Appendix. Power Grid Interconnections in the ASEAN Region (by Country)

Cambodia

Electric Power Industry

Power companies in Cambodia are regulated by the Ministry of Industry, Mines and Energy (MIME) and the Electricity Authority of Cambodia (EAC), with the former controlling through power policies, power source development projects, amongst others, and the latter through power business licensing, electricity charge approval, etc.

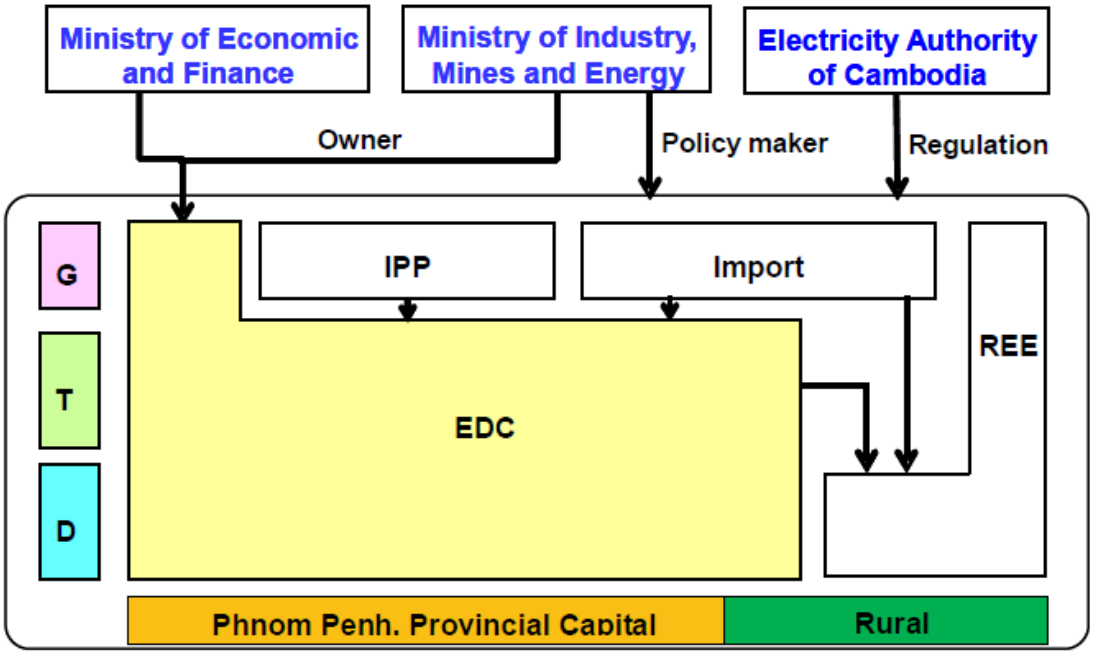
In major cities such as Phnom Penh and in provincial capitals, the Electricité du Cambodge (EDC), under the jurisdiction of MIME and the Ministry of Economic and Finance, supplies power from its power plants and power imported from independent power producers (IPPs) and neighbouring countries. EDC is the only national company that generates, transmits, and distributes power nationwide.

For areas outside the EDC's coverage, rural electricity enterprises supply the power. Rural electricity enterprises are divided into those that distribute power generated by themselves and those that distribute power purchased only from EDC, IPPs, etc. The share of the net system energy demand of power supplied by rural electricity enterprises for the whole nation is small.

Since a power transmission network that covers the whole nation has not been established in Cambodia, its power supply is delivered using independent systems for each area. The percentage of electricity imported from Thailand, Viet Nam, and Lao PDR, and in the total electric power generation reached approximately 60 percent in 2012. As a side note, IPPs accounted for 92 percent of the domestically generated electric power in 2012.

Figure A-1 outlines the power supply system in Cambodia.

Figure A-1. Electric Power Industry in Cambodia



D = distribution, EDC = Electricité du Cambodge, G = generation, IPP = independent power producer, REE = rural electricity enterprise, T = transmission.
Source: Japan International Cooperation Agency.

The Electricity Law was promulgated in February 2001 to regulate the electricity sector in Cambodia. Under this law, power companies are obligated to obtain licenses from EAC which issues eight types of licenses, namely, 1) generation license, 2) transmission license, 3) distribution license, 4) consolidated license, 5) dispatch license, 6) bulk sale license, 7) retail license, and 8) subcontract license.

There are two types of transmission license: one is the national transmission license, issued only to state power transmission companies and grants them right to provide transmission service for delivering electric power to distribution companies and bulk power consumers throughout Cambodia, and the other is the special purpose transmission license that grants the right to construct, own, and operate specified transmission facilities in Cambodia for specified purposes. The national transmission license is given only to EDC. A special-purpose transmission license was issued in February 2007 to the Cambodia Power Transmission Lines Co., Ltd., a private power transmission company that deals with a 115-kV line from the Thai border to Banteay Meanchey, Siem Reap, and Battambang. The same license was later issued to several companies that carry out 22-kV power transmission.

Power Infrastructure Development Plan

In 2012, the national electrification rate in Cambodia increased to 35 percent, with almost 100 percent electrified households in urban areas and 25 percent in rural areas. Power sources in the county remain small and reliance on diesel power generation with costly fuel is high. As a result, electricity charge in Cambodia is higher than those in neighbouring countries.

With such background, the mainstays of Cambodia's power supply development strategy are the development of large-scale power sources using hydraulic and coal-fired power, integration with the ASEAN and the Greater Mekong Subregion networks under bilateral or multilateral cooperation to utilise power from neighbouring countries during power plant construction, and development of power distribution networks that connect major cities in the southern and western regions.

The MIME objectives of power trade with neighbouring countries are:

- To cooperate in power generation and transmission projects investment in Cambodia for power trade and exchange with countries in the region.
- To cooperate in power development between countries to enhance power system stability and efficiency to boost energy security in the region.
- To encourage and facilitate power purchases in the border areas as the country's contribution to reducing poverty and enhancing the material and spiritual life of the people in remote, mountainous, and border areas.

Cambodian EDC and rural electricity enterprises licensed by MIME carry out cross-border power trading through power purchase agreements with power companies on the other side of the border. Before these agreements can be concluded, EDC and rural electricity enterprises are required to report the contents of agreements to EAC and receive inspections.

A 230-kV high-voltage interconnection line with Viet Nam was opened by Cambodia in 2009, and imported power is supplied to the latter's southern grid and to Phnom Penh. This line is connected at 14 cross-border points by 22-kV transmission lines. With Thailand, the northern grid was connected and power import was started in 2007 by a 115-kV transmission line interconnected at seven cross-border points by 22-kV transmission lines. Additionally, Lao PDR and Stung Treng province are interconnected by

22-kV transmission lines.

To meet current domestic demand, electricity imports from neighbouring countries are needed. However, based on potential indigenous resources and the memorandum of understanding amongst members in the ASEAN region as well as the Greater Mekong Subregion power trade cooperation, Cambodia would be capable of exporting more than 4,000 MW of electricity by 2020.

Technical Standards

In 2004 Cambodia promulgated a ministerial order *(prakas)* called the 'General Requirements of Electric Power Technical Standards' (GREPTS) related to Thermal Power Generation, Transmission, Distribution, Hydropower, Renewable Energy and Internal Wiring. GREPTS is not a specification-type code where numbers are stipulated in detail but a performance-type code. In developed countries, the power industry is well developed and can handle performance-type code, which requires power companies to have well-skilled operation and operation technique. However, the organisational system of power business in Cambodia is fragile and its capability not high enough. MIME and EAC cannot adequately apply electric power technical standards by GREPTS alone. To that end, the 'Specific Requirements of Electric Power Technical Standards' (SREPTS) related to Thermal Power Generation, Transmission and Distribution was promulgated as *prakas* in 2007, along with the improvement in the technical investigation capability for EAC. Additionally, SREPTS related to hydropower was promulgated in 2010.

