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**PLANNING ISSUES FOR
NEWLY INDUSTRIALISED AND
DEVELOPING COUNTRIES**

**Working Group
C1.26**

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Working Group C1.26 OF CIGRE STUDY COMMITTEE
C1
On Power System Planning and Development

*"PLANNING ISSUES FOR
NEWLY INDUSTRIALISED AND
DEVELOPING COUNTRIES"*

*Report Prepared by
WG 37.26
for
Study CIGRE Committee 37/C1*

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Planning Issues for Newly Industrialised and Developing Countries - Report from ASEAN Countries

Executive Summary

Background

This report by Working Group WG37.26 is submitted to Study Committee C1 to meet the terms-of-reference established in November 1998 and revised in September 2002. The two main objectives of the working group are:

- 1) To provide a platform for discussion and exchange of information/experience on power system planning among newly industrialized and developing countries; and
- 2) To publish a document that summarises planning practices and issues for each participating utilities that would be useful for benchmarking and comparisons.

To ensure that the first objective could be met, at the 2002 C1 Meeting in Paris it was agreed that the working group should focus work in the ASEAN region so that organization of meetings or workshops could be conveniently arranged. Furthermore there are already existing regional utility organizations such as the HAPUA (Head of ASEAN Power Utilities/Authorities) that would be able to support the working group activities if they are conducted in the region. Several organization meetings were convened before a final workshop was held on 3rd and 4th August 2004 in Bangkok Thailand that provided the forum/platform thus meeting the first objective.

To meet the second objective, this report entitled "Planning Issues for Newly Industrialised and Developing Countries" was presented to Study Committee C1 at the 2004 Paris General Session. The report is divided into 7 chapters. Chapter 1 provides the background to the working group. Chapters 2 through 7 contain planning practices, issues and their summaries covering the topics as required by the working group terms-of-reference. The chapters are:

- Chapter 2: Electricity Industry Structure
- Chapter 3: Load and Energy Forecasting
- Chapter 4: Planning and Design Criteria
- Chapter 5: Planning Approaches and Methods
- Chapter 6: Financing Issues
- Chapter 7: Specific Technical Issues

The following sections provide summaries of the above chapters.

*Convener - Prutichai Chonglertvanichkul (Thailand), Secretary - Sallehuddin Yusof (Malaysia)

Electricity Industry Structure

Singapore is most advanced in ESI reform and restructuring. The city state is well known for efficiency and business innovations. Therefore, it is not surprising that the republic has planned the electricity industry reform meticulously and within less than 10 years it has reached a stage where full wholesale competition has been achieved and steps towards full retail competition is evolving and currently benefiting many large customers.

Indonesia has mandated electricity industry reform in the country's Law No. 20. It is important to note that Indonesia has diversified population, incomes and economic activities. The population is spread over many small and large islands spanning from East in Irian Jaya to the Northeast in Aceh. There are many isolated power systems and large proportion of the population is yet to benefit grid connected electricity supply. Law No. 20 mandated that at least one of the power systems - most likely the Java-Bali Interconnected network - must achieve wholesale and retail competition in stages. Through current interpretation of the law, the plan is to immediately restructure Java-Bali system into various private generators or generators operating on IPP basis and various regional distributors with the Transmission Owner/Operator coordinating the various players. For the future, Law No. 20 is interpreted that the transmission network has to be operated by an independent entity. It is planned that by year 2007 retail competition would be achieved for selected number of customers.

The Philippines has made significant progress to gain efficiency through industry reform while many other ASEAN countries are still discussing their restructuring plans. A transmission owner/operator, that is, National Transmission Corporation (Transco) has been established whose responsibilities include to operate the transmission network and to coordinate the players through the provisions of the Grid Codes. The Transco also plays an important role to ensure that the grid is planned optimally including to suggest next locations of generators.

Cambodia and Lao PDR have the lowest electrification rate among the ASEAN countries. Therefore, for both countries two main objectives are rural electrification and grid expansion for accessibility of electricity to the population. Cambodian large electricity grids in the south and northeast are managed by the state-owned utility EdC (Electricite du Cambodge) that is organized as a vertically integrated utility. Cambodia needs also to coordinate and regulate more than 20 isolated power systems operated by independent enterprises. Therefore, the task of the government to electrify the country requires the industry structure to be organized in somewhat complex manner in order to effectively coordinate the many players. Lao PDR power industry is dominated by two players; the vertically integrated utility EdL (Electricite du Lao) and existing and future IPPs that directly export power to the neighbouring countries (Thailand and Vietnam). While EdL is organized to focus on domestic

electrification the IPPs are developing large hydro sites for power export. EdL has a task to also exploit the development of the IPPs for domestic supplies and establishing the Lao PDR Transmission Grid.

Brunei Darussalam electricity industry is dominated by the state-department DES (Department of Electricity Supply). Electricity industry is an important national activity for operating the oil and gas business of the country and therefore keeping the status quo with close government control and monitoring is the main objective. However, some initiatives have been introduced to create sense of competition to the DES.

Thailand has traditionally been dividing the responsibility to operate the electricity industry to three major government authorities namely EGAT (Electricity Generating Authority of Thailand, PEA (Provincial Electricity Authority of Thailand) and MEA (Metropolitan Electricity Authority of Thailand). The planned reform would see that generating plants in EGAT to operate on commercial basis like other IPPs (known as Account Unbundling) and EGAT Transmission to be the sole network owner/operator with a single-buyer within it. MEA and PEA will continue with the status quo and remained monopoly and regulated.

Vietnam has been experiencing double digit annual electricity growth rate even during the economic crisis of the late 1990's and this has exerted strain on financial resources to expand generation. Therefore, the generation sector has been opened to IPPs and this has initiated restructuring plan that will see more private sector participation. Vietnam has planned to evolve from current vertically integrated structure to that allowing for wholesale competition and to be followed by retail.

Malaysia started early in ESI reform through introduction of "competition" in the generation sector. The main utility in Peninsular Malaysia was initially (2000) reforming itself through unbundling initiatives by creating separate business units, but recently (2002/2003) the company has reverted back into vertically integrated structure. There is also no clear direction to ESI reform apart from the plan to review the structure in year 2007.

Load and Energy Forecasting

Brunei that currently (2004) has peak load of 450MW employs trending method by projecting historical demand into the future and add any known step loads during the early years. Because of the relatively small geographical size and well coordinated administrative machineries, new loads such as residential development, commercial areas and oil and gas support industries are easily identifiable and thus providing accurate source of information for load forecasting.

EdC of **Cambodia** currently manages two main power networks; Southern system that includes the capital Phnom Penh and Western system of Siem Rep province that borders Thailand. EdC employs trending method and complemented with known loads as well as target electrification level as their forecasting method. For national forecasts, supply to isolated areas - villages and towns - are undertaken by more than 20 REEs (Rural Electrification Enterprises) and therefore inputs from the REEs are also included. Because of lack of investment in generation, Cambodia is currently and will continue in the near future to suffer shortage of power and thus may results in brownouts and blackouts.

Indonesia employs regression analysis taking into account GDP growth, historical trend and rural electrification target for forecast of sales and demand. PLN (Perusahaan Listrik Nasional) also takes into consideration their targets for taking over supplies of captive loads.

Singapore employs both end-use and regression analysis with economic factors. SP PowerGrid establishes energy and demand forecast by areas with inputs on land-usage, industrial and commercial developments through close coordination with various authorities. These area level forecasts would then be reconciled with the national level forecast established by the EMA (Energy Market Authority of Singapore).

Thailand employs the most sophisticated forecasting technique with the applications of end-use analysis by both PEA and MEA while EGAT uses regression analysis for system forecast. These two forecasts will then be reconciled at the top government committee level of Thailand Load Forecast Subcommittee (TLFS). MEA and PEA regularly (once in three years) conduct survey of consumption for various categories of customers. The two distribution utilities also compiled data of load profiles for various types of customers. From energy forecasts and integration of load profiles, transmission substation forecasts are established. Once substation forecasts are established, these will have to be reconciled with the total system forecast carried out by EGAT at TLFS. When the two forecasts are agreed and approved by NEPO (National Energy and Policy Office), they are then used for planning purposes by all utilities.

Lao PDR employs regression and sectoral analysis with economic factors and rural electrification targets as inputs. EdL has compiled figures of consumption levels for various sectors of customers and use these for their forecasting.

Vietnam employs regression analysis for national forecast as well as sectoral analysis. These two forecasts are reconciled by EVN (Electricity of Vietnam). EVN is currently building database of consumption patterns and profiles for various categories of customers for future use.

Malaysia (Peninsular) employs regression analysis with economic factors and demographic factors for system forecast and regression analysis complemented with known loads for district/regional forecasts. These two forecasts are reconciled within TNB (Tenaga Nasional Berhad) before a single forecast is presented to the government for approval.

Table 1 below summarises methods and approaches used for load/energy forecasting by various countries/utilities in ASEAN countries.

Table 1: Summary of load forecasting methods employed in ASEAN utilities

N o	Country	Historical trend	Known Loads *	Electrification Target	Regression Analysis	Sectoral analysis	End-Use Method	Top-Down Approach	Bottom-up Approach
1	Brunei	Y	Y						
2	Cambodia	Y	Y	Y					
3	Indonesia	Y	Y	Y	Y	Y		Y	
4	The Philippines								
5	Singapore		Y		Y		Y	Y	Y
6	Thailand				Y		Y	Y	Y
7	Lao PDR		Y	Y	Y	Y		Y	Y
8	Vietnam				Y	Y		Y	Y
9	Malaysia		Y		Y	Y		Y	Y

* Rural target/captive loads

Planning and Design Criteria

Table 2 below summarises generation planning criteria as applied in the ASEAN countries. All countries that use LOLP (Loss of Load Probability) have applied 24 hours/year as the criteria. In terms of reserve margin Thailand is maintaining a figure of not less than 15% while Malaysia and Indonesia are keeping to around 30%. Lao PDR is maintaining reserve margin to not less than 15% with their 100% hydro resources. Vietnam is maintaining reserve margin to about 20%.

Table 2: Summary of generation planning criteria in ASEAN countries

No	Country	Loss of Units	LOLP Hours/year	Reserve Margin %	Fuel Mix Policy	RE Policy
1	Brunei	Y				
2	Cambodia	Y		> 15%		
3	Indonesia		24	28% - 33%	Y	
4	The Philippines					
5	Singapore					
6	Thailand		24	> 15%	Y	Y
7	Lao PDR		24	> 10%	100% hydro	
8	Vietnam		24	> 20%	Y	
9	Malaysia		24	25% - 30%	Y	Y

Table 3 summarises main parameters of transmission planning criteria applied by countries in ASEAN. All countries are using deterministic criteria. Only Thailand is now mandated to use probabilistic reliability criteria to justify investment. Also, EGAT has established voltage stability criteria. Malaysia applies (N-2) contingency extensively in the network while Vietnam applies (N-2) for supplies to large load areas.

Table 3: Summary of transmission planning criteria in ASEAN countries

No	Country	N-1	N-2	Voltage Stability	Reliability Evaluation	Voltage*	Frequency Normal
1	Brunei	Y				±5% ----	
2	Cambodia	Y				+2%, -5%	
3	Indonesia	Y				±5% ----	50±0.5Hz
4	The Philippines	Y				±5% ±10%	
5	Singapore	Y					
6	Thailand	Y		Y	Y		
7	Lao PDR	Y				±5% ±10%	
8	Vietnam	Y	Y			±5% ----	50±0.5Hz
9	Malaysia	Y	Y			±5% ±10%	50±0.25Hz

*Normal & contingency

Planning Approaches and Methods

Planning approach and method employed by each country depends very much on the criteria adopted. For Brunei and Cambodia providing sufficient generation capacity to meet simple unit outage criteria makes it unnecessary to perform dynamic programming generation expansion studies as employed by Thailand, Vietnam, Indonesia and Malaysia. Both SP PowerGrid of Singapore and Transco of the Philippines are not responsible for generation planning.

Methods for transmission planning seem to be uniform throughout ASEAN. Following establishment of load forecast and generation expansion, transmission planning are carried out. Thailand, Indonesia, Lao PDR, The Philippines have presented flow diagrams of their planning steps. These are useful references to benchmark types of analysis to be considered.

There seem to be an overall lacking in method and approach towards voltage and reactive power planning in all ASEAN countries.

Financing Issues

Brunei is 100% self-financing its power sector development. Singapore generation sector is completely market driven and therefore additions are based on price signals and financing arrangement by the generation companies themselves while transmission and distribution are self-financed.

Cambodians are paying high price for electricity (only about 20% grid-connected). The country requires large amount of financial assistance for power sector development. Since the country has only recently (late 1990's) recovered from war, many issues related to foreign investments, regulations and trades have to be resolved. However, steady assistance from multi-lateral agencies such as the World Bank are beginning to help in accelerating required development.

Lao PDR has established a strategy for sustainable development of its large hydro potential for export and some proportion of the output for domestic use to complement small hydro development. Large hydro development for export is left to the private developers to make the financial arrangement - it must be noted Lao PDR Government through EdL takes some stakes in those large hydro companies. For the development of domestic power infrastructure, EdL depends on assistance from international donors as well as multi-lateral lending agencies.

Indonesia depends on borrowings, project financing and very limit amount of self-financing for power sector development. With respect to external borrowings there are several sources including, development banks such as the ADB, soft loans and bonds. All

external borrowings are government guaranteed. PLN's ability for self-financing is however becoming limited and scarce.

Thailand's source of financing for power sector development includes local debt, foreign debt and self financing (25% for EGAT). Local debts include public bonds, commercial bank and financial institutions. With respect to foreign debts the sources are; foreign bonds, multi-lateral agencies like the World Bank, Export Credit and Supplier's Credit.

Vietnam requires massive investment in power sector development particularly generation sector. Presently to finance its power sector development, Vietnam has to depend on foreign loans.

Specific Technical Issues

Only EGAT of Thailand responded to items under specific technical issues. We believe that other countries/utilities have or are addressing the listed issues. For reasons of limited time and resources, those issues could not be presented at the August 2004, Bangkok Workshop.

EGAT in addressing increasing short-circuit level has examined several methods including the use of new power electronic devices and concluded that, the traditional method remained cost-effective.

EGAT in planning against possible system collapse in the Northeastern region has applied both security constraint generation and load-shedding.

Chapter 1: Introduction

1.1 Background

- 1.1.1 CIGRE Working Group 37.26 on "Planning Issues for Newly Industrialised and Developing Countries" has been established by CIGRE Study Committee C1 (formerly SC37) on "Power System Planning and Development" since 1998. Due to changes in the convenership of the working group, it was not able to meet its objectives as originally planned. At 2002 CIGRE General Session, Study Committee C1 decided to transfer chairmanship of the working group to Prutichai Choglertvanichkul of Thailand while Sallehudin Yusof of Malaysia remained the secretary. It was also decided that the work of the working group should focus on countries/electric utilities in the ASEAN (Association of South East Asian Nation) region.
- 1.1.2 The main objective of the working group is to provide platform for exchange of information on planning issues among newly industrialised and developing countries and to publish those information for industry reference.
- 1.1.3 To meet the working group objective, a workshop was held on 3rd and 4th August 2004 in Bangkok Thailand that provided opportunities for utilities in the ASEAN region to exchange information and discussed planning issues as required by the working group's terms-of-reference. To facilitate comparative assessment across utilities, each country/utility presented the issues in a structured manner and followed by discussions.
- 1.1.4 The workshop was organized in Bangkok Thailand with the support of HAPUA (Head of ASEAN Power Utilities/Authorities) and jointly organized by Electricity Generating Authority of Thailand (EGAT), Thai National Committee of CIGRE and Asia-Oceania Regional Council of CIGRE (AORC-CIGRE).
- 1.1.5 This synthesized workshop report would provide each regional utility the opportunity for benchmarking of practices with regional best practices and pave the way for further inter-utility collaborative effort amongst regional utilities in the face of common issues particularly on system planning.

1.2 Working Group Terms-of-Reference and Workshop Contents

1.2.1 The terms-of-reference for the working group was established by Study Committee C1. The main objective of the working group is to document issues, methods and approaches for carrying power system planning by developing and newly industrialized countries. The report could then be referred to by regional utilities to benchmark planning methods and strategies. The subjects/aspects covered by the report include:

1) Electricity Industry Structure

- ❖ Utilities and regulations;
- ❖ Structure of generation, transmission, distribution and retail business;
- ❖ Future plan of electric industry reforms;
- ❖ Grid Codes and roles.

2) Load and Energy Forecasting

2.1 Economic Growth Factors & Load Growth

- Economic factors that are influencing load and energy forecasts from a macro point of view;
- Summary of correlation between economic growth factors and load growth;
- Relationship between economic growth & infrastructure development;
- Impacts power sector restructuring factors

2.2 Load Forecasting Approach and Methodology

- Describe methods used;
- Applications of end-use method - micro forecast at the distribution level;
- The process of reconciliations between macro and micro forecast;
- Coordination between distribution and transmission at interfaces;
- Load forecast approach for rapidly developing cities and newly created townships;
- Keeping track of changing customer load intensity at the distribution level;
- Impacts of distributed/dispersed generation and electricity market.

3) Planning and Design Criteria

3.1 Generation Planning

- List of criteria used and applications;
- Generation margin;
- Generation mix;

3.2 Transmission Planning and Design Criteria

- List of transmission planning and design criteria;

- Impacts of deterministic criteria on investment;
- Applications of probabilistic criteria;
- Approach to using probabilistic criteria;
- Power quality criteria - standards and their applications;

4) Planing Approaches and Methods

4.1 Coordination of Planning

- Approach to coordinate planning among various players;
- Roles of the various entities/players and a coordinating body;
- Roles of government, regulators and independent grid operators, market forces;

4.2 Roles of Interconnections

- Planning approach to sharing of energy resources;
- Coordination of interconnection planning;

4.3 Environmental Issues

- List of environmental issues;
- Meeting environmental regulation in planning;

4.4 General Grid System Planning

- Planning process and procedures;
- Planning cycles;
- Planning reports;

5) Financing Issues

- ❖ Source of funds and requirements;
- ❖ Issues on private investments in the power sector and requirements;
- ❖ Flexible investment plan;
- ❖ Roles of lending agencies and their requirements.

6) Specific Technical Issues

6.1 Containment of Short-Circuit Levels

- Available methods and technologies;
- Experiences of developed countries;

6.2 Applications of New Technologies

- FACTS and their roles;
- Cost effectiveness of new technologies;
- Operation and maintenance issues;

6.3 Planning Against System Collapse

- Cost of blackout/system collapse;
- Tools used;
- Planning of system islanding;

6.4 Network Configurations

- Network configurations used;
- Planning in anticipation of embedded generation;

6.5 Embedded/Dispersed Generations;

- Embedded generation experience;
- Issues related to connections of embedded generations

6.6 Voltage Stability and Reactive Compensation

- Voltage stability problems;
- Reactive power forecasting;
- Load models;
- Reactive compensation

1.2.2 The above issues were discussed by the 9 ASEAN countries/utilities at a Workshop held on August 3rd and 4th 2004 in Bangkok, Thailand. All workshop participants were requested to prepare PowerPoint presentations to discuss each country's experience and issues faced on each subject above, if applicable.

1.3 Workshop Participants and Other Contributors

1.3.1 Table 1.1 lists participants of the workshop from 9 countries in ASEAN. These participants contributed to accomplishing the tasks of the working group.

Table 1.1: List of workshop participants

No	Country	Name	Company/ Organisation	Email
1	Brunei Darussalam	Hamdan Haji Abd Latip	DES	desmail@brunet.bn
		Lim Cheng Quan		desmail@brunet.bn
2	Cambodia	Chan Sodavath	EdC	
		Sor Pengkhy		
		Mak Thom		
3	Indonesia	Abdul Rahman Afiff	PT PLN (Persero)	
		Endro Supriyanto		esupriyanto@pln.co.id
		Susanto Wibowo		s.wibowo@pln-jawa-bali.co.id
4	Lao PDR	Boungnong Bouttavong	EdL	
		Vongmany Soneketssoulinh		
5	Malaysia	Sallehuddin Yusof	APS	salleh@pc.jaring.my
		Baharom Hamzah	TNB	
		Cham Kok Teng		
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		Mr. Nghiem Van Lap		lapnv@evn.com.vn

1.3.2 There were also contributions from members of Study Committee C1 as listed in table 1.2.

Table 1.2: Other contributors to the working group

No	Name	Country	Company/ Organisation	Email	Specific contribution
1	Peter Wallace	Australia			Work organisation
2	T. Watanabe	Japan			Load Forecasting
3	Eric Cleobury	UK			Planning Criteria

1.4 Contents of this Report

1.4.1 This report comprises of chapters to cover the subjects as outlined in the working group terms-of-reference. Those chapters are as follows:

- (a) **Chapter 1: Introduction**, provides background to the working group, terms-of-reference and list of contributors.
- (b) **Chapter 2: Electricity Industry Structure - 2004**, outlines current and future industry structures in the participating countries including issues and problems with respect to electrifications.
- (c) **Chapter 3: Load/Energy and Sales Forecasting**, discusses methods for forecasting including factors, organisation and coordination.
- (d) **Chapter 4: Planning and Design Criteria**, outlines both generation and transmission planning criteria used by each country.
- (e) **Chapter 5: Planning Approaches and Methods**, discusses how planning are carried out in each country/utility.
- (f) **Chapter 6: Financing Issues**, discusses financing issues particularly sources of funds and related issues.
- (g) **Chapter 7: Specific Technical Issues**, outlines selected technical issues and how they are resolved by contributing utilities.
- (h) **Appendices:**
 - i. **Appendix A** - - List of Contributions at the Workshop, 3rd - 4th August, 2004.
 - ii. **Appendix B** - Contribution by NGC on "A Summary of Recent International Comparisons of Planning Criteria"

Chapter 2: Electricity Industry Structure - 2004

2.1 Introduction

2.1.1 The approach and method to power system planning depend greatly on the structure of the power industry in the country. As described in this chapter there is a diversity of structures in the ASEAN countries ranging from the traditional vertically integrated to that with wholesale and retail competition. The complexities of the structures do not necessarily depend on the degree of market liberalization but also on the fundamental needs to electrify the rural population.

2.1.2 Since early 1990's, many countries around the world have embarked on electricity supply industry reform with varying objectives but basically as the next approach to improve the industry's efficiency so that the benefits to be accrued would be passed to the customers in terms of reduced electricity tariff. There were many approaches to reform undertaken depending on the status of the industry in each country and the underlying socio-political and economic objectives. But the basic approach adopted was to introduce competition in the various sectors of the industry.

2.1.3 Since in many countries the incumbent utilities were already operating as vertically integrated unit owning at least two of the industry's three business areas of generation, transmission and distribution, some structural changes needed to be carried out before competition could be introduced. Two major terms are commonly used to describe the Reform process:

- 1) Liberalisation is the term use to describe opening of electricity market to business players and usually means removal of monopoly.
- 2) Restructuring is the process of re-organising the industry structure such that competition could be introduced

Although there was initial move to open competition to all three sectors of the industry, it is now accepted that efficiency could be obtained by allowing competition in the wholesale and retail businesses. 'Wholesale' refers to business of production of electricity from energy resources and selling it to customers or pool market while 'retail' refers to business of buying electricity in bulk and selling it to customers.

- 2.1.4 In the ASEAN countries, the wave of electricity industry reform began to sweep the region as soon as the process was initiated and implemented in Europe particularly the U.K. The initial move of industry liberalisation in many ASEAN countries was in the wholesale business when Independent Power Producers (IPP) were allowed to build power plants and sell electricity directly to the incumbent utilities through normally a long term based power purchase agreement (PPA). As the business evolved the commercial terms of new PPAs were improved to encourage further competition. Now in at least one ASEAN member country, Singapore, a full competition in wholesale business has been achieved with generators bidding their supply to the market operator on a daily basis.
- 2.1.5 In this chapter, we will describe current and planned industry structure in each ASEAN member country before presenting a summary.

2.2 Brunei Darussalam

- 2.2.1 Brunei Darusaalam is an oil-rich Kingdom located on the northern part of the Borneo Island between two Malaysian states of Sabah and Sarawak. The country is divided into two parts and covered an area of 5,765 sq. km. Total population of Brunei is about 340,000 and with GDP per capita of US\$15,000, the people of Brunei have high purchasing power as compared to other ASEAN countries except for Singapore (with GDP per capita of > US\$19,000). The country's economy is dominated by oil and gas industries. Electricity supply therefore plays a very crucial role in ensuring the industrial production runs efficiently. Therefore, secure and reliable supply is the prime objective of the electricity supply industry.
- 2.2.2 The current (2004) structure of electricity industry in Brunei is as shown in figure 2.1. The Department of Electrical Services (DES) under the auspices of Ministry of Development is the government authority mandated to look after and to be responsible for the operation and development of the electricity sector. DES has two major functions/responsibilities:
- 1) As a utility, DES is responsible for the Generation, Transmission & Distribution of electricity to the end-users. It is a vertically integrated utility.
 - 2) As a service provider, DES is also responsible to set standards for the implementation of electricity usage in public buildings as well as overseeing their overall electro-mechanical maintenance. In this case DES acts as the Regulator.

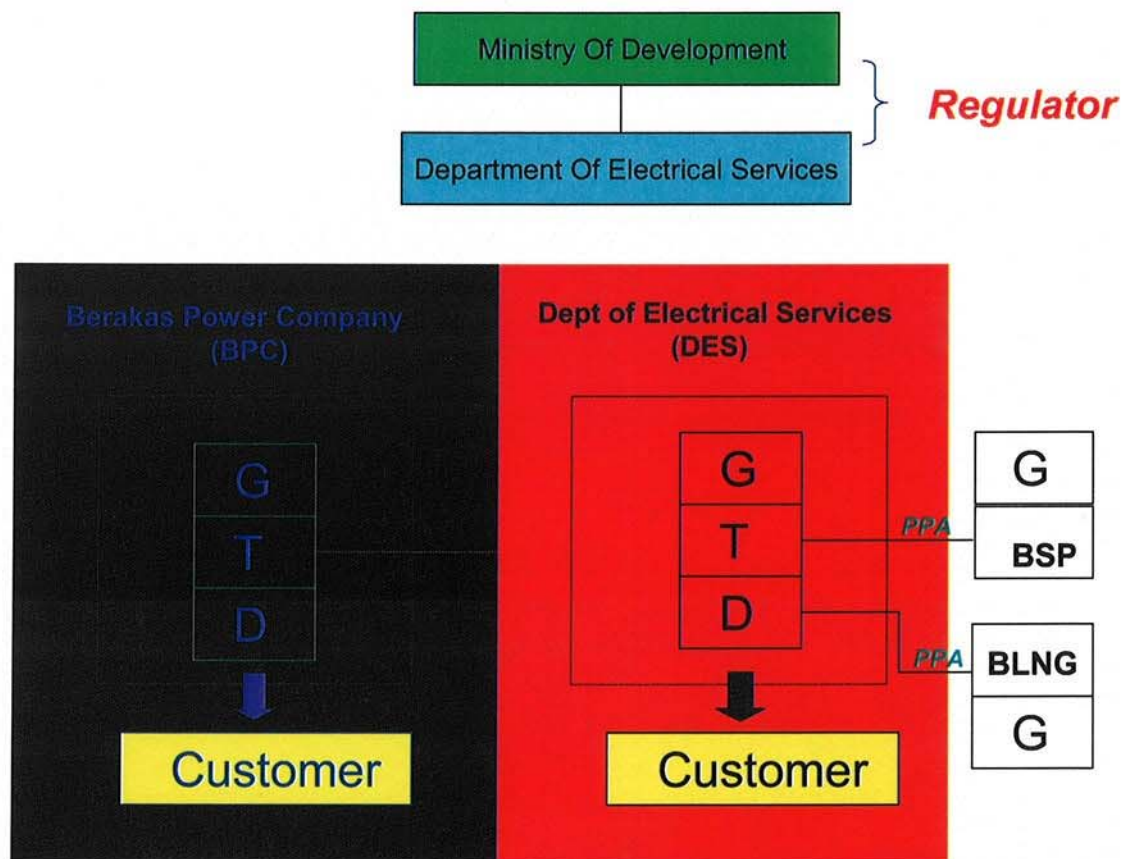


Figure 2.1: Current (2004) Electricity Industry Structure for Brunei Darussalam

2.2.3 DES, since its establishment has been dominating the electricity industry in Brunei but recently, the situation has changed with the introduction a new industry player, namely:

- Berakas Power Company Sdn. Bhd. (BPC).

The two IPPs - BSP and BLNG have been connected to DES's network since their establishment. Although BPC is wholly owned by the government investment arm, its establishment has in effect introduced some kind of "competition" at least in terms of more efficient operation counterpart to DES. BPS is also viewed as another vertically integrated utility in Brunei but with 90% of its generation being sold to DES and 10% to its own customers. BS (Brunei Shell) sells excess electricity to DES through a PPA. Similarly, the same commercial arrangement has been established with BLNG (Brunei LNG).

2.2.4 With current demand of the order of 450MW and that DES is an important department of the government, it is not expected that the current structure be changed significantly in the future.

2.3 Cambodia

2.3.1 Cambodia who became member of ASEAN in 1999 is located in the Indochina Region bordering Thailand in the West, Vietnam in the East, Lao PDR in the North and faces the Gulf of Thailand in the South. It is a country with total land area of 181,035 sq. km and population of about 12 million people whose main economic activities comprise of agriculture and garment related industries.

2.3.2 The main energy resource employed by the population of Cambodia is wood - mainly for cooking. Access to electricity energy is limited where only 20% of the population is connected to the country's power grid and have to pay comparatively high price of between 9 and 25 US¢/kWh. For 40% of the population served by rural type generation or batteries are paying with tariff of between 40 and 80 US¢/kWh. Phnom Penh (the capital city) has the highest electrification ratio of more than 65% while other towns are electrified in less than 30%. Therefore, in terms of electricity, the country's objective is twofold; rural electrification and to reduce tariff - to reduce cost of supply. To achieve these objectives, the industry structure for the country is organized in a somewhat complex form as shown in figure 2.2.

2.3.3 Structure in figure 2.2 has been establish to properly regulate isolated power grids supplied mostly by small- and medium-size diesel generators and operated by private enterprises. There are at present at least 22 licensed small isolated systems and numerous unlicensed ones. Electricity demand continues to grow at 10%-12% per annum, with most of this growth in the Phnom Penh area - South of Cambodia.

