	59.40	61.85	65.76	2.1%	1.1%	1.5%
THA	147.01	180.37	210.86	257.53	309.56	355.03	3.7%	3.5%	3.6%
VNM	92.17	148.35	219.59	295.41	398.83	538.70	9.1%	6.2%	7.3%
YNN	136.50	188.88	223.71	260.19	296.66	324.67	5.1%	2.5%	3.5%

Source: ERIA Research Project Report 2012, "Analysis on Energy Saving Potential in East Asia"

The demand for energy in the East Asian region has risen steadily to date, and is expected to increase continuously forward due to the expansion of the power supply region, the industrialisation in line with economic growth, rising income levels, and urbanisation.

With Indonesia, Malaysia, Thailand, Viet Nam and China (Yunnan Province) showing particularly dramatic increases in demand, it will be essential to expand and augment all power-related facilities including power generation, transmission and distribution facilities in all of these countries.

From 2010 to 2035, Indonesia's power demand is projected to rise from 169.8TWh to 733.1TWh, Malaysia's from 124.1TWh to 371.8TWh, Thailand's from 147.0TWh to 355.0TWh, Viet Nam's from 92.2TWh to

538.7TWh, and Yunnan Province's from 249.4TWh to 593.2TWh.

Increases in demand during the period up to 2020 are expected to be particularly substantial in Cambodia and Lao PDR.

Power demand in Cambodia is forecast to increase by 13.2 percent a year over the 25-year period from 2010 to 2035, soaring by 28.6 percent a year over the 10-year period leading up to 2020. Much of Cambodia is still without electricity, with the country's electricity supply currently confined largely to the capital region and major cities. As of June 2012, the household electrification rate for the country as a whole stood at approximately 35 percent, with the rate for urban areas at almost 100 percent; whereas that for rural areas was only around 25 percent. Moreover, latent power demand is believed to be considerable even in regions where power is already supplied, because the power demand from many of the production plants and hotels found in these regions are supplied by private power generators. Against this backdrop, the Government of Cambodia has set out targets of achieving 100 percent village electrification by 2020, and over 70 percent household electrification by 2030; and aims to improve the state of Cambodia's power generation and distribution facilities and ensure an affordable and stable supply of power.

It is expected that in Lao PDR, power demand will increase as its manufacturing and commercial industries develop as a result of foreign investment and as progress is made in policies aiming to increase the country's electrification rate. Power demand in Lao PDR is forecast to increase by 8.8 percent a year over the 25-year period from 2010 to 2035, soaring by 19.8 percent a year over the 10-year period leading up to 2020. The Government of Lao PDR has set out a target of raising the household electrification rate in Lao PDR to 90 percent by 2020.

2.2. Projected power generation capacity

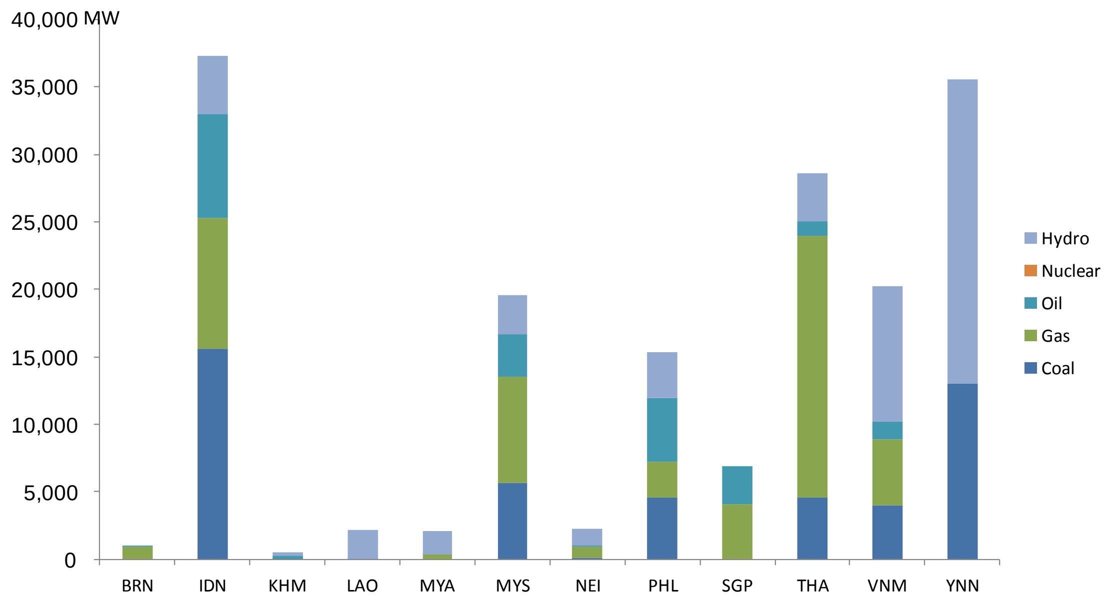
When assuming the power generation capacity for each country, the study utilised the dataset published by Platts; "World Electric Power Plants Database (as of 2012)". This dataset was segregated by country, type and installed capacity. For some countries, figures are based on information obtained by the working group (WG) of this study. The results are set out in Figure 2.2.

The projected future installed capacity was then estimated, assuming that peak demand in each country would rise proportionally with the total demand (TWh) for the country, and that new power plants would be constructed to meet the estimated peak demand.

The following conditions were established for the operational life time of each type of power generation.

Coal-fired power plants: Expected to be retired after 40 years of use
Gas-fired power plants : Expected to be retired after 30 years of use
Oil-fired power plants : Expected to be retired after 40 years of use
Nuclear power plants : Expected to be retired after 40 years of use
Hydropower plants : All expected to continue operation into the future

Figure 2.2: Breakdown of existing power generation capacity as of 2012 (MW)



(MW)

	Coal	Gas	Oil	Nuclear	Hydro
BRN	0	885	32	0	0
IDN	15,603	9,680	7,705	0	4,343
KHM	10	0	286	0	207
LAO	0	0	8	0	2,125
MYA	0	347	29	0	1,678
MYS	5,685	7,875	3,136	0	2,897
NEI	60	824	143	0	1,200
PHL	4,598	2,656	4,653	0	3,441
SGP	0	4,077	2,850	0	0
THA	4,568	19,366	1,133	0	3,517
VNM	3,964	4,884	1,328	0	10,051
YNN	13,047	0	0	0	22,495

Source: Drafted by IEEJ based on Platts World Electric Power Plants Database and the information obtained by the WG of this study

2.3. Hydropower generation potential

Figure 2.3 shows the potential of the various energy sources among the ASEAN countries. The mismatch between high electricity demand areas and the ones rich in resources for power generation areas is evident, thereby becoming the main motivation to expand international interconnected grid network in this region.

In addition, the reserves-to-production ratios of fossil fuels are declining in most of the ASEAN countries. First reason is their expansion of domestic demand in line with their economic growth. Second reason is the maintenance of export volumes in order to obtain foreign currencies. And the third reason is the need to adhere to long-term export agreements that are already in place.

This means that countries such as Indonesia, Malaysia, Thailand, and Viet Nam in particular, where power demand is expected to increase substantially, now increasingly need to import energy resources, resulting in rising power costs in these areas.

Conversely, while domestic demand for electric power is lower in countries in the Mekong Basin such as Lao PDR, Cambodia, or Myanmar, compared to their neighbours, these countries also possess rich hydropower resources and have massive potentials for future development.