SREPTS stipulates necessary telecommunication lines for Supervisory Control and Data Acquisition (SCADA) systems and voice communication systems between national control centres in Cambodia and neighbouring countries at the time of interconnection of power systems.

Indonesia

Electric Power Industry

In Indonesia, PT PLN, a government-owned company, is in charge of supplying power throughout the country under the supervision of the Ministry of Energy and Mineral Resources. PLN basically assumes a vertically integrated business form but, associated with the advancement of structural reform, also carries out division of the

power generation sector and work separation of the power supply and distribution sectors.

In the Java-Bali area where the business scale is large, the power-generation sector owns PT Indonesia Power and PT PJB, both subsidiary companies. The power transmission and distribution sectors are separated into business units inside PLN, where the power transmission work is operated by P3B Java-Bali and the power distribution by five distribution offices for each district.

In Sumatra, all the power generation, transmission, and distribution sectors are separated into business units. Power plant units for Northern Sumatra and Southern Sumatra are established for the power generation sector, P3B Sumatra for the power transmission sector, and one distribution office and six district offices are established at each district for the power distribution sector.

In other areas, vertical integration type management is carried out by the district offices established for nine districts.

Additionally, there are PT PLN Batam (supply area: Batam Island, a free-trade zone) and PT PLN Tarakan (supply area: Tarakan Island at East Kalimantan) that are, as subsidiaries of PLN, in charge of power supply at specific regions.

Table A-1 outlines the power supply system at each area in Indonesia.

Table A-1. Electric Power Industry in Indonesia

Java-Bali Area

Generation sector	Transmission sector	Distribution sector
PT Indonesia Power PT PJB IPP	P3B Java-Bali	5 Distribution Offices

Sumatra Area

Generation sector	Transmission sector	Distribution sector
Northern Sumatra Power Plant Unit Southern Sumatra Power Plant Unit IPP	P3B Sumatra	1 Distribution Office 6 District Offices

Other Regions

Generation sector	Transmission sector	Distribution sector
[vertical integration] 9 District Offices, PT PLN Batam, PT PLN Tarakan		

IPP = independent power producer.
Source: Created from Japan Electric Power Information Center material.

For financial independence, PLN has introduced a business division system centred on the Java-Bali and Sumatra areas, which have well-interconnected power systems, and where power trading is carried out amongst business units. In other areas, power supply is still through vertical integration.

Operating an international power transmission interconnection system requires an appropriate and transparent consignment charge system. Especially since international interconnections are planned and considered between West Kalimantan and Malaysia, and between Batam Island and Singapore, it is desirable that in terms of accounting, the transmission sector in these areas is also separated as a business unit.

Power Infrastructure Development Plan

In progress in Indonesia is the construction of two international interconnection lines between the Sumatra Grid and Peninsular Malaysia, and between the West Kalimantan Grid and Sarawak.

The interconnection between the Sumatra Grid and Peninsular Malaysia is a

250-kV high-voltage direct current project with a total length of 257 km including overhead lines and submarine lines, with transmission capacity of 600 MW. The commercial operation date is December 2019. The following are Indonesia's aims for this project:

- Acquire foreign currencies by exporting electricity in addition to exporting conventional resources through the construction of a coal-fired power plant that utilises large resources of low-rank coal in Sumatra.
- Realise efficient power supply for Indonesia and Malaysia and improve the supply reliability by connecting the two areas with different electricity demand peaks (Sumatra in the evening, and the Malaysian Peninsula in daytime).

The interconnection between the West Kalimantan grid and Sarawak is a 275-kV high-voltage alternating current project with transmission capacity of up to 200 MW. The background and aims of this project are described as follows:

- Electric power is constantly short in West Kalimantan where mainstream power generation uses oil, resulting in high cost of power supply.
- By importing electricity that utilises abundant hydropower in Sarawak, reduced electricity costs and improved supply reliability are expected.

Other than the two mentioned projects, interconnection plans are also being considered between Batam Island and Singapore, and between the Sumatra Grid and Singapore.

Regulations for cross-border electricity trading in Indonesia are contained in Law No. 30/2009 on Electricity which stipulates that cross-border electricity trading is to be carried out by power suppliers licensed by the government.

As stipulated in the law, cross-border electricity purchases may be made on the following conditiopns:

- Local electricity needs are not yet met.
- Purchases only act as support to meet local electricity needs.
- Purchases are not adverse to the state and national interest with respect to sovereignty, security, and economic development.
- Purchases are meant to improve the quality and reliability of local electricity supply.

- Purchases are not to disregard the development of domestic electricity supply capability.
- Purchases are not to raise dependence on electricity procured from abroad.

Cross-border power sales shall be made if:

- The electricity needs of the local and surrounding areas have been met.
- Power sale prices are not subsidised.
- They do not compromise the quality and reliability of the local power supply.

These provisions indicate that Indonesia considers power trading outside the country (especially power imports) as a supplementary measure for securing power supply capability, and is adopting a cautious approach to its promotion and expansion.

Technical Standards

Business at PLN is carried out by each business unit based on the Standard PLN (SPLN) established as company standards. SPLN provides standards for power generation, transmission, distribution, supervisory control, and data acquisition system, and, generally, in a form compliant with the International Electrotechnical Commission. However, the SPLN contents are not sufficient, and PLN has been conducting activities to enrich contents.

Lao PDR

Electric Power Industry

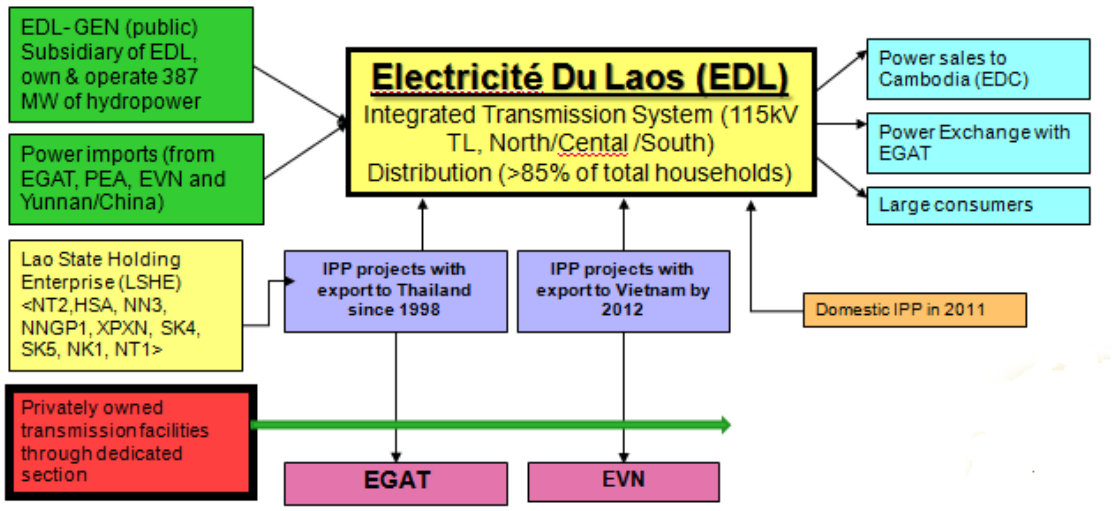
The Electricité du Laos (EDL) is a state-owned corporation under the Ministry for Energy and Mines which owns and operates the country's main generation, transmission, and distribution assets, and manages electricity imports into its grids and exports from its stations. Surplus electricity is exported to Thailand and Viet Nam, and electricity is imported from Thailand, Viet Nam, and the People's Republic of China's Yunnan Province for some areas in the country without power transmission interconnections. EDL also engages in capital participation on independent power providers for domestic power supply.