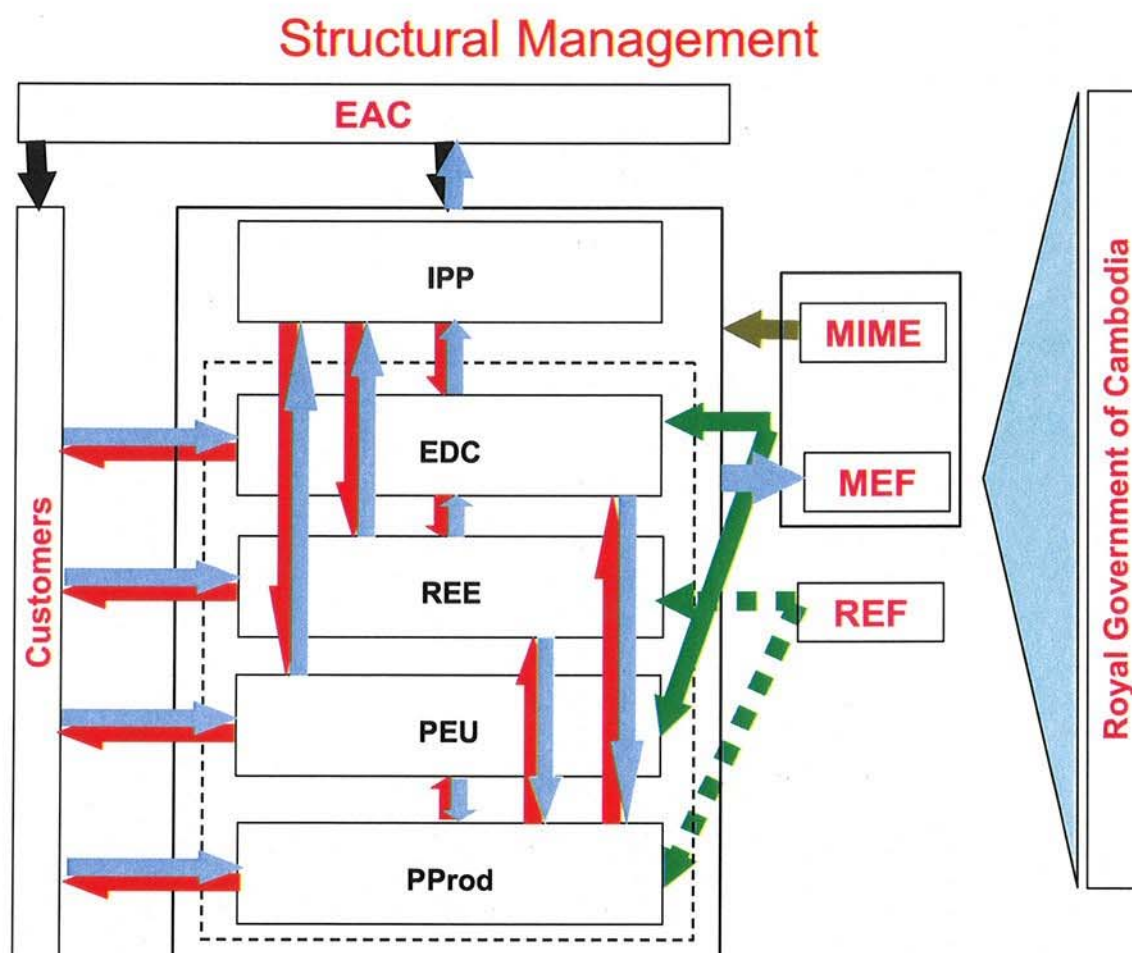


Figure 2.2: Current (2004) Electricity Industry Structure for Cambodia

2.3.4 Two ministries are involved overseeing and supporting the industry, namely:

- 1) Ministry of Industry, Mineral and Energy (MIME) responsible for planning and policy
 - 2) Ministry of Finance (MEF) responsible of financing.
- Rural Electrification Fund (REF) is a government body (with its own board) that has been established to source and provide funds for private developers in pursuing rural electrification.

2.3.5 The electricity industry is regulated by the EAC (Electricity Authority of Cambodia) to ensure that the various players are performing their activities to meet the country's electrification objectives. The main industry player is the state-owned EDC (Electrite du Cambodge) that owns power plants, transmission and distribution facilities. Currently EDC operates in the southern and eastern parts of the country. REEs (Rural Electrification Enterprises) are private distributors licensed by the EAC to supply rural population.

PEUs (Provincial Electricity Utilities) are electric utilities operating in isolated towns and areas throughout the country that come under the jurisdiction of the Ministry of Industry, Mineral and Energy. With the involvement of many players and trading with neighboring countries of Thailand and Vietnam the administration of power flows is also somewhat complicated as shown in figure 2.3.

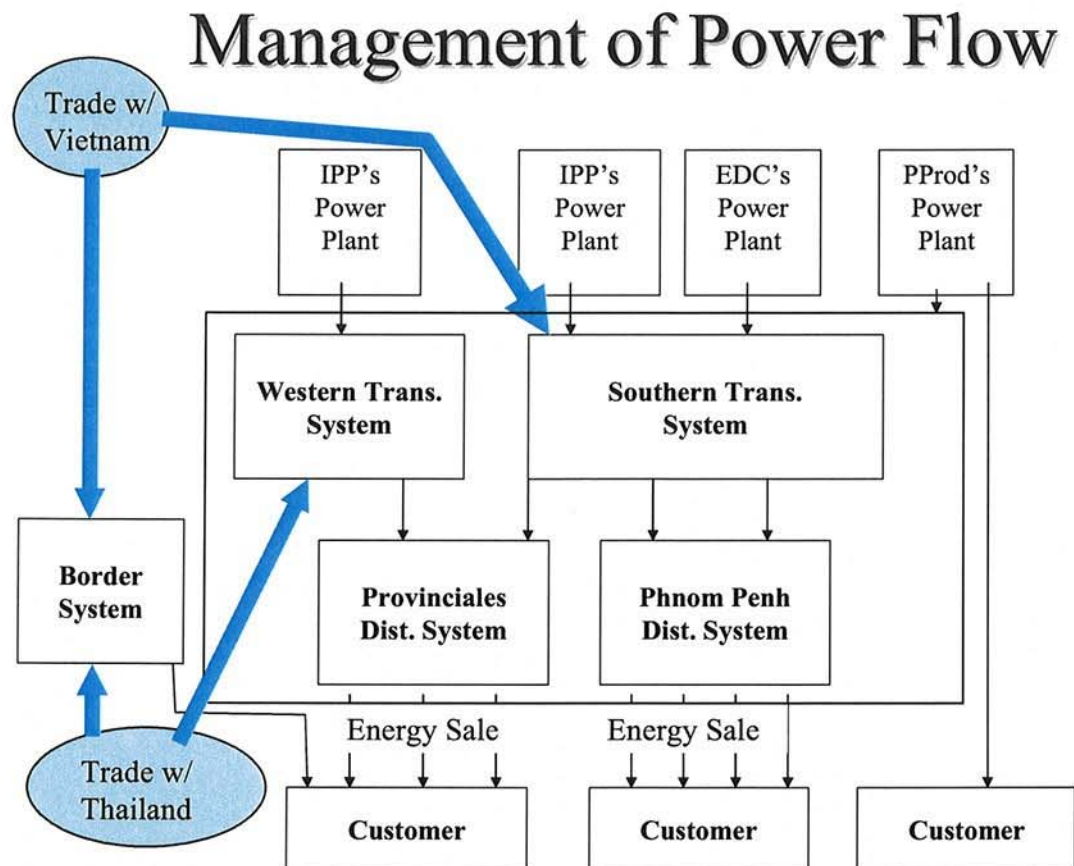


Figure 2.3: Managements of power flows among various industry players in Cambodia

2.4 Indonesia

2.4.1 The present day and the evolution of electricity industry structure in Indonesia are dictated by the provisions in the new Electricity Law, Law No. 20 - 2002. Prior to this, the 1985 Electricity Law (Law No. 15) was enforced and comparisons of the main provisions of the 1985 and 2003 laws with respect to industry structure are given in table 2.1.

Table 2.1: Comparison of Electricity Law 2002 and 1985 w.r.t Industry Structure in Indonesia

No	Items	1985	2002
1	Electricity supply obligations	It is the Government obligation to supply enough electricity to the public	Electricity supply is carried out through competition and transparency. The sector is open to all players with the same level of playing field and opportunity.
2	Industry players	PLN, a state own utility solely set up as Government agency in executing the obligation. PLN is the sole electricity venture authority holder.	PLN became one of the many players.
3	Policy	Ministry of Energy	Ministry of Energy
4	Regulation	Ministry of Energy	Independent Regulator
5	Structure	PLN Vertically Integrated	PLN to be unbundled

2.4.2 Based on the 2002 Electricity Law, Indonesia has established a Two-Phase Plan for industry reform that will lead to wholesale and retail competition. In Phase I, wholesale generation competition would be established under the Single Buyer Market model. By 2007 at least one the power systems in Indonesia (Indonesia has many provincial power networks) must already fully implement Single Buyer model and most like the Java-Bali Interconnected system. In Phase II, following the implementation of required hardware and software, competition is to be allowed in the retail sector creating a Multi-Buyer Multi-Seller Market (MBMS). Competition in retail sales will start with large customers connected at high voltage level and later expanded to medium voltage customers. For reasons of supply quality and special service requirements, some low voltage customers may be allowed to have choice of suppliers.

2.4.3 Electricity Law 2002 also identified industry players in the current and future structures as follows:

- 1) Generation companies.
- 2) Transmission Company (natural monopoly).
- 3) Distribution Company (natural monopoly).
- 4) Retailer (for LV customers with tariff set by Regulator).
- 5) Agent (for MV and HV customers).
- 6) Market Operator (independent).
- 7) System Operator (independent).

The Phase I Single-Buyer Industry Structure is shown in figure 2.4 while the Phase II Multi-Buyer/Multi-Seller Model is illustrated in figure 2.5.

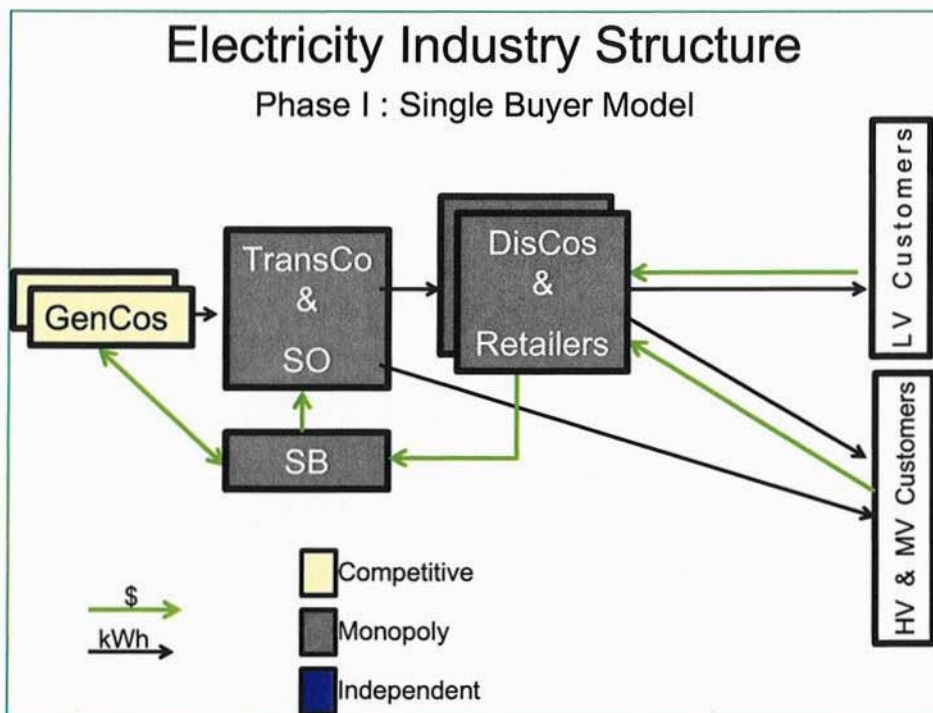


Figure 2.4: Phase I Single-Buyer Model for Indonesia

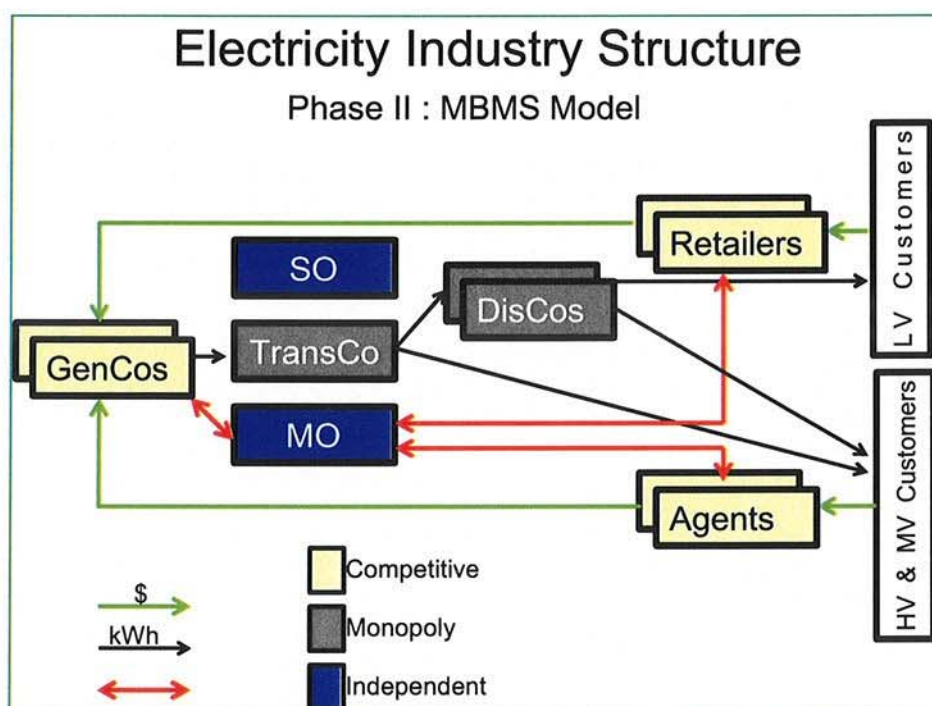


Figure 2.5: Phase II Multiple-Buyer/Seller Model for Indonesia

2.5 The Philippines

2.5.1 Among the ASEAN countries, The Philippines has made tremendous progress in implementing industry reform. Following the Industry Reform Act of 2002, a new electricity industry structure has been established having the following characteristics:

- 1) Separation of generation and transmission
- 2) Comprises of regulated and competitive areas
- 3) Competitive generation dispatch
- 4) Establishment of National Transmission Corporation a natural monopoly in transmission, owner and operator of the transmission system.
- 5) Establishment of the regulating body, ERC (Electricity Regulatory Commission)

The industry structure is illustrated in figure 2.6.

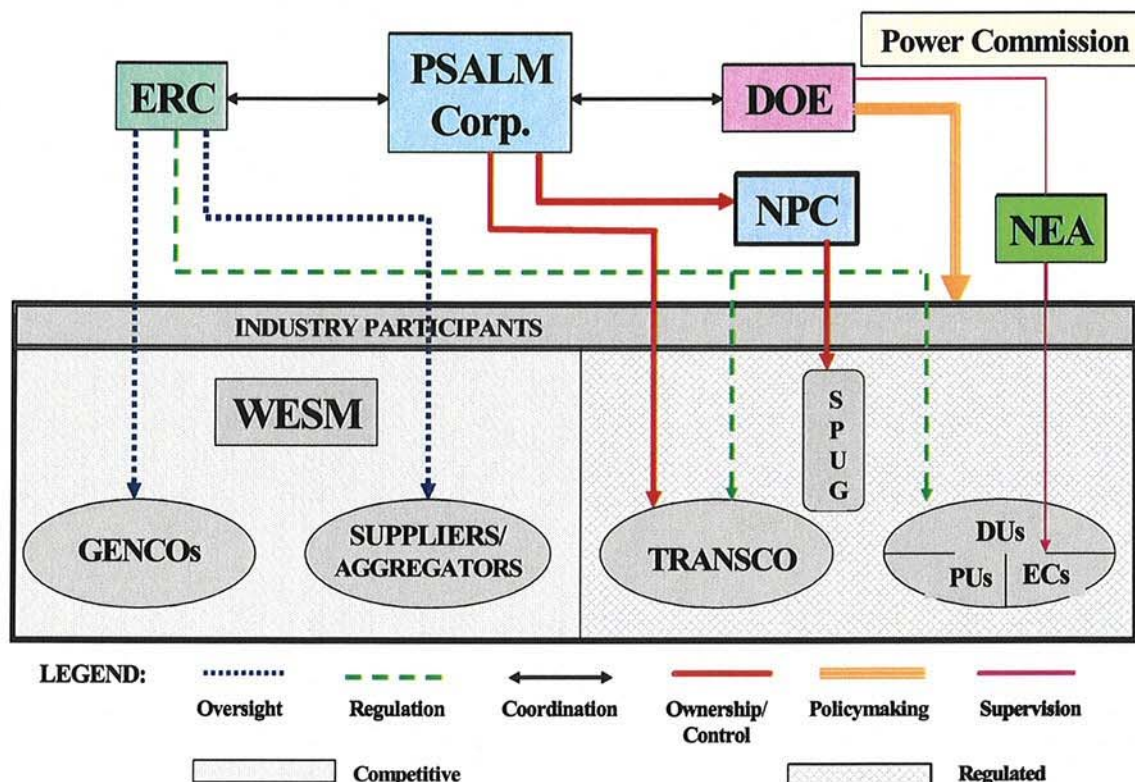


Figure 2.6 Industry structure in The Philippines

2.5.2 As shown in figure 2.6, the various players in the industry can be placed under any of the three areas:

- 1) Policy making/Regulatory
- 2) Competitive
- 3) Regulated

National Power Corporation (NPC) who prior to this owned both generation and transmission has been separated into several generators and one transmission entity, Transco. Generation and transmission companies belong to PSALM (Power Sector Asset Liability Management Corporation), a government corporation. The Wholesale Electricity Spot Market (WESM) is currently being established for wholesale trading purposes. The establishment of the structure in figure 2.6 including overseeing behavior of the players is undertaken by the Energy Commissioner.

2.5.3 A Grid Code has also been established from provisions of the Imperial Law. This document contains transmission planning and operating criteria as well as planning and operating procedure including procedure for generation impact studies. It is important to note that the Transco is regulated-monopoly that assume central roles in assisting the DOE (Department of Energy) and the ERC in ensuring critical national policies are implemented.

2.6 Singapore

2.6.1 Among the ASEAN countries Singapore is considered to have advanced its electricity industry reform closer to having total competition in both wholesale and retail business. The present day industry structure in Singapore is as illustrated in figure 2.7 with Energy Market Authority (EMA) of Singapore overseeing both the commercial and technical aspects of the industry.

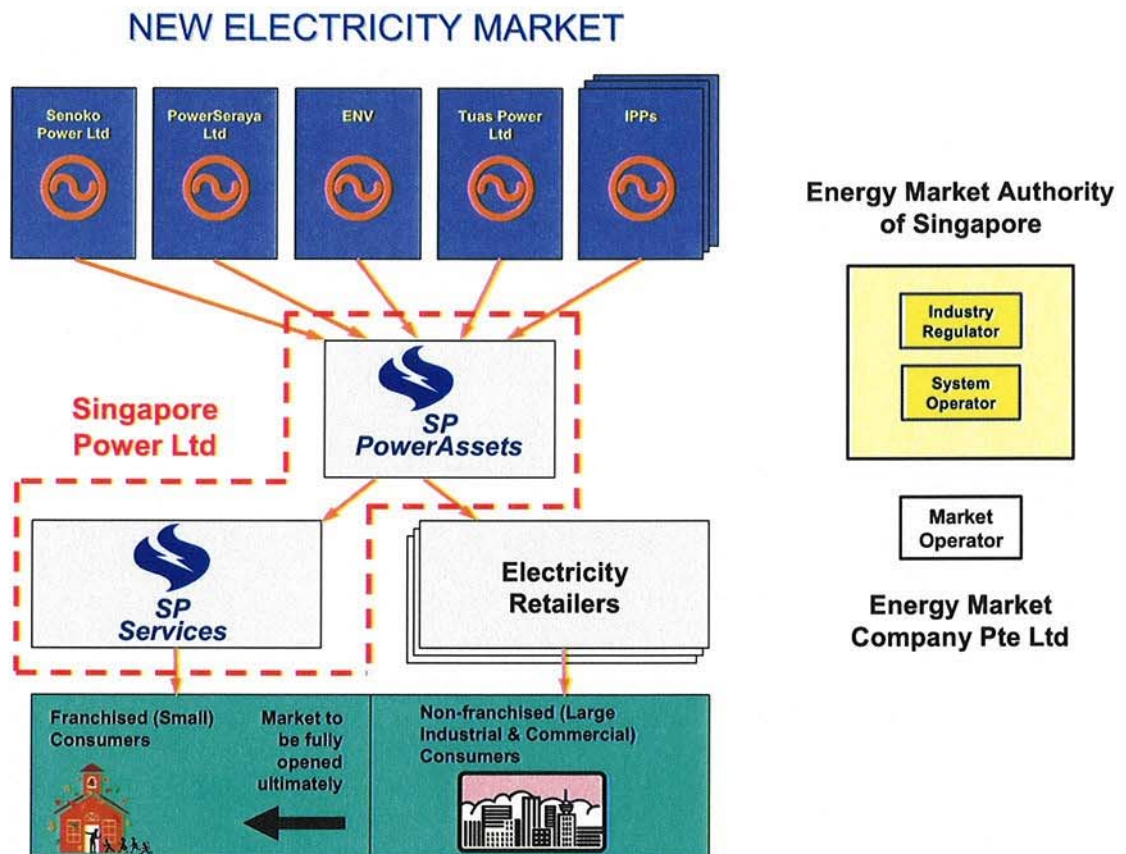


Figure 2.7: Industry structure in Singapore

2.6.2 Timeline for industry restructuring in Singapore is as shown in figure 2.8. By 2007 full competition in retail sector would be implemented. Currently, in the wholesale sector there are 7 players and for retail 6 licensees. The transmission network is owned by SP PowerAssets and managed by SP PowerGrid. The network is operated and controlled by the 'system operation' arm of the Energy Market Authority (EMA).

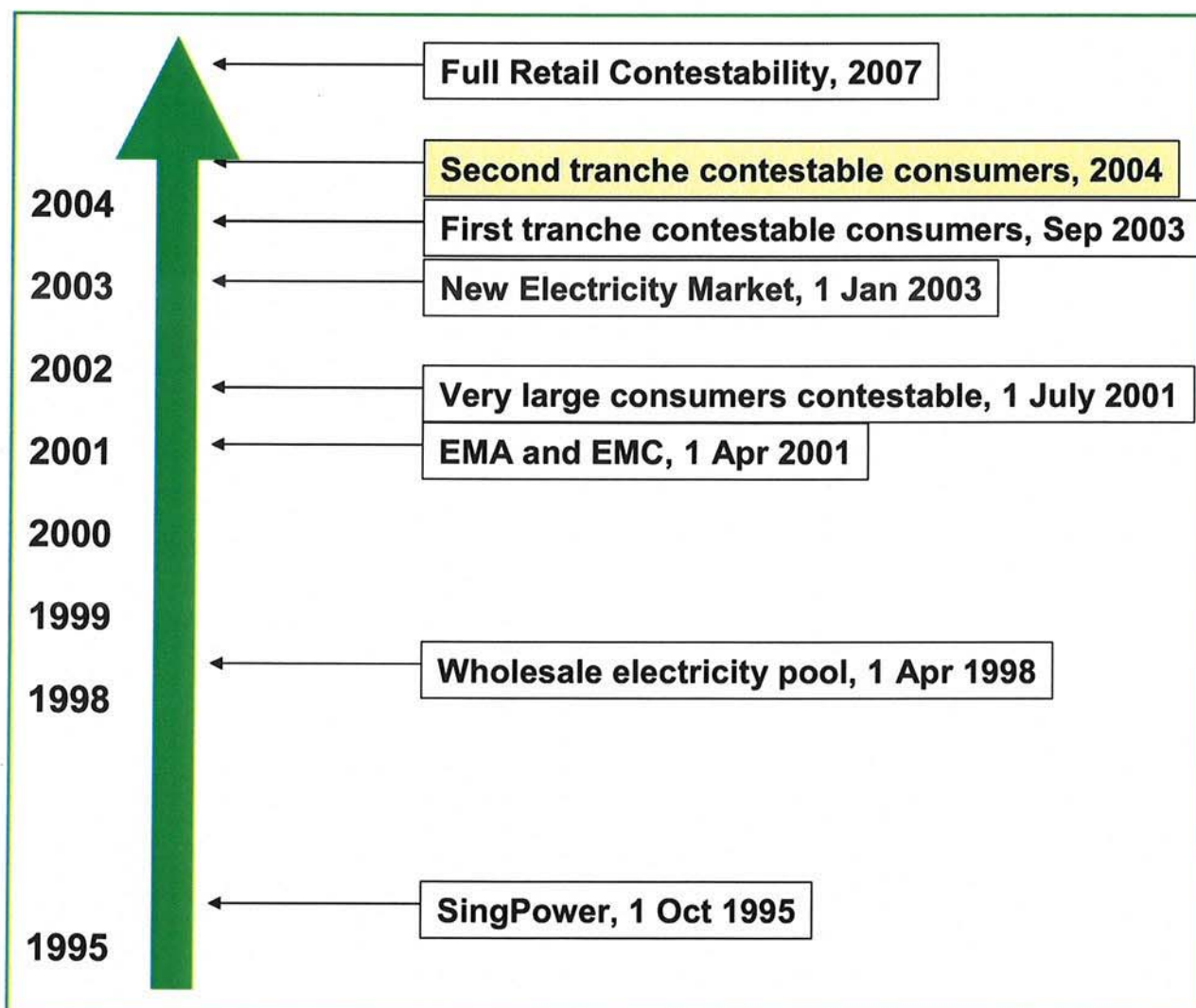


Figure 2.8: Timeline for Restructuring in Singapore

2.7 Thailand

2.7.1 The current industry structure in Thailand is shown in figure 2.9. Generation business is carried out three major players:

1. EGAT Power Plants;
2. Independent Power Producers; and
3. Small Power Plants (SPP).

The whole transmission network in Thailand is owned and operated EGAT (Electricity Generating Authority of Thailand) whose main functions are:

- 1) Power Purchase - single-buyers
- 2) System operation
- 3) Transmission asset owner and developer
- 4) Supply electricity in bulk to Distribution companies and large customers

2.7.2 Distribution business in Thailand is carried out by two companies, MEA (Metropolitan Electricity Authority) focuses in Greater Bangkok Area and PEA (Provincial Electricity Authority) supply the rest of the customers in the provinces. The industry is regulated by EPPO (Electric Power Policy Office).

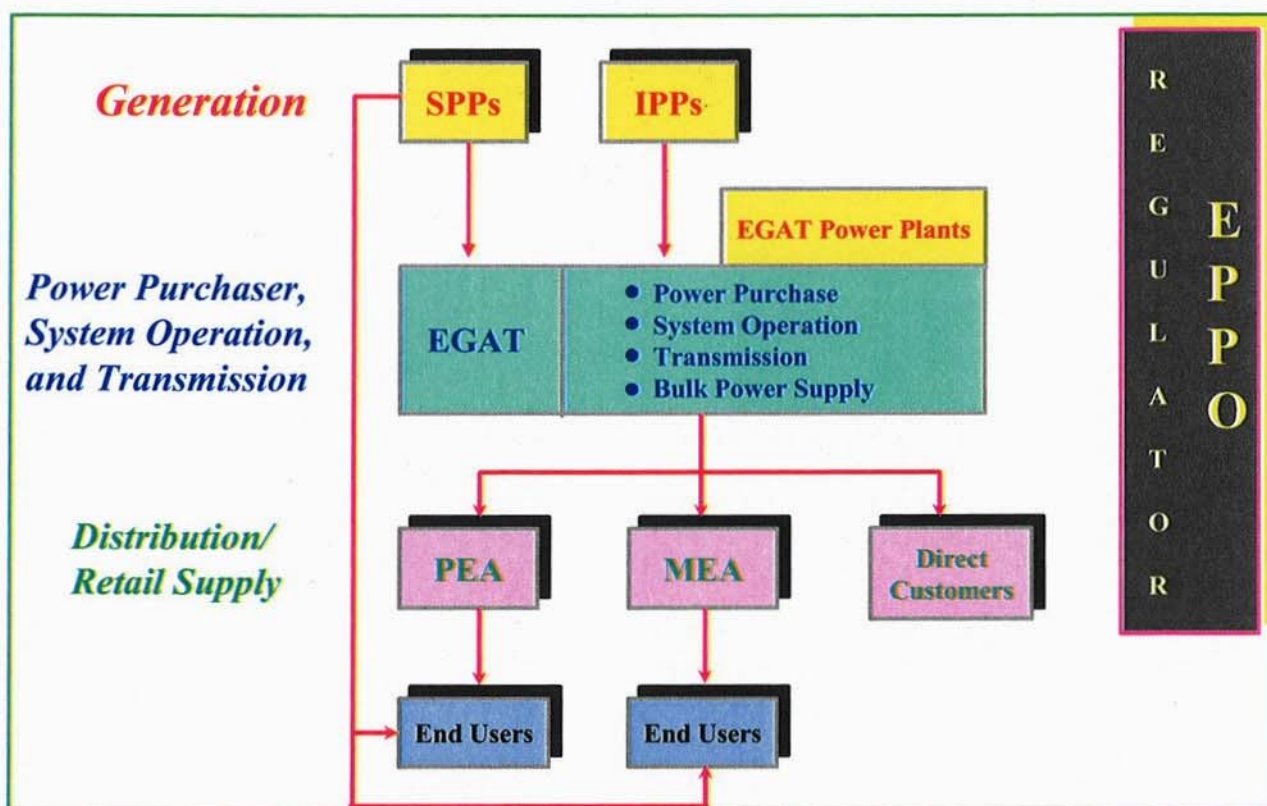


Figure 2.9: Current electricity Industry Structure in Thailand

2.7.3 The Ministry of Energy of Thailand has planned for the industry to be restructured further into a so called 'Enhanced Single-Buyer Model' as shown in figure 2.10. Under this proposed system, the main features include:

- EGAT Transmission that owns the transmission asset will be the single-buyer and system operator.
- EGAT Transmission and Generation would be account unbundled. In other words separated into two different business units,.
- MEA and PEA will continue to be monopoly and regulated.

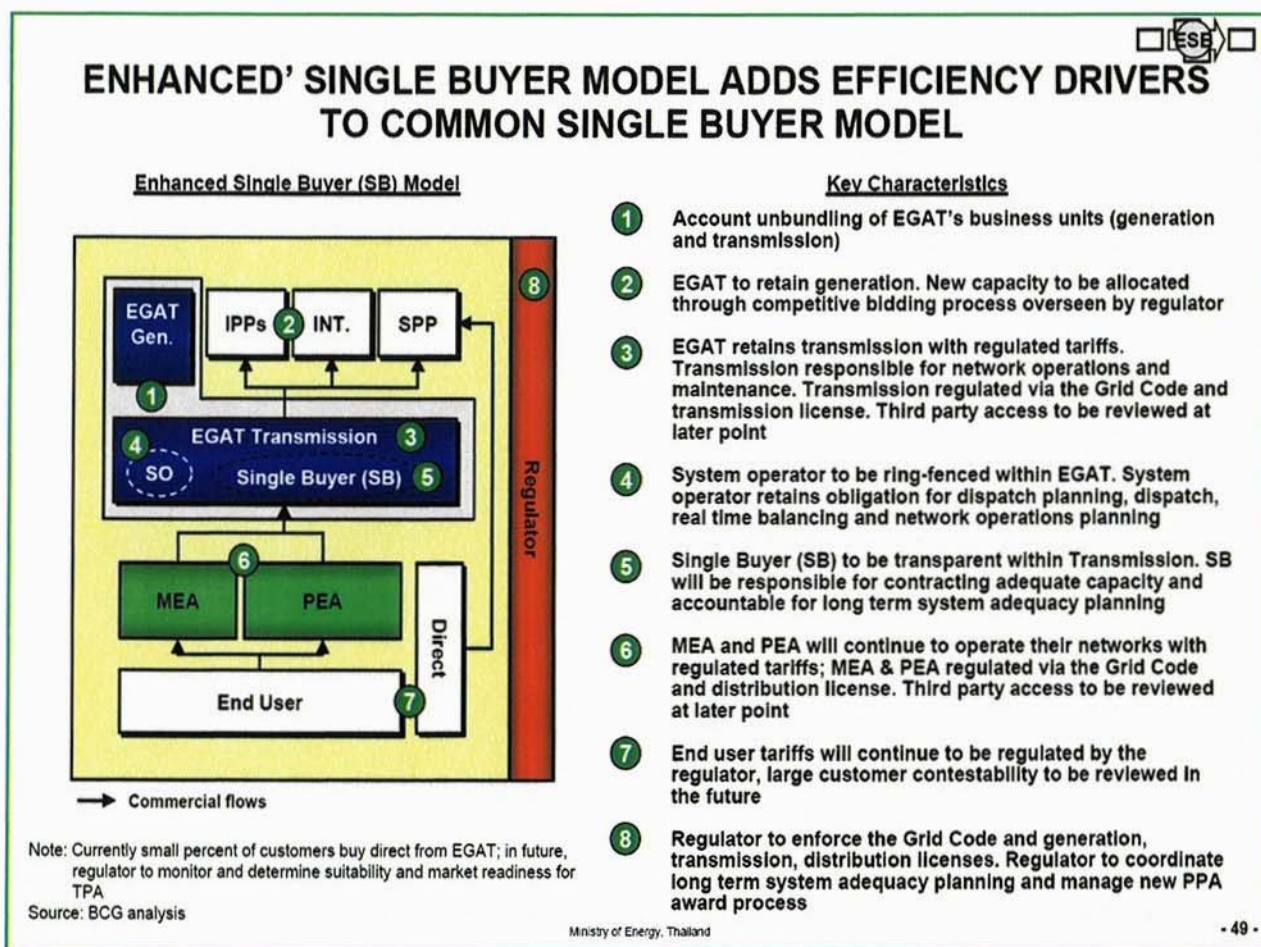


Figure 2.10: Proposed restructuring of Thailand's power industry

2.8 Lao PDR

2.8.1 Lao PDR like Cambodia is also a new member of ASEAN and has one of the lowest electrification rates in the region. Most of the poor live in rural areas and depend on agriculture for their livelihoods. Therefore, rural development particularly electrification is critical to reducing poverty level. Electricity supply industry in Lao PDR is dominated by e: Electricité Du Laos (EdL), that was established in 1959. EdL is structured in accordance with the law on business as company incorporated in Lao PDR. The company is registered as a state Owned Enterprise and is wholly owned by the Government of Lao PDR ("GOL").