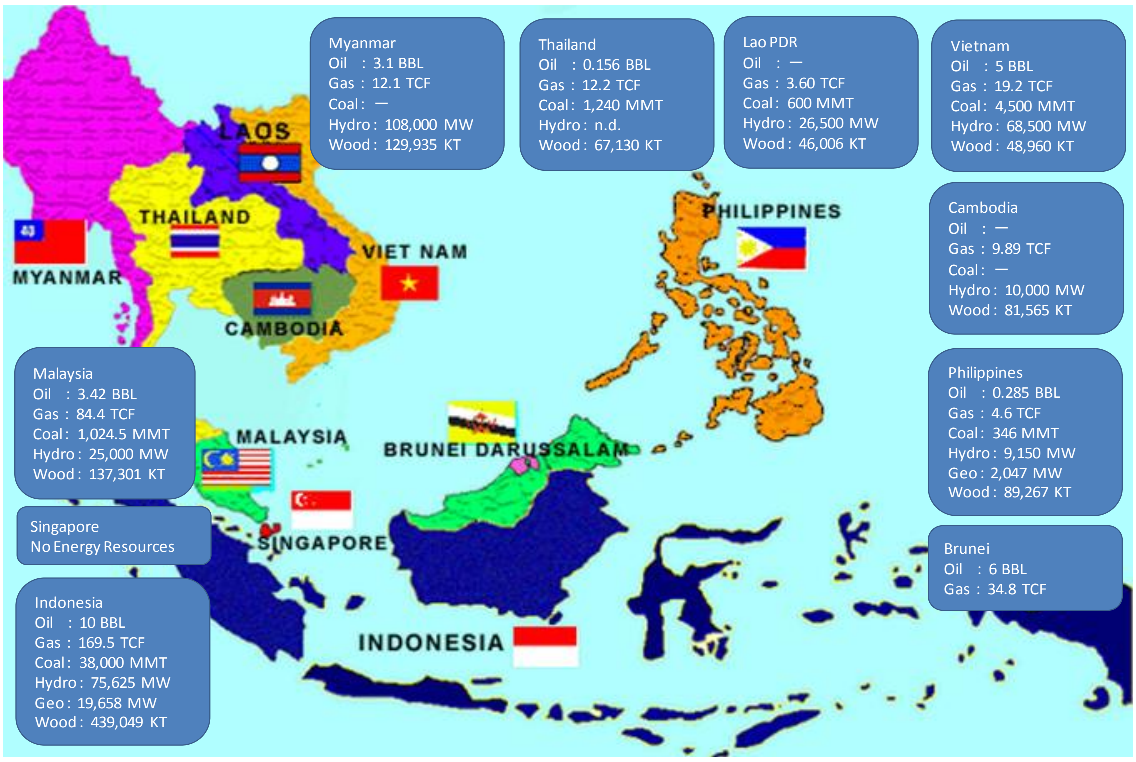
As a country whose terrain is characterised by the Mekong River which cuts through approximately 1,500km of the country’s length, and by the multiple tributary rivers which flow into the Mekong River from high-elevation areas such as the Annamite Range, Lao PDR's hydropower development potential could theoretically be as high as 26,000 to 30,000MW. It is estimated that no more than around one-tenth of this potential is currently developed.

In addition, calculations by the Ministry of Industry, Mines, Energy (MIME) of Cambodia estimate that the hydropower resources with development potential in Cambodia could provide 10,000MW of power (5,000MW from the main stream of the Mekong River itself, 4,000MW from the subsidiary basin, and 1,000MW from other parts of the Mekong River); and that no more than around 3 percent of this potential is currently developed.

Furthermore, it is estimated that the hydropower potential of Myanmar could theoretically reach 108,000MW, and development works making use of economic cooperation and direct investment from China, Thailand and India have gone into full swing in recent years.

Development of international grid networks in the EAS region is expected to help optimise the power supply as a whole. In addition, power export through interconnection becomes an important sector for economic growth in these countries. Neighbouring countries will also benefit from the diversification of their energy supplies and lower power costs through importing power.

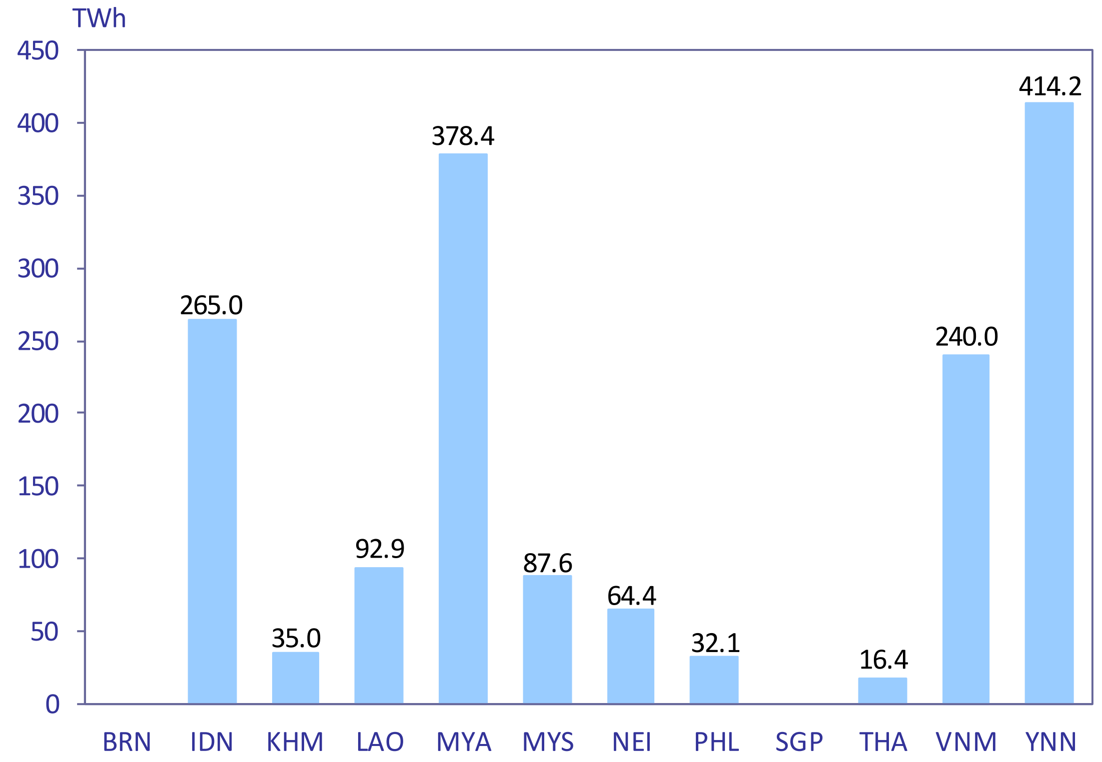
Figure 2.3: Potential of the various energy resources in the countries of ASEAN



Source: "ASEAN Interconnection Briefing on ASEAN Power Grid" (EAGT) - 14th March 2013

Figure 2.4 shows the potential of the hydropower resources of the various countries in the simulation model developed in this study. The figures were developed by taking the power generation capacity figures (MW) shown in Figure 2.3 as a baseline, and provisionally assuming a uniform utilisation rate of 40 percent. However, given the data constraints, the projected figures for Thailand, India (northeast region), and China (Yunnan Province) have been calculated based on their power infrastructure development plans, information obtained by the working group of this study, and other sources.

Figure 2.4: Projected hydropower development potential in 2035 (TWh)



Source: IEEJ projections

2.4. Projected load curve

The development of power resources is dictated by the power demand during peak times rather than by the annual power demand for the country in question. In recent years, there have been changes in the load curve in much of the East Asian region due to changes in the industrial structure and living environments in the region.

As early as the mid-1990s, power consumption patterns in Thailand, the Philippines, Indonesia (Java-Bali Transmission Line), and Viet Nam (southern region) were beginning to display a load curve which peaked during the daytime when industrial demand is high since these countries are relatively mature markets.