Meanwhile, the Lao Holding State Enterprise, a 100-percent government funded

national company established in February 2005, invests into IPPs for exporting. This company currently funds a total of nine power plant projects consisting of eight hydropower plants and one coal-fired thermal plant. However, EDL funds for those projects had been determined before the establishment of this state enterprise.

Figure A-2 outlines the power supply system in Lao PDR.

Figure A-2. Electric Power Industry in Lao PDR



EDC = Electricité du Laos, EGAT = Electricity Generating Authority of Thailand, EVN = Electricity Viet Nam, IPP = independent power provider, kv = kilo volt,
NT2/HSA/NN3/NNGP1/XPXN/SK4/SK5/NK1/NT1 = abbreviation of name of power plant.
Source: Provided by the Electricité du Laos during the 1st Meeting of the research working group of the Economic Research Institute for ASEAN and East Asia, 2014.

Lao PDR has ample hydropower resources, in its energy policies, the power sector is positioned as an important sector that contributes to economic growth. The government body that oversees energy policies stipulates that the power sector should:

- Maintain and expand an affordable, reliable, and sustainable electricity supply to sustain economic growth and poverty alleviation.
- Promote power generation for export as source of revenue.
- Develop and enhance the legal and regulatory framework to effectively direct and facilitate power sector development.
- Reform institutions and institutional structures to clarify responsibilities, strengthen commercial functions, and streamline administration.

Under such circumstances, the necessity of restructuring the power industry and building manpower capacity is starting to be regarded as important challenges for the power business system of Lao PDR. Especially, to realise the above-mentioned power sector policy, the following points are recognised as priority items:

- Establishment of power grid company as transmission system operator,
- Improvement of performance standards,
- Improvement of the legal framework, and
- Setting up of an independent power regulator.

Power Infrastructure Development Plan

Lao PDR actively develops IPP power plants to export and trade power with neighbouring countries. For that reason, the country's power resource development plan takes into account the following options:

- Power resource development for domestic use

Most projects for developing power sources to meet domestic demand are for relatively small plants with less than 100-MW output. However, these projects require expansion of the main system or establishment of interconnections and, in respect to the scale of demand, are considered economically disadvantageous. It is for that reason that projects with scales that match the demands are chosen for carefully selected areas. Project types for domestic supply are roughly divided into those by EDL and those by IPPs, with the latter having the larger share. Development funds are mainly sourced through low-interest loans from international aid organisations, with loans from the People's Republic of China increasing in later years.

- Procurement from projects for exporting

Most planned projects for exporting electricity to neighbouring countries are on IPPs with an output of 100 MW or higher. It is not only economical to purchase part of generated power for domestic demand but also advantageous in lowering the financial burden of EDL on power resource development. According to the contract between the Lao government and IPPs, five percent of power output for export is to be supplied inside the country. However, project development becomes uncertain when IPPs end up relying on investors and energy business operators from overseas projects become uncertain.

- Import from neighbouring countries

Interconnection systems with neighbouring countries have advantages during the wet season when the country sells surplus power to its neighbours and during the dry season when it mitigates power shortages, the weak point of the energy mix where hydropower is the main element. In Lao PDR, in addition to development of hydropower plants for domestic consumption, construction of lignite-fired thermal power plants is in progress in the Hongsa District. The domestic power system is not linked nationwide, however, and the supply area is divided into northern, central 1, central 2, and southern areas. Therefore, Lao PDR is in a situation where power imports from Thailand, Viet Nam, and the People's Republic of China are essential in maintaining its supply and demand balance.

Power supply in Lao PDR except in rural off-grid areas is categorised into three: 1) EDL power plants, 2) IPP power plants (for domestic consumption, for export), and 3) import from Thailand, Viet Nam and the People's Republic of China. This supply structure is a basis of power development plans prepared by MEM and EDL.

Power transmission network development plans include both the domestic system and international interconnection system, based on the power source development plan.

Since there may be situations where one area has excess supply power while other areas are short of it and forced to purchase power from neighbouring countries, establishment of an interconnection system throughout the country is prioritised to enable power interchange within the country.

For domestic interconnection system, the establishment of 115–500-kV power transmission lines is promoted along with power source development by IPPs for power export. The following is how Lao PDR plans and undertakes power trading with its neighbouring countries.

- A memorandum of understanding on power cooperation programme was signed with the Royal Thai Government in 1996 and 2006 under which 3,000 MW is to be supplied to Thailand with subsequent increase of 7,000–10,000 MW.
- In 1998 and 2006, memorandums of agreement were signed with the Government of Viet Nam to supply the latter with 3,000 MW power with subsequent increase of 5,000 MW.

- In 1999 an agreement on cooperation in the power sector was signed with Cambodia to supply the latter with about 300 MW of power.

Technical Standards

From May 2000 to April 2003, the Japan International Cooperation Agency (JICA) conducted in Lao PDR the Electric Power Technical Standard Establishment Project; and in February 2004, the Lao Electric Power Technical Standards was established. Prior to these, no integrated concept or rules on design for power facilities in Lao PDR existed, and the performance and operation methods of power facilities varied depending on the region. Also, development by foreign capital was based on the design and construction standards of the funding country that various troubles arose in power supply and system operation. The Lao Electric Power Technical Standards stipulate technical standards in engineering works for hydropower plants, hydropower generation, power transformation, transmission, distribution, and interior wires. Likewise, inspection, maintenance, and equipment updating are based on these technical standards.

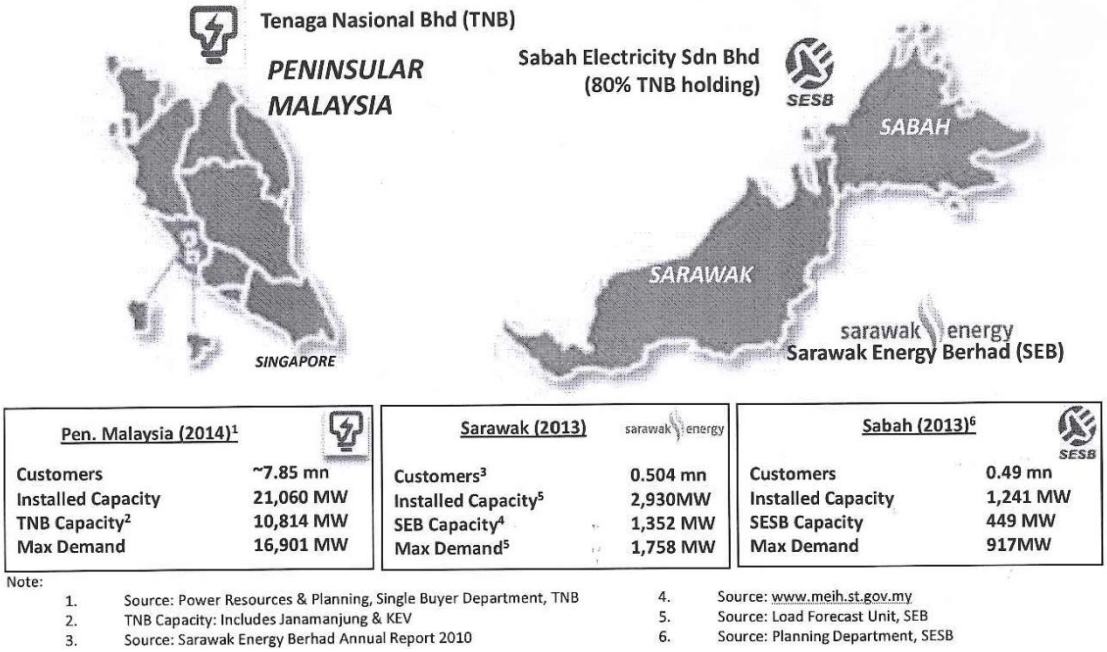
Meanwhile, no load dispatching centres or common grid code in Lao PDR is reported. To date, depending on the systems distributed in the country, it has been possible to operate only at several power plants and a few relevant facilities (e.g. fixed-power importers). However, amidst the advancing development of interconnection network in the country and pursuant to power trade framework expansion from bilateral to multilateral, the establishment of an organisation that monitors the power system throughout the country and the appropriate operation of regulations and standards for interconnecting systems has become an urgent task.