2.8.2 EdL is responsible for generation, transmission and distribution in the major grids in Lao PDR. It owns and operates the country's main generation, transmission and distribution assets, and manages cross border electricity exchanges involving its generating plant and grids. It is a state-owned corporation under the Minister for Industry and Handicrafts. EdL has its own board of directors. The industry structure dominated by EdL is illustrated in figure 2.11 showing also cross-border trading with neighbouring country utilities.

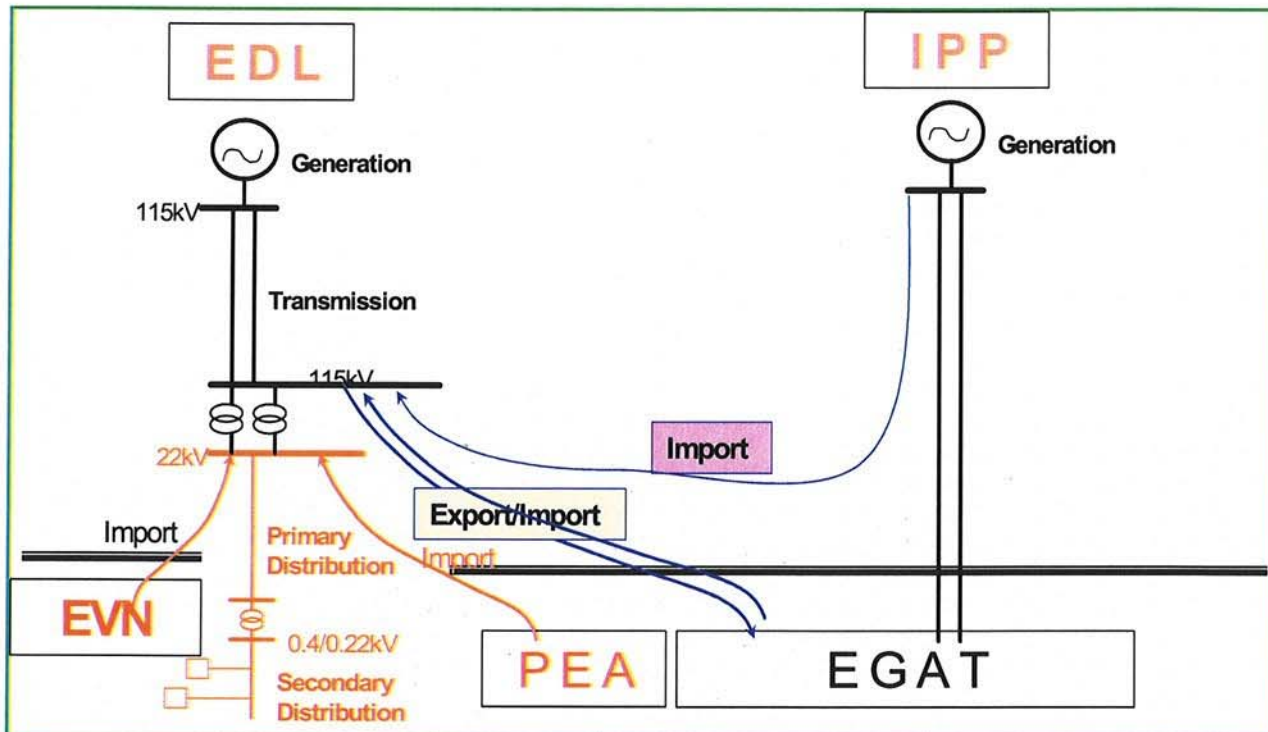


Figure 2.11: Electricity industry structure in Lao PDR

2.8.3 It is expected the future industry structure for the country would be dictated by the principle objective of electrification and export of power to neighbouring countries and this is as shown in figure 2.12. EdL has recently established their own technical standards. However, regulations or codes for electric facilities have not been established in Lao PDR

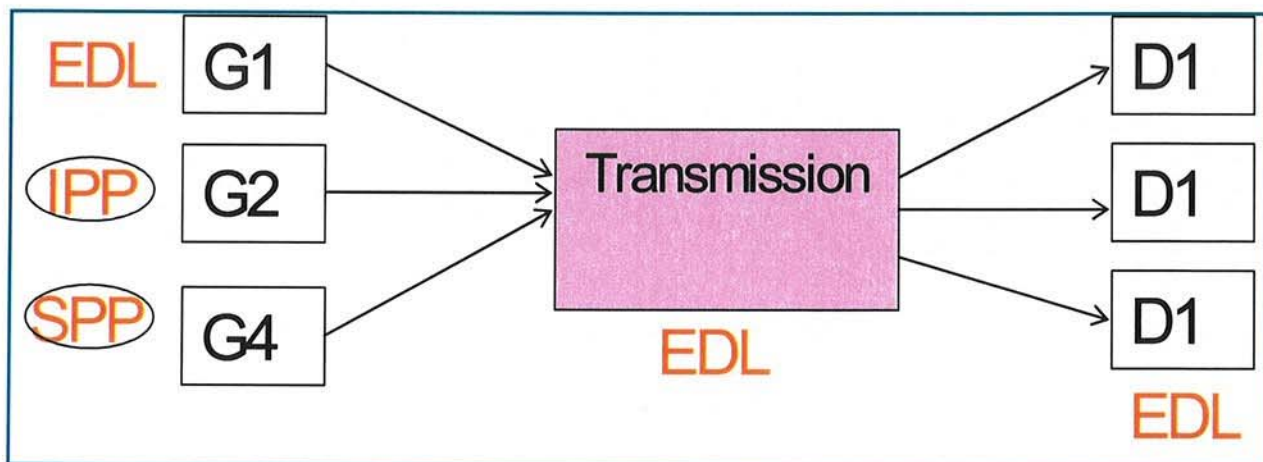


Figure 2.12: Future industry structure for Lao PDR

2.9 Vietnam

2.9.1 Current electricity supply industry in Vietnam is dominated by EVN (Electricity of Vietnam). EVN is a vertically integrated utility with small proportion (less than 10%) of IPP involved in generation. On the distribution side, there exist IPDs (Independent Power Distributors) owning low voltage network in rural areas. The transmission network is owned and operated by EVN. The present organization of the industry in Vietnam is shown in figure 2.13.

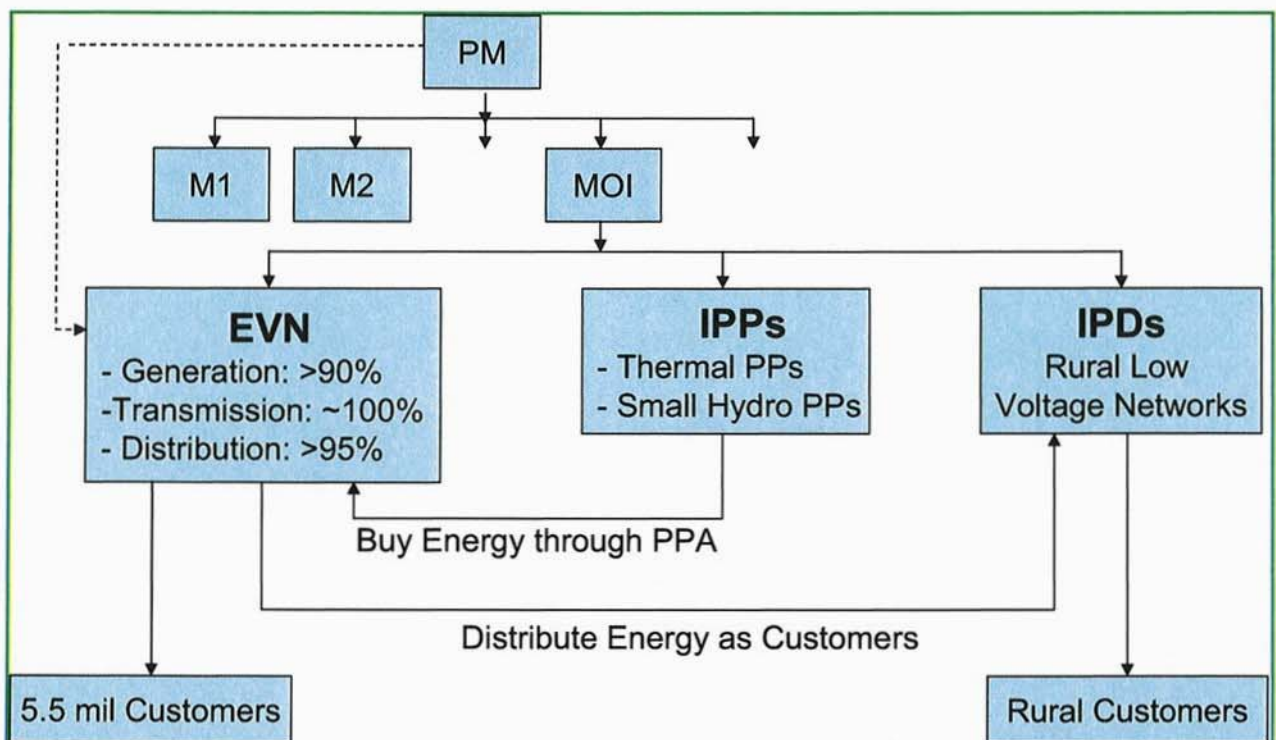


Figure 2.13: Current electricity industry structure in Vietnam

2.9.2 EVN itself is a large organization comprising of many companies to efficiently distribute electricity in this elongated country facing South China Sea to the East and mostly highlands to the West. The rapid growth in demand (12% - 15% annually) has exerted strain on capital resources of EVN and the country and therefore there is significant initiative to further encourage private generation. EVN is currently buying power from 34 IPPs and BOTs with total capacity of about 1400 MW. As part of GMS (Greater Mekong Subregion) plan, regional interconnections will become important options and power tariff and market are expected to be more competitive. It has also become necessary to restructure power sector to catch up with the changing situation in exchange process and cooperation in generation, transmission and distribution and encourage private capital investment.

2.9.3 It is expected that a competitive bidding mechanism in generation will be implemented in year 2004. The objectives of this scheme are:

- To Create an open, transparent and competitive environment in generation
- To Give incentives for investors to participate in generation development.

Power plants would be selected through a competitive bidding process measured in terms of lowest price of electricity delivered and each will sign PPAs with EVN. EVN is the single buyer.

2.9.4 The near future plan to restructure the industry is to achieve "Limited Competitive (Wholesale) Electricity Market" as shown in figure 2.14 and later to achieve "Fully Competitive (Retail) Electricity Market" as shown in figure 2.15.

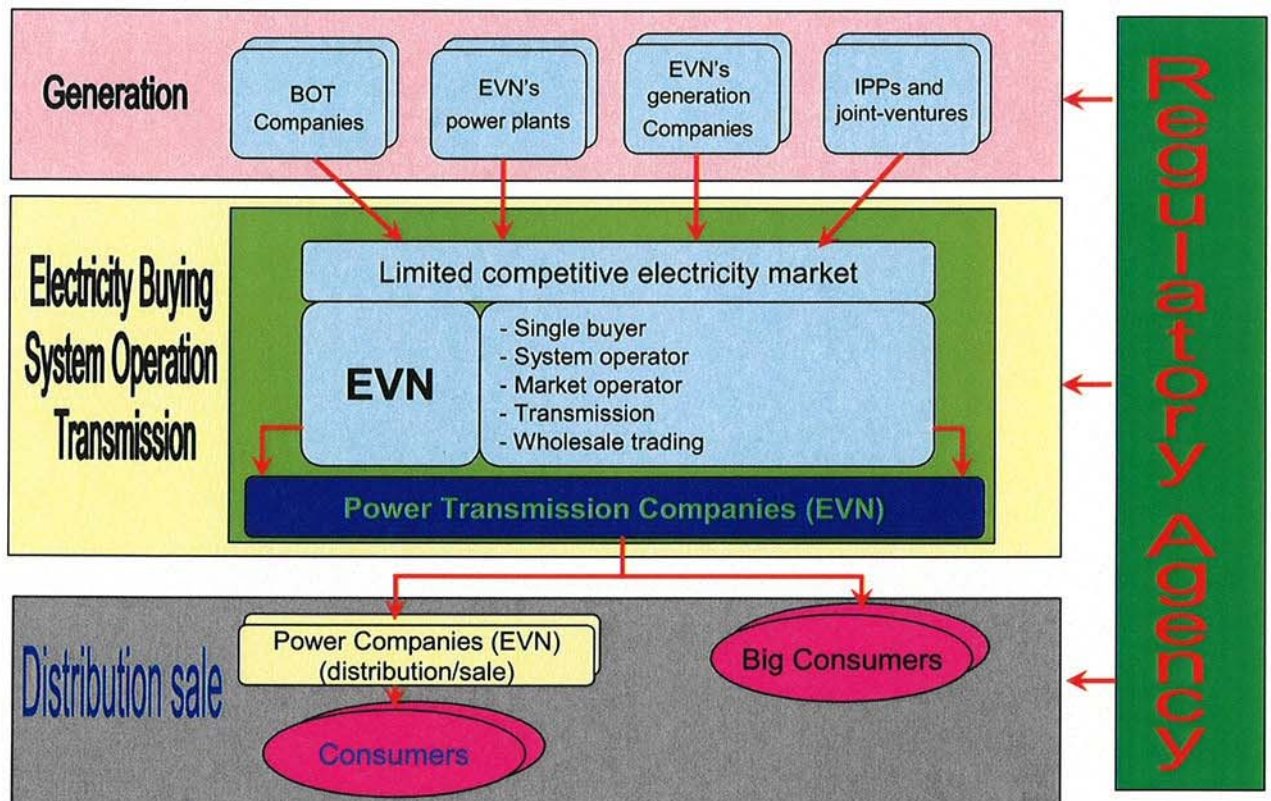


Figure 2.14: Limited Competitive (Wholesale) Electricity Market for Vietnam

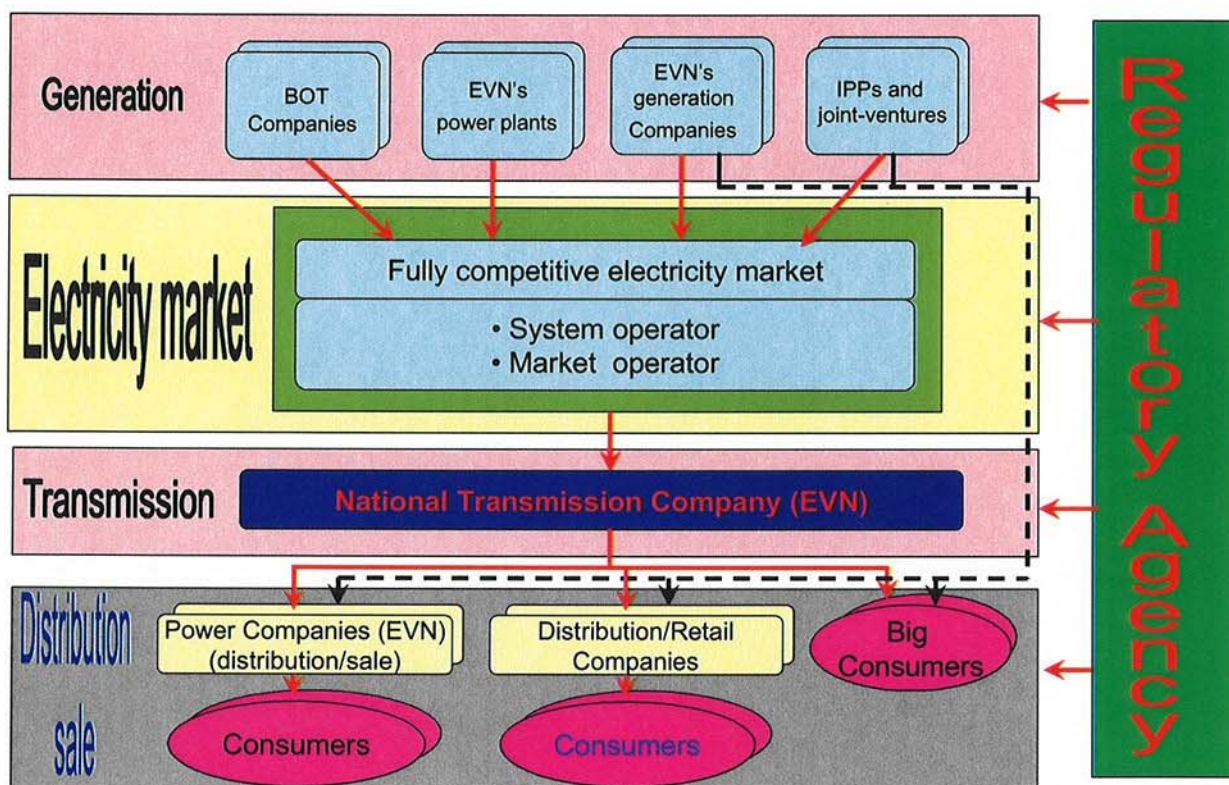


Figure 2.15: Fully Competitive (Retail) Electricity Market for Vietnam

2.10 Malaysia (Peninsular)

2.10.1 The current industry structure in Peninsular Malaysia is shown in figure 2.16 with two major players:

1. TNB (Tenaga Nasional Berhad)
2. IPPs (Independent Power Producers)

There are several IPPs each having a PPA with TNB. TNB is the vertically integrated utility owning some generating plants, the transmission and distribution. The regulator is the Energy Commission that issues licenses for the various business sectors.

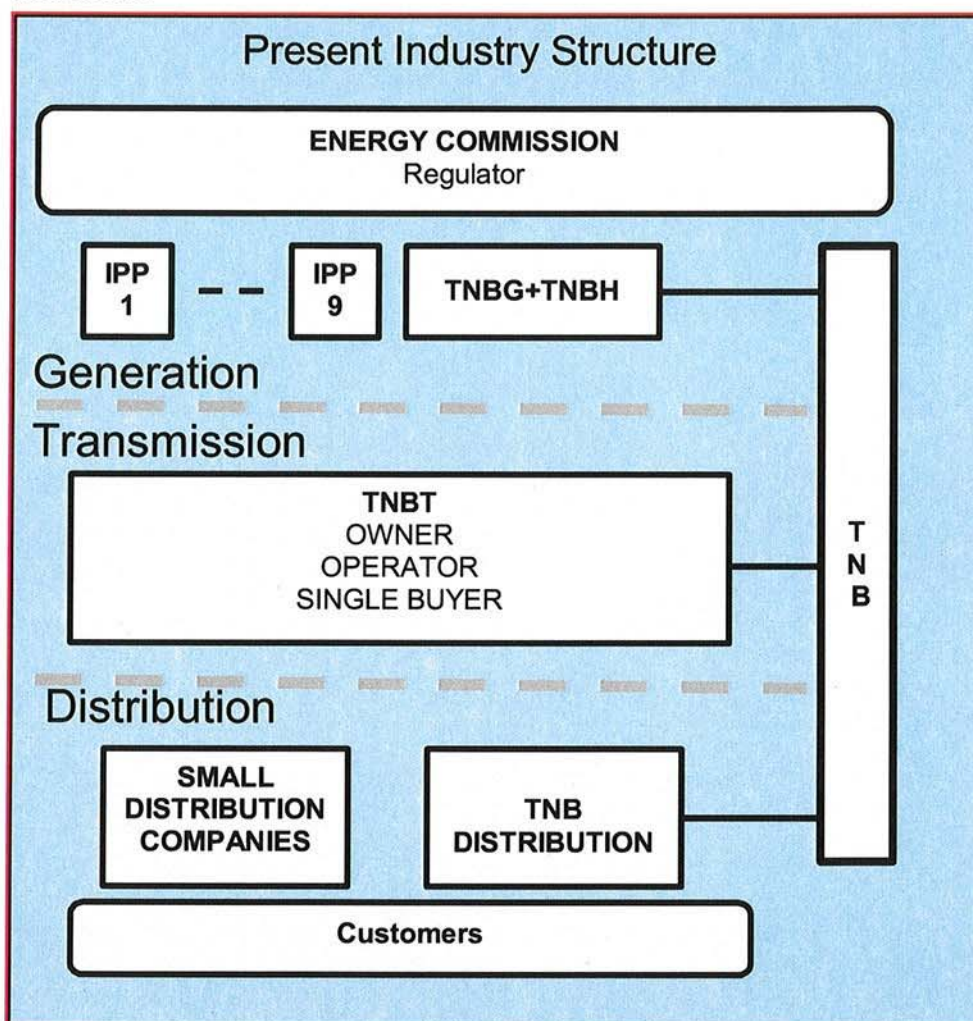


Figure 2.16: Electricity Industry Structure in Peninsular Malaysia

2.10.2 Although in early 2000 there was moves by TNB reorganize itself into business units (taking steps to unbundled), the situation has been reversed since 2003 and now TNB remains a single vertically integrated utility. It is also not known as to the direction of reform of the power industry. The next round of industry structure review is in year 2007.

2.10.3 There is already a Grid Code established since 1994. This Code is currently maintained by the Regulator.

2.11 Summary of Current Electricity Industry Structure

- 2.11.1 **Singapore** is most advanced in ESI reform and restructuring. The city state is well known for efficiency and business innovations. Therefore, it is not surprising that the republic has planned the industry reform meticulously and within less than 10 years it has reached a stage where full wholesale competition has been achieved and steps towards full retail competition is evolving and currently benefiting many large customers.
- 2.11.2 **Indonesia** has mandated electricity industry reform in the country's Law No. 20. It is important to note that Indonesia has diversified population, incomes and economic activities. The population is spread over many small and large islands spanning from East in Irian Jaya to the Northeast in Aceh. There are many isolated power systems and large proportion of the population are yet to benefit grid connected electricity supply. Law No. 20 mandated that at least one of the power systems - most likely Java-Bali Interconnected network - must achieve wholesale and retail competition in stages. Through current interpretation of the law, the plan is to immediately restructure Java-Bali system into various private generators or generators operating on IPP basis and current regional distributors with a Transmission Owner/Operator coordinating the various players. For the future, Law No. 20 is interpreted that the transmission network has to be operated by an independent entity. It is planned that by year 2007 retail competition would be achieved for selected number of customers.
- 2.11.3 **The Philippines** has made significant progress to gain efficiency through industry reform while many other ASEAN countries are still discussing their restructuring plans. A transmission owner/operator, that is, National Transmission Corporation (Transco) has been established whose responsibilities include to operate the transmission network and to coordinate the players through the provisions of the Grid Codes. The Transco also plays an important role to ensure that the grid is planned optimally including to suggest next locations of generators.
- 2.11.4 **Cambodia and Lao PDR** have the lowest electrification rate among the ASEAN countries. Therefore, for both countries two main objectives are rural electrification and grid expansion for accessibility to the population. **Cambodian** large electricity grids in the south and northeast are managed by the state-owned utility EdC who is organized as vertically integrated utility. Cambodia has also to coordinate and regulate more than 20 isolated power systems operated by independent enterprises. Therefore, the task of the government to electrify the country requires the industry structure to be

organized in somewhat complex form in order to effectively coordinate the many players. Lao PDR power industry is dominated by two players; the vertically integrated utility EdL and IPPs present and future that directly export power to the neighbouring countries. While EdL is organized to focus on domestic electrification the IPPs are developing large hydro sites for power export. EdL has a task to also exploit the development of the IPPs for domestic supplies and establishing Lao PDR Transmission Grid.

- 2.11.5 Brunei Darussalam electricity industry is dominated by the state-department DES (Department of Electricity Supply). Electricity industry is an important national activity for operating the oil and gas business of the country and therefore keeping the status quo with close government control and monitoring is the main objective. However, some initiatives have been introduced to create sense of competition to the DES.
- 2.11.6 Thailand has traditionally been dividing the responsibility to operate the electricity industry to three major government authorities namely EGAT (Electricity Generating Authority of Thailand, PEA (Provincial Electricity Authority of Thailand and MEA (Metropolitan Electricity Authority of Thailand). The planned reform would see that generating plants in EGAT to operate on commercial basis like other IPPs (Account unbundling) and EGAT Transmission to be the sole network owner/operator with a single-buyer within it. MEA and PEA will continue with the status quo and remain monopoly and regulated.
- 2.11.7 Vietnam has been experiencing double digit annual electricity growth rate even during the economic crisis of the late 1990's and this has exerted strain on financial resources to expand generation. Therefore, the generation sector has been opened to IPPs and this has initiated restructuring plan that will see more private sector participation. Vietnam has planned to evolve from current vertically integrated structure to that allowing for wholesale competition and to be followed by retail.
- 2.11.8 Malaysia started early in ESI reform through introduction of "competition" in the generation sector. The main utility in Peninsular Malaysia was initially (2000) reforming itself through unbundling initiatives by creating separate business units, but recently (2002/2003) the company has reverted back into vertically integrated structure. There is also no clear direction to ESI reform apart from the plan to review the structure in year 2007.

Chapter 3: Load/Energy and Sales Forecasting

3.1 Introduction

3.1.1 Load/energy and sales forecasting is the beginning of the planning cycle. The technical approach and methods to forecasting in each country has remained more or less the same while there were changes in industry structures. However, the changes in industry structures in some countries have resulted in shifting of responsibilities for establishing electricity forecasts. At the same time, there is a need for greater coordination among the various players and government departments.

3.1.2 The objective of this chapter is to provide overview of the long-term forecasting approaches and methods adopted by the participating utilities. Approaches and methods to forecasting vary considerably depending on the size of the each power system, objectives as well as industry structure.

3.2 Brunei Darussalam

3.2.1 The DES is responsible to carry out the national electricity forecast for Brunei. The method employed by DES comprises of:

1. Trend analysis; and
2. Complementing it with expected loads to be connected.

The trend analysis takes into consideration national GDP growth as established by Brunei Development Board who would also have records of future investments in the country. The forecast established by DES will be submitted to a National Committee of Forecast.

Table 3.1: Load growth trend for Brunei

YEAR	No	DES Network		BPC Network	Total Brunei	Growth Rate %
		Lumut Gadong	Belingus	MW	MW	
1990	1	178.00	2.00	0.00	180.00	
1991	2	194.00	2.10	0.00	196.10	8.94
1992	3	209.00	2.40	12.50	223.90	14.18
1993	4	228.00	2.40	16.20	246.60	10.14
1994	5	240.00	2.50	35.90	278.40	12.90
1995	6	244.00	3.30	62.80	310.10	11.39
1996	7	262.00	2.90	80.70	345.60	11.45
1997	8	245.20	3.30	136.70	385.20	11.46
1998	9	252.10	3.50	154.50	410.10	6.46
1999	10	233.30	3.40	145.20	381.90	-6.88
2000	11	237.30	3.90	157.28	398.48	4.34
2001	12	249.30	4.00	158.96	412.26	3.46
2002	13	246.90	4.40	174.59	425.89	3.31
2003	14	254.00	4.50	183.70	442.20	3.83

3.2.2 Table 3.1 shows load growth trend from Brunei between 1990 and 2003. Like most ASEAN countries, Brunei enjoyed strong growth in the 1990's and then significantly affected by the economic crisis of 1997. The current trend is sustained growth of between 3% and 4%. To plan for the industry's development DES has established a forecast with slightly higher growth rate of 5% as reference indicated in figure 3.1.

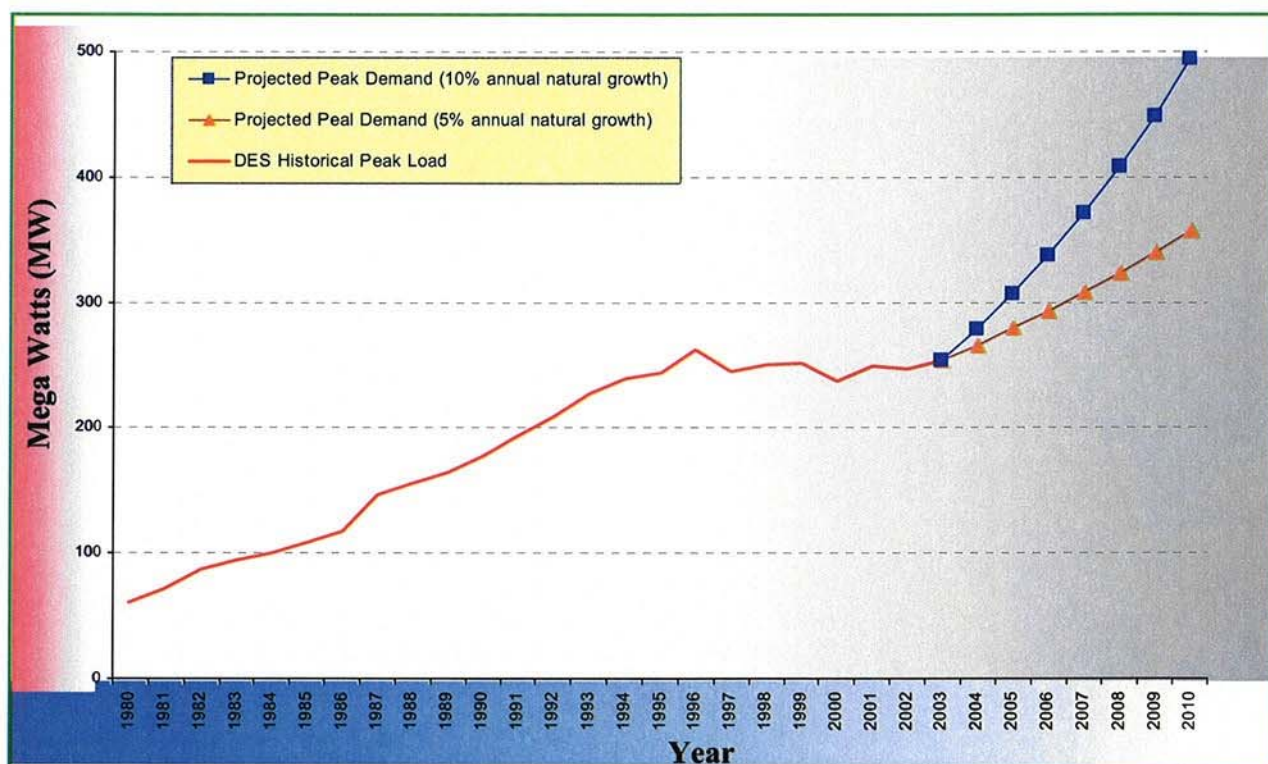


Figure 3.1: DES supply and demand outlook (2003 - 2010)

3.3 Cambodia

3.3.1 Energy and demand forecast for Cambodia is carried out by the Ministry of Industry, Mine and Electricity (MIME) with the assistance of experts from EdC. The method employed include:

1. Trend analysis
2. Rural electrification target
3. Loss reduction target
4. Known load to be connected (in the early years)

Trend for demand in Cambodia (represented by two EdC regions of the South and Northwest) between 1999 and 2003 is shown in figure 3.2. As indicated in figure 3.2 Cambodia has been enjoying double-digit electricity growth rate and this trend is expected to continue.



Figure 3.2: Load growth trend for EdC

3.3.2 It is expected that Cambodia will enjoy and double-digit growth rate of between 12% to 15% and this is expected to put strain on the country's financial capability to expand generation as indicated in figure 3.3.