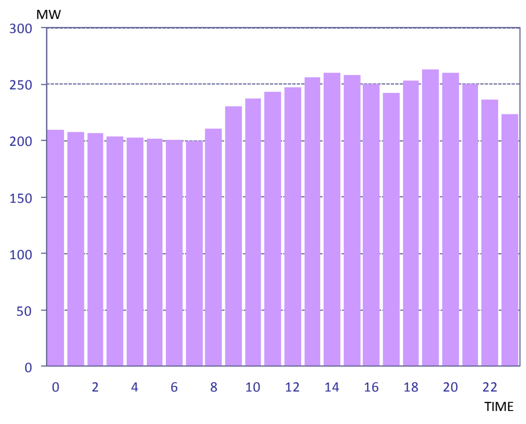
Meanwhile, the power consumption patterns of other East Asian countries have, until recent years, retained the traditional electric lighting-centered demand mode, where the daily peak occurs from early evening through nighttime. However, with the growing power demand for industrial purposes in recent years due to economic development, there are now signs that the rate of increase in the daytime peak is starting to exceed the rate of interest in the nighttime peak. This means that the extent of the gap between the daytime and nighttime peaks in power demand is decreasing year on year.

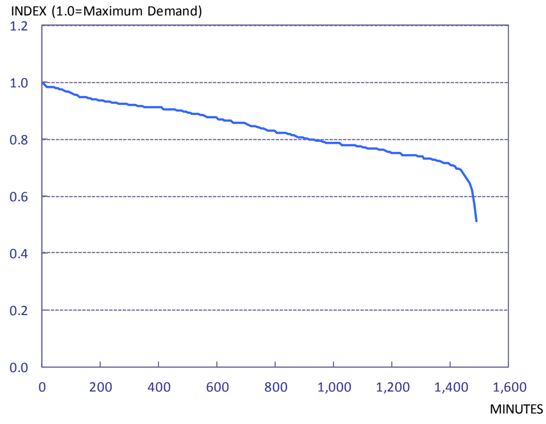
Although future long-term trends in the load curve are difficult to predict with any accuracy because they are intricately connected with a range of factors, including culture and climate, as well as the economic circumstances of the country or region, the simulation model created by this report has been established as follows.

As a general rule, peak power for each country was established using the daily load curve and load duration curve on the days of maximum power demand taken from the most recent data that could be obtained for each country. However, for countries where such data were difficult to obtain, the peak power was established using data from neighbouring countries where the pace of economic development was similar.

The following figures show the daily load curve and load duration curve projected for each country in the simulation model of this study. However, given the data constraints, the projected curves for Yunnan province in China have been assumed to be similar to Viet Nam's data.

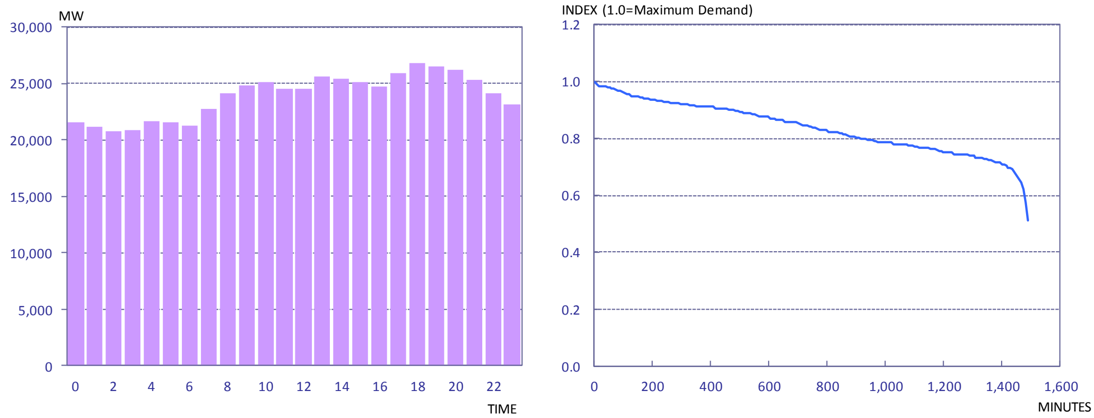
Figure 2.5: Daily load curve (average for 2006) and load duration curve for BRN





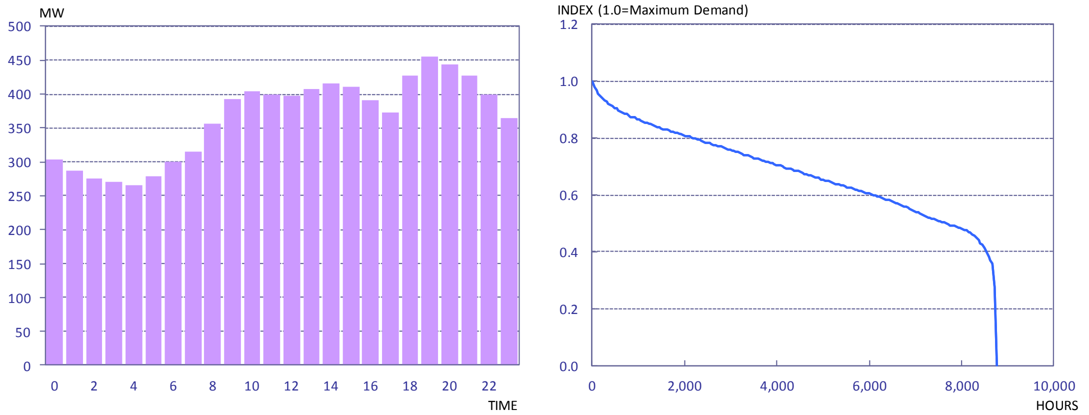
Source: by IEEJ based on Japan Electric Power Information Center (JEPIC) materials

Figure 2.6: Daily load curve (dry season, 2013) and load duration curve for IDN



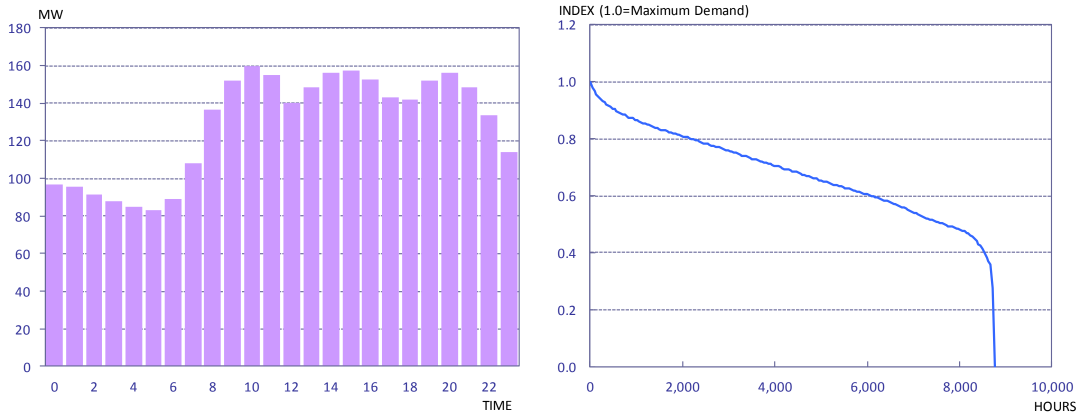
Source: by IEEJ based on 1st WG presentation materials (Nov. 2013)