Malaysia

Electric Power Industry

Malaysia's grid is divided into Peninsular, Sabah, and Sarawak systems, with Peninsular Malaysia taking the largest demand. Currently, the Tenaga Nasional Berhad (TNB) is cardinally supplying power in Peninsular Malaysia, Sabah Electricity Sdn Bhd in Sabah state, and 100-percent state government funded Sarawak Energy Berhad in Sarawak state.

Figure A-3. Electric Power Industry in Malaysia



Pen. Malaysia (2014)[1]	
Customers	~7.85 mn
Installed Capacity	21,060 MW
TNB Capacity[2]	10,814 MW
Max Demand	16,901 MW

Sarawak (2013)	
Customers[3]	0.504 mn
Installed Capacity[5]	2,930MW
SEB Capacity[4]	1,352 MW
Max Demand[5]	1,758 MW

Sabah (2013)[6]	
Customers	0.49 mn
Installed Capacity	1,241 MW
SESB Capacity	449 MW
Max Demand	917MW

Note:
1. Source: Power Resources & Planning, Single Buyer Department, TNB
2. TNB Capacity: Includes Janamanjung & KEV
3. Source: Sarawak Energy Berhad Annual Report 2010
4. Source: www.meih.st.gov.my
5. Source: Load Forecast Unit, SEB
6. Source: Planning Department, SESB

Mn = million, MW = megawatt.
Source: Provided by the Tenaga Nasional Bhd during the 2nd Meeting of the research working group of the Economic Research Institute for ASEAN and East Asia, 2014.

Malaysia was to introduce the principle of market competition to the power generation and retail sectors from the 1980s to the 1990s. However, in response to the change in the domestic and overseas assessment on electricity liberalisation, it withdrew the project in 2001 ahead of other Asian countries.

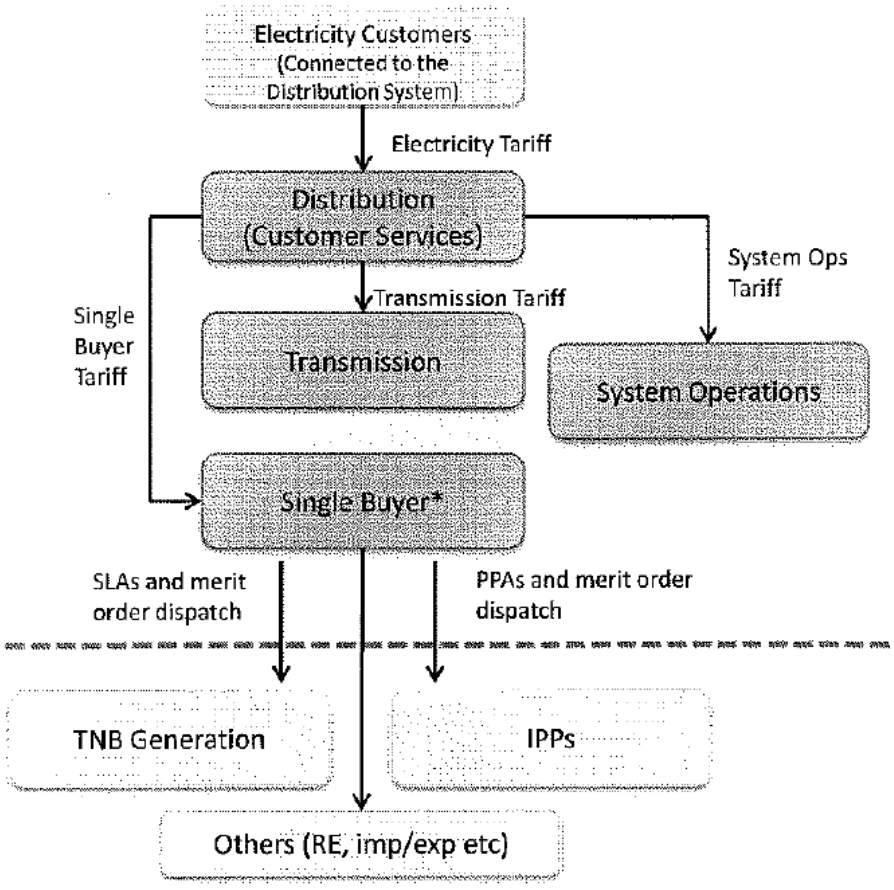
Then, to improve the management efficiency of power businesses, the power sector in Malaysia was transformed from a vertically integrated industry into a managed market model, regulated by Suruhanjaya Tenaga (the Energy Commission). In this model, the aim was to maintain the current power supply system as much as possible and establish a wholesale electricity market, with 'stable power supply' and 'maintenance of electricity charge level' as objectives.

In the Peninsular region, the TNB account was unbundled into five business entities: TNB generation, system operator, single buyer, transmission, and customer services. To promote efficiency improvement and pass through imbalance costs, natural monopolies, i.e. system operator, single buyer, transmission, and distribution are regulated under the Incentive Based Regulation which consist of a building block model used to develop revenue requirements and appropriate price control mechanisms

developed by the Energy Commission. Specifically, the single buyer and the system operator entities remain within TNB but they are ring-fenced to ensure transparency. Suruhanjaya Tenaga supervises the operation of the single-buyer entity, which is obligated to procure the lowest-cost energy in an efficient and transparent manner.

In the competitive sectors where TNG generation, IPPs, and others (e.g. small renewable energy power producers, power importers) participate in, improved efficiency was achieved by single-buyer rules and competitions such as 'lowest cost dispatch', 'transparent operations', and 'governance arrangements'.

Figure A-4. Flow of Power Trading in Peninsular Malaysia



IPP = independent power producer, RE = renewable energy, SLA = Service Level Agreement which means minimum electricity supply obligation of power company for consumer, TNB = Tenaga Nasional Bhd.

Source: Provided by Tenaga Nasional Bhd during the 2nd Meeting of the research working group of the Economic Research Institute for ASEAN and East Asia, 2014.

Power Infrastructure Development Plan

Peninsular Malaysia is currently interconnected with Thailand in the north and with Singapore in the south.

- TNB–Electricity Generating Authority of Thailand Interconnection

The Malaysia–Thailand high-voltage direct current interconnection system consists of the Gurun converter station in northern Malaysia and the Khlong Ngae converter station in southern Thailand. Both converter stations are linked by a 300 kV DC overhead line with a length of 110 km (approximately 86 km on the Malaysian border and 24 km on the Thai border). Currently, the converter station is configured as a monopolar converter with the power transfer capacity of 300 MW. This interconnection, which represents the first cross-border DC link in the ASEAN region, is an important stepping stone to the realisation of the ASEAN power grid which will significantly enhance the energy security and economic integration of the region.

- TNB–Power Grid Ltd. Interconnection

Malaysia is interconnected with Singapore between the Plentong Substation and the Senoko Power Station by 275 kV HVAC (capacity of 2 × 250 MVA). However, this interconnection is limited to emergency situations, and has no past record of power trading to date.

To further strengthen the national grid, six more interconnection projects are in the pipeline.