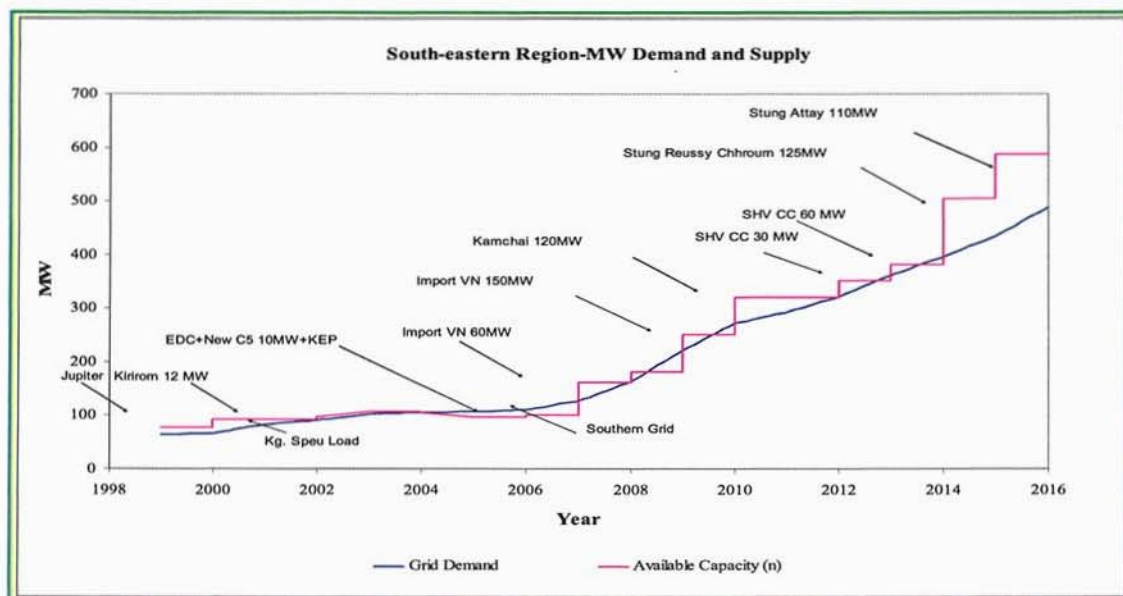


Figure 3.3: Load demand forecast and generation expansion for EdC

3.4 Indonesia

3.4.1 Based on past experience, the following factors have significant influence on electricity energy and demand growth in Indonesia:

1. Economic Growth (GDP growth by regional and sector).
2. Electrification program
3. Captive power (self generation) take over.

Power sector restructuring initiatives have shifted focus to forecasting of sales thus putting emphasis on effort to electrification and taking over of captive power. Currently, Indonesia is 63% electrified and there are many captive power installations scattered throughout the country. Therefore, electricity tariff (by sector) is becoming major factors that influence the load growth.

3.4.2 Load and energy forecast method employed by PLN of Indonesia are summarized as follows:

1. Use of regression analysis with economic factors as inputs for two main sectors.
2. For Manufacturing Industry, Commercial and Public Sectors:
Sales forecast for the sector = f(GDP of the sector, Electricity Tariff for the sector)
3. For Residential Sector:
Number of customer = f(electrification ratio)
Sales forecast for a residential sector = f(Electricity consumption/customer, Tariff for household, Number of customer)

Based on the method employed, PLN has database for consumption pattern for different categories of customers. The government provides the electrification programme target to be achieved by the industry.

3.4.3 Table 3.2 shows the results of load/energy forecast for Java-Madura-Bali (JAMALI) interconnected power systems up to year 2013. Indonesia is expected to enjoy annual growth rate of about 6% in the long term.

Table 3.2: Load/Energy Forecast for Java-Madura-Bali Interconnected System

POWER BALANCE OF JAMALI SYSTEM 2004-2013											
										SCENARIO-1	
ITEM		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Install Capacity	(MW)	18608	19466	20046	22316	22856	23831	25251	26451	28151	29851
Retired	(MW)				300						
Additional Capacity	(MW)	858	580	2270	840	975	1420	1200	1700	1700	1600
Total Installed Capacity	(MW)	19466	20046	22316	22856	23831	25251	26451	28151	29851	31451
Seasonal Variation	(MW)	685	685	685	685	685	685	685	820	955	955
Forced Outage	(MW)	897	928	1048	1077	1129	1204	1267	1331	1395	1479
Derating	(MW)	339	350	396	406	426	454	478	502	526	558
Maintenance	(MW)	1804	1858	2069	2119	2209	2341	2452	2610	2767	2915
LSC	(MW)	15741	16225	18118	18569	19382	20567	21568	22888	24208	25543
Peak Load	(MW)	14522	15386	16275	17165	18226	19344	20539	21798	23141	24557
Growth Peak Load	%	2.4	5.9	5.8	5.5	6.2	6.1	6.2	6.1	6.2	6.1
Spinning Reserve	(MW)	1219	839	1843	1404	1157	1223	1030	1090	1067	986
Reserve Margin	%	34	30	37	33	31	31	29	29	29	28
Load Factor	%	72	72	72	72	72	72	72	72	72	72
Production	(GWh)	91592	97040	102652	108261	114953	122009	129542	137482	145954	154883
Growth Production	%	2.4	5.9	5.8	5.5	6.2	6.1	6.2	6.1	6.2	6.1

3.5 The Philippines

3.4.1 Load and energy forecast including generation expansion plan for The Philippines are established carried out by the department of Energy (DOE) with inputs from various industry players including the MERALCO, and provincial/municipal electric utilities.

3.6 Singapore

3.6.1 Singapore currently has full competition in the wholesale market. While EMA (Energy Market Authority) is responsible to forecast demand and energy for the republic, SP PowerGrid provides inputs to EMA by also carrying out detailed forecasts that includes:

1. Area load forecast using customer database;
2. Use land-usage forecast coordinated with HDB (Housing Development Board);
3. Close coordination other developers such as JTC, EDB and major investors (see figure 3.4 for full list of development authorities);
4. Regular coordination meetings; and
5. Reconciliation of forecast with overall EMA forecast.

- | | |
|--|--|
| <ul style="list-style-type: none"> • Master Planner (URA) <ul style="list-style-type: none"> – Land Use – Land Sale – Sites for Substations – Cable Installation • Industrial Park Developers(JTC) <ul style="list-style-type: none"> – Industrial Development – Sites for Substations • Major Industrial Developers (EDB) <ul style="list-style-type: none"> – Supply requirement – Timely provision of supply | <ul style="list-style-type: none"> • Housing Development Authority (HDB) <ul style="list-style-type: none"> – Housing Development programme – Sites for Substations • Road Authority(LTA) <ul style="list-style-type: none"> – Road/ Bridge Construction/Extension – Cable Installation • Mass Rapid Transit Authority (LTA) <ul style="list-style-type: none"> – MRT Extension – Cable Installations |
|--|--|

Figure 3.4: List of development authorities involved in load forecasting led by SP PowerGrid

3.6.2 Demand growth and forecast for Singapore is shown in figure 3.5. The city-state has enjoyed steady growth of 5.2% up to year 2003 and expected to grow at slightly lower pace of 4.2% up to year 2013.

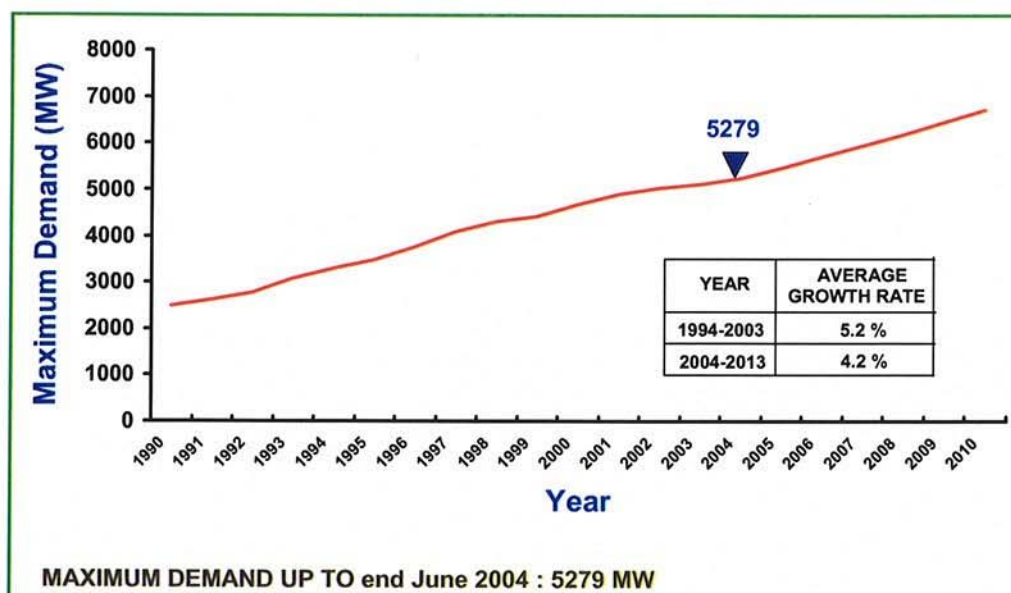


Figure 3.5: Demand forecast for Singapore up to year 2010

3.7 Thailand

3.7.1 Among the ASEAN utilities Thailand has the most comprehensive and sophisticated load and energy forecasting approaches and methods. The current basic structure of the industry as shown in figure 3.6 dictates the responsibility of each major industry players of EGAT, PEA and MEA. The forecasts are then submitted to Thailand Load Forecast Subcommittee (TLFS) for scrutiny and endorsement. The TLFS comprises of following members:

1. Representatives from public sector
2. Representatives from consumers
3. Representatives from EGAT, MEA, PEA
4. The Association of Private Power Producers

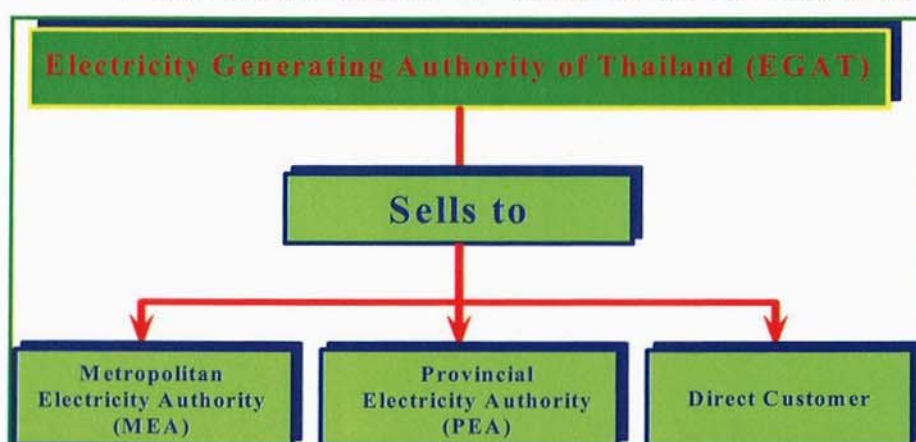


Figure 3.6: Responsibility of EGAT, PEA and MEA to forecast

3.7.2 The general framework for load and energy forecasting adopted for Thailand is shown in figure 3.7. The end-use models employed by PEA and MEA have database of customers energy use and demand being regularly updated. The energy forecast established is complemented several categories of customer load profile before demand forecast is calculated.

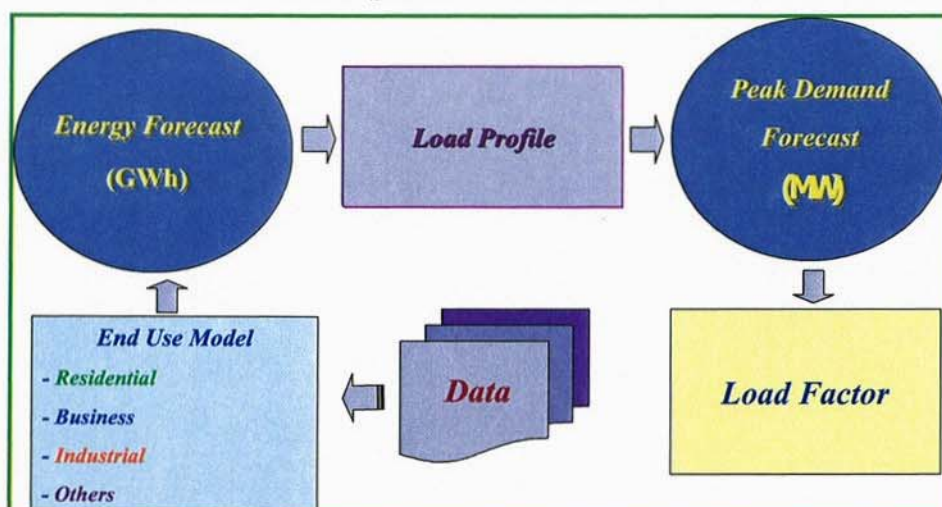


Figure 3.7: Framework of Load Forecasting in Thailand.

3.7.3 Energy forecasting process in Thailand is shown in figure 3.8. Using energy consumption database of four major categories of customers, total consumption is first calculated and distribution loss added before energy forecast of distribution areas are established. These forecasts are then placed at every substation level (in PEA and MEA) having connection to the transmission network of EGAT. EGAT then adds transmission losses to the energy forecast before arriving and the generation level forecast.

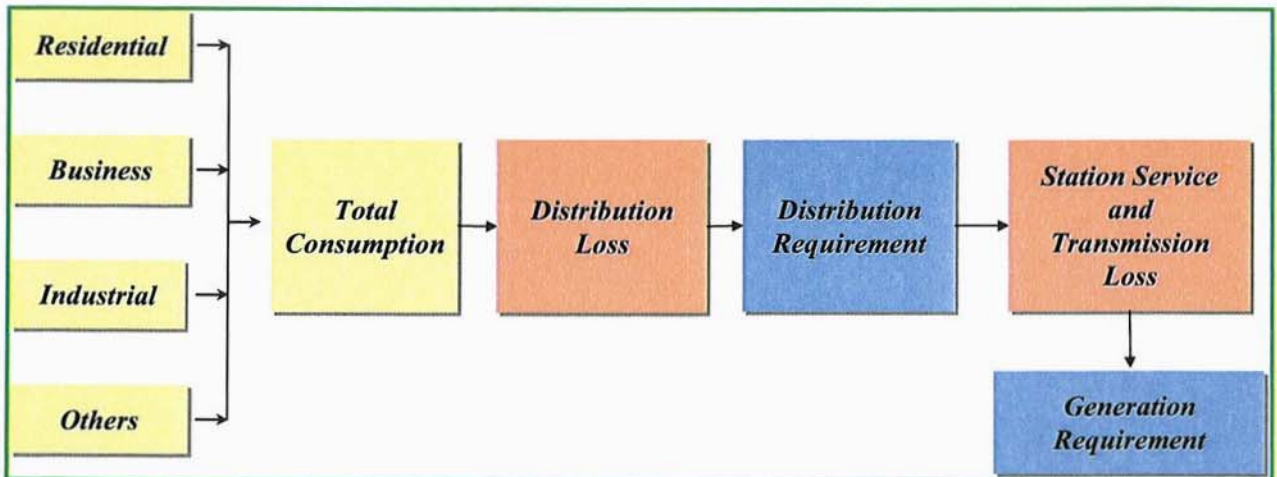


Figure 3.8: Energy forecasting process in Thailand

3.7.4 From the energy forecast, the peak demand is calculated using demand profile of various categories of customers as illustrated in figure 3.9. Load profile of different categories of customers are obtained from surveys carried once in 3 - 4 years.

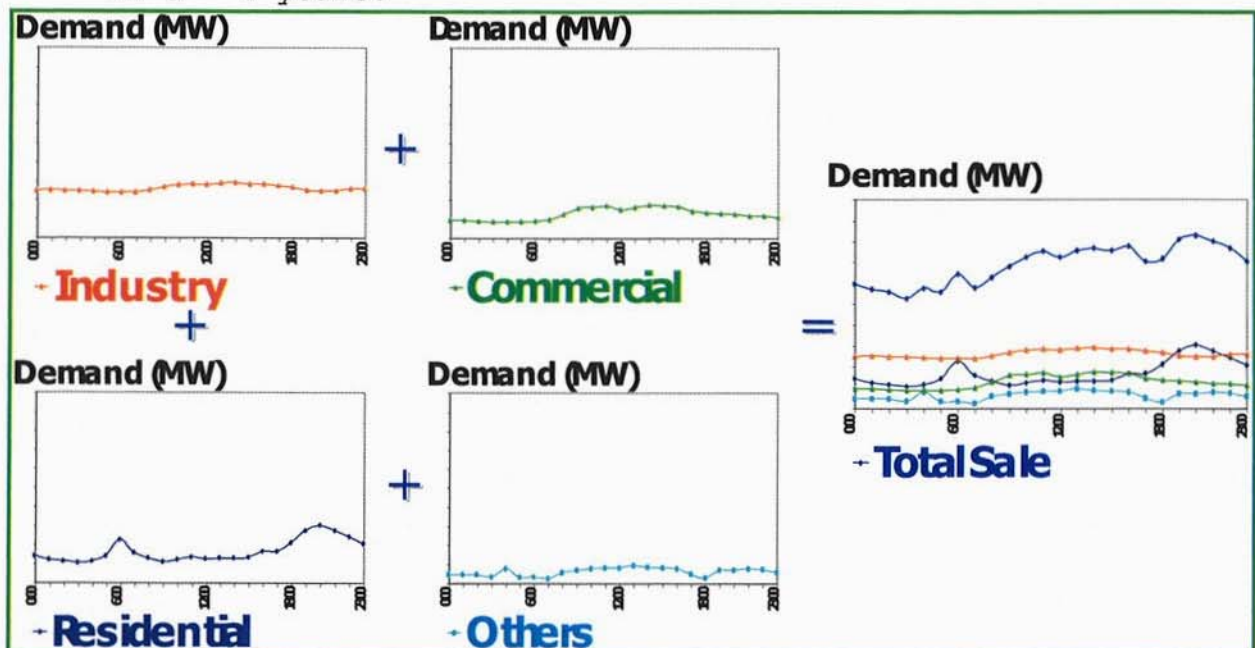


Figure 3.9: Forecast of demand profile

3.7.5 Table 3.3 shows the result of forecast for Thailand up to year 2015. Like Indonesia Thailand is expected to enjoy energy growth rate of more than 6% and Thailand will continue to have the largest electricity industry in ASEAN.

Table 3.3: Demand and Energy forecast for Thailand up to Year 2015

Case: Moderate Economic Growth							
Fiscal Year	Peak Demand			Energy Requirement			Load Factor %
	MW	Increase		GWh	Increase		
		MW	%		GWh	%	
Actual							
2541	14,179.9	-326.4	-2.25	92,134.4	-590.2	-0.64	74.2
2542	13,712.4	-467.5	-3.30	90,414.0	-1,720.5	-1.87	75.3
2543	14,918.3	1,205.9	8.79	96,780.7	6,366.7	7.04	74.1
2544	16,126.4	1,208.1	8.10	103,165.2	6,384.5	6.60	73.0
2545	16,681.1	554.7	3.44	108,389.2	5,224.0	5.06	74.2
2546 2003	18,121.4	1,440.3	8.63	116,738.0	8,348.8	7.70	73.5
Average Growth							
2535 - 2546	-	839.7	7.00	-	5,626.1	7.46	-
Forecast							
2547 2004	19,600	1,479	8.16	126,811	10,073	8.63	73.9
2548	21,143	1,543	7.87	136,784	9,973	7.86	73.9
2549	22,738	1,595	7.54	147,658	10,874	7.95	74.1
2550	24,344	1,606	7.06	158,212	10,554	7.15	74.2
2551	26,048	1,704	7.00	169,280	11,068	7.00	74.2
2552	27,852	1,804	6.93	180,942	11,662	6.89	74.2
2553 2010	29,808	1,956	7.02	193,530	12,588	6.96	74.1
2554	31,844	2,036	6.83	206,674	13,144	6.79	74.1
2555	33,945	2,101	6.60	220,253	13,579	6.57	74.1
2556	36,173	2,228	6.56	234,672	14,419	6.55	74.1
2557	38,515	2,342	6.47	249,843	15,171	6.46	74.1
2558 2015	40,978	2,463	6.39	265,788	15,945	6.38	74.0
Average Growth							
2547-2551	-	1,585.3	7.53	-	10,508.4	7.72	-
2552-2556	-	2,025.0	6.79	-	13,078.4	6.75	-
2557-2558	-	2,402.5	6.43	-	15,558.0	6.42	-

Thailand Load Forecast Subcommittee: 16 January 2004

Thailand Load Forecast Subcommittee: 16 January 2004

3.8 Lao PDR

3.8.1 Lao PDR has experienced overall elasticity figures between GDP growth and electricity demand ranging from 1.8 to 2.7. However, for forecasting purposes slightly lower figures of 1.5 and 1.2 are used for industrial and commercial sectors (see table 3.4). Load and energy forecasts are prepared by EdL for the whole country. For Lao PDR, GDP growth has positive effect on electricity demand. Additionally, power sector liberalisation – in this case private investment in generation – has enabled Lao PDR to earn foreign exchange. Currently there two 2 IPP projects are in operation namely:

1. Theun Hinboun HPP (1998); and
2. Houay Ho HPP (1999).

Both of them are exporting power to Thailand.

Table 3.4: Summary of load growth factors for Lao PDR

Period	Average Growth Rates		Relation Factor against GDP	Relation Factor (Applied)
	1991 to 2000 (%)	1995 to 2000 (%)		
1. Growth of GDP (Whole Country)				
(a) Total	6.7	6.4		
(b) Industry	10.2	10.1		
(c) Commercial & services	7.0	7.1		
2. Growth of Energy Consumption (Whole Country)				
(a) Total	12.0	13.5	1.79 ~ 2.11	
(b) Industry	23.6	15.9	1.57 ~ 2.31	1.5
(c) Commercial & services	6.3	10.5	0.9 ~ 1.4	1.2
3. Growth of Energy Consumption (Vientiane Municipality)				
(a) Total	7.5	8.0	1.12 ~ 1.25	
(b) Industry	19.7	11.5	1.14 ~ 1.93	1.0
(c) Commercial & services	3.1	6.2	0.44 ~ 0.88	0.9

3.8.2 Load and energy forecast is carried out by each province (18 in total). Forecast for four categories are established – residential, industrial, agricultural and commercial/services. In addition, demands from known specific developments are included as well as estimated system losses.

3.8.3 For forecasting demand/energy for the residential sector, the following factors/methods are used:

1. Electrification ratio to be achieved by year 2020 is 90% from the present 38.9 % (year 2003);
2. The number of households to be electrified every year is forecasted based on population projection and the estimated number of household (Population Census 1995 was the basis for population & household projections);

3. Average energy consumption per household is assumed for each type of households;
4. Energy consumption by household consumers newly connected to the Grid is estimated from number of households to be connected and the estimated energy consumption per household;
5. Residential demands already connected to the Grid are to be increased with an annual growth rate of 5%.

Table 3.5 shows the electrification targets for Lao PDR and table 3.6, estimated energy consumption per housegold.

Table 3.5: Electrification target for Lao PDR

Year	No. of Village Electrified		No. of Household Electrified	
	Nos.	(%)	Nos.	(%)
2003	3,245	29	340,550	38.9
2010	5,5584	50	733,926	70
2020	8,906	80	1,140,396	90

Table 3.6: Estimated Average Energy Consumption/Household

Region	Urban and Rural with access road (kWh/year)	Rural without access road (kWh/year)
Northern	600	75
Central 1 (except Vientiane Mu.)	900	100
Vientiane Municipality	1,500	100
Central 2	695	100
Southern	720	75
Annual increase	3%	-

3.8.4 For forecasting demand/energy for industrial, commercial and service sectors the following guides are used:

1. For existing customers already connected to the Grid, the demand is to be increased according to the estimated relation factors between GDP growth and growth of energy consumption.
2. For villages which will be connected to the Grid during study period, non-residential power demand for each type of village is assumed by referring to the actual data for electricity demand.

Table 3.7 shows estimates of GDP growth and energy consumption growth rates used in forecasting.

Table 3.7: Estimate of GDP and consumption growth

Estimate of GDP Growth			
	2000 to 2005	2005 to 2010	2010 to 2020
GDP Total	6.5	6.0	5.0
GDP Industry sector	8.5	8.0	6.5
GDP Service sector	7.0	6.5	5.5

Estimated Growth Rate of Energy Consumption			
	2000 to 2005	2005 to 2010	2010 to 2020
(unit: %)			
Whole Country			
(1) Industry Sector	12.75	12.0	9.75
(2) Commercial & Service Sector	8.4	7.8	6.6
Vientiane Municipality			
(1) Industry Sector	8.5	8.0	6.5
(2) Commercial & Service Sector	6.3	5.9	5.0

3.8.5 For the agricultural sector, the following guidelines are used for forecasting:

1. Energy consumption for premises already connected to the Grid as of year 2003 will remain constant.
2. According to the Ministry of Agriculture & Forestry, it is expected that approximately 1,500 number of electric driven pumps (55 MW in total) will be installed all over the country. These additional loads are added to Agriculture sector. Running hour is assumed at 1,200 hours per annum.

3.8.6 System losses are taken into consideration by including target and actual reduction as indicated in figure 3.10.

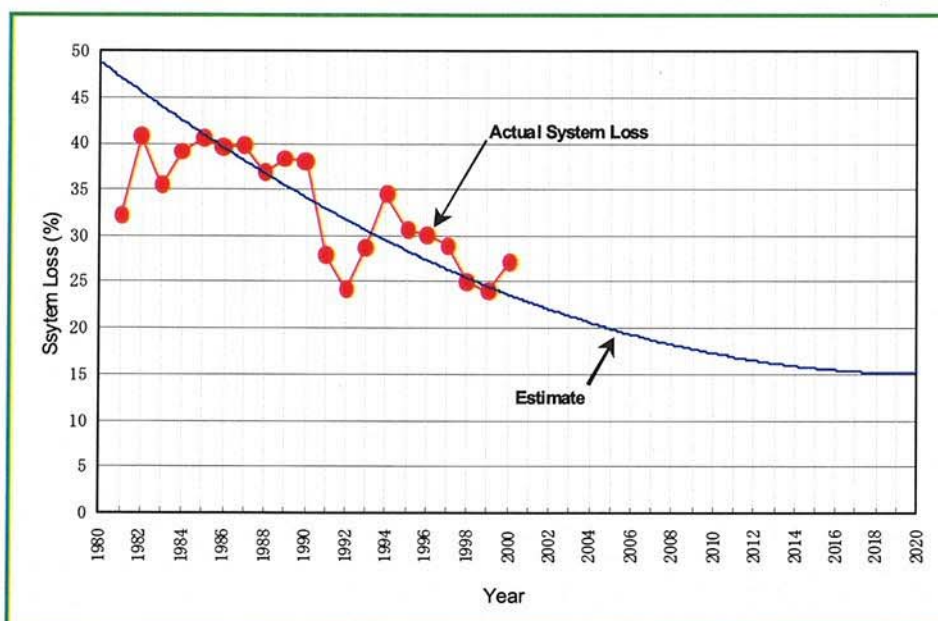


Figure 3.10: System loss reduction estimates for Lao PDR

- 3.8.7 Results of load/energy forecast indicate the followings:
1. Energy Consumption in 2010 is 2,648 GWh (11% of Growth rate)
 2. Average growth is about 226 GWh per annum for the period of (2003-2010) and 221 GWh per annum for the period (2003-2020)
 3. Peak Load in 2010 is 510.7 MW (9% of Growth rate) and 923 MW (6% of Growth rate) in 2020.
 4. Average growth is about 39.8 MW per annum for the period of (2003-2010) and 40.7 MW per annum for the period (2003-2020)

Figure 3.11 shows the forecasted maximum demand by regions and country up to year 2020.

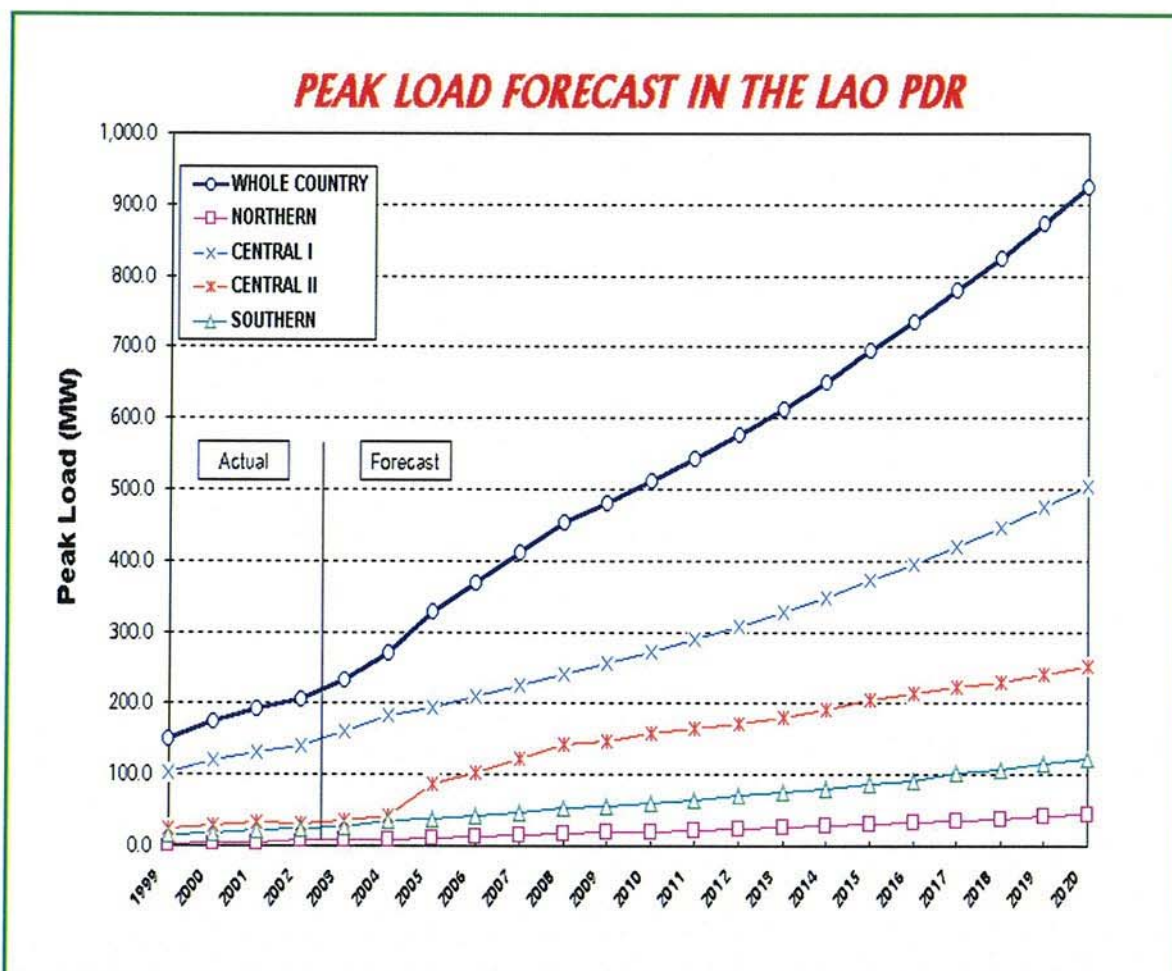


Figure 3.11: Demand forecast for Lao PDR 2003 - 2020

3.9 Vietnam

3.9.1 In EVN energy forecasting is carried using the following approaches:

1. Top-down Method: In this method the long term elasticity between power demand and GDP is used and estimated by economics segments of industry, agriculture, Commercial, and domestic;
2. Bottom up Method: In this approach, the penetration of electricity use in economic segments are estimated - motor, heating, lighting;
3. Regression Method

The Top-down Method is basic approach and other methods are to support.

3.9.2 For load profile forecast, in the past the whole system load pattern was evaluated. Now EVN is in the process of building up database of load profiles of various sectors of the consumers. Table 3.8 shows various factors used for load forecasting and figure 3.12 shows the result of the current demand forecast for Vietnam up to year 2020.