Figure 2.7: Daily load curve (average for 2007) and load duration curve for KHM



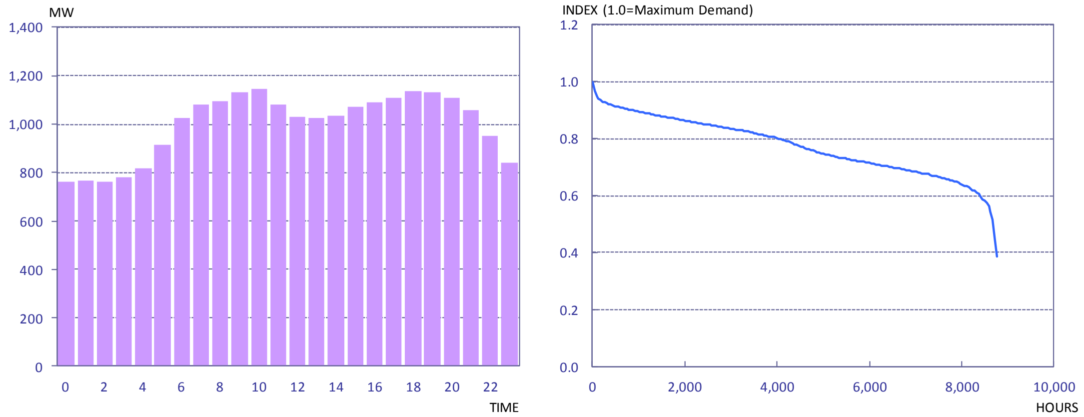
Source: by IEEJ based on Cambodia's Profile in Power Sector by Tonn Kunthel

Figure 2.8: Daily load curve (dry season, 2012) and load duration curve for LAO



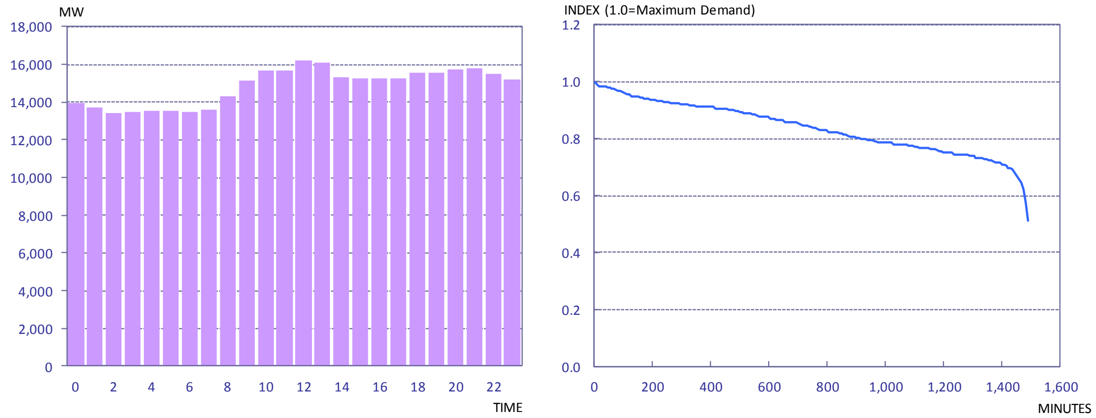
Source: by IEEJ based on 1st WG presentation materials (Nov. 2013)

Figure 2.9: Daily load curve (rainy season, 2007) and load duration curve for MYA



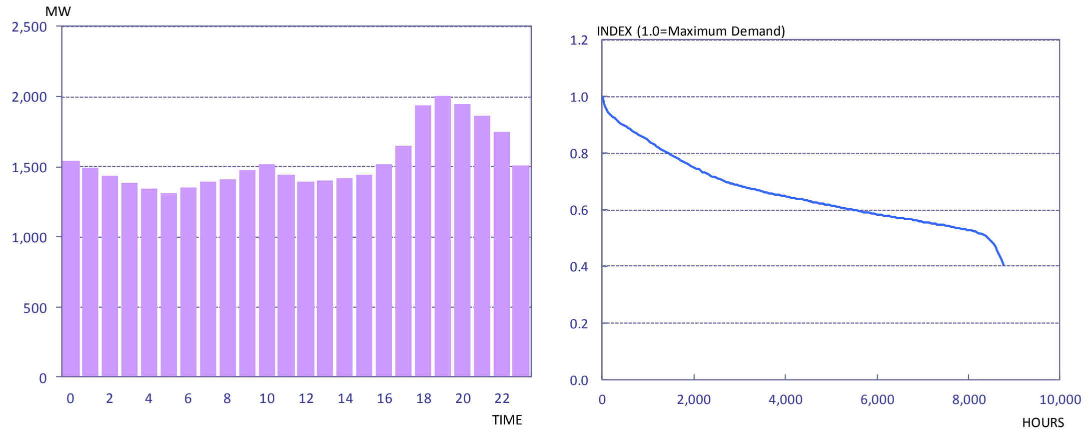
Source: by IEEJ based on JEPIC materials

Figure 2.10: Daily load curve (June 2012) and load duration curve for MYS



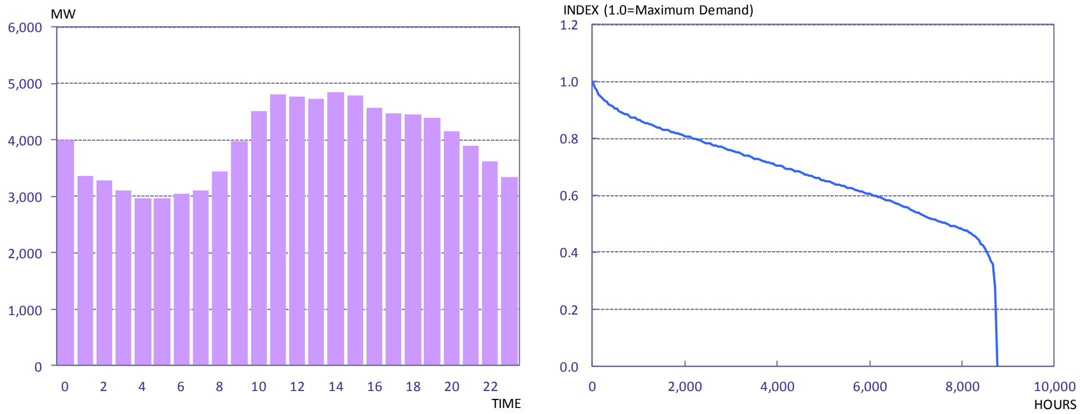
Source: Energy Commission, Grid System Operation and Performance Report 1st Half 2012

Figure 2.11: Daily load curve (July 2013) and load duration curve for NEI



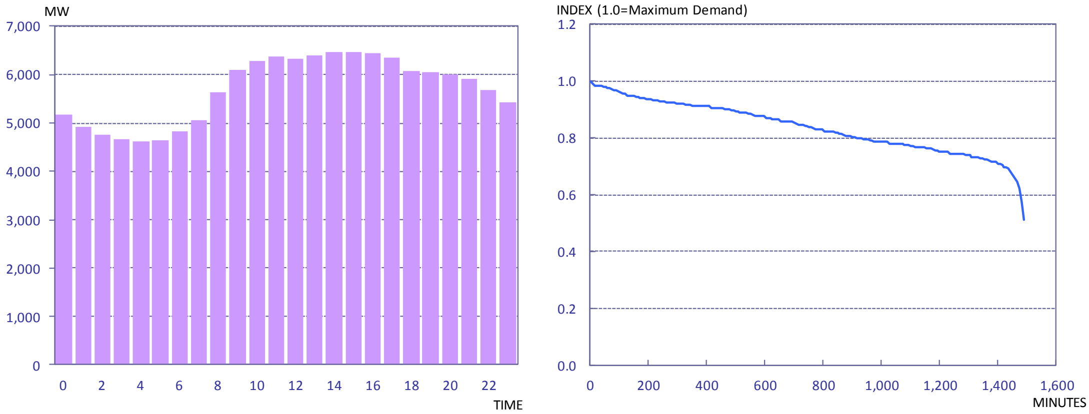
Source: by IEEJ based on 1st WG presentation materials (Nov. 2013)