- Sumatra–Peninsular Malaysia

This 250 kV HVDC interconnection, with a capacity of 600 MW, is premised upon Sumatra's rich indigenous resources and different load curves between Peninsular Malaysia and Sumatra. It is expected to be completed in December 2019.

- Sarawak–Peninsular Malaysia

This 500 kV HVDC interconnection, with a capacity of 2 x 1000 MW, is driven by the large hydro-potential resources but relatively low demand in Sarawak and high energy demand in Peninsular Malaysia. It is expected to be completed in 2024.

- Singapore–Peninsular Malaysia

This 275 kV HVAC interconnection, with a capacity of 2 × 250MVA, is under study.

- Rantau Panjang–Sg. Kolok

The interconnection agreement for this 132-kV HVAC interconnection (TNB) and 115-kV HVAC (EGAT), with a capacity of up to 100 MW, is still being finalised.

- Sarawak–West Kalimantan

This 275-kV HVAC interconnection, with capacity of up to 200 MW, is expected to be completed in January 2015.

- Sarawak–Brunei Darussalam

This 275-kV HVAC interconnection, with capacity of 200 MW, is still under discussion.

At present, the existing and planned interconnections between Malaysia and neighbouring countries are transacted through bilateral arrangements and are designed for usage during emergency conditions.

Malaysia, however, is considering interconnections as long-term alternatives to meet future demand and to diversify its energy mix. An example is the planned Peninsular Malaysia–Sumatra 600-MW HVDC interconnection project.

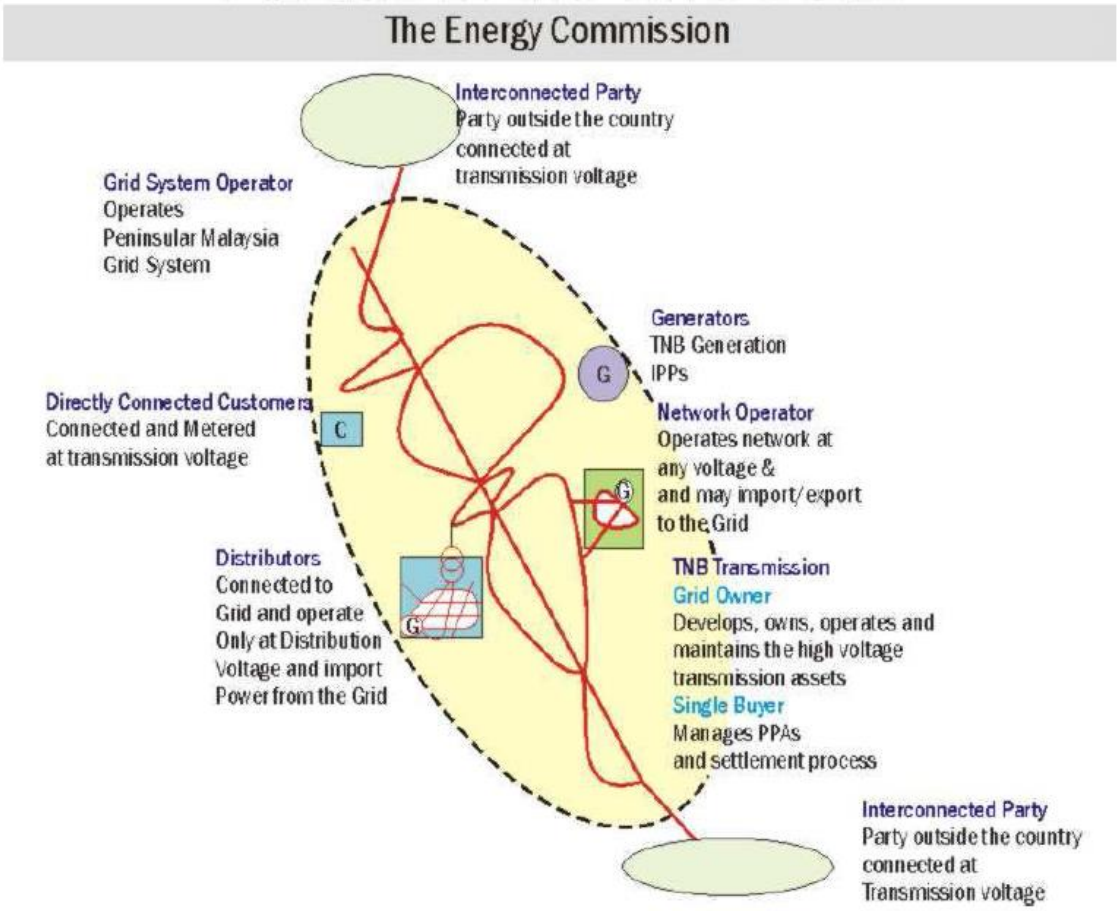
Furthermore, the latest development sees Malaysia taking an unprecedented move toward multilateral power trading. The Lao PDR, Malaysia, Thailand, and Singapore Power Integration Project is the first energy cooperation involving four ASEAN countries.

Technical Standards

The Malaysian Grid Code, or the Grid Code, published by Suruhanjaya Tenaga, is a regulatory instrument to coordinate various electricity supply activities. It is a set of technical specifications which defines the parameters that an electricity-generating plant and grid system network has to meet to ensure proper functioning of the electrical grid. It is used by utility companies such as TNB and IPPs in Peninsular Malaysia and serves as the main guidelines in electricity supply operation to ensure that electricity supply in Peninsular Malaysia remains reliable.

Figure A-5 illustrates how the various parties identified in the Grid Code are connected or associated with the grid system.

Figure A-5. Parties in the Malaysian Grid Code



IPP = independent power producer, PPA = purchase power agreement, TNB = Tenaga Nasional Bhd.
Source: GSO known as the System Operations Department in TNB.

The Grid Code highlights the roles and responsibilities of parties managing or using the system, either connected directly or connecting to the grid and distribution systems including generators, grid system operators, distribution system operators, single buyers, and bulk power consumers.

Suruhanjaya Tenaga chairs the Grid Code committee which is represented by members from the industry. The Grid Code has been in force since 1 January 2011.

Singapore

Electric Power Industry

Singapore has been promoting the liberalisation of the electricity market. The Energy Market Authority (EMA), established in April 2001 under the Ministry of Trade and Industry, functions as an agency for power system operation and for energy planning and development. The main roles of EMA are:

- to ensure a reliable and secure energy supply,
- to promote effective competition in the energy market, and
- to develop a dynamic energy sector in Singapore.

At present, the power business system in Singapore is separated at the possession level into competitive sectors (generation and retail) and non-competitive sectors (transmission and distribution).

At the non-competitive sectors, SP PowerAssets Ltd owns and manages the national electricity transmission system that delivers electricity from generation companies to consumers. SP PowerAssets has appointed SP PowerGrid Ltd to manage and operate all aspects of the transmission business. SP PowerGrid is licensed by EMA as transmission agent licensee. EMA sets stringent performance standards for SP PowerAssets Ltd because of the critical role it plays in the industry.

Meanwhile, in the liberalised sectors, the Energy Market Company operates the National Electricity Market of Singapore; Asia's first liberalised electricity market opened for trading on 1 January 2003. The Energy Market Company is the exchange for wholesale electricity trading, providing transparent and competitive trading platform and the governance for the market. Generation companies offer every half-hour to sell electricity into the wholesale electricity market. All sales and purchases of electricity through the wholesale market are settled through the Energy Market Company. Generators and retailers or major users can enter into financial bilateral agreements outside the wholesale market.