Table 3.8: Factors used by EVN for load forecasting

<u>Criteria</u>	<u>1990</u>	<u>2002 (2003)</u>
GDP (USD/capita)	114	407
Final Energy Consumption – FEC (KgOE/cap.)	63	208 (295)
Electricity consumption per capita (KWh/cap.)	94	380 (420)
Energy intensity (KgOE/1000USD)	344	512 (535)
FEC Growth (%/annual)		10,1 (11,1)
Power Generation Growth (%/annual)		13,9 (14,2)
Energy/GDP Elasticity		1,40
Electricity/GDP Elasticity		1,85

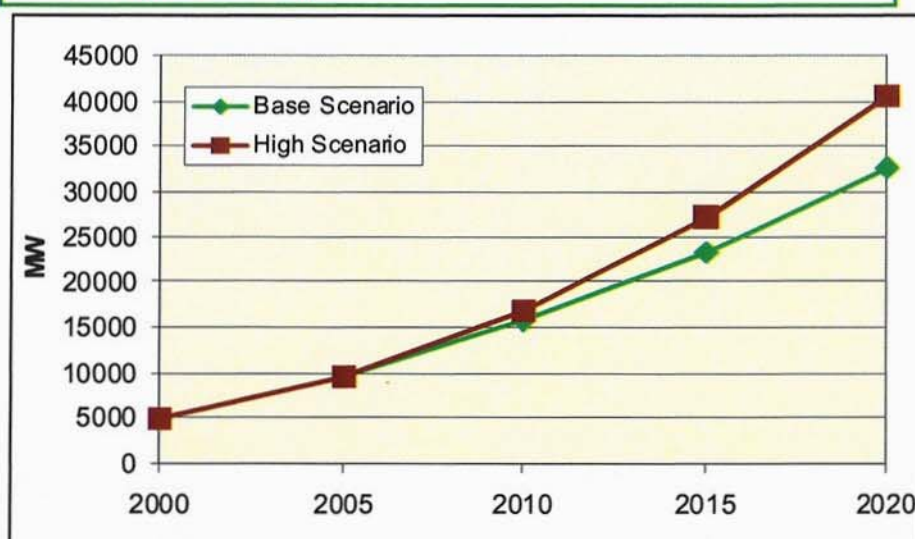


Figure 3.12: Demand forecast for Vietnam up to year 2020

3.10 Malaysia (Peninsular)

3.10.1 Electricity consumption in Peninsular Malaysia is anticipated to grow as the Malaysian economy emerges stronger and more resilient from the slowdown in the late 1990's. The projected electricity sales for the TNB integrated system (excluding Sabah) is 64,292 GWh in 2003, and 112,174 GWh in 2010. This represents an average annual growth rate of 8.3% for the period 2003 - 2010. System peak demand is forecasted to increase from 11,329 MW in 2003 to 19,094 MW in 2010, representing an average annual growth rate of 7.7% over the period 2003 - 2010.

3.10.2 Figure 3.13 shows the relationship between GDP growth and energy consumption including the impact of the '1997 Financial Crisis'.

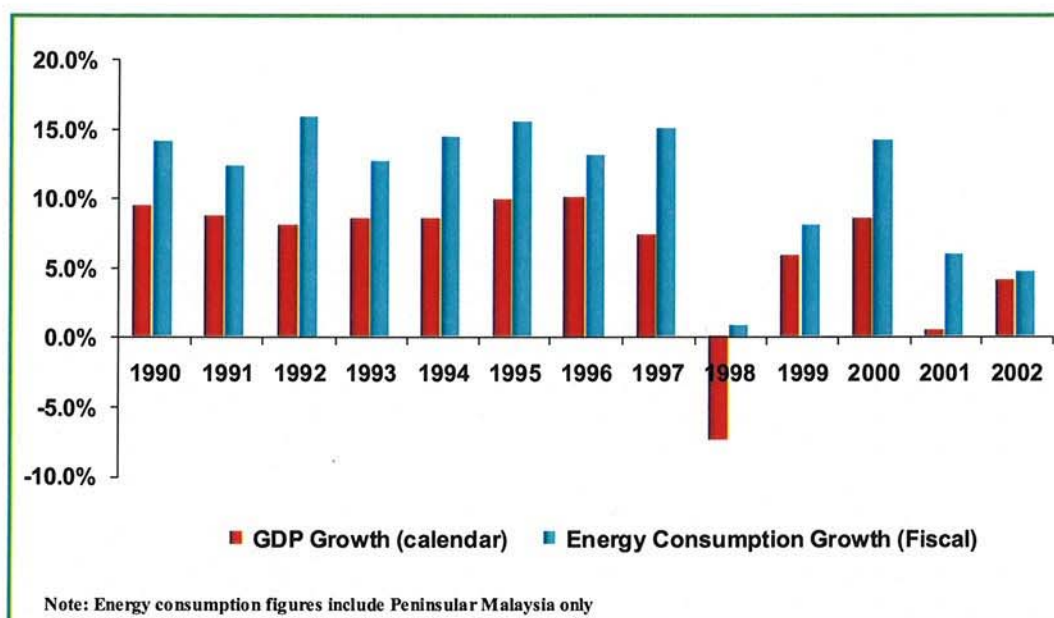


Figure 3.13: Peninsular Malaysia GDP growth and electricity energy consumption

3.10.3 Figure 3.14 illustrates the influence of GDP on electricity demand and energy sales for Peninsular Malaysia between 1994 and 1999. Under steady GDP growth between 1994 and 1997, the demand growth rate ranges between 1.4 to 1.6 times of the GDP growth. The economic crisis between 1997 and 1998 that resulted in the 1998 GDP growth of -7.4% caused electricity demand to increase only by 2% instead of 12% to 16% between 1994 and 1997. It is clear in the case of the Malaysian example, GDP has strong influence on the electricity demand and energy growth.

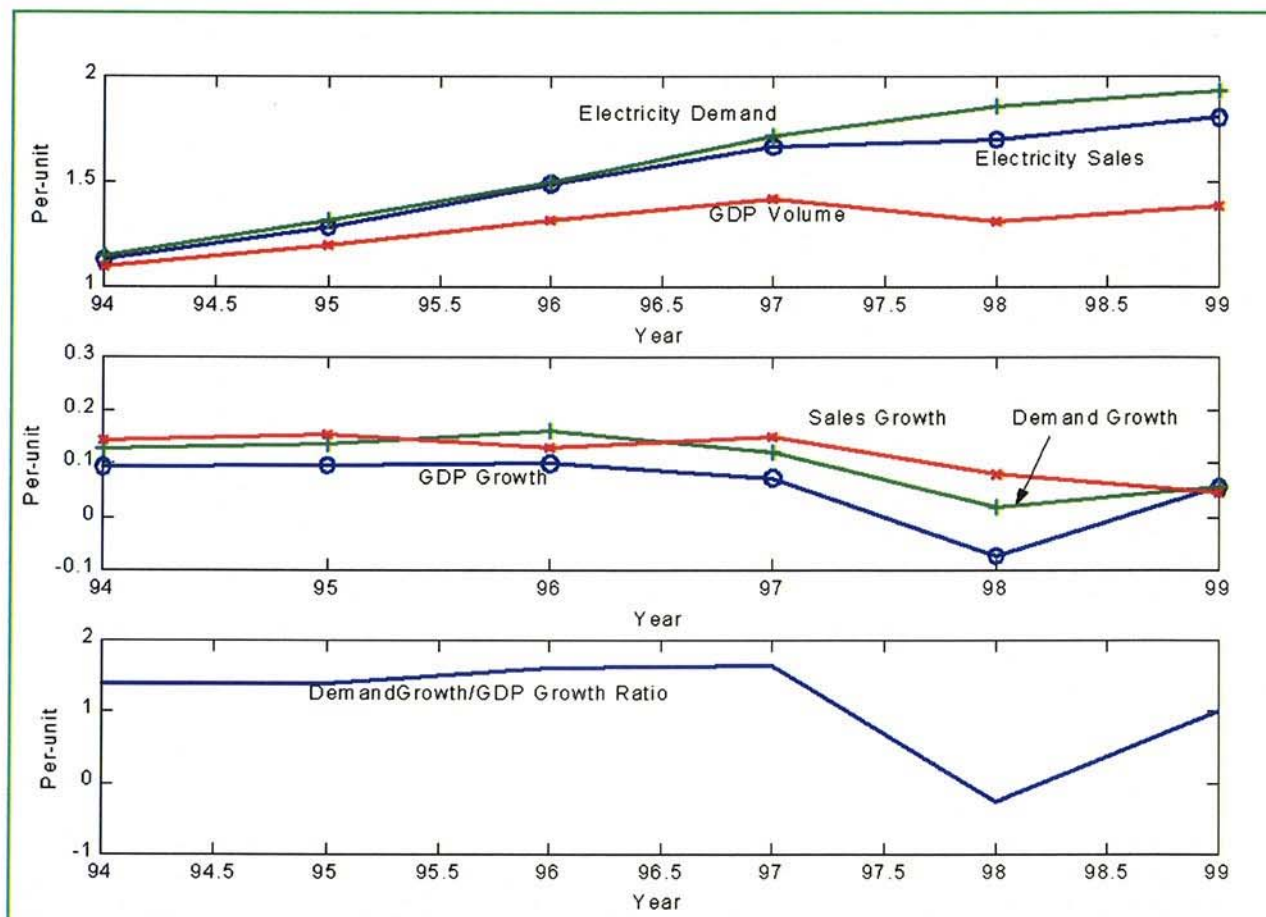


Figure 3.14: Demand growth and GDP - Peninsular Malaysia, 1994 - 1999

3.10.4 The annual MW load and MW-hour energy forecast are prepared by the Load Forecasting Section of the System Planning and Development Unit. The unit carries out both long and shorter term forecasts for TNB planning, operational planning and on the day for national load dispatch purposes.

3.10.5 For Peninsular Malaysia, electricity demand and energy forecasts are carried out from both macro (top-bottom) and micro (bottom-up) levels by TNB. The macro forecast seeks to determine the overall or Peninsular-wide projection of demand and energy for the next 15 - 20 years. While the micro forecast seeks to determine projection of demand and energy on district levels - distribution areas - for the next 10 - 15 years. The macro forecast is carried out by the System Planning and Development Unit of TNB while micro forecast is conducted by distribution planning at the district and regional levels. On completion of both, the sum of all micro forecasts from all districts and regions in the Peninsular is compared with that of the macro forecast and this process is "reconciliation". The discrepancies between the two forecasts are evaluated, debated and modified to finally arrive at the agreed levels.

- 3.10.6 Macro forecast is based on an 'integrated approach'. In the integrated approach, the method is divided into two stages:
- 1) Trend analysis of sales and demand is applied for the short-term (2-3 years) forecast complemented by known new major sales based on large industrial and commercial development; and
 - 2) Econometric model is then used for medium and long-term forecasts to project for the next 15 - 20 years.
- 3.10.7 In the econometric model, historical data for a dependent variable such as energy sales or demand are correlated to historical data of independent variables that have explained the changes in the dependent variables historically, and are, consequently, projected to have the same influence in the future. Three major historical and forecast independent variables are used, namely:
- a) GDP growth
 - b) Population
 - c) Electricity price
- 3.10.8 GDP growth forecast is obtained from government organisation such as the National Economic Planning Unit (EPU) or the independent organisation such as the Malaysian Institute of Economic Research (MIER). Population forecast is obtained from Government Census Department. While future electricity price is inflated based on the forecast inflation rate also obtainable from the Government Statistical Department. Experience has indicated that GDP growth rate has the most significant influence on electricity demand and energy - factors of 1.4 - 1.6 times, disregarding the short-term economic downturn.
- 3.10.9 Micro level forecast in a distribution district or station is also carried out in two stages:
- 1) Next Year Forecast is carried out based on the past trend (restricted to 2 - 3 year historical) and known addition of customers through applications of electricity and major projects. This forecast is also used for the annual operating financial budget.
 - 2) Trend Analysis is then carried out for future projection of the next 5 - 10 years taking into consideration the impacts of known major development during the early years.
- 3.10.10 Reconciliation of macro and micro level forecast is an important step before the final forecast are agreed upon. Once the Peninsular-wide or the macro forecasts are accepted, the figures are then desegregated into regional, district/station, transmission substations and distribution medium voltage feeder levels in proportion to the original micro forecasts.

3.11 Contribution from Japan (TEPCO) on Load Forecasting

3.11.1 Typical utility practice is to perform demand forecasting in four stages as follows:

- 1) Demographic forecast
- 2) Economic forecast
- 3) Electricity usage forecast, including demand side management
- 4) Annual demand, peak demand forecasts

3.11.2 For demographic forecast - the following parameters are determined:

- Population
- Composition of population such as ratios among ages, sex and number of a family

The forecast is conducted based on past trend and experiences of other countries (or areas) with similar conditions.

3.11.3 In economic forecast, typical factors determined, include:

- GDP growth rate
- Industry development by category
- Floor space increase in buildings and housings
- Income increase

Economic forecast is conducted based the national or regional target, trend in the past and experiences in other areas with similar conditions.

3.11.4 In electricity usage forecast, the main factors that are determined, include:

- Typical electricity demand per appliance, product, family, floor area
- Saturation ratio forecast regarding major appliances such as air conditioner or electricity heating
- Electrification ratio in rural areas

The forecast is conducted based on the demographic and economic forecast, past trend and experiences in other areas with similar conditions.

3.11.5 To account for demand side management, the following factors are determined:

- Forced demand curtailment policy (such as rolling blackout)
- Estimation on DSM by government subsidiary or electricity industry

Generation plan might be incorporated at this stage to assess the incentives for DSM to the customers.

3.11.6 The electricity demand forecast is then conducted to determine the followings:

- Annual energy (kWh), based on synthesis of the factors described above

- Peak Demand (kW) including estimation on transmission loss including social factors, estimation on load factor, referring to the trend in the past and experiences in other areas with similar conditions

Several scenarios regarding demand growth are established to secure flexibility as well as economy of the system development plan. If necessary, demand forecast in the partitioned (local) areas would be worked out in the same manner especially for transmission system planning.

3.11.7 Past experience has shown that improvements in forecast accuracy will become more important in competitive environment. Among the possible improvement areas identified are:

- More comprehensive and accurate statistics (or data) including load survey on the customers
- Proper forecast methods most appropriately reflecting the actual situations while picking up proper information. It would be normally a combination of "Econometric regression" and "End use customer segmentation".
- Continuous refinement (correction or modification) on the forecast methods
- Quick response to the latest domestic and international economic conditions

3.12 Summary of Load Forecasting Approaches and Methods

3.12.7 Brunei that currently (2004) has peak load of 450MW employs trending method by projecting historical demand into the future and add any known step loads during the early years. Because of the relatively small geographical size and well coordinated administrative machineries, new loads such as residential development, commercial areas and oil and gas support industries are easily identifiable and thus providing accurate source of information for load forecasting.

3.12.8 EdC of Cambodia currently manages two main power networks; Southern system that includes the capital Phnom Penh and Western system of Siem Rep province that borders Thailand. EdC employs trending method and complemented with known load as well as target electrification level as their forecasting method. For national forecasts, supply to isolated areas - villages and towns - are undertaken by more than 20 REE (Rural Electrification Enterprises) and therefore inputs from the REEs are also included. Because of lack of investment in generation Cambodia is currently and will continue in the near future to suffer shortage of power and thus may results in brownouts and blackouts.

- 3.12.9 **Indonesia** employs regression analysis taking into account GDP growth, historical trend and rural electrification target for forecast of sales and demand. PLN also takes into consideration their targets for taking over supplies to captive loads.
- 3.12.10 **Singapore** employs both end-use and regression analysis with economic factors. SP PowerGrid establishes energy and demand forecast by areas with inputs on land-usage, industrial and commercial developments through close coordination with various authorities. These area level forecast would then be reconciled with the national level forecast established by the EMA (Energy Market Authority).
- 3.12.11 **Thailand** employs the most sophisticated forecasting technique with the applications of end-use analysis by both PEA and MEA while EGAT uses regression analysis for system forecast. These two forecasts will then be reconciled at the top government committee level of Thailand Load Forecast Subcommittee (TLFS). MEA and PEA regularly (once in three years) conduct survey of consumption for various categories of customers. The two distribution utilities also compiled data of load profiles for various types of customers. From energy forecasts and integration of load profiles, transmission substation forecasts are established. Once substation forecasts are established, these will have to be reconciled with the total system forecast carried out by EGAT at TLFS. When the two forecasts are agreed and approved by NEPO (National Energy and Policy Office), they are then used for planning purposes by all utilities.
- 3.12.12 **Lao PDR** employs regression and sectoral analysis with economic factors and rural electrification targets as inputs. EdL has compiled figures of consumption levels for various sectors of customers and use these for their forecasting.
- 3.12.13 **Vietnam** employs regression analysis for national forecast as well as sectoral analysis. These two forecasts are reconciled by EVN. EVN is currently building database of consumption patterns and profiles for various categories of customers for future use.
- 3.12.14 **Malaysia** (Peninsular) employs regression analysis with economic factors and demographic factors for system forecast and regression analysis complemented with known loads for district/regional forecasts. These two forecasts are reconciled within TNB before a single forecast is presented to the government for approval.
- 3.12.15 Table 3.9 summarises methods and approaches used for load/energy forecasting by various countries in ASEAN.

Table 3.9: Summary of load forecasting methods employed in ASEAN utilities

No	Country	Historical trend	Known Loads *	Electrification Target	Regression Analysis	Sectoral analysis	End-Use Method	Top-Down Approach	Bottom-up Approach
1	Brunei	Y	Y						
2	Cambodia	Y	Y	Y					
3	Indonesia	Y	Y	Y	Y	Y		Y	
4	The Philippines								
5	Singapore		Y		Y		Y	Y	Y
6	Thailand				Y		Y	Y	Y
7	Lao PDR		Y	Y	Y	Y		Y	Y
8	Vietnam				Y	Y		Y	Y
9	Malaysia		Y		Y	Y		Y	Y

* Rural target/captive loads

Chapter 4: Planning and Design Criteria

4.1 Introduction

4.1.1 After knowing the expected future demand of electricity and before embarking on planning for generation and/or transmission investments, a set of limits on network performance under various conditions and methods on how these limits are to be tested must be known and these are called planning criteria or planning standards. Standards are for the purposes of protecting customers by ensuring that the quality of supply particularly the reliability aspect and quality voltage be maintained for it to be usefully consumed.

4.1.2 For generation planning, the following are important parameters for comparison:

- List of criteria used and applications;
- Generation margin; and
- Generation mix;

4.1.3 With respect to transmission planning, the following information were requested for comparison purposes:

- List of transmission planning and design criteria;
- Impacts of deterministic criteria on investment;
- Applications of probabilistic criteria;
- Approach to using probabilistic criteria; and
- Power quality criteria - standards and their applications;

4.2 Brunei Darussalam

4.2.1 To keep abreast with rapid growth in electric power demand, the Government of Brunei through the DES (Department of Electrical Services) has allocated significant amount of financial resources in the previous and current 5-year National Development Plans. The **main objectives of electricity infrastructure developments** are:

- to develop electric power infrastructure to provide reliable and continuous electric power for the nation;
- to support the development of industries and
- to enable the population to improve their quality of life.

4.2.1 For Brunei, **generation planning standard** is based on a deterministic approach as follows:

- Double outage contingency criteria for a generation station. This criteria must satisfy the following conditions:
 - Assuming the largest unit is out of service on scheduled maintenance; and
 - The next largest unit also out of service due to forced outage.

4.2.2 For **transmission and distribution** networks, the following planning criteria are adopted:

1. In the planning for the transmission system, single outage contingency criteria (N-1) and a maximum voltage drop of five percent (5%) are used.
2. For the development of the 66kV and 11kV distribution network, supply to an area should come from two separate sources.
3. To ensure that power sharing capability between Brunei East and Brunei West is provided to improve generation efficiency and thereby maximizing the economic utilization of the national resources.

For fuel, Brunei will continue to use a mix of the country's resources of natural gas, distillate and diesel as indicated in table 4.1.

Table 4.1: Installed generating units and fuel types - Brunei

Power Stations	Fuel Type	2000 (MW)	2001 (MW)	2002 (MW)	2003 (MW)
<i>DES Network</i>					
Gadong 1	Natural gas	128.0	128.0	128.0	128.0
Gadong 1A	Natural gas	0	0	99.0	99.0
Gadong 2	Natural gas	132.0	132.0	132.0	132.0
Lumut Co-generation	Natural gas	180.0	180.0	180.0	180.0
Belingus	Diesel	7.5	7.5	13.5	13.5
<i>BPC Network</i>					
Jerudong	Nat gas/Distillate	73.6	73.6	73.6	73.6
Gadong 3	Nat gas/Distillate	55.2	55.2	55.2	55.2
Berakas	Nat gas/Distillate	128.8	128.8	128.8	128.8
	TOTAL	705.1	705.1	810.1	810.1

4.3 Cambodia

4.3.1 EdC of Cambodia currently focuses in two supply areas, namely; the Southern and Northwest regions. For the two areas, EdC is expected to face shortage of generation because of lack of financial resources and investments. However, for **generation planning** purposes deterministic criteria of (N-2) is used, that is, loss of second largest unit on forced outage following the largest unit on maintenance outage. In addition to this the installed **reserve margin** is to be maintained above 15% - current reserve margin is between 10% and 15%. EdC is also planning generation expansion to gradually reduce reliance on import of power from Vietnam, now at 40% to 20%. Cambodia is expected to continue to depend on diesel and heavy fuel oil as basic fuel for power generation.

4.3.2 For transmission system planning, EdC uses the following criteria:

- (N-1) contingency
- Voltage under normal condition to remain between +2% and - 5%
- Under contingency situation voltage could deviate between - 10% and +10%
- Frequency under normal condition to remain between 49.5Hz and 50.5Hz.
- Minimum frequency allowable under contingency is 47Hz.

4.4 Indonesia

4.4.1 For the Java-Bali interconnected system, the basic principle for generation expansion is to achieve 'least cost development' with target reliability of LOLP level less than 1 day/year and generation margin to be maintained between 28% and 30%. But outside Java-Bali generation margin is to be maintained between 33% and 44%.

4.4.2 For calculating the reserve margin, PLN takes into consideration the following factors:

1. Maintenance outage of 9.3 % from total capacity;
2. FOR (Forced Outage Rate) of 5.3 % from thermal capacity;
3. Seasonal variation of 27 % from hydro capacity;
4. Derating of 2 % from thermal capacity; and
5. Spinning reserve of > 600 MW.

The above factors are indicated in table 4.2 showing power balance for Java-Madura-Bali system up to year 2013.

Table 4.2: Power balance for Java-Madura-Bali System, 2004 - 20014

POWER BALANCE OF JAMALI SYSTEM 2004-2013											
										SCENARIO - 1	
ITEM		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Install Capacity	(MW)	18608	19466	20046	22316	22856	23831	25251	26451	28151	29851
Retired	(MW)				300						
Additional Capacity	(MW)	858	580	2270	840	975	1420	1200	1700	1700	1600
Total Installed Capacity	(MW)	19466	20046	22316	22856	23831	25251	26451	28151	29851	31451
Seasonal Variation	(MW)	685	685	685	685	685	685	685	820	955	955
Forced Outage	(MW)	897	928	1048	1077	1129	1204	1267	1331	1395	1479
Derating	(MW)	339	350	396	406	426	454	478	502	526	558
Maintenance	(MW)	1804	1858	2069	2119	2209	2341	2452	2610	2767	2915
LSC	(MW)	15741	16225	18118	18569	19382	20567	21568	22888	24208	25543
Peak Load	(MW)	14522	15386	16275	17165	18226	19344	20539	21798	23141	24557
Growth Peak Load	%	2.4	5.9	5.8	5.5	6.2	6.1	6.2	6.1	6.2	6.1
Spinning Reserve	(MW)	1219	839	1843	1404	1157	1223	1030	1090	1067	986
Reserve Margin	%	34	30	37	33	31	31	29	29	29	28
Load Factor	%	72	72	72	72	72	72	72	72	72	72
Production	(GWh)	91592	97040	102652	108261	114953	122009	129542	137482	145954	154883
Growth Production	%	2.4	5.9	5.8	5.5	6.2	6.1	6.2	6.1	6.2	6.1

4.4.3 With respect to generation mix, the following criteria are used:

1. Maximizing the utilization of indigenous energy resources, especially non-tradable energy resources such as: low rank coal, geothermal and hydro.
2. Minimizing the use of fuel oil based generation.

However, for Java-Bali system, generation mix for the future would mainly consist of coal and natural gas (or LNG) based generations as indicated in figure 4.1.

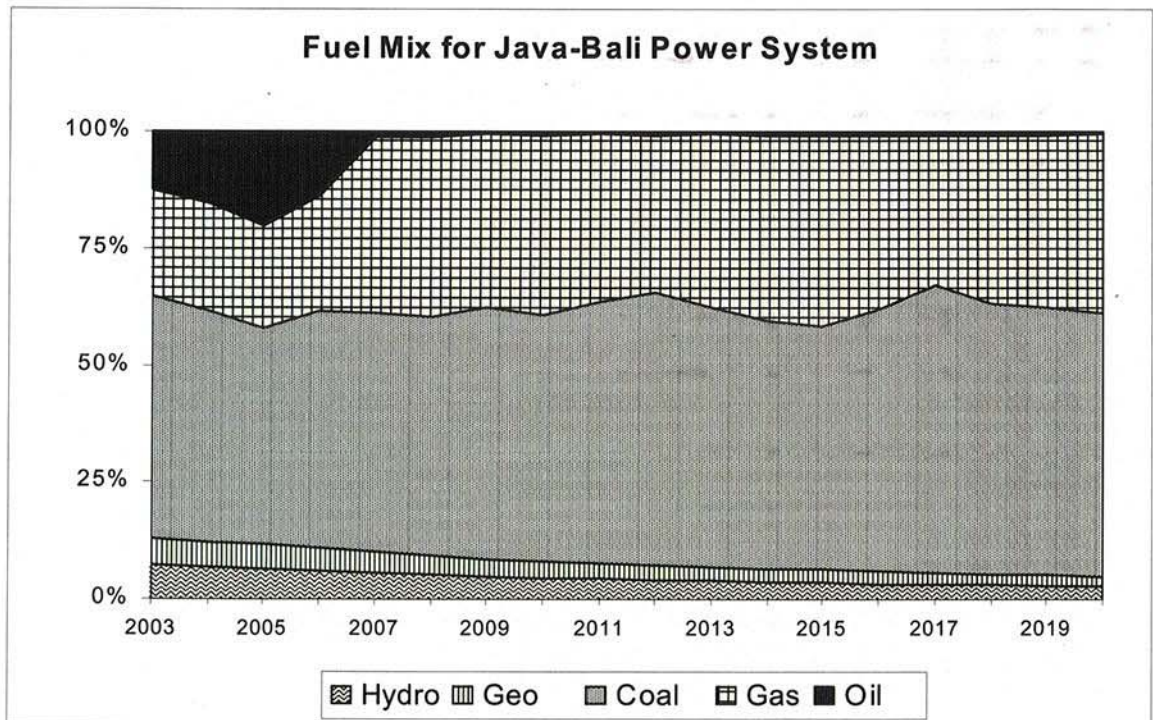


Figure 4.1: Planned fuel mix for Java-Bali system

4.4.4 For transmission planning (N-1) outage criterion is maintained. Under normal condition frequency is allowed to deviate between 49.5Hz and 50.5Hz. Voltage deviations under normal condition are:

- a) 500 kV : +5 %, -5%
- b) 150 kV : +5 %, -10 %
- c) 70 kV : +5 %, -10 %

Short circuit levels are also checked to be maintained below the following values:

- a) 500 kV : 50 kA
- b) 150 kV : 50 kA
- c) 70 kV : 31 kA

4.4.4 The following standard transformer capacities are used:

- a) 150 kV : 3 x 60 MVA
- b) 70 kV : 3 x 30 MVA

Allowable loading on transformers and lines is 70 %.

4.4.5 Frequency policy applied by PLN for Java-Bali interconnected system is shown in figure 4.2. Any frequency excursion beyond $\pm 0.5\text{Hz}$ would require load-shedding measures be initiated. Both definite frequency and rate of change of frequency are used for load-shedding.

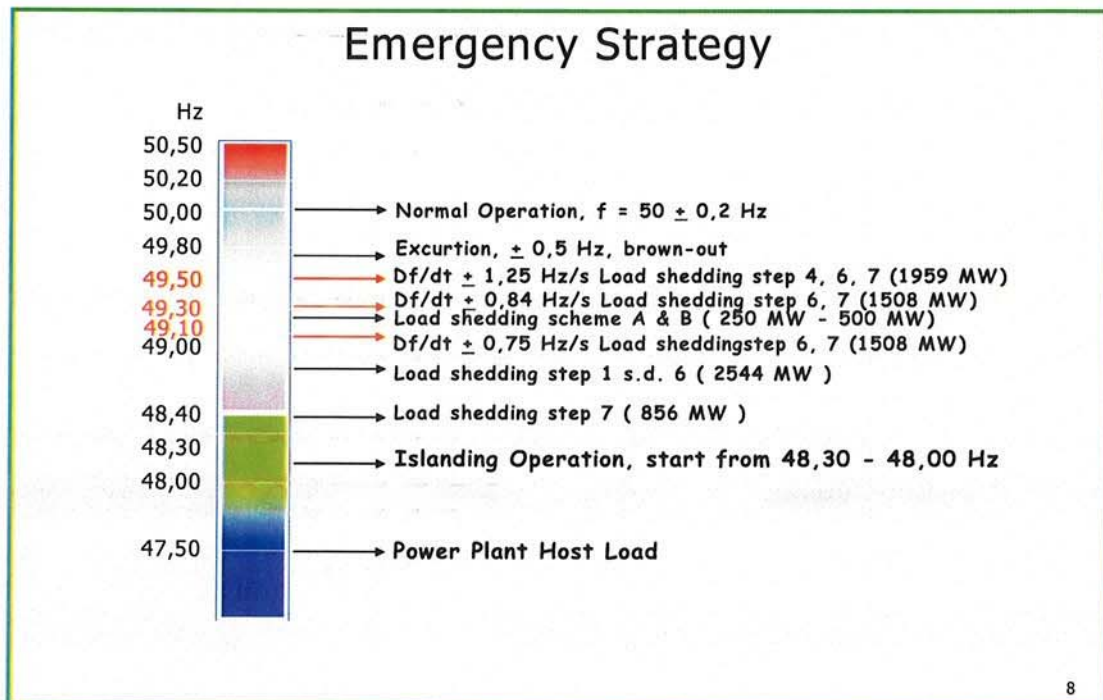


Figure 4.2: PLN Frequency Policy for Java-Bali System

4.5 The Philippines

4.5.1 Transmission planning criteria employed by Transco are specified in the Philippine Grid Code managed by the Grid Management Committee. The criteria are as follows:

- (a) N-1 RULE (Loss of Single Element of the Power System)
 - The generators must remain stable
 - The under - frequency load shedding (ALD) must not be activated
 - The power flows must remain lower than the rating of the network
 - equipment and must not overload the remaining elements
 - The bus voltages must remain within limits
- (b) THERMAL CRITERIA (Power Flow within Thermal Capacity Rating)
 - During Normal Capacity Rating
 - During Emergency Capacity Rating
- (c) VOLTAGE CRITERIA (Voltage Variations in the System)
 - 5% of Nominal Rating - Normal Operation
 - 10% of Nominal Rating - Single Outage Event
 - >+ 10% of Nominal Rating - Grid Emergency and Restoration Period
- (d) STABILITY CRITERIA (Stable Operation of Generators & Other Machines)
 - During Normal Operation
 - During N - 1 Contingency

4.6 Singapore

4.6.1 Singapore employs (N-1) criteria as the basic requirement for investment in transmission system expansion. With full wholesale competition established, planning need to consider various generation dispatch scenarios and could under certain situation become extreme, for example all generation from one side of the island. For economic evaluation of expansion plans, least cost approach is used.