Figure 2.12: Daily load curve (September 2011) and load duration curve for PHL



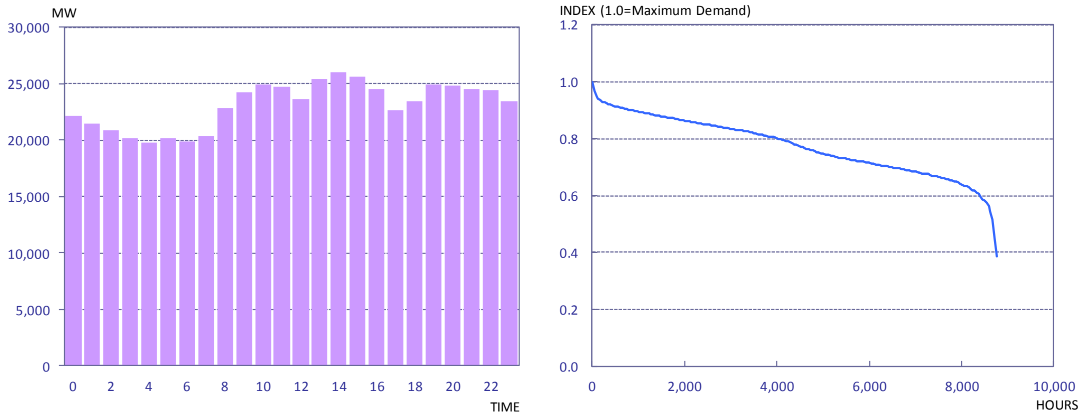
Source: Manila Electric Company (MERALCO), Investors' Briefing & Teleconference 2011

Figure 2.13: Daily load curve (May 2010) and load duration curve for SPG



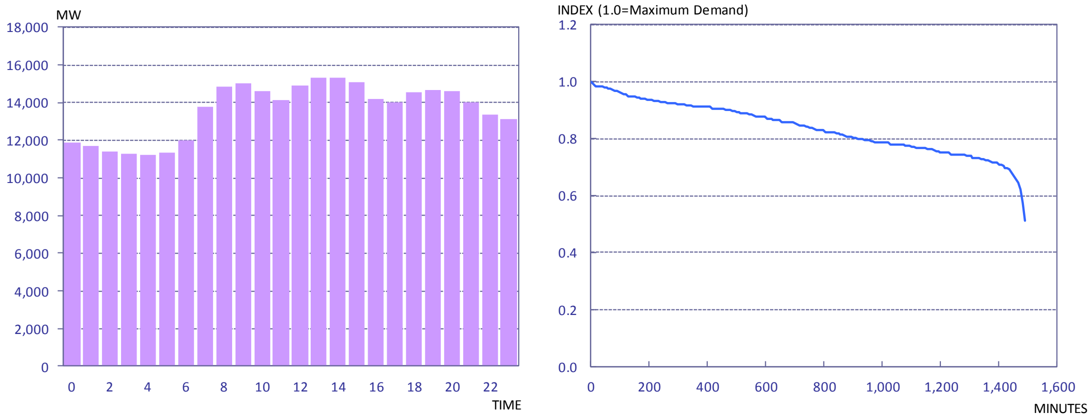
Source: Energy Market Authority, Statement of Opportunities for the Singapore Energy Industry 2011

Figure 2.14: Daily load curve (April 2012) and load duration curve for THA



Source: by IEEJ based on 1st WG presentation materials (Nov. 2013)

Figure 2.15: Daily load curve (August 2011) and load duration curve for VNM



Source: Created by IEEJ based on 1st WG presentation materials (Nov. 2013)

2.5. Projected power costs (Construction costs and O&M costs)

The cost of power generation consists of construction costs, fuel costs, variable costs other than fuel costs, and fixed costs. This chapter will set out the projected costs other than fuel costs. Future power generation costs were projected based on the assumption that countries will adopt similar type of technologies for the new construction and that the costs of these will be similar; country-wise, differences are not considered.

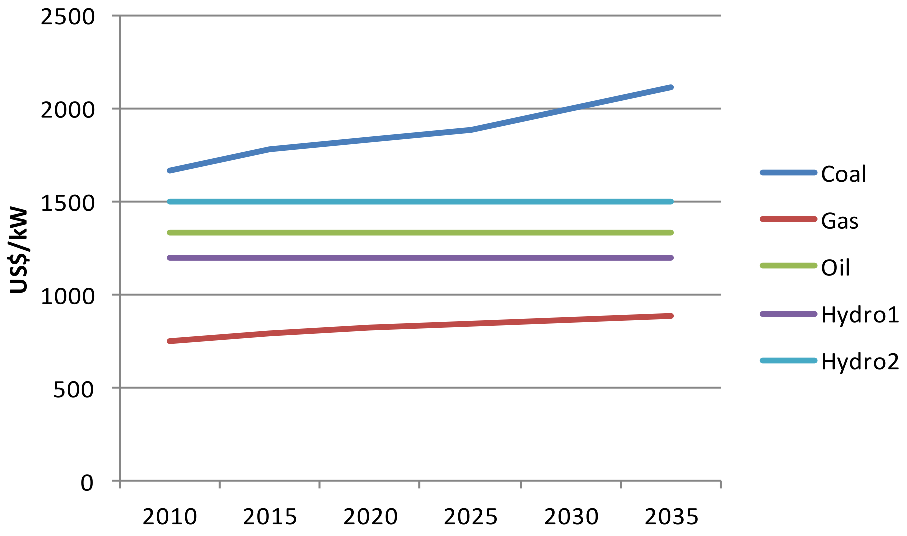
Projected construction costs were calculated using various materials as references, including the costs projected by;

OECD/NEA, IEA "Energy Technology Perspectives 2012" (ETP2012) EIA "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants"

Although ASEAN countries possess hydropower resources of tremendous potential, the level of difficulty of developing the hydro resources varies by country, and developing such resources is expected to become increasingly difficult as development progresses. In this analysis, therefore, hydropower plants are divided into "Hydropower 1" (where development is believed to be relatively easy) and "Hydropower 2" (where development is believed to be relatively difficult), and two different costs are assumed, respectively.

With regards to thermal power generation, it is assumed that increasingly advanced power generation technologies will gradually be adopted in coal-fired and gas-fired power generation, and that power generation costs will therefore tend to rise in line with the adoption of new technology. More precisely, it is assumed that there will be a shift towards combined cycle technology in gas-fired power generation; while in coal-fired power generation, there will be a move away from the traditional subcritical pressure boilers as supercritical and ultra-supercritical pressure boilers are introduced. The same cost is assumed for oil-fired power generation throughout the period, on the grounds that there is believed to be little room for technological development with this mode of power generation.[2]

Figure 2.16: Projected future construction costs (by energy source)



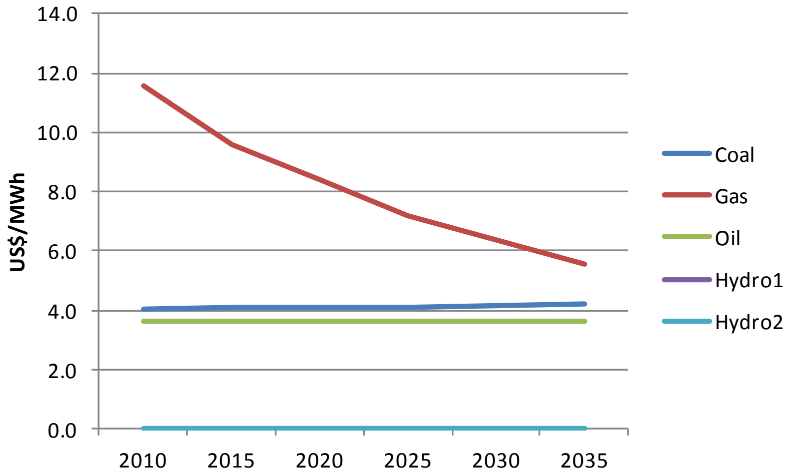
Source: Calculated by IEEJ based on costs projected by OECD/NEA, IEA's "ETP2012" and EIA's "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants"

Fixed costs are assumed to make up 10 percent of construction costs for coal-fired power generation, Hydropower 1 and Hydropower 2,5 percent of construction costs for gas-fired power generation, and a uniform rate of USD94/kW for oil-fired power generation.