EMA started reviews of the regulatory framework for electricity imports from 2011. According to a consultation paper, an electricity importer to Singapore must first be authorised under an electricity license issued by EMA under the Electricity Act. The import licensee will be required to comply with all relevant codes of practices and

performance standards applicable to the local-generation licensees. It will also have to be registered with the Energy Market Company as a market participant and comply with the Electricity Market Rules. This includes competing in the wholesale electricity market (by submitting half-hourly offers) to secure dispatch of the overseas power plants.

The biggest challenge for Singapore is how to incorporate imported subsidised power from vertically integrated markets into the domestic liberalised market structure.

Power Infrastructure Development Plan

Since there are no domestic energy resources in Singapore, enhancement of energy security is an important task for the country. Currently, over 80 percent of power used in Singapore is generated by imported pipeline gas and liquefied natural gas. EMA highly prioritises the diversity in the energy portfolio mix where fuel types and suppliers are combined, from the viewpoint of energy security and environmental consideration. Power imports from neighbouring countries are considered as one option to realise this.

By introducing the system of importing power, Singapore will be able to use new energy options such as coal-fired thermal power and hydropower. Additionally, it is expected to gain economic benefits by promoting competition in the Singaporean power market.

Especially, a strong intention of the Singaporean government is reflected in the LTMS project to develop a power transmission network between Lao PDR and Singapore, and many deliberations on project investigation have been held. The background factors include the improvement in energy security, expansion of renewable energy, reduction in power costs, and space saving. For this project, Singapore agreed on a power purchase of 100 MW from Lao PDR through a pilot scheme, and Thailand and Malaysia as relay companies are offering support.

At present, only one international interconnection line exists in Singapore, which is a 450-MW HVDC to Peninsular Malaysia. However, the electricity exchange with Malaysia is currently limited to emergency situations and all power transfers are settled via power swaps with a typically predetermined monthly volume of transactions.

International interconnection construction projects in Singapore that have taken concrete shape are as follows:

- Singapore–Peninsular Malaysia: 600-MW HVDC power purchase

- Singapore–Batam (Indonesia): 200/200/200-MW HVAC power purchase
- Singapore–Sumatra (Indonesia): 600-MW HVDC power purchase

EMA indicated the following points as the objectives of the framework in the consultation paper relating to the regulatory framework, released in 2011, for electricity imports:

- To govern the orderly entry of electricity imports into Singapore's electricity market in a way that translates to cost savings for all consumers, in both the contestable and non-contestable sectors.
- To ensure that the security and reliability of Singapore's power system are not compromised.

Accordingly, the following items are stipulated in detail to facilitate electricity importers in making investment and commercial decisions:

- Requirements pursuant to the Electricity Act
- Quantity of electricity imports
- Process to select the importer(s)
- Securing benefits for consumers
- Participation of local-generation licensees or their affiliates

Technical Standards

Under the Electricity Act, EMA has issued the codes of practice (Market Support Services Code, Metering Code, Code of Conduct for Retail Electricity Licensees, Transmission Code, and Regulated Supply Service Code) to regulate the activities and conduct of the electricity industry.

The Transmission Code sets the minimum conditions which the transmission licensee must meet in fulfilling its obligations to provide transmission services and to provide non-discriminatory access to the transmission licensee's transmission system. It spells out the rights and obligations of the transmission licensee in providing transmission services, together with the rights and obligations of the users of transmission services. It also lays out the technical requirements for those who are connected to the transmission system.

Additionally, to ensure that electricity is delivered reliably with high quality of service, EMA has set performance standards for SP PowerAssets Ltd, the transmission licensee.

Based on these electricity legislations and regulations, Singapore maintains extremely high-power supply reliability even compared to other developed countries. In 2013, the system average interruption duration index that measures the average interruption time per customer in minutes was 0.47, and the system average interruption frequency index that measures the average number of interruptions per customer was 0.015.

Thailand

Electric Power Industry

Until 1992, the power business system in Thailand was a three-company system consisting of the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority, and the Provincial Electricity Authority. EGAT was in charge of power generation and transmission, and the last two agencies with power distribution.

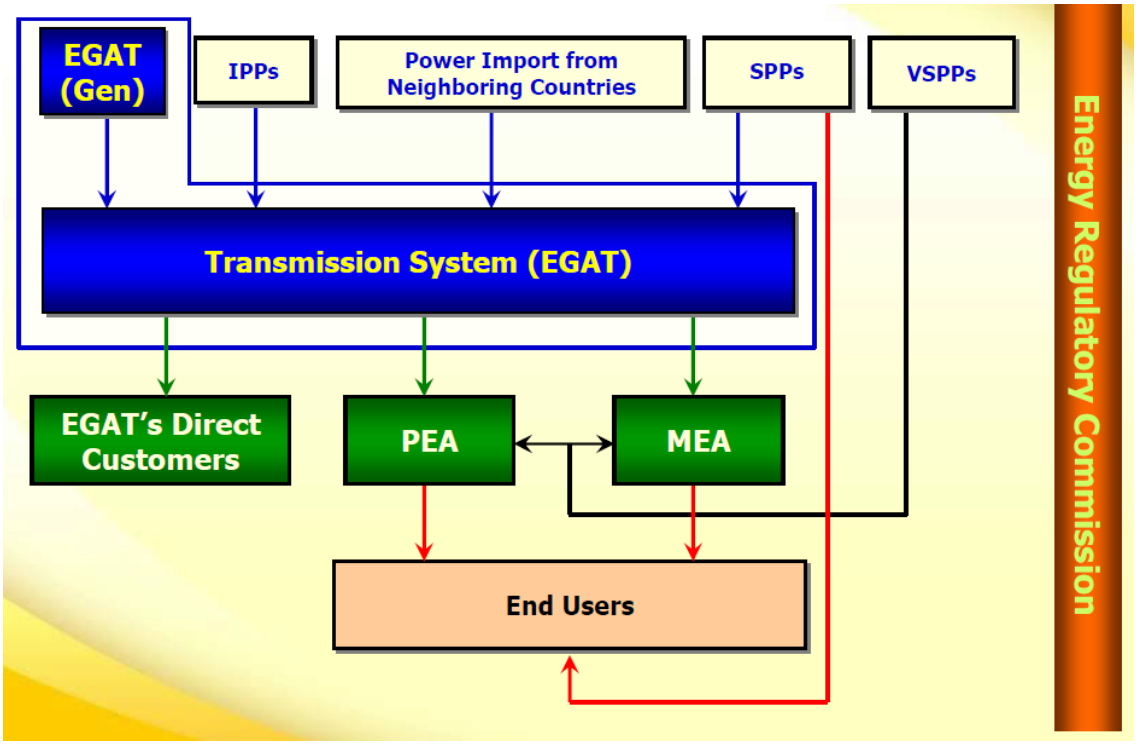
In the 1990s, private capital entry into public utilities was promoted, and it was decided to conduct system reform for the power industry. In 1992, private capital entered the power generation sector, and independent power producers (IPPs) and small power producers with 90 MW or less started to enter the market. Further, in 2002, from the viewpoint of promoted use of renewable energy and effective utilisation of energy, renewable energy power generators with 1 MW or less were designated as very small power producers and were allowed to sell electricity to the Metropolitan Electricity Authority and the Provincial Electricity Authority. Later, in 2006, the allowable power generation scale for very small power producers was raised to 10 MW, and cogeneration generators were also newly regarded as very small power producers.

EGAT possesses and operates 45 percent (15,482 MW) of the system generating capacity as of January 2015. EGAT also purchases electricity from IPPs, SPPs, or neighbouring countries (Lao PDR and Malaysia) and sells wholesale the electricity to the Metropolitan Electricity Authority and the Provincial Electricity Authority, in addition to direct supply to bulk consumers. Additionally, EGAT possesses power distribution and

transformation facilities and power supply facilities, and carries out system operations, etc.

Figure A-6 outlines the power supply system in Thailand.