4.6.2 SP PowerGrid in their planning emphasizes on system security and therefore, the system is tested under two situations:

1. Single/More Probable Contingencies; and
2. Extreme Contingencies

Single contingencies are defined as unplanned or planned outage of a single network item such as a circuit, transformer, reactor. More probable contingencies are defined as unplanned or planned outage of a single circuit, single transformer or single reactor

4.6.3 When tested using Single/More Probable Contingencies. all equipment shall as far as possible operate within maximum continuous ratings and voltage limits and the following conditions must be satisfied:

- (a) No power interruption
- (b) No prolonged excessive overloading
- (c) No cascading effect
- (d) No system instability

4.6.4 Extreme contingencies considered in planning are:

- (a) Outage of a generating station
- (b) Outage of a substation
- (c) Outage of a switchboard
- (d) Outage of multiple circuits installed at the same location

When tested with any of the above contingencies, the system must maintain steady state and dynamic stability and remedial action of automatic load shedding is allowed.

4.6.5 For equipment design criteria, the following guidelines are used:

1. Standardization of equipment design
2. Minimum inventory costs for spare parts
3. Economies of scale in purchasing
4. Simplicity in design and operation

Table 4.3 shows standards employed by SP PowerGrid for major transmission equipment.

Table 4.3: Design standards and practices for transmission equipment in Singapore

<u>A SWITCHGEAR</u>	<u>400KV</u>	<u>230KV</u>	<u>66KV</u>
1) RATED SHORT CIRCUIT CURRENT (KA)	63	50/63	40
2) RATED DURATION OF SHORT CIRCUIT (SEC)	1	1	3
3) TYPE	GIS	GIS	GIS
<u>B TRANSFORMERS</u>			
1) CAPACITY (MVA)	500	200/150	75
<u>C CABLES</u>			
1) RATED SHORT CIRCUIT CURRENT (KA)	63KA FOR 1 SEC	50/63KA FOR 1 SEC	40KA FOR 3 SEC
2) TYPE	SINGLE CORE OIL-FILLED PPLP INSULATED COPPER CONDUCTOR	SINGLE CORE OIL-FILLED PAPER INSULATED COPPER CONDUCTOR	SINGLE CORE XLPE COPPER OR ALUMINIUM CONDUCTOR
3) CIRCUIT CAPACITY (MVA)	1000	250/500	100
<u>D BUSBAR</u>			
1) RATED CURRENT (A)	4000	3150	3150
2) SWITCHGEAR CONFIGURATION	ONE AND HALF BREAKERS	ONE AND HALF BREAKERS OR DOUBLE BUSBAR	CONVENTIONAL DOUBLE BUSBAR

4.7 Thailand

4.7.1 Generation expansion planning for Thailand is currently carried out by EGAT. Upon release of official national load forecast by the Thailand Load Forecast Subcommittee (TLFS), the cycle for generation expansion planning starts - normally at the beginning of the year. Examples of the criteria and guidelines applied for this year's (2004) expansion plan are:

- From year 2006, 500MW of peak to be shaved;
- Maximum LOLP 24 hours/year;
- Minimum reserve margin, 15%;
- 5% renewable portfolio standard; and
- Regional strategic energy collaboration.

4.7.2 After taking into consideration already committed power plants in the future and alternatives units for expansion as listed below:

- 700 MW Gas-Fired Combined Cycle
- 700 MW Coal-Fired Thermal
- 220 MW Gas Turbine
- Renewable Portfolio Standard

Dynamic programming approach is applied to arrive at optimal expansion plans. The results would be summarized in Power Development Plan Chart as shown in figure 4.3, showing peak demand, generation additions and reserve margins.

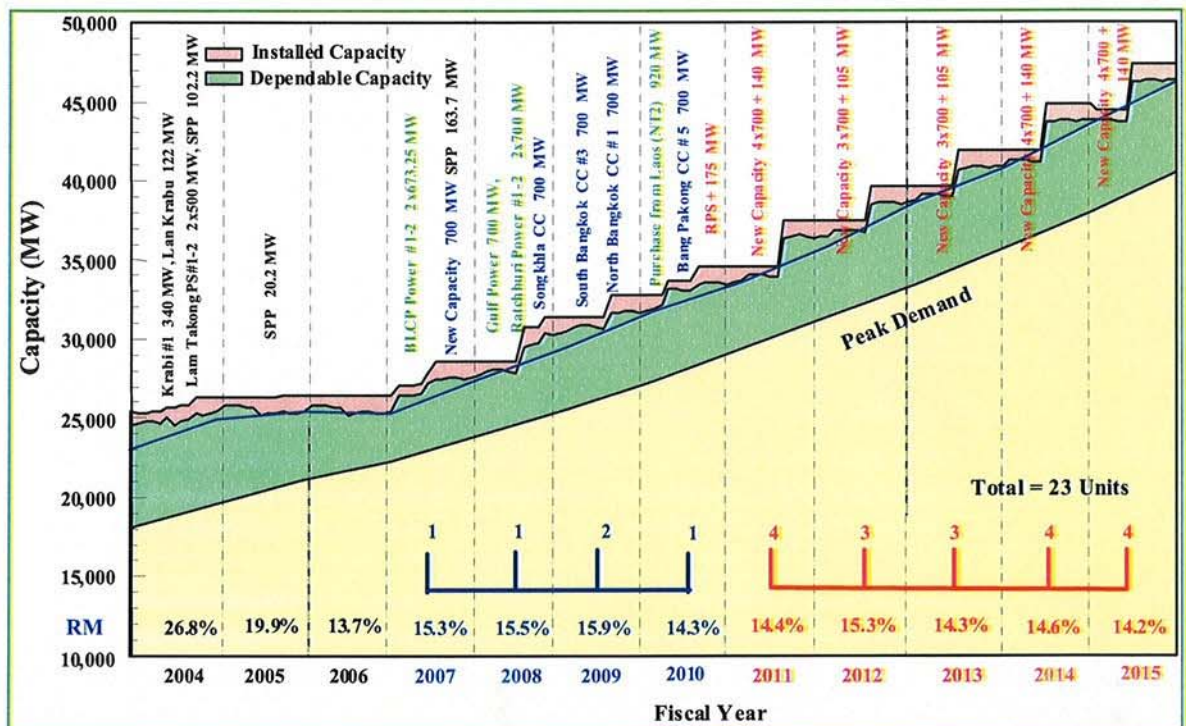


Figure 4.3: Thailand PDP (Power Development Plan) Chart, 2004

4.7.3 The generation expansion optimization also allows EGAT to examine the resulting fuel mix and to ensure that it is inline with the government policy particularly the required increasing used of renewable energy as indicated in figure 4.4.

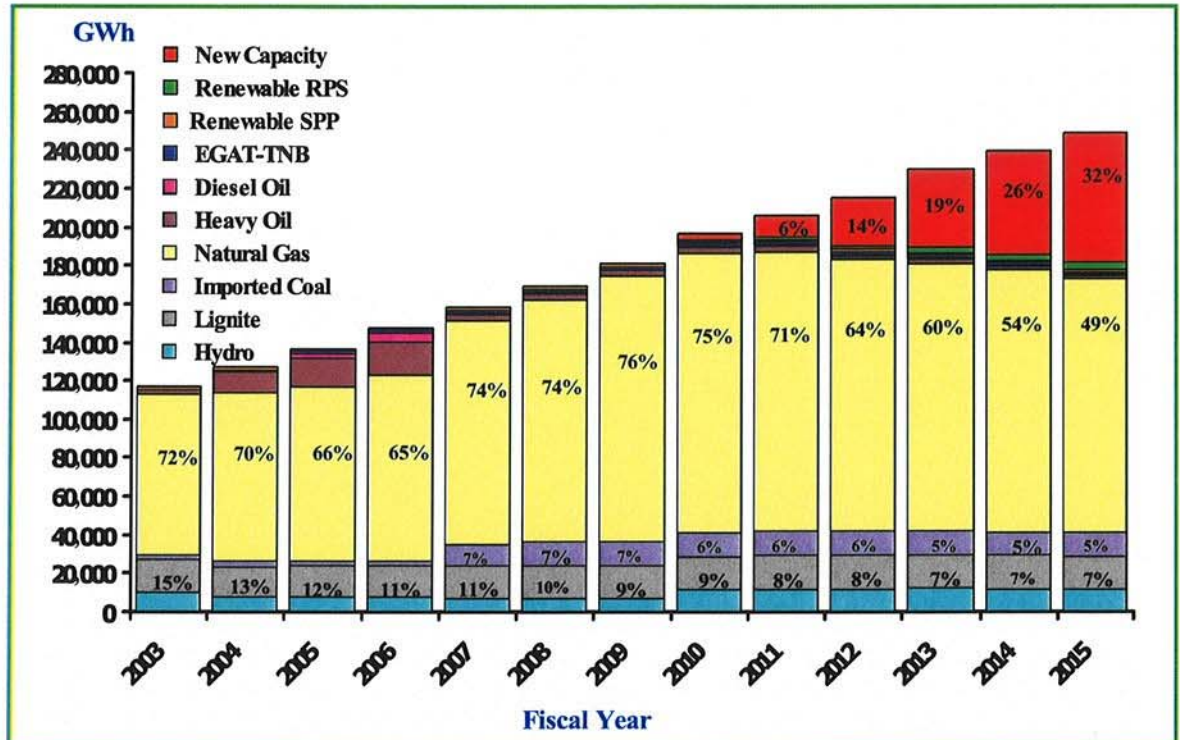


Figure 4.4: Generation fuel mix, Thailand up to year 2015.

4.7.4 For EGAT, there are three main objectives for carrying out transmission system planning:

- 1) To support the new generation facility;
- 2) To cope with the increasing demand and maintain or increase system reliability; and
- 3) To develop the interconnections with the neighboring countries.

In carrying out transmission planning, the following basic principles are used:

- a) Transmission expansion projects are based on the regional distribution of load growth and generation planning (power development plan)
- b) The power flow and stability study are carried out to identify the need of network expansion in next 5 - 7 years
- c) The expansion program is based on the optimum solution

4.7.5 Basic procedures involved in carrying out transmission planning are:

- 1) Power System Analysis (Steady State and Transient)
- 2) Transmission Line Route & Substation Planning
- 3) Cost Estimation
- 4) Economic and Financial Analysis
- 5) Submit for Approval

4.7.6 With respect to transmission planning criteria, EGAT has established a set based on deterministic approach that covers aspects:

- a) Steady state evaluations or tests;
- b) Stability evaluation or tests; and
- c) Voltage stability/collapse evaluation or tests.

The following criteria are applied:

- 1) For steady-state and stability tests, the system must continue to operate satisfactorily following (N-1) contingency; and
- 2) For voltage stability/collapse tests, the system voltage must be maintained following loss of two circuits on the same tower structure.

4.7.7 The above Planning Criteria are designed to achieve the following major objectives:

- 1) To identify transmission power transfer limits on the basis of thermal capability and proximity to voltage collapse and instability;
- 2) To identify reactive compensation requirements under normal and contingency conditions to maintain the system voltage within the specified voltage criteria;
- 3) To optimize system design and voltage control to obtain minimum real and reactive power losses;
- 4) To co-ordinate reactive power control equipment with other equipment for transient over-voltage control;
- 5) To identify short circuit levels for equipment rating; and
- 6) To identify conditions in which the system may be transiently and/or dynamically unstable and the means by which stability may be maintained.

4.7.8 For transmission lines, EGAT has established design criteria as shown in table 4.4.

Table 4.4: EGAT Transmission line design criteria

Description	500kV	230kV	115kV
Power Frequency, Hz	50	50	50
Switching Surge Factor, p.u.	2.32	2.50	-
Standard BIL, kV	1,550	1,050	550
Max. Operating Conductor Temp, °C	75	75	75
Ambient Temp, °C	27	32	32
Wind Velocity, km/hr	-	2.2	2.2
Span Length, m	440	430	330
Minimum Ground Clearance, m (Rail road)	16	11.5	10.5
Wind Load, kg/m²	-	153	70
Standard Conductors:	4x795	1272	477
MCM ACSR	4x1272	2x1272	795
		4x1272	2x795

4.7.9 For substations, EGAT applies design criteria as shown in table 4.5.

Table 4.5: EGAT Substation design criteria

	System Voltage (kV)			
	500	230	115	22
• Max. Continuous Voltage (kV)	550	242	121	24
• Rated Lightning Impulse Withstand Voltage (kV)	1550	900	550	150
• Rated S/C Current (kA)	50	50	31.5	31.5
• System Frequency (Hz)	50	50	50	50
• Min. Clearance, mm (metal to metal)				
Phase to Phase	5600	2260	1400	390
Phase to Ground	3100	1800	1100	260

	System Voltage (kV)			
	500	230	115	22
• Design Clearance, mm (Center to Center)				
Phase to Phase				
Main Bus	8000	5000	2500	1000
Branch Bus	9000	3500	2250	1000
Phase to Ground				
Main Bus	16000	9000	7300	5000
Branch Bus	9000	6000	5300	-

Source: Specification No.50000

Substation Construction Technical Specification
Supply and Construction of 230/500 kV Switchyard

4.7.10 EGAT has also started to apply probabilistic evaluation method in transmission planning to evaluate Internal Rate of Return (IRR) to justify the feasibility of the projects, example, Transmission System Expansion Project No.10 (TS.10). The approach to the probabilistic evaluations include:

1. Use of DIGSILENT Powerfactory software to calculate the improvement of reliability level of the system after the modification;
 2. The results compared are the energy not supplied for the system before and after the modification;
 3. The average outage rates used are those based on the statistical record of the transmission line outage probability at different voltage levels and service areas.
- Table 4.5 shows outage rate of transmission lines at various voltage levels in different regions of Thailand.

Table 4.6: Line outage rated used by EGAT for reliability calculations

Voltage Level	Average Outage Rate (No. per cct-km/Yr)				
	MEA	Central	Northeast	South	North
69 kV	-	0.1128	0.6884	-	0.1852
115 kV	-	0.1325	0.0435	0.0922	0.0617
230 kV	0.2458	0.0723	0.0306	0.0322	0.0339
500 kV	0.1893	0.0367	-	-	0.0480

4.7.11 The outage cost (THB/kWh) applied to study Transmission System Expansion Project No.10 is adopted from a study conducted by Energy Research Institute, Chulalongkorn University. This study estimated that the outage cost is 68.06 THB/kWh.

4.7.12 Thailand has also established power quality criteria based on the work of a Committee on Power System Reliability Improvement comprising of members from:

1. Electricity Generating Authority of Thailand (EGAT)
2. Metropolitan Electricity Authority (MEA)
3. Provincial Electricity Authority (PEA)

The terms of reference for committee are:

- a. To define the acceptable range of harmonic voltage distortion and harmonic current distortion of electrical equipment in industrial plants; and
- b. To define the acceptable point of voltage fluctuation in the power system.

4.7.13 With respect to harmonics, the objective is to control Harmonic Voltage Distortion and Harmonic Current Distortion. For this purposes the following standards and recommendations are used:

- 1) Engineering Recommendation G.5/3
 - September 1976 The Electricity Council Chief Engineer Conference, "Limits for harmonics in The United Kingdom Electricity Supply System"
- 2) The State Energy Commission of Western Australia (SECWA)
 - Part 2: Technical Requirement
- 3) IEC 1000 Electromagnetic Compatibility (EMC)
 - Part 4: Testing and Measurement Techniques

- Section 7: General Guide for Harmonics and Interharmonics Measurements and Instrument for Power Supply Systems and Equipment Connected thereto.

4.7.14 For voltage fluctuations, the objective is to determine Voltage Fluctuation to protect electrical system and customers. For this purpose, the following standards/recommendations are used:

- 1) A.S 2279.4-1991 Australia Standard
- 2) Engineering Recommendation P.28, 1989, "Planning Limits for Voltage Fluctuations caused by Industrial, Commercial and Domestic Equipment in The United Kingdom"

4.8 Lao PDR

4.8.1 For generation planning, EdL of Cambodia applies the following criteria:

- Reserve margin (defined as the percentage of dependable capacity over the peak demand in each year) to be maintained not less than 15%.
- Loss of load probability (LOLP) (some portion of electricity demand is not serve by the available generating capacity in that year) maximum of 24 hour/year allowed.
- Energy Not Served (ENS) or Expected Unserved Energy (EUE) is the estimated sum of energy shortage in basic supply in each year, due to the treatment of unit outages (Max. 0.1%).
- Generation mix, in Lao PDR almost 100% of generation comes from Hydropower Power Plants.

- 4.8.2 For transmission planning, the following criteria have been proposed and used in previous planning studies (see table 4.7) .

Table 4.7: Transmission Planning Criteria for EdL

Pre-disturbance Steady-state

No.	Item	Criteria
i	Loading	Overloading of system element is not permitted
ii	Bus Voltage	0.95 p.u. - 1.05 p.u.
iii	Generator Reactive Capacity	Power factor of 0.9 leading to 0.85 lagging provided that the operating point is within reactive capacity curve
iv	Transmission, Substation Power Factor	0.9 or above
v	Frequency	+/- 0.25 Hz
vi	Spinning Reserve	Sufficient to cover the loss of the largest unit in the system
vii	Effective Short-circuit ratio (ESCR)	2.5 and above

Stability Criteria

No.	Item	Criteria
I	Bus Voltage	To remain between 0.7 p.u. and 1.25 p.u.; 1.25 p.u. for less than 200 ms
ii	Transient Stability	All generating units to remain in synchronism after normal contingencies without interruption of load. After extreme contingencies, control measures, such as load shedding are allowed
iii	Small signal Stability	Noticeable damping of system oscillations

Post-disturbance steady-state

No.	Item	Criteria
I	Loading	Continuous overloading is not permitted
ii	Bus Voltage	0.9 p.u - 1.1 p.u.
iii	Frequency	To remain between 49 Hz and 52 Hz

4.8.3 For testing the network, the following contingencies are proposed to be applied (see table 4.8).

Table 4.8: Test contingencies for planning purposes - EdL

Normal Contingencies

No.	Item	Criteria
i	No fault loss	Loss of the largest generating unit
ii	Single element outage (N-1)	Three phase fault for 7.5 cycles (150 ms) followed by a loss of a single-circuit transmission element or a generator
iii	Single element outage (N-2)	Three phase fault for 7.5 cycles (150 ms) followed by a loss of a double-circuit transmission lines. If too restrict, apply two simultaneous single phase fault in different circuits.

Extreme Contingencies

No.	Item	Criteria
i	Loss of Bus-section	Single phase-to-ground fault 12.5 cycles (250 ms) followed by the loss of entire bus section
ii	Stuck Breaker	Single phase-to-ground fault 12.5 cycles (250 ms) with stuck breaker in loss of two transmission elements
iii	Loss of Bus	No fault loss of an entire bus
iii	Loss of Right-of-Way	Three phase fault for 7.5 cycles (150 ms) followed by the loss of Right-of-Way

4.9 Vietnam

4.9.1 Vietnam has established power sector development policies comprising of the following guiding principles:

- 1) Power Development Plan for 10 years planning with outlook to next 10 years is carried out by 5 year period. The 6th PDP (2006 - 2015 with outlook to 2025) will start in September 2004).
- 2) The policies of the 5th PDP are:
 - a. Meet the power demand of all customers with ever higher quality and better services;
 - b. Diversify types of power sources;
 - c. Co-operate with GMS and ASEAN countries to promote the establishment regional interconnected power network;
 - d. Use advanced technologies, that cause less negative environmental impact;
 - e. Develop, synchronically, transmission and distribution network with power generation;
 - f. Research possibility of application of Nuclear Power Plant in late years of period 2010-2020.

4.9.2 The following measures have been identified to be able to achieve the policies:

- 1) Power development program needs a large investment (about 1.5 - 2 bill USD/annually), therefore the measures of mobilizing investment from public sectors must be promoted;
 - Equitize of companies;
 - Encourage IPP, BOT, BTO, BT forms of investment;
 - Promulgate the Electricity Law and other related decrees;
- 2) Restructure power sector, split the generation, the transmission and the distribution parts independently from one another to strengthen the competitiveness and effectiveness

4.9.3 Generation planning is carried out using the following criteria:

- 1) Reserve margin to be maintained to $\geq 20\%$ during dry season;
- 2) LOLP to be applied is 0.00274 (~ 24 hours/year);
- 3) System losses of 12.9% in 2003 to gradually reduced to 7 - 8% by year 2020;
- 4) Generation Optimum Solution is carried out using WASP III and to gradually move to another package, STRATEGIST.

4.9.4 Current generation mix by regions is:

- 1) Northern System: Hydropower and Coal-fired
- 2) Centre System: Hydropower and CCGT;
- 3) Southern System: Gas-fired, Oil-fired, Coal fired and hydropower

4.9.5 With respect to transmission planning, the following basic criteria are used:

- 1) Voltages at 500kV, 220kV during normal condition to be maintained $\pm 5\%$;
- 2) Frequency under normal condition to be maintained to 50Hz (± 0.5);
- 3) For Reliability criteria
 - (N-1) contingency is generally applied throughout; and
 - (N-2) contingency applied in planning to large load Centers.

4.10 Malaysia

4.10.1 The current criteria for generation margin assessment used by TNB are based on a loss of load expectation (LOLE) of 1 day/year. This means that the peak load may not be fully met for some 1440 cumulative minutes of peak load operation in a year. This does not mean that the total peak load may not be met. It actually means that the calculation process employed will register every minute of system operation even if the peak load was not met by 1MW.

4.10.2 TNB takes into consideration two generation margins as defined below and illustrated in figure 4.5.

- (a) The Total Capacity Margin is defined as the amount of installed generation and interconnection capacities available over and above system peak load.
- (b) Operational Capacity Margin is defined as the amount of installed generation and interconnection capacities available over and above system peak load fully taking into account generation and interconnection plant maintenance, forced outages and planned outages over a specific operating period.

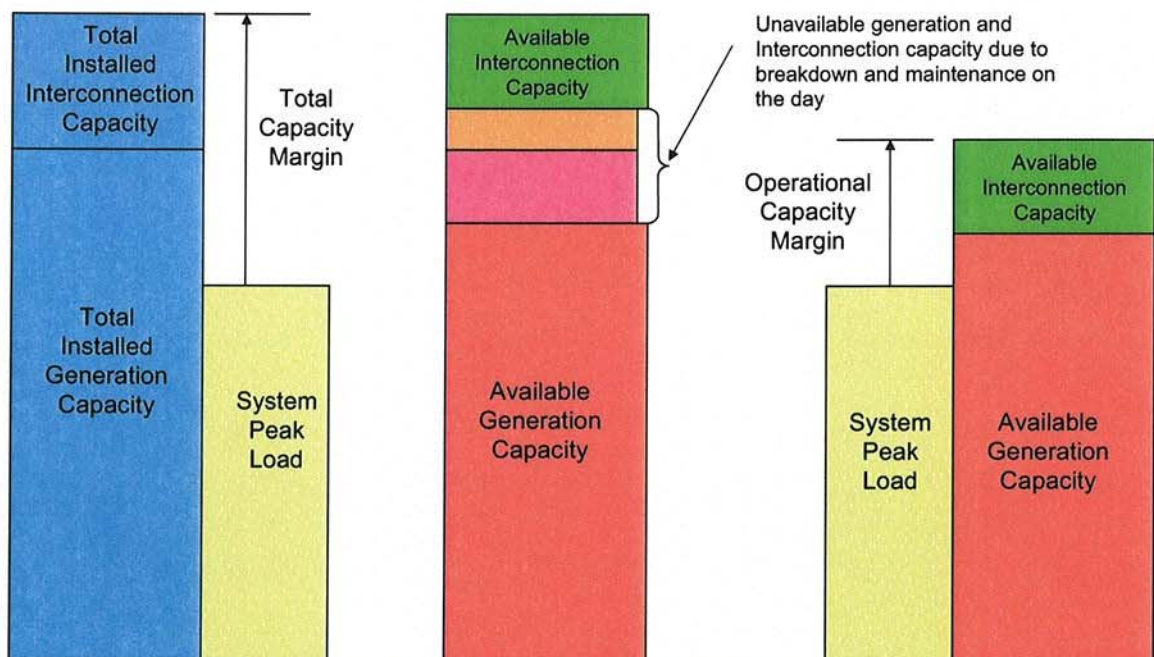


Figure 4.5: Concept of Total & Operational Capacity Margin as applied by TNB

4.10.3 The longer term development of the Peninsular Malaysia transmission system is carried out by the Grid System Planning Section of the System Planning and Development Unit of the System Planning Department of TNB. There is a comprehensive "Transmission Network Planning Manual" prepared in April 1998 which describes the:

- a) Structure and major components of the TNB power system;
- b) Essential planning activities for the transmission and sub-transmission systems;
- c) Planning standards, standard substation layouts and protection provisions;
- d) Contingency Analysis and methodology; and
- e) Economic analysis of system development options.

The manual also includes fault statistics for the 275, 132 and 66kV systems.

4.10.4 TNB has also established a document entitled "TNB Operational and Planning Security Standards" dated July 1998 that includes:

- 1) System Operating States and Contingencies;
- 2) System Planning Criteria - Grid System;
- 3) Voltage Support and Reactive Power;
- 4) System performance Standards;
- 5) Generator Specifications;
- 6) Frequency Control Standard;
- 7) Overloading of Transmission Equipment;
- 8) Recorders.
- 9) System Modelling Data Requirements;
- 10) System protection and Control;
- 11) Transmission protection System;
- 12) Under frequency Load Shedding;
- 13) Under Voltage Load Shedding;
- 14) Transmission Control Devices.
- 15) System Restoration;
- 16) Static (Steady-State) Analysis Data;
- 17) Machine Data Required in System Studies.

The document examines credible and non-credible fault and outage conditions in detail and sets out the performance objectives for the planned system.

4.10.5 The transmission planning process currently uses the following security criteria for system development and transmission investment purposes:

- 1) For the 500kV system (n-1) contingencies only are considered;
- 2) For parts of 275kV system in the loop (n-2) contingencies are considered;
- 3) For radial parts of 275kV system only (n-1) contingencies are considered.

All above contingencies are considered based on 3 phase fault cleared in 150milli-seconds.

4.10.6 The present long term planning criteria as applied by TNB is an order of magnitude more severe than that applied by an average international utility in that:

- (n-2) outages are considered as appropriate to the actual operating practice and reality of the Malaysian system and supported by fault statistics; and
- the 150 millisecond fault clearance time is some 50% larger than the usual 80-100millisecond fault clearance time actually obtained in practice.

This means that a considerable degree of robustness is introduced at the system planning stage and through the subsequent implementation of planned investments.

4.11 Contribution from the National Grid Company (NGC), UK on Planning Criteria (Year 2000)

4.11.1 With respect to 'survey on planning criteria', the first of the surveys was carried out in 1992 by CIGRE[29] and compared data collected from 24 different countries/utilities. The second was a '10 country comparison' conducted in 1993 by NGC. In addition to the 10 countries selected for the NGC comparison, NGC have also had useful discussions with Scottish Power and Scottish Hydro Electric, which for convenience are reported under the '10 country comparison'. The third survey was taken from an Ontario Hydro Report[30], and is primarily related to trends in security thinking in North America.

4.11.2 The 1992 CIGRE survey considered data collected from the following 24 countries/utilities:

European (14)

Belgium/CPTE

Denmark/ELKRAFT

Finland/IMATRAN

France/EDF

Inst

Ireland/ESB

Italy/ENEL

Netherlands/DEGB

Norway/NWR&EA

Portugal/EDP

Romania/ICEMENERG

Slovenia/Milan Vidmar Elec

Spain/FECSA

Sweden/VATTENFALL

UK/NGC

Non-European (10)

Australia/SECV

Brazil/ELECTROBRAS

Canada/Ontario Hydro

China/EPP&EInst

CIS/Acad. of Sciences

Ivory Coast/CIdE

Japan/CRIEPI

Jordan/JEA

South Africa/ESKOM

USA/AEP

For the '10 country comparison', data was collected from the following 10 countries/utilities:

European (4)

France/EDF
Spain/RED Electrica

Germany/RWE
Italy/ENEL

Non-European (6)

Australia/SECV
Canada/Ontario Hydro
Japan/Chubu EPCo

New Zealand/TRANSPower
South Africa/ESKOM
USA/AEP

- 4.11.3 **System Performance.** Against a wide range of international utilities, NGC's disturbance performance (ie. loss of supply) is better than average and about average when compared with those utilities which are most like NGC (see Appendix B). Comparison of transmission system performance in terms of investment and operational costs could not be undertaken as data availability was limited by its commercial sensitivity.
- 4.11.4 **Operational Security Standards.** NGC's existing operational security standards have many features in common with those of comparable utilities. For example, they are deterministic, usually consider N'-D events, where possible exploit equipment short-term ratings and require the ability to control generation to avoid significant consequences, particularly instability and system splits.
- 4.11.5 Another common feature of the operating standards of NGC and those of other utilities, is the flexibility to relax the operational security level from N'-D to N'-1 in order to avoid excessive costs. The NGC standard does not allow this relaxation if the N'-D outage would result in instability or excessive voltage or frequency variations.
- 4.11.6 Many other measures taken to maximise operational performance and economy fall outside the operational security criteria. These include the coordination of generation and transmission outages, the use of demand side measures, generator intertripping and 'disaster scenario' planning. Most of these also feature in NGC's activities, although the first is of course easier to achieve in a utility which owns both the generation and the transmission.
- 4.11.7 The weather related cost-benefit operational security standard identified as Alternative 3 in Chapter 4 introduces a procedure for deciding in which areas and under which weather conditions the security level should be relaxed from N'-D to N'-1. Examination of international practice suggests that although NGC would be unusual in having such measures

formalised in its operational criteria, a few utilities have adopted and many are interested in adopting some form of probabilistic standards. The Scottish companies are using and Italy is actively considering the introduction of meteorological data into operational security assessments.

4.11.8 **Planning and Security Standards**. NGC's existing planning standards also share many features of the standards commonly used in other utilities.

4.11.9 Use of N-2 is by no means exceptional worldwide. It is also important to note that NGC's N-2 criterion may provide a level of security similar to that in utilities which use an N-1 criterion but which first deplete their networks by assuming the removal of circuits before applying the security test. All utilities allow an element of judgement by system planners bringing possible relaxation into a strict N-2 test.

4.11.10 NGC's existing voltage and stability criteria are also very similar to those currently used by almost all utilities. In particular, three phase faults, even though rare, are used by almost all utilities worldwide as a test in stability analyses.

4.11.11 Deterministic planning criteria, similar to NGC's existing standards, are again used by most utilities. However, there is evidence of an increasing interest and movement towards probabilistic criteria, particularly among utilities most like NGC. If NGC were to adopt the cost-benefit standards identified, it would not be alone because the three utilities in France, Spain and Italy already use probabilistic techniques in transmission planning. Several others use such techniques to supplement deterministic techniques.

4.11.12 Other findings include:-

- on customer choice, four of the ten countries approached in NGC's '10 country comparison' agree levels of connection performance with customers. Of these, three will permit connections to be below an accepted normal level. To date no degradation in overall system performance has been seen as a result.
- on generator connections, most utilities seek to achieve high availability and operational flexibility in the connection of main generation to their system by the use of double busbar substations. However, other designs such as 1½ and 1⅓ switch arrangements are also used. The criteria, used by many utilities to determine the number of circuits for generating station to system connection, are consistent with the normal level of connection criteria.

- four of the ten countries in NGC's '10 country comparison' consider the intertripping of demand as a means of deferring capital investment. Five of the ten countries consider the intertripping of generation. Those countries which consider demand intertripping also consider the value of lost load in transmission investment planning.
- The value assigned to lost load, or unserved energy, varies between US\$0.7/kWh (for domestic load in Australia) to US\$10 (for commercial load in Australia). However, the 1992 CIGRE survey shows that Australia, Canada, France, Italy, South Africa and Spain use values in the range US\$1.5-6 but only for generation planning. The value of £2.345 presently used in England and Wales falls within this range at around US\$1.52 (at £1 = US\$1.54).
- The North America survey which is based upon information received from six Canadian utilities, twenty one USA utilities and two USA Power Pools, is as indicated, related to trends in security standards thinking rather than a comparison of existing standards.
- In essence the allocation of costs and benefits is seen as an issue of prime importance now and in the future in North America. Using appropriate methods for determining the cost-benefit of transmission capacity and I^2R losses are chief amongst the concerns. For example, Ontario Hydro hold the view that current methods are not entirely satisfactory and that reassessment and examination of other approaches is required.