Variable costs other than fuel costs are envisaged as follows, using costs projected by OECD/NEA, IEA's "ETP2012" and EIA's "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants" as references. There is a dramatic decrease in the projected costs for gas-fired power generation because it is projected that there will be a progressive shift away from traditional single cycle generation towards combined cycle generation, for which variable costs are relatively low.

[2]The cost for nuclear, biomass and geothermal power generation is abbreviated because these types of power generation are exogenous to the design of the model calculations.

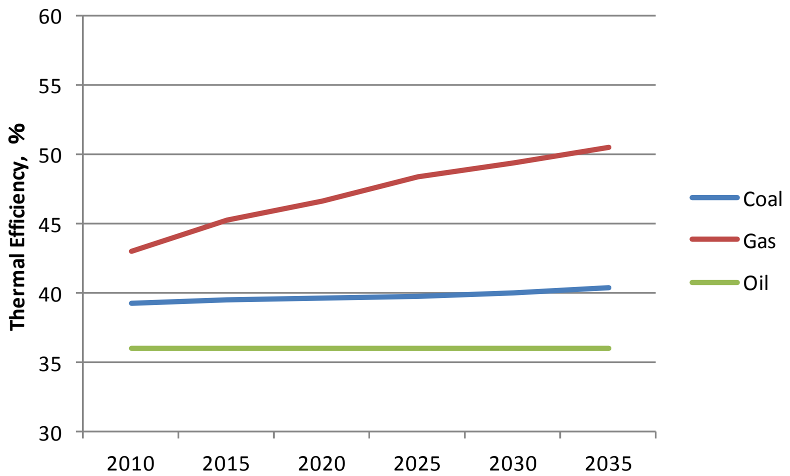
Figure 2.17: Projected future variable O&M costs (by energy source)



Source: Calculated by IEEJ based on costs projected by OECD/NEA, IEA's "ETP2012" and EIA's "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants"

The thermal efficiency of newly constructed thermal power generation plants is set out as follows.

Figure 2.18: Projected thermal efficiency (by energy source)



Source: IEEJ projections

2.6. Projected annual discount rate

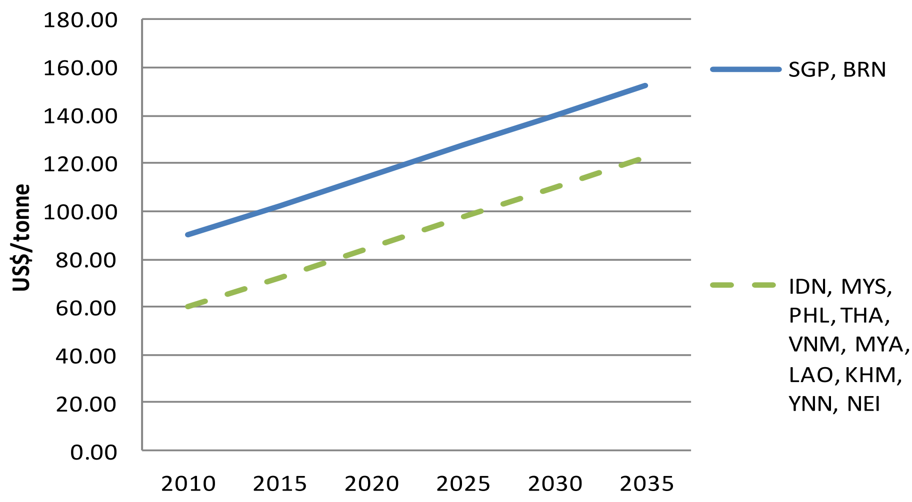
The discount rate can differ according to the investment risk and economic climate for each country and scenario, and on what the objective of the evaluation is. However, the simulation model in this report provisionally assumes a uniform rate of 10 percent by bringing together available sources of information and opinions from several experts.

2.7. Projected fuel costs

Future costs for coal and natural gas were projected as follows.

Projected coal prices were divided into two levels: prices for coal-producing countries and prices for coal-importing countries. Indonesia, Malaysia, the Philippines, Thailand, Viet Nam, Myanmar, Lao PDR, Cambodia, China and India are coal-producing countries. Two other countries—Singapore and Brunei—are coal-importing countries. Coal prices for 2010 are set at USD60/ton for coal-producing countries and USD90/ton for coal-importing countries. The price of USD60/ton for coal-producing countries was determined based on the extraction costs plus costs of transportation to ports. Prices are expected to rise by USD2.5/ton per year from 2010 onwards, taking inflation and the rising costs of coal production into consideration. This rate of increase was determined based on the estimated average rate of increase in Asian costs, insurance, and freight (CIF) calculated for the period between 1991 and 2013 in IEA Coal Information 2013.

Figure 2.19: Projected future coal prices (Steam coal)

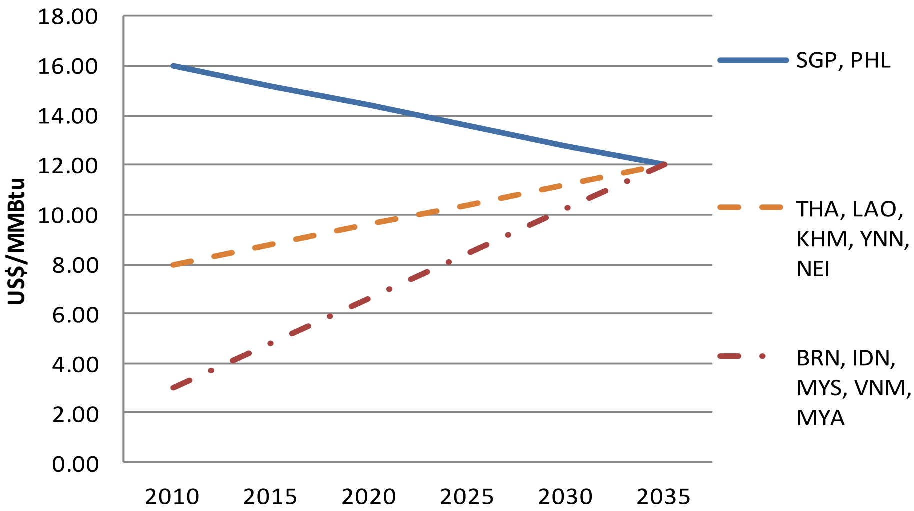


Source: IEEJ projections

Projected prices for natural gas are divided into three levels: countries which import natural gas and do not produce any domestically (Singapore and the Philippines); countries which currently possess some domestic gas fields but where the price of gas used domestically is relatively high

(Thailand, Lao PDR, Cambodia, China and India); and countries which currently possess natural gas fields and where the price of gas used domestically is relatively low (Brunei, Indonesia, Malaysia, Viet Nam and Myanmar). As of 2010, these prices stood at USD16/MMBtu, USD8/MMBtu and USD3/MMBtu respectively. These figures are converging into a provisional figure of USD12/MMBtu up to the year 2035, based on the prospect that increasing trade liquidity is expected in the natural gas market as the natural gas/LNG import increases over time in most Asian countries, and as short-term trading is expected to increase.