Figure A-6. Electric Power Industry in Thailand



EGAT = Electricity Generating Authority of Thailand, IPP = independent power producer, MEA = Metropolitan Electricity Authority, PEA = Provincial Electricity Authority, SPP = small power producer, VSPP = very small power producer.
Source: Electricity Generating Authority of Thailand.

Thorough review of the power business system was planned in Thailand, from the 1980s onward. When the economy suffered as a result of the Asian financial crisis in 1997, the Thai government was forced to request support from the International Monetary Fund (IMF), and formulated the Master Plan for State Enterprise Sector Reform. This master plan included full liberalisation centred on establishment of a power pool market referencing the system in the United Kingdom and division and privatisation of EGAT.

However, due to strong opposition from consumer groups and the general public as well as the lessons learnt from the December 2003 California electricity crisis, the Thai government discarded the retail liberalisation and power pool plans and announced the Cabinet decision reconfirming the core roles of EGAT in the power generation and transmission sectors. The newly indicated power sector structure of Thailand was to

maintain the integrated power generation and transmission system of EGAT, thoroughly implement the management and accounting separation, and start the Energy Regulatory Commission to ensure fairness and transparency of competition in the power generation sector. The Energy Regulatory Commission was established as an independent organisation which does not belong to any administrative agency. Its main role in the power business includes operation of the Power Development Fund; issuance of business licences for generation, transmission, distribution, retail, and system operation; and electricity charge regulations. In June 2005, EGAT converted its funds into stocks and temporarily became EGAT Plc but the Supreme Administrative Court ordered the suspension of its stock listing and it reverted to a public corporation.

Power Infrastructure Development Plan

Thailand's current official power development plan is PDP 2010: 3rd Revision (2012–2030), endorsed by the Cabinet on 19 June 2012. A new PDP 2015 is being prepared. To cope with increased power demand in the future due to economic and industrial growth and to ensure the stability and reliability of the system, PDP 2010: 3rd Revision (2012–2030) positions power import from neighbouring countries as one of important power supply options, and accounts for a certain percentage in the share of installed capacity and power generation share.

Currently, EGAT imports electricity under six projects with a total capacity of 2,404.6 MW (6.93 percent of total system installed generating capacity of January 2015). According to PDP 2010: 3rd Revision, additional 3,316 MW power supply will be purchased from neighbouring countries in 2014–2019.

Furthermore, Thailand has concluded memorandums of understanding on power purchase with Lao PDR, Myanmar, People's Republic of China, and Cambodia, and system development toward power imports is in progress. Regional integration is currently bilateral with one-way power flows.

Table A-2. Electricity Import of Thailand, 2014–2019

Project	Fuel	Contractual Capacity (MW)	Scheduled Commercial Operational Date (SCOD)
1. Hong Sa Lignite Units 1-3	Lignite	1,473	Jun./Nov. 2015 Mar. 2016
2. Xe-Pian Xe-Namnoy	Hydro	354	Feb. 2019
3. Nam Ngiep 1	Hydro	269	Jul. 2019
4. Xayaburi	Hydro	1,220	Oct. 2019
Total		**3,316**	

MW = megawatt.
Source: *Electricity Generating Authority of Thailand Annual Report 2013*.

Table A-3. Memorandums of Understanding Between Thailand and Neighbouring Countries

	Capacity (MW)	Signed Dated	Endorser
Thailand–Lao PDR	**7,000**	**22 December 2007**	Ministry of Energy
Thailand–Myanmar	**1,500**	**4 July 1997**	Ministry of Office of the Prime Ministry
Thailand–China	**3,000**	**12 November 1998**	Ministry of Office of the Prime Ministry
Thailand–Cambodia	**N.A.**	**3 February 2000**	Ministry of Office of the Prime Ministry

Note: The first memorandum of understanding between Thailand and Lao PDR was signed on 4 June 1993.
Source: Energy Regulatory Commission of Thailand.

Technical Standards

According to EGAT, the Grid Code consists of the following main sections:

- Glossary and Definitions

A list of technical terms used in the individual procedures, with their definitions.

- Planning Procedures

Technical and design criteria and procedures to be followed in the planning of developments to the transmission system, including information to be provided by generators.

- Connection Conditions

Procedure covering a) the technical requirements which must be met by a generator before connection to the transmission system is allowed and the procedure to be followed by EGAT and a generator in seeking permission for connection.

- Operating Procedures

A series of procedures covering the operation of transmission system, external interconnectors, and generation, including a) preparation of demand forecasts, scheduling, and dispatch timescale; b) planning of transmission, external interconnector, and generation maintenance outages; and (c) operational liaison, coverage, safety, communications and event and incident reporting.

- Scheduling and Dispatch Procedures

A series of procedures covering the scheduling and dispatch of generating units, including a) daily submission, by generators, of information on capacity available and operating characteristics of their units; b) daily submission, by externally interconnected parties, of information on capacity available and imports and exports expected across their external interconnectors; c) preparation of the daily generation programme; and d) dispatch of generating units.

- General Conditions

This part of the Grid Code is designed to achieve a) a section covering general communications between EGAT, externally interconnected parties, and the generators; b) the rules covering 'unforeseen circumstances'; c) the rules covering the granting of derogations to the Grid Code; and d) the rules controlling modifications to, and issue of, the Grid Code

Viet Nam

Electric Power Industry

In Viet Nam, the Ministry of Energy (currently, Ministry of Industry and Trade) directly controlled until 1994 the public power corporations established in each of the northern, central, and southern regions. In 1995, the three corporations were integrated into Electricity Vietnam (EVN), a national enterprise that carries out integrated operation

of power generation, transmission, and distribution.

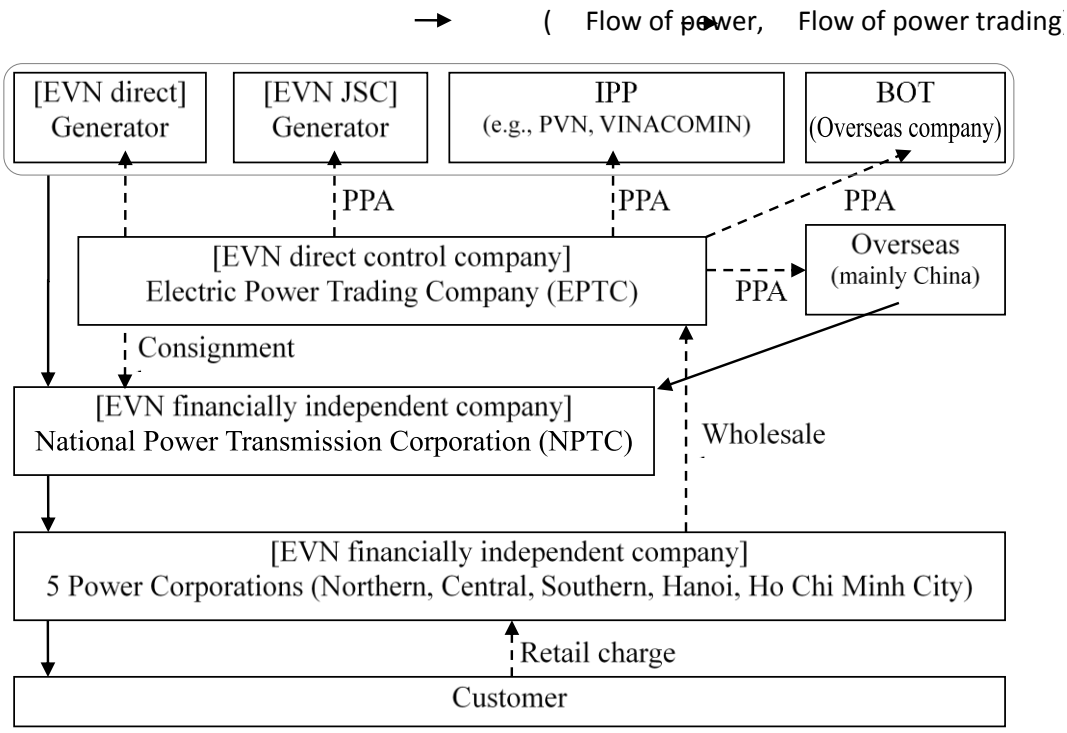
However, during the formation of the electricity market, the government announced on 22 June 2006 Decision No. 148/2006/QD-TTg of the Prime Minister forming the parent company, Vietnam Electricity Group, for implementing competition in electricity market, and EVN is undertaking organisational reforms based on the Decision.