4.11.13 **Conclusions.** All the countries/utilities considered use deterministic techniques for some or all of their operational and planning criteria. The deterministic planning and operating standards presently used by NGC share many of the features and are not considered out of step with those used by the other utilities. There is however evidence in current thinking of a trend towards the use of probabilistic techniques. Several overseas utilities currently supplement 'baseline' deterministic planning standards with risk-based economic assessments and some have implemented probabilistic planning standards. Some utilities are using or considering adopting weather related operational standards and many actively relax their N'-D operational security level where higher costs are not considered justified by an increased risk.

4.12 Summary of Planning and Design Criteria

4.12.1 Table 4.9 summarises generation planning criteria as applied in the ASEAN countries. All countries using LOLP have applied 24 hours/year as the criteria. In terms of reserve margin Thailand is maintaining a figure of not less than 15% while Malaysia and Indonesia are keeping to around 30%. Lao PDR is maintaining reserve margin to not less than 15% with their 100% hydro resources. Vietnam is maintaining reserve margin to about 20%.

Table 4.9: Summary of generation planning criteria in ASEAN countries

No	Country	Loss of Units	LOLP Hours/year	Reserve Margin %	Fuel Mix Policy	RE Policy
1	Brunei	Y				
2	Cambodia	Y		> 15%		
3	Indonesia		24	28% - 33%	Y	
4	The Philippines					
5	Singapore					
6	Thailand		24	> 15%	Y	Y
7	Lao PDR		24	> 10%	100% hydro	
8	Vietnam		24	> 20%	Y	
9	Malaysia		24	25% - 30%	Y	Y

4.12.2 Table 4.10 summarises main parameters of transmission planning criteria applied by countries in ASEAN. All countries are using deterministic criteria. Only Thailand is now mandated to perform reliability criteria to justify investment. Also EGAT has established voltage stability criteria. Malaysia applies (N-2) contingency extensively in the network while Vietnam applies (N-2) for supplies to large load areas.

Table 4.10: Summary of transmission planning criteria in ASEAN countries

No	Country	N-1	N-2	Voltage Stability	Reliability Evaluation	Voltage*	Frequency Normal
1	Brunei	Y				±5% -----	
2	Cambodia	Y				+2%, -5%	
3	Indonesia	Y				±5% -----	50±0.5Hz
4	The Philippines	Y				±5% ±10%	
5	Singapore	Y					
6	Thailand	Y		Y	Y		
7	Lao PDR	Y				±5% ±10%	
8	Vietnam	Y	Y			±5% -----	50±0.5Hz
9	Malaysia	Y	Y			±5% ±10%	50±0.25Hz

*Normal & contingency

Chapter 5: Planning Approaches, Methods and Results

5.1 Introduction

5.1.1 This chapter summarises planning approaches and methods used by each participating country. The focus is to describe briefly the process and procedures involved in carrying out both generation and transmission planning.

5.1.2 Issues/items to be discussed include the followings:

Coordination of Planning

- Approach to coordinate planning among various players;
- Roles of the various entities/players and a coordinating body;
- Roles of government, regulators and independent grid operators, market forces;

Roles of Interconnections

- Planning approach to sharing of energy resources;
- Coordination of interconnection planning;

Environmental Issues

- List of environmental issues;
- Meeting environmental regulation in planning;

General Grid System Planning

- Planning process and procedures;
- Planning cycles;
- Planning reports;

5.2 Brunei Darussalam

5.2.1 Brunei DES performs annual review of network performance and load forecast before generation and network planning process begins. The plan is dominated by requirements to meet load demand as well as to review the need to implement the current master plan. Since the system is relatively small simulation tool is not applied as planning aid.

5.2.2 The DES has established long term generation and transmission plan including interconnection with Malaysia. The existing network as shown in figure 5.1 will be gradually developed the one as shown in figure 5.2.

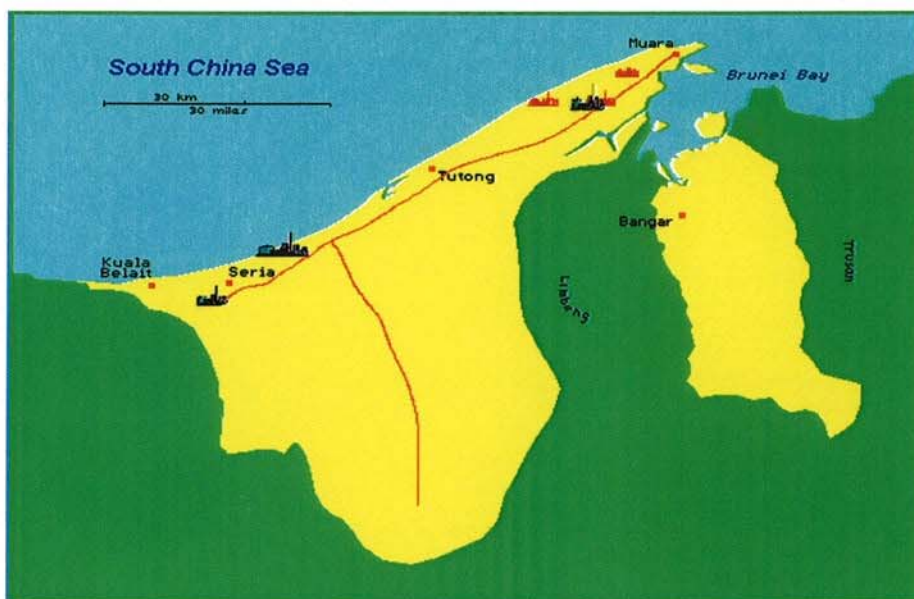


Figure 5.1: Brunei - existing system, 2004

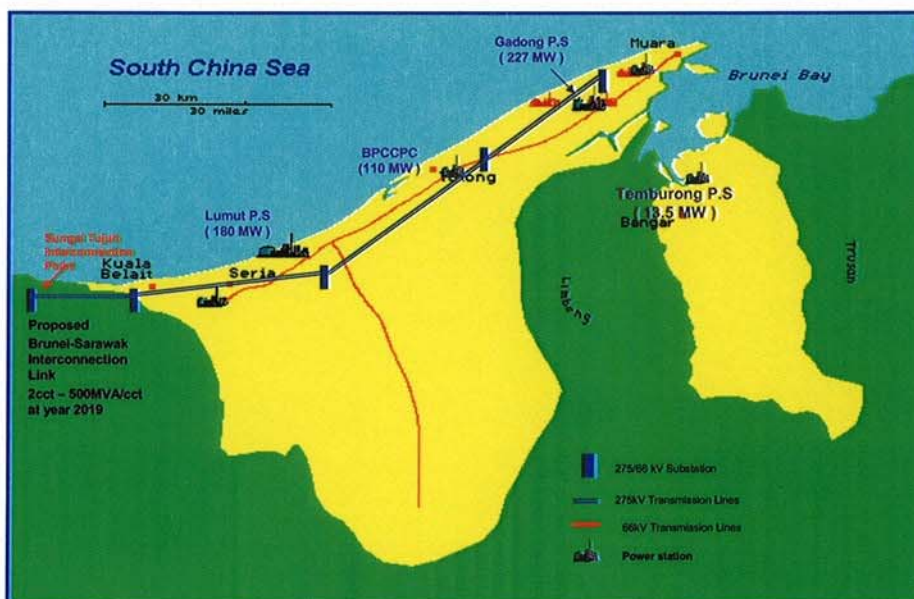


Figure 5.2: Brunei - transmission system for future development

5.3 Cambodia

5.3.1 The planning approach adopted by EdC is based on establishing a master plan for development of generation and transmission. This master plan is continuously reviewed by EdC as well as through with the assistance of lending agencies such the World Bank and Japanese Government through JAICA. Cambodia has already established long-term generation development plan with the following alternative energy resources:

- 1) Hydroelectricity: 10,000 MW in northern and 1,000 MW in southern of Cambodia.
- 2) Gas: There are prospect of gas field in the off-shore of Cambodia.
- 3) Coal: Import.
- 4) Import from Neighboring countries (GMS/ASEAN Grid)
- 5) Renewable: Bio-mass, Solar PV, Minihydro/Pikohydro.
- 6) Diesel: Isolated rural
- 7) Transmission/Interconnection: 22 kV, 35 kV, 115 kV, 230 kV

5.3.2 For the period 2003 - 2008, EdC has established the following generation development plans:

- 1) Install 90MW Generating Plant in Phnom Penh
- 2) Japanese Grant Aid 10MW HFO Plant in Siem Reap with a commissioning date in 2005.
- 3) Development of Kirirom 3 (18 MW)
- 4) Kamchay Hydropower Plant 120 MW connecting to the National Grid expected to be commissioned in 2008.
- 5) Develop 90MW Thermal Power Plant in Sihanoukville

Identified transmission development plan for the period 2003 - 2008 are:

- 1) Construct the Southern and Western Grid of Cambodia
- 2) Interconnection with Viet Nam (Southern Grid): PPA with EVN was signed
- 3) Interconnection with Thailand (North-Western): PPA with THL was signed

Figure 5.3 indicates the development plan for period 2003 - 2008.

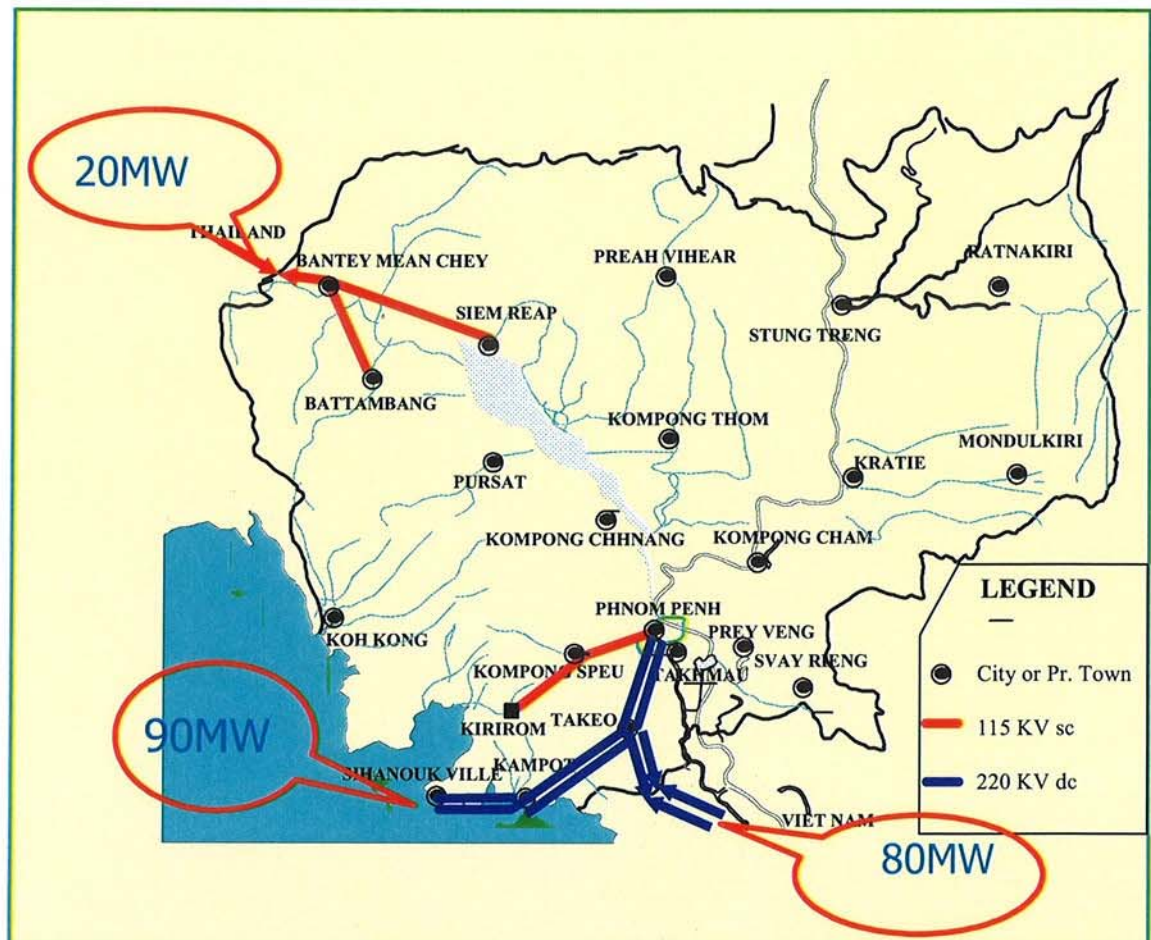


Figure 5.3: EdC development plan, 2003 – 2008

5.3.3 EdC has also established a long term development plan that covers the period 2009 – 2014. Under this plan the following features have been identified:

▪ Generation:

- o Increase supply power via southern and western grid to cover the growing peak demand in Phnom Penh.
- o Construct the Stung Attay, Battambang Hydro Power Stations.
- o Second stage of 90 MW CC Plant in Sihanoukville

▪ Transmission:

- o Construction transmission line linking western and southern grid

Figure 5.4 shows the indicative development plan for EdC between 2009 and 2014.

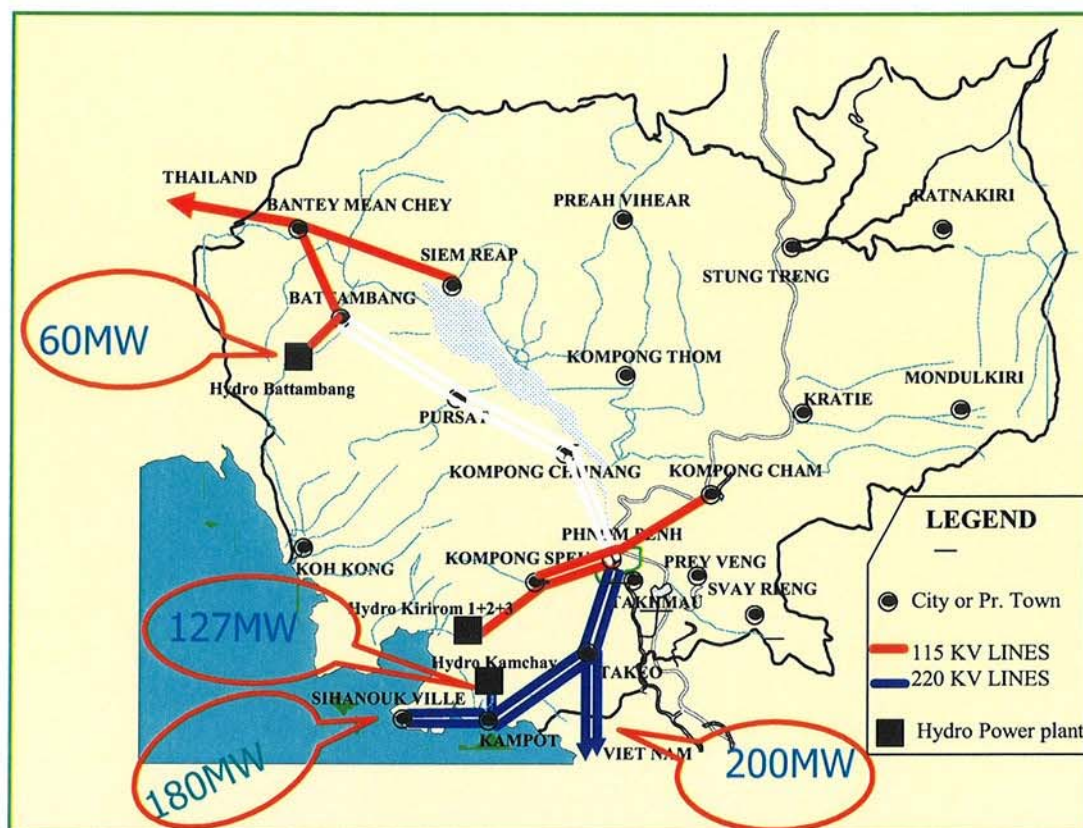


Figure 5.4: EdC development plan, 2009 – 2014

5.3.4 A longer term indicative development plan has also been established by EdC taking advantage of the country's geographical position in the Greater Mekong Subregion (GMS) for interconnections to three neighbouring countries of Thailand, Lao PDR and Cambodia. The indicative plan for Cambodia up to year 2020 is shown in figure 5.5.

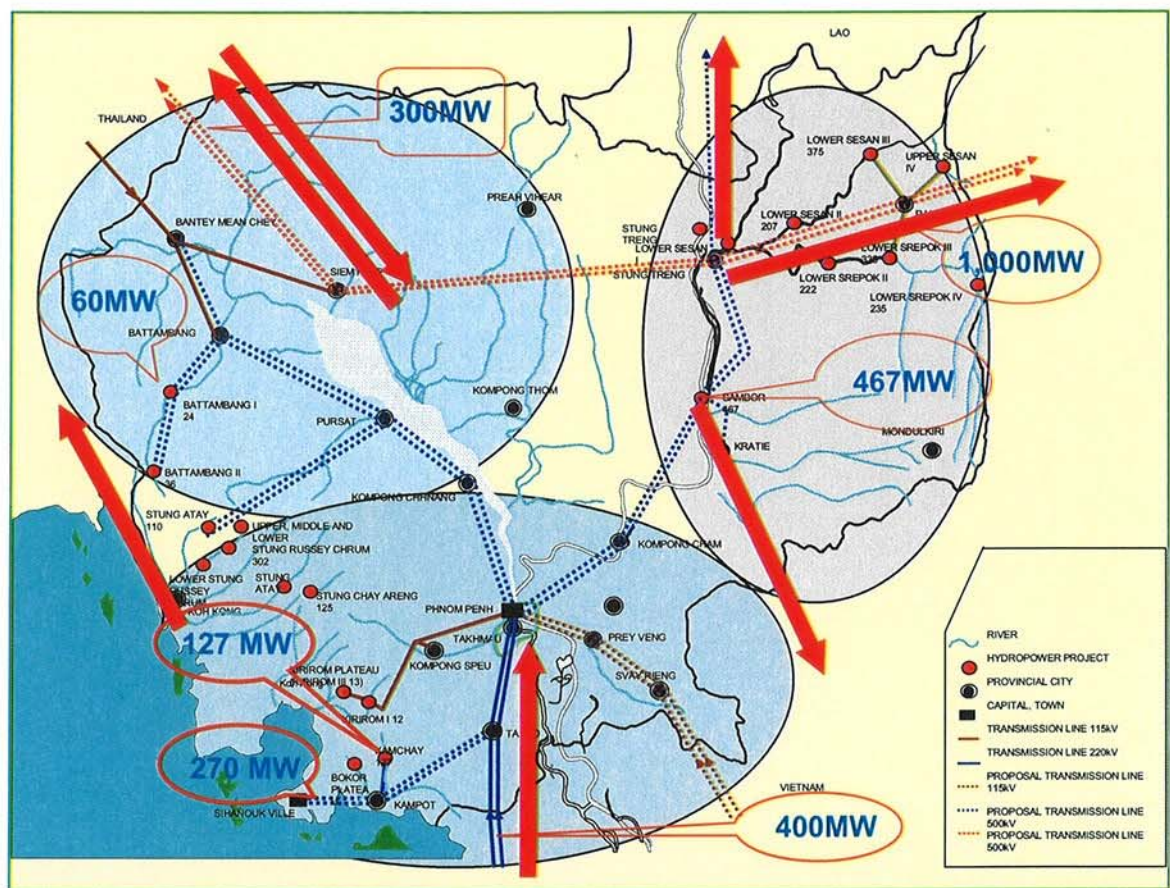


Figure 5.5: EdC indicative development plan, 2015 – 2020

5.4 Indonesia

5.4.1 In Indonesia planning are carried at various levels and coordinated centrally. Each regional authority or provincial government prepare and publish their General Plan of Regional Electricity (GPRE). Based on the GPRE and other inputs from the regional communities, the Central Government prepares and publishes General Plan of National Electricity (GPNE). At electricity industry players' levels, in the so called competitive region (e.g Java-Bali), the system operator (SO) prepares and publishes Development Plan of its power system with reference to GPNE. While in the non-competitive region, the respective utility must prepare and publish Development Plan of its region based on its GPRE and GPNE.

5.4.2 Since Indonesia is a large country comprising of many islands and provinces, interconnection would be an important aspects of electricity supply industry development. Therefore, the country has established planning approaches with respect to development of interconnection:

- For interconnection between islands: the approach where appropriate to start with AC Link first, and to evolve to DC Link later.
- For a wide straits (≥ 5 km), the benefit of AC Link is limited to fuel saving and more flexibility in power generation. Later on, DC Link will be developed in connection with the development of cheap indigenous fuel resources in one of the island.
- Example: Interconnection between Java and Sumatra, AC Link is planned for year 2008 and DC Link in 2010.
- For a narrow strait (≤ 5 km), the AC Link could be seabed cable for small power transfer or overhead (EHV) for large power transfer.

PLN Head office is the coordinator for the planning.

5.4.3 For interconnection between regions in one island outside Java-Bali, for example, Sumatra where typical power systems would cover large areas but with low demand. For these interconnections, the main benefits are limited to fuel saving and more flexibility in power generation. An example of this situation is interconnections between Southern and Northern Sumatra, where there are 3 major load centers with distance between them in the order of 500 km and load demand of 1000 MW each. Regional planning and interconnections is coordinated through a Regional Planning Forum that meets twice a year.

5.4.4 Transmission grid planning for the Java-Madura-Bali Interconnected System is carried out by PLN P3B a division of PLN that also operates the network. The grid planning procedure is carried out in several steps as shown in figure 5.6.

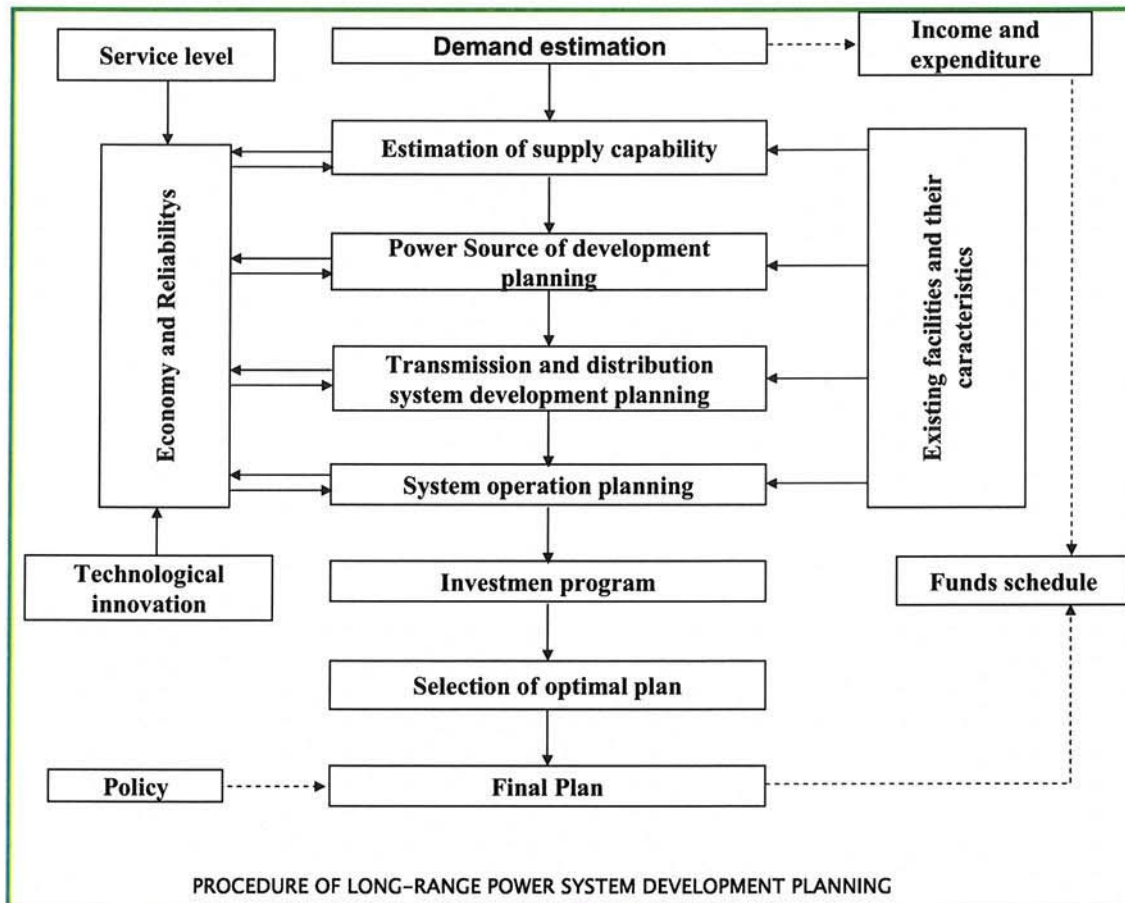


Figure 5.6: PLN P3B Long-term Planning Procedure

5.4.5 Referring to figure 5.6, the grid planning process starts after the establishment of the approved demand estimation or forecast. The demand estimation is not only serving as input to network planning but also for forecasting of revenue that will be used to establish appropriate capital and operational funding requirements and budgets.

5.4.6 The initial activity is to estimate or assess the capability of the existing and previously planned network (Estimation of supply capability) to cater for new demand forecast. The procedure for making the assessment is part and parcel of 'transmission planning' that takes into consideration various factors/analysis (see figure 5.7) that will be described next.

5.4.7 With respect to voltage control, there are several attributes evaluated for making assessments:

- 1) Keeping of Suitable Voltage Level at each point (substation, customer etc.)
- 2) Balance of Reactive Power
- 3) Steady State in Power System to achieve Reduction of Transmission Losses
- 4) Countermeasure for correcting Voltage problems - Optional Planning of Phasa Modifying Equipment and Voltage Control Equipment including Capacitor, Reactor, Load ratio Adjuster and generator etc.

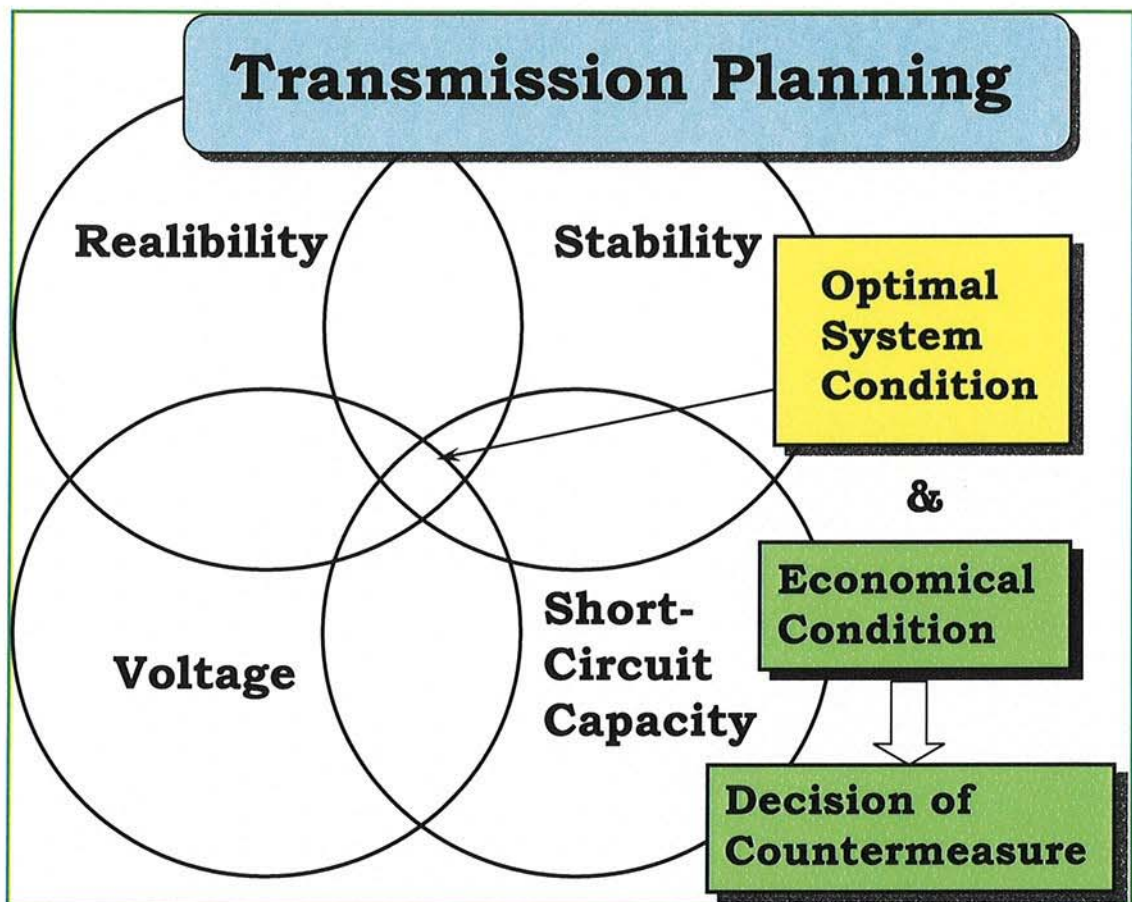


Figure 5.7: Transmission planning consideration

5.4.8 Issues related to short-circuit currents that are examined include:

- Equipment short-circuit capacity - evaluate possible damage to power equipment such as disconnecting switch, CT and Line etc.
- Trouble to communication line due to induced voltage
- Special attention to large scale and concentration of many power plant in an area

5.4.9 On the subject of Stability and Reliability in Power System, the following objectives and strategies are considered:

- Avoidance of Power Shortage
 - Reserve of Power Resources
- Reduction of Supply Interruption
 - Improvement of Device Reliability
 - Earlier Repair of Outage
- Keeping of Steady state of Power System
 - Keeping of Power Quality
 - Prevention of Chain Reaction of Fault

5.4.10 As indicated in figure 5.6, PLN takes into consideration operational problems in planning. As examples the present Java-Madura-Bali interconnected system is facing the following behaviour/issues:

- Power transfer is from the East to the West (see figure 5.8)
- Voltage quality degradation during peak periods
- Bottlenecks on 500/150kV interbus transformers with loading greater 90% for many substations.
- Bottlenecks on some transmission lines
- Overloading of distribution transformers

PLN uses voltage mapping to assist in identifying voltage problems in the system as shown in figure 5.9.