Figure 2.20: Projected future natural gas prices



Source: IEEJ projections

2.8. Projected cross-border trading capacity of grid

Two initiatives are currently underway for developing power grid interconnection in the East Asian region: the ASEAN Power Grid (APG) which will cover 10 ASEAN countries; and the Greater Mekong Sub-region (GMS) grid which will cover six countries/regions in the Mekong Basin, including Yunnan Province in China.

The maximum power grid capacity projected in the simulation model of this project, based on the APG and GMS plans, is set out in Table 2.2. However, the power grid capacity between Myanmar and India (northeast region) is based on the joint hydropower development projects of 2,080MW capacity in that nation, because neither the APG nor the GMS contains its line.

Table 2.2: Projected international interconnection transmission capacity in 2020 and later (GW)

	BRN	IDN	KHM	LAO	MYA	MYS	NEI	PHL	SGP	THA	VNM	YNN
BRN												
IDN												
KHM												
LAO			0.3									
MYA												
MYS	0.3	2.2										
NEI					2.1							
PHL						0.5						
SGP						1.1						
THA			2.3	7.9	11.7	0.8						
VNM			0.4	2.7								
YNN				3.0	2.0						8.5	

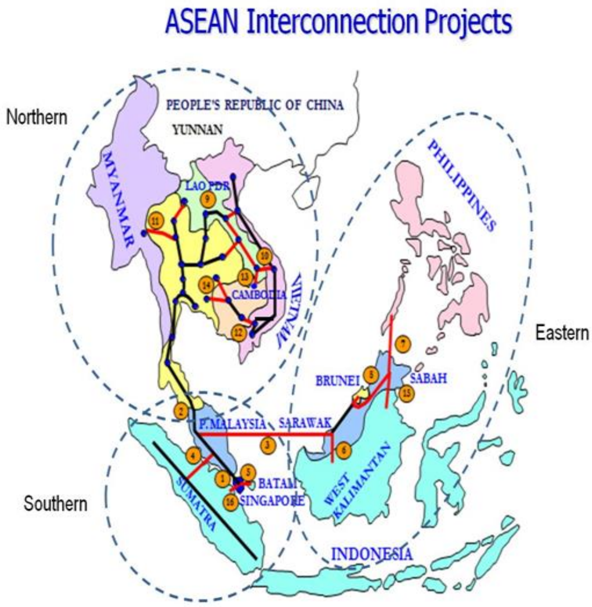
Source: Established by IEEJ based on the ASEAN Power Grid and Greater Mekong Subregion

An outline of the APG and GMS grids is described below as a reference.

In the APG concept, 16 international power grid projects are specified, with the HAPUA office (comprising electric power utilities and authorities connected with electric power) playing a central role in promoting the individual projects.

The current progress as of August 2013 as reported by HAPUA, indicates the following: six power grid projects (Projects 1, 2, 9, 10, 12 and 14) are defined as "partially existing" and four more power grid projects (Projects 4, 6, 8 and 13) are defined as "under construction," with memoranda of understanding (MOUs) having been signed for the projects. Work is expected to start soon on the remaining six power grid projects (Projects 3, 5, 7, 11, 15 and 16).

Figure 2.21: ASEAN Power Grid (APG)



		Earliest COD
1)	P.Malaysia - Singapore (New)	2018
2)	Thailand - P.Malaysia	
•	Sadao - Bukit Keteri	Existing
•	Khlong Ngae - Gurun	Existing
•	Su Ngai Kolok - Rantau Panjang	2015
•	Khlong Ngae – Gurun (2nd Phase, 300MW)	2016
3)	Sarawak - P. Malaysia	2015-2021
4)	P.Malaysia - Sumatra	2017
5)	Batam - Singapore	2015-2017
6)	Sarawak - West Kalimantan	2015
7)	Philippines - Sabah	2020
8)	Sarawak - Sabah – Brunei	
•	Sarawak –Sabah	2020
•	Sabah – Brunei	Not Selected
•	Sarawak – Brunei	2012, 2016
9)	Thailand - Lao PDR	
•	Roi Et 2 - Nam Theun 2	Existing
•	Sakon Nakhon 2 – Thakhek – Then Hinboun (Exp.)	Existing
•	Mae Moh 3 - Nan - Hong Sa	2015
•	Udon Thani 3- Nabong (converted to 500KV)	2018
•	Ubon Ratchathani 3 – Pakse – Xe Pian Xe Namnoy	2018
•	Khon Kaen 4 – Loei 2 – Xayaburi	2019
•	Thailand – Lao PDR (New)	2015-2023
10)	Lao PDR - Vietnam	2011-2016
11)	Thailand - Myanmar	2016-2025
12)	Vietnam - Cambodia (New)	2017
13)	Lao PDR - Cambodia	2016
14)	Thailand - Cambodia (New)	2015-2020
15)	East Sabah - East Kalimantan	2020
16)	Singapore – Sumatra	2020

STATUS OF ASEAN INTERCONNECTION PROJECT
AUGUST 2013 DATA

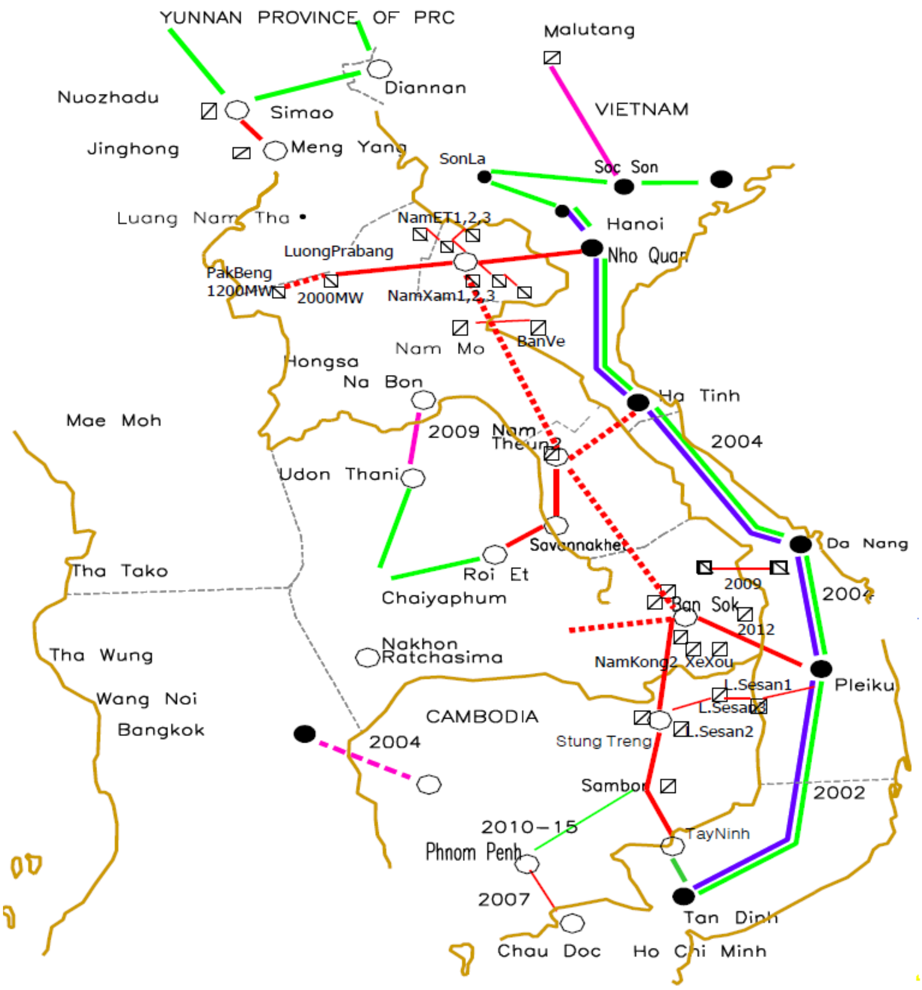
SYSTEM REGION	EXISTING	ON-GOING	FUTURE	TOTAL (MW)
NORTHERN REGION	2,659	6,062	16,374	25,095
9. Thailand - Lao PDR	2,111	3,352	2,465	7,928
10. Lao PDR-Vietnam	248	2,410		2,658
11.Thailand- Myanmar			11,709	11,709
12.Vietnam-Cambodia	200			200
13.Lao PDR - Cambodia		300		300
14.Thailand - Cambodia	100		2,200	2,300
SOUTHERN SYSTEM	450	600	1,800	2,850
1. P. Malaysia - Singapore	450		600	1,050
4. P Malaysia - Sumatra		600		600
5. Batam - Singapore			600	600
16. Singapore - Sumatra			600	600
EASTERN SYSTEM		400	800	1,200
6. Sarawak - W. Kalimantan		200		200
7. Philliines - Sabah			500	500
8. Sarawak - Sabah - Brunei		200	100	300
15. E.Sabah - E. Kalimantan			200	200
NORTHERN - SOUTHERN SYSTEM	380	100	300	780
2. Thailand - P.Malaysia	380	100	300	780
SOUTHERN - EASTERN SYSTEM			3,200	3,200
3. Sarawak - P. Malaysia			3,200	3,200
GRAND TOTAL	3,489	7,162	22,474	33,125