EVN currently owns and manages major power plants, the National Load Dispatching Center, the National Power Transmission Corporation, the Power Corporation, the Power Engineering Consulting Company, etc., and engages in the formulation of the power master plan, creation of the electricity charge revision plan, etc.

The EVN is divided into 'direct control company' which is 100 percent owned by EVN and whose budget is allocated by EVN, 'financially independent company' which is 100 percent owned by EVN yet is financially independent of it, and 'joint stock company', a corporation whose stocks are partly owned by EVN.

Figure A-7 outlines the power supply system in Viet Nam.

Figure A-7. Flow of Power Trading in Viet Nam



EVN = Electricity Vietnam, JSC = joint stock company, IPP = independent power producer, PVN = Petro Vietnam, VINACOMIN = Vietnam National Coal-Mineral Industries Holding, BOT = build, operate, and transfer, PPA = power purchase agreement.
Source: Created based on Japan Electric Power Information Center material.

Power purchase from generators (including imports from neighbouring countries) is comprehensively carried out by the Electric Power Trading Company under the direct control of EVN, as a single buyer under the directive from the National Load Dispatching Center. The Electric Power Trading Company uses the power transmission lines of the National Power Transmission Corporation (NPTC) when it sells power to Power Corporation, and pays the incurred consignment charge to NPTC. While the consignment charge is stipulated by the Electricity Regulatory Authority of Vietnam based on the notification by the Ministry of Industry and Trade, the actual applied price is adjusted at EVN.

Each sector of power generation, transmission, and distribution is financially independent from EVN and power trading is carried out amongst sectors. However, although it can be said that the foundation of ensuring transparency of consignment charges has been established, there is a gap between the consignment charges stipulated by the Electricity Regulatory Authority of Vietnam and the actual applied consignment charges arising from the financial condition of EVN. Thus, it is desirable to consider and implement a system that further improves transparency.

Power Infrastructure Development Plan

According to the 'National Power Development Plan Period 2011–2020, Vision to 2030' (Decision No.1208/QD-TTg dated 21 July 2011), the placement of power imports/exports in power resource development and share in the energy mix are described as follows:

- Carry out effective import and export of power with neighbouring countries, mutual interest protection, and information exchange with countries with high hydropower potential including Lao PDR, Cambodia, and the People's Republic of China, and strengthen power imports by securing the stability of the power transmission network. The planned amount of imported power is approximately 2,200 MW in 2020 and approximately 7,000 MW in 2030.

  As of 2020, the planned total output by all power plants is approximately 75,000 MW, of which the percentage of imported power is 3.1 percent while power production (including imports) is approximately 330 billion kWh, of which the percentage of

imported power is 3.0 percent.

- By 2030, the projected total output by all power plants is approximately 146,800 MW, of which the percentage of imported power is 4.9 percent, whilst power production (including imports) is approximately 695 billion kWh, of which the percentage of imported power is 3.8 percent.

Amidst concerns over power shortages, the Viet Nam government started power imports in 2004 to stabilise its power supply, with the People's Republic of China as its main import source. Power is also imported from Lao PDR and Cambodia, albeit small in volume. Both countries are rich in water resources and high in hydropower generation potential, and Viet Nam is planning to receive power supply by concluding cooperative agreements with both countries in the energy sector and investing into hydropower plant construction projects.

Following is the National Power Development Plan's power transmission network interconnecting plans with Viet Nam's neighbouring countries.

- International interconnection with the People's Republic of China
  - Maintain the currently conducted power imports by the 110-kV and 220-kV transmission lines.
  - Consider power imports of 2,000–3,000 MW by 500-kV transmission line or HVDC.

- International interconnection with Lao PDR
  - In the northern area of Lao PDR, interconnect with the 220-kV and 500-kV transmission lines of Thanh Hoa and Nho Quan (Ninh Binh Province), Son La Province.
  - In the southern and central areas of Lao PDR, interconnect with 220-kV and 500-kV transmission lines of Thach My (Quang Nam Province) and Pleiku (Gia Lai Province).

- International interconnection with Cambodia
  - Carry out power trading by additional construction of 220-kV or 500-kV transmission line depending on the trading capacity.

For later years, EVN's planned development of power sources is allocated to IPPs such as Petro Vietnam (PVN) and Vietnam National Coal-Mineral Industries Holding (VINACOMIN) due to poor financing by EVN. However, because wholesale prices are being suppressed, investment has become inactive and development is delayed. It is desirable that Viet Nam improves its investment environment to facilitate raising of funds required for development of new power sources and to secure power supply capability through steady implementation of international interconnection projects.

Technical Standards

The power system of Viet Nam can be roughly divided into the northern system where hydropower plants are concentrated, the southern system where gas-fired power plants (centred on Ho Chi Minh City) are concentrated, and the central system located between the two and interconnects the north and the south.

The northern, central, and southern systems were interconnected in 1994 upon the completion of the 500-kV transmission line from north to south. In 2005, after the second route was completed, the configuration has become 500-kV and 220-kV mainstay systems centred on two 500-kV north–south power transmission line routes. Local systems use 110 kV and are spreading to the cities.

The line length by voltage as of 2014 is 4,887 km for 500 kV, 12,166 km for 220 kV, and 15,602 km for 110 kV. The installed capacity of substations as of 2014 is 19,350 MVA for 500-kV systems, 31,202 MVA for 220-kV systems, and 35,653 MVA for 110-kV systems.

Viet Nam is connected with neighbouring People's Republic of China, Lao PDR, and Cambodia. The National Power Development Plan describes the following points as the power transmission line development planning indices.

- Ensure that systems important in power-distribution equipment satisfy the N-1 standards and other systems satisfy the quality standards stipulated for distribution equipment.
- Develop power-distribution equipment complying with the technical standards of countries in the region, and ensure the connection of Viet Nam power systems and power systems of countries in the region.
- Ensure that power-distribution equipment is simple, flexible, has a backup system,

and the quality of supplied electricity (voltage, frequency) is guaranteed.

- Select an appropriate transmission voltage based on the transmission capacity and distance.

As part of EVN, NPTC is required to be financially independent including financing for maintenance and establishment of new facilities, and for its financial management to stand on revenues from consignment charge. However, since the financial standing of EVN is worsening, NPTC is forced to trade at prices lower than the prices specified by the government. For that reason, NPTC itself is also falling into financial difficulty and has come to a situation where development of distribution facilities is not catching up with the rapidly progressing power source development. Therefore, to promote the National Power Development Plan, the task is to address the financing and human resources issues.

The power supply and demand in the southern region are expected to remain tight in the future, and it will still be necessary to have long-distance power transmission by 500-kV transmission lines from the northern region to the southern region. In addition to overloading transformers and transmission lines, wide-area power outage due to transmission loss or voltage drop has become a social problem. Therefore, improvement of system configuration and technical ability for improving power quality (e.g. maintenance of voltage and frequency) as well as stabilisation of the system through international interconnections also are major tasks for Viet Nam.