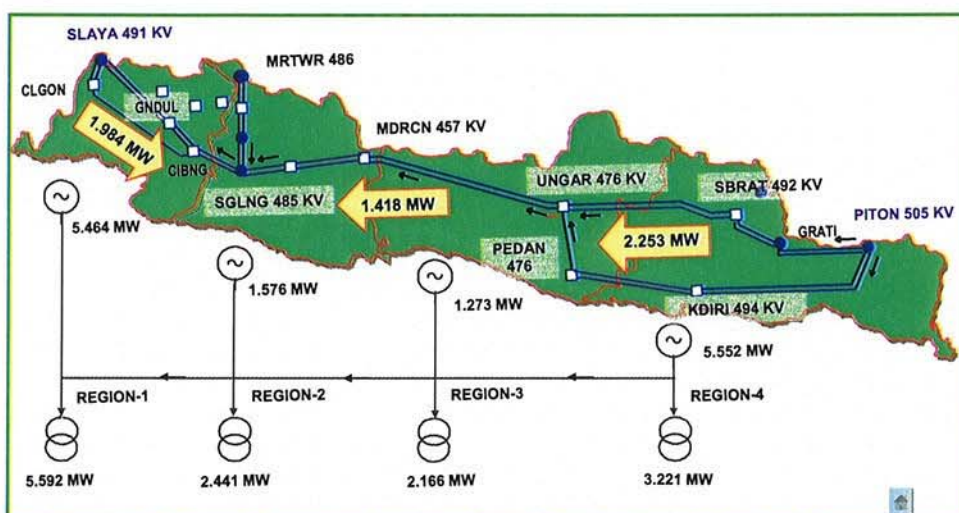


Figure 5.8: Power transfer East to West for Java-Madura-Bali System

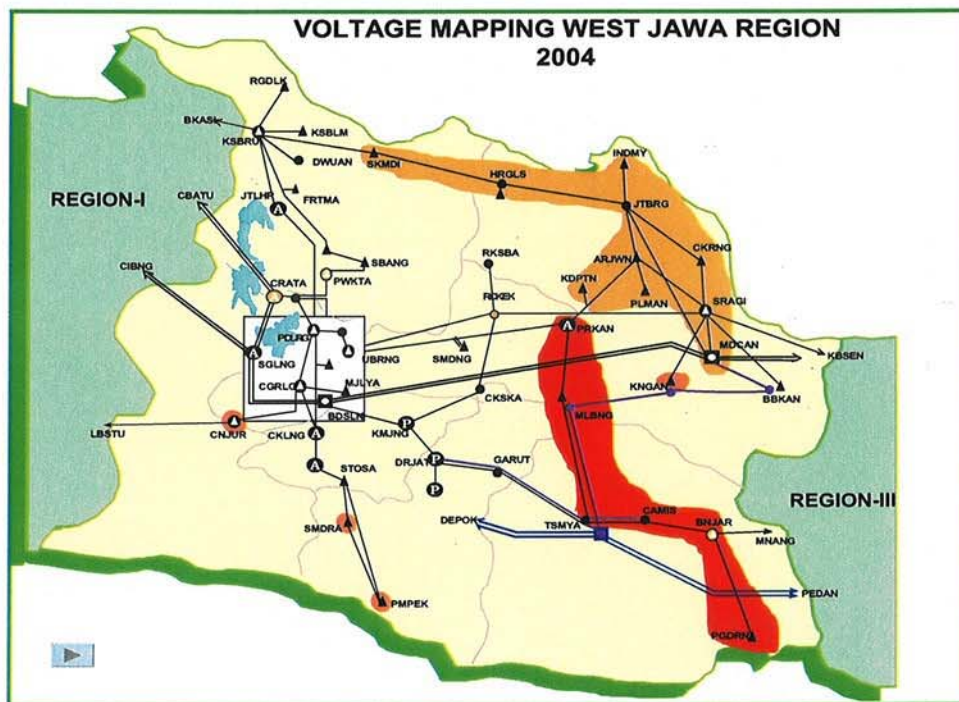


Figure 5.9: Voltage mapping of the network

5.5 The Philippines

5.5.1 Transmission system development process adopted by Transco of the Philippines is shown in figure 5.10 whose result is called Transmission Development Plan. A TDP is a documented plan, program or strategy that embodies the infrastructure projects necessary to meet customer demand and ensure the reliability, adequacy, and stability of the nationwide transmission system. The TDP is an integral part of the Power Development Program (PDP) and the Philippine Energy Plan (PEP) formulated by the Department of Energy (DOE).

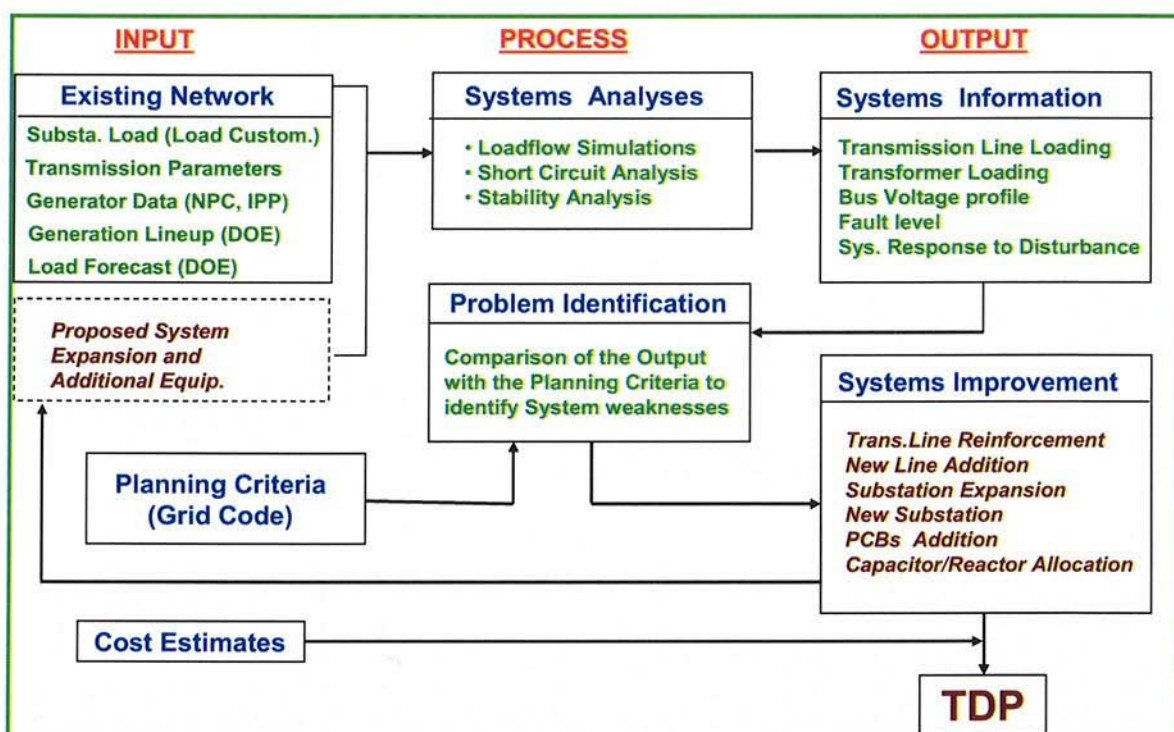


Figure 5.10: Transmission Development Plan process for Transco of the Philippines

5.5.2 Rehabilitation and expansion projects in the TDP are the bases for the capital expenditure program. The capital expenditure program is to be evaluated and approved by the Energy Regulatory Commission (ERC). Once approved, the TransCo can proceed with the capital expenditure program for which it earns a return in accordance with the Regulatory Guidelines.

5.6 Singapore

5.6.1 Singapore having a liberalized electricity industry derived inputs for planning from various industry players including:

- 1) System demand forecasts - by Energy Market Authority (EMA)
- 2) Generation planting schedule - by EMA
- 3) Generation investment - by Gencos, based on the planting schedule by the EMA
- 4) Area load forecast - by SP PowerGrid

5.6.2 There are also planning inputs from other authorities that have to be coordinated. These inputs are as follows:

- a) Master Planner (URA)
 - Land Use
 - Land Sale
 - Sites for Substations
 - Cable Installation
- b) Industrial Park Developers (JTC)
 - Industrial Development
 - Sites for Substations
- c) Major Industrial Developers (EDB)
 - Supply requirement
 - Timely provision of supply
- d) Housing Development Authority (HDB)
 - Housing Development programme
 - Sites for Substations
- e) Road Authority (LTA)
 - Road/ Bridge Construction/Extension
 - Cable Installation
- f) Mass Rapid Transit Authority (LTA)
 - MRT Extension
 - Cable Installations

5.6.3 Planning process adopted by SP PowerGrid of Singapore is divided into three main purposes/objectives:

- 1) FOR BULK POWER TRANSMISSION FROM POWER STATIONS:
 - TECHNICAL ANALYSIS
 - EXTENSION AND REINFORCEMENT OF TRANSMISSION SYSTEM
 - FINANCIAL EVALUATION
- 2) POWER TRANSMISSION TO MEET AREA/REGIONAL LOAD GROWTH:
 - LOAD FORECAST
 - TECHNICAL ANALYSIS
 - FINANCIAL EVALUATION
 - DEVELOPMENT OPTIONS
 - TRANSFER OF LOAD TO ADJACENT S/S WHERE THERE IS
 - SPARE CAPACITY
 - INSTALLATION OF ADDITIONAL T/Fs AT EXISTING S/S
 - NEW S/S TO TAKE OVER PART OF THE LOADS FROM EXISTING HIGHLY LOADED S/S

3) SYSTEM RENEWAL:

- LIFE EXPECTANCY --- 30YEARS
- A CONTINUED RENEWAL PROGRAMME IS DEvised TO ENSURE SYSTEM SECURITY AND RELIABILITY

5.6.4 Annually, SP PowewrGrid prepares and submits a Ten-Year Transmission Development Plan (based on results of area forecasts) together with costing details to EMA. The Regulator is then responsible to make assessment and approval of capital expenditure. Assessment of system security and reliability is however the responsibility of the PSO (Power System Operator).

5.6.5 Future development/strategies in network planning include:

- Improvement in asset utilisation
- Review criteria for renewal of old assets
- Application of new technologies

While the challenges ahead facing SP PowerGrid and Singapore transmission system include:

- Commercially driven dynamic market
- Power quality needs
- Land for substation development
- Space for transmission cables
- Stringent authority requirements

5.7 Thailand

5.7.1 Generation planning is performed at EGAT based on Least Cost Analysis using dynamic programming to achieve two main objectives:

- Loss of load probability (LOLP) of 1day/year; and
- Reserve margin of not less than 15%

5.7.2 For the least cost analysis, the followings are objective functions to be minimized:

- Capital investment costs
- Salvage value of the investment costs
- Fuel costs
- Fuel inventory costs
- Non-fuel operation and maintenance costs
- Cost of energy not served
- Costs of purchased energy and demand

5.7.3 The dynamic programming is carried out using "NewEnergy Associates Strategist (Version 3.1.4)" whose principle is illustrated in figure 5.11. The result of generation planning study is the Power Development Plan. Figure 5.12 show the PDP for 2004.

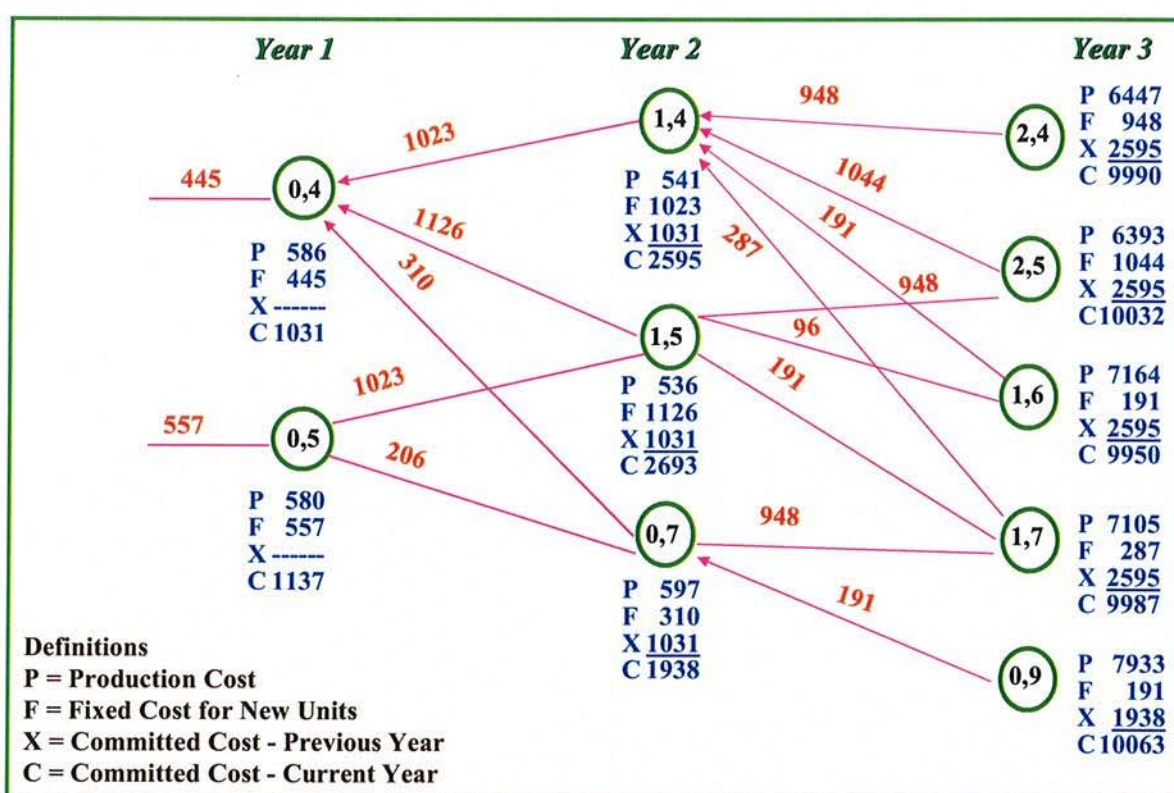


Figure 5.11: Dynamic programming principle for generation expansion planning

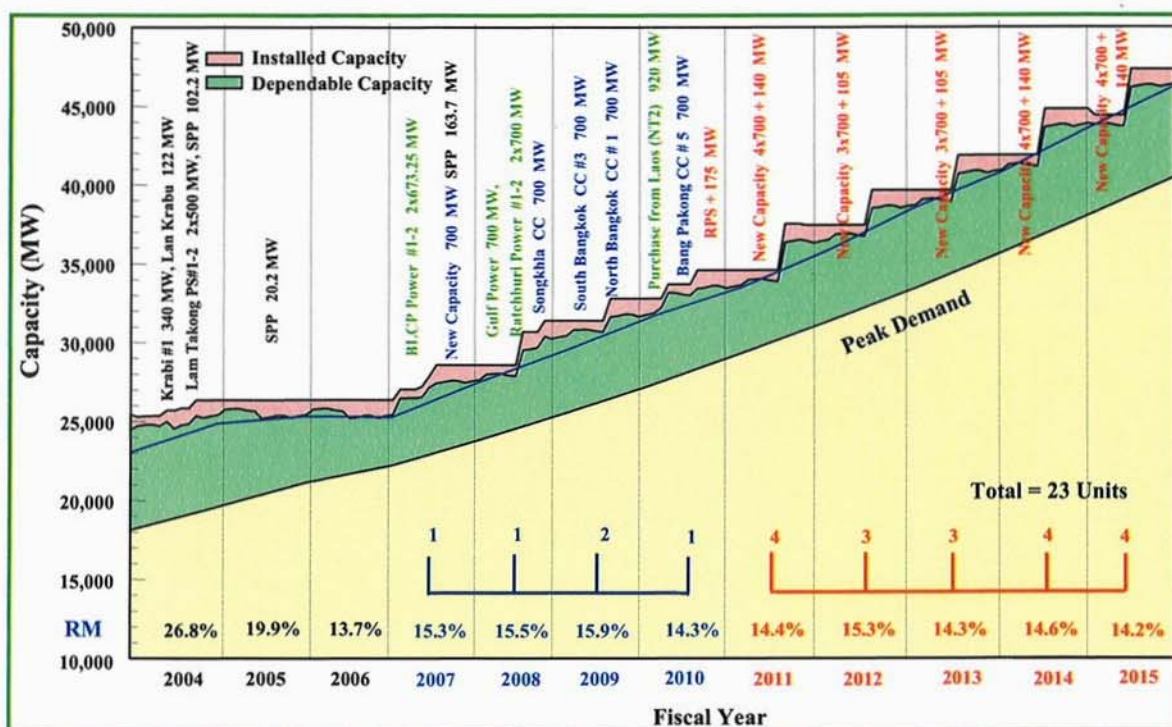


Figure 5.12: PDP for Thailand - Year 2004

5.7.4 Transmission planning in EGAT is performed in accordance with planning cycle and process as shown in figure 5.12. Following approval of the National Load Forecast by the TLFS (Thailand Load Forecast Subcommittee), the transmission planning cycle begins with the review of Power Development Plan (PDP) as established by Generation Planning.

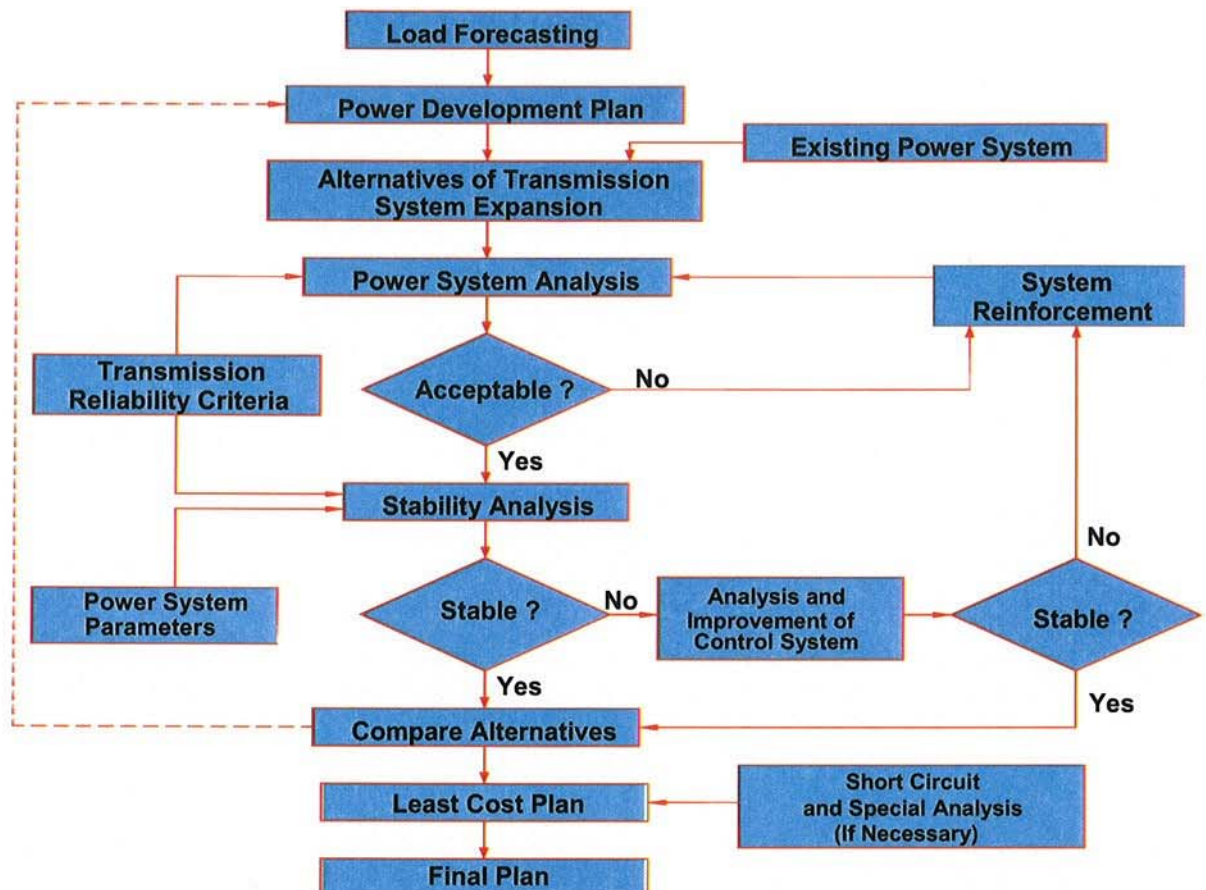


Figure 5.13: Transmission Planning Cycle & Process for EGAT

5.7.5 Alternative transmission system expansion plans are established through iterative use of power system analysis tools to check and apply planning criteria. System reinforcements are carried out to satisfy the planning criteria and these are usually recognized during steady state analysis including reliability. EGAT's experience indicates that power stability could normally be maintained to within criteria requirements using control measures.

5.7.6 Those options that satisfy planning criteria would then be costed and least cost plan established. Special analysis including short-circuit would only be carried out on the least cost plan.

5.8 Lao PDR

5.8.1 Lao PDR having vast hydro resources depends on export of electricity as significant portion of foreign exchange earnings. Therefore, Lao PDR in their planning will continue to promote sharing of energy resources and coordination of interconnection planning with the rest of ASEAN countries particularly that of GMS (Greater Mekong Subregion).

5.8.2 Transmission planning process carried out by EdL of Lao PDR is as shown in figure 5.14. Following establishment of load forecast two tasks are carried out:

- 1) Power development program - generation expansion; and
 - 2) Disaggregation of the load forecast to various substations.
- Planning is carried out by examining the power system diagram of the whole country from the existing Master Plan and identifies lines and substations that may need to be established to meet demand and export requirements. System analysis is then carried out including optimization - least cost analysis. System analysis is carried out using the procedure as shown in figure 5.15.

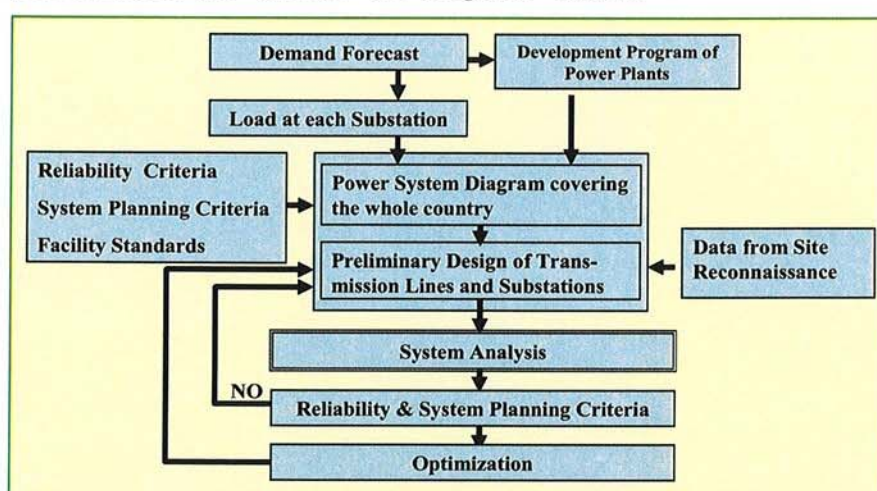


Figure 5.14: Lao PDR Transmission Planning Process

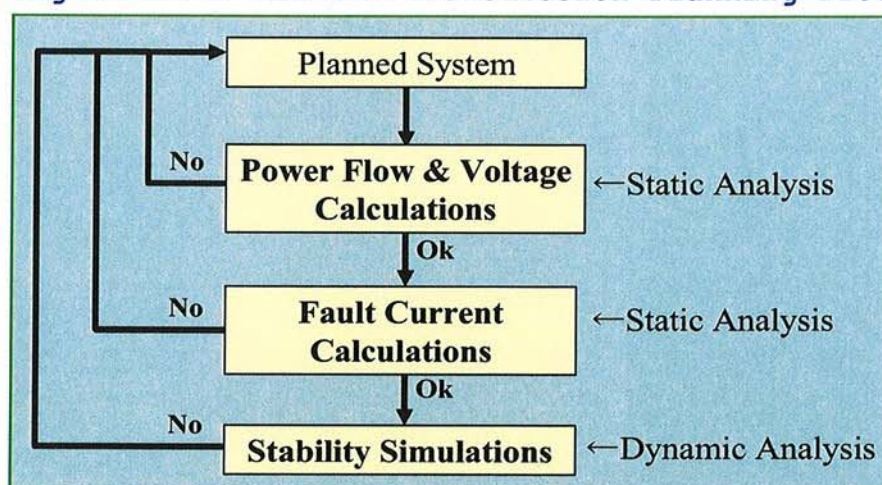


Figure 5.15: System analysis procedure

5.9 Vietnam

5.9.1 EVN of Vietnam performs both generation and transmission planning following establishment of annual load forecast. Based on the 2004 planning exercises various generation and transmission development have been identified. Figure 5.16 shows the generation fuel mix up to year 2020. It must be noted that among the ASEAN countries only Vietnam is considering nuclear option. Both Indonesia and The Philippines have put on hold the nuclear option.

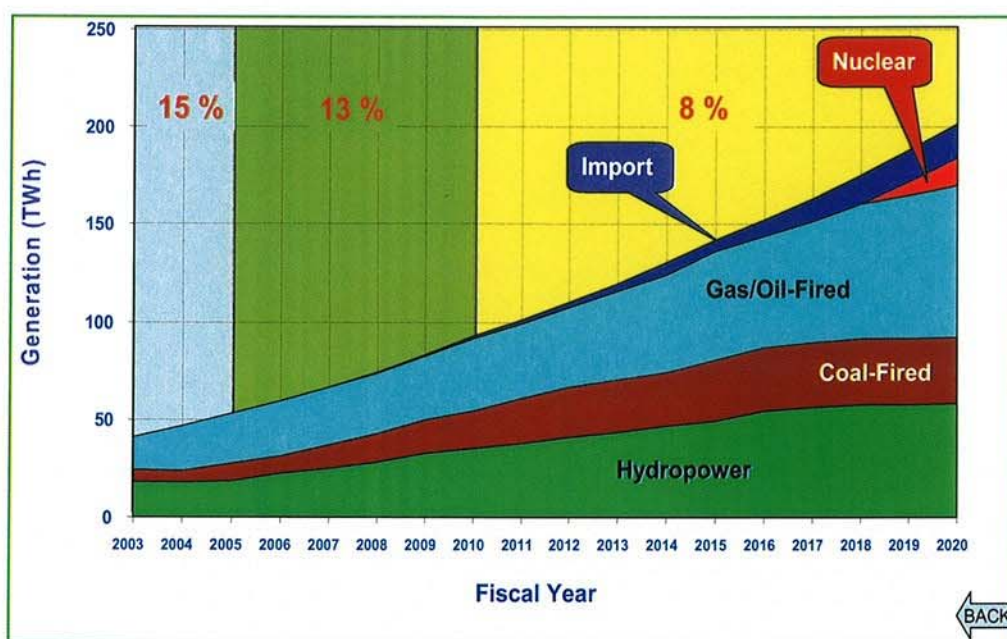


Figure 5.16: Vietnam generation mix up to year 2020

5.9.2 The corresponding capacity addition up to year 2020 is shown in figure 5.17. It is noted that the capacity will be doubled by 2010 and quadrupled by 2020.

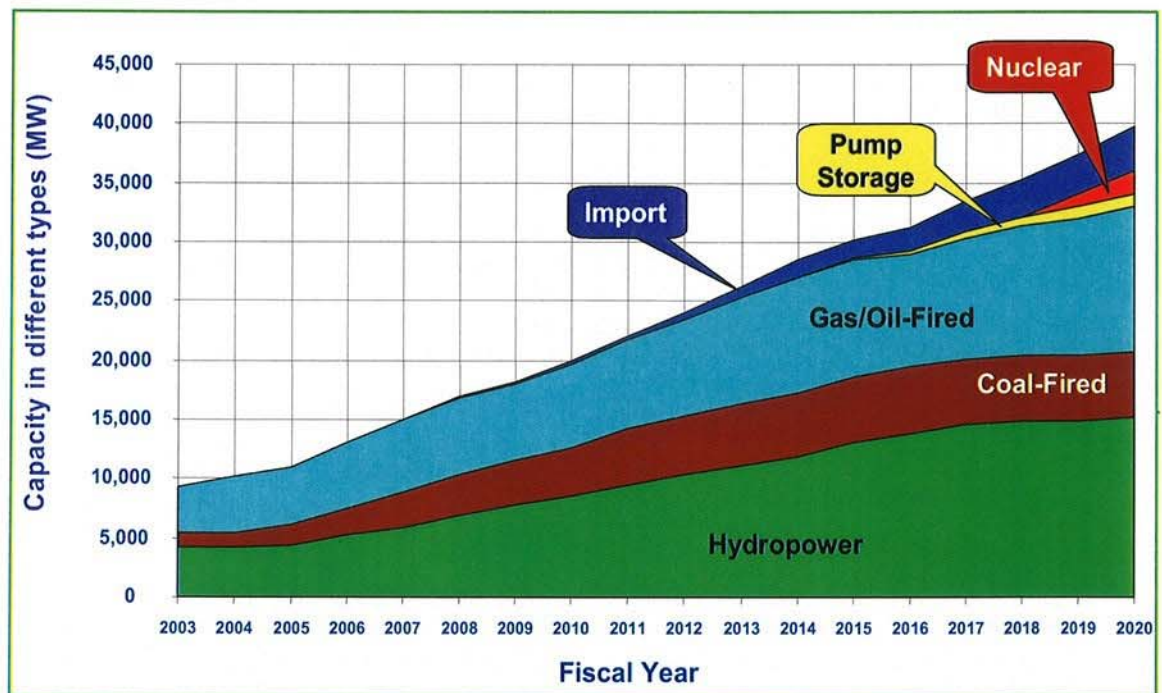


Figure 5.17: Capacity addition up to year 2020 for Vietnam

5.9.3 The transmission grid developments that have been identified up to year 2020 are indicated in figure 5.18. Two interconnections with Lao PDR and one each with Cambodia and China are also being planned. Detailed proposed interconnections with Lao PDR and Cambodia are shown in figure 5.19.

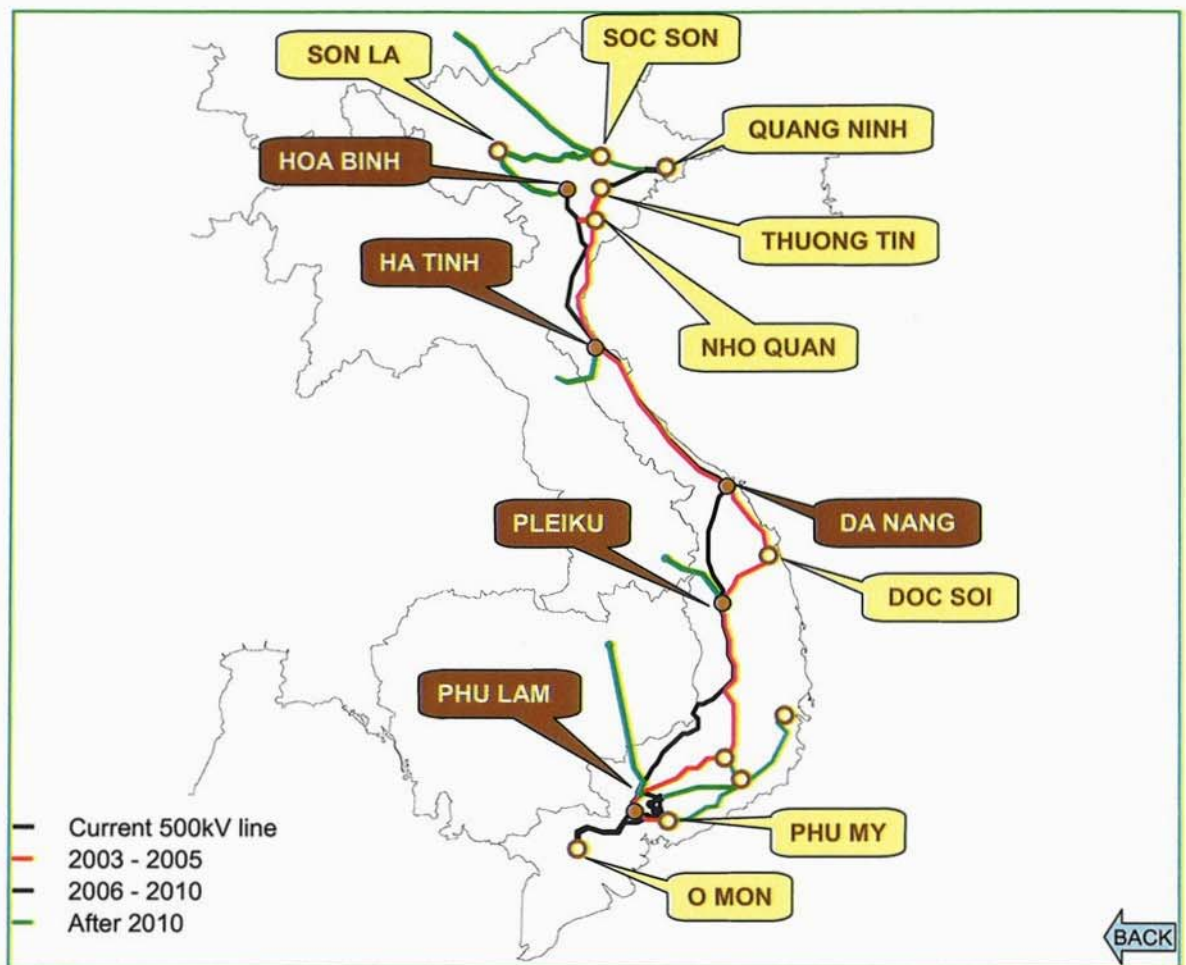


Figure 5.18: Transmission development plan - Vietnam