Source: HAPUA Secretariat, "APG Interconnection Status"-Revised by August 2013

The GMS program is an inter-regional development program led by the ADB in which multisectoral partnerships are being developed in the Mekong Basin region in infrastructure domains, including transportation, energy and communication, among six countries/regions consisting of Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam and China (Yunnan Province, with the Guangxi Zhuang Autonomous Region also participating since 2004).

Initiatives in the energy sector are underway, centering primarily on upgrading international power grids, and the MoU on the Roadmap of Regional Power Trade was signed in 2008. Figure 2.22 gives the specific details of the power grid projects that are underway.

Figure 2.22: Greater Mekong Sub-region (GMS)



Interconnection		Voltage	Capacity	Distance
Cambodia—Lao PDR	Stung Treng—Ban Hat	115kV	80MW	56km
Cambodia—Thailand	North West Cambodia—East Thailand	250kV	300MW	290km
Cambodia—Vietnam	HPPs e.g. Sambor, Sre Pok, Sre San—Tan Dinh	230kV	–	90km
	Kampong Cham—Tai Ninh	115kV	80MW	64km
	Phnom Penh—Chau Doc	230kV	300MW	110km
China—Lao PDR	China—North Lao PDR	500kV	3,000MW	600km
	China border—HPPs in North Lao PDR	115kV	–	33km
China—Myanmar	Yunnan—Ta Pein and Shweli HPPs	500kV	2,000MW	880km
China—Thailand	Yunnan (Jinghong and Nuozhadu HPPs) —Tha Wung	500kV	3,000MW	1,300km
China—Vietnam	Hong He HPP—North Vietnam	500kV	1,500MW	450km
	Wenshan, Yunnan—North Vietnam	500kV	1,500MW	400km
	Malutang HPP, Yunnan—Soc Son	500kV	460MW	270km
	Guangxi or Yunnan—Quang Ninh	500kV	5,000MW	600km
Lao PDR—Thailand	Hong Sa TPP—Mae Moh	500kV	1,400MW	200km
	Na Bong—Udon Thani	500kV	1,000MW	220km
	Nam Theun 2 HPP—Roi Et 2	500kV	1,000MW	220km
Lao PDR—Vietnam	Luang Prabang HPP—Nho Quan	500kV	–	400km
	Nam Mo HPP—Ban Ma HPP or Ban Mai	230kV	100MW	90km
	Nam Theun 2 HPP—Ha Tinh	500kV	–	190km
	Xe Kaman 3 HPP—Da Nang	220kV	150MW	115km
	Savannakhet—Pleiku	500kV	1,000MW	165km
Myanmar—Thailand	Ta Sang HPP—Mae Moh and Tha Tako	500kV	1,500MW	600km
	HPP in Thanlwin basin—Phitsanulok	500kV	1,500MW	300km
Thailand—Vietnam	Pleiku (Vietnam) —Ban Sok (Lao PDR) — Savannakhet (Lao PDR) —Roi Et (Thailand)	–	–	–
	Ha Tinh (Vietnam) —Nam Theun 2 (Lao PDR) — Savannakhet (Lao PDR) —Roi Et (Thailand)	–	–	–

Source: ADB, "Roadmap for Energy and Power Integration in the GMS" - 29th September 2009

2.9. Transmission loss rate

Theoretically, assuming identical transmission conditions (type and diameter of transmission line, number of lines, current values etc.), the transmission loss rate could be said to be proportional to the distance over which power is transmitted. In practice, however, transmission conditions are never identical because electricity from other power plants flows through the same transmission lines, the current value changes continually in response to the power usage conditions, and various types and diameters of transmission lines are in use. For these reasons, it is generally considered that although transmission losses grow as the transmission distance increases, in practice, the extent of such losses is not perfectly proportional to the distance and cannot therefore be quantified in a uniform manner.

Given the constraints on the data and other factors, the following simplified conditions are used in the simulation model in this study.

AC transmission	1% loss per 100km
DC transmission	1% loss per 100km + 2% loss for AC-DC converter facilities

2.10. Transmission costs

When calculating costs associated with power transmission, the actual construction costs of the transmission plants and the costs of repairing, maintaining and managing these facilities must be considered. In addition, when constructing power grids within the East Asian region, the need for submarine cables for supplying power to opposite sides of channels and to islands must be taken into consideration, as well as the construction of the usual overhead transmission lines.

The conditions for calculating such transmission costs in the simulation model of this report are as follows.

Principally, the individual costs of all facilities including power lines, pylons and transformer stations should be massed in order to estimate the transmission line construction costs. However, given the data constraints, in this simulation model, unit costs per unit of distance (km) are assumed for the whole transmission lines excluding transformer stations, and the costs calculated according to the transmission distance. By adding this figure to the construction costs according to the number of transformer stations (switching stations) that are likely to be needed for the route in question, an estimate is obtained for the total costs required.

In a precise sense, the unit construction costs for the transmission line stands at USD0.9 million/km/2 circuits for overhead lines and USD5 million/km/2 circuits for submarine cables, based on the most recent actual performance figures for construction in neighbouring countries. The estimated sum of construction costs of transformer stations (switching stations) was obtained by assuming fixed costs[3] of USD20 million per station, and adding additional costs[4] of USD10 million per line.

Turning to O&M costs, ideally, the personnel costs, raw material costs and others should be estimated separately. However, given the data constraints, total construction costs of approximately 0.3 percent/year were assumed in this simulation model.

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[3]Shared costs required to install a single switching station such as the cost of securing land and installing shared facilities.
[4]Costs required for installing the number of devices in accordance with the number of lines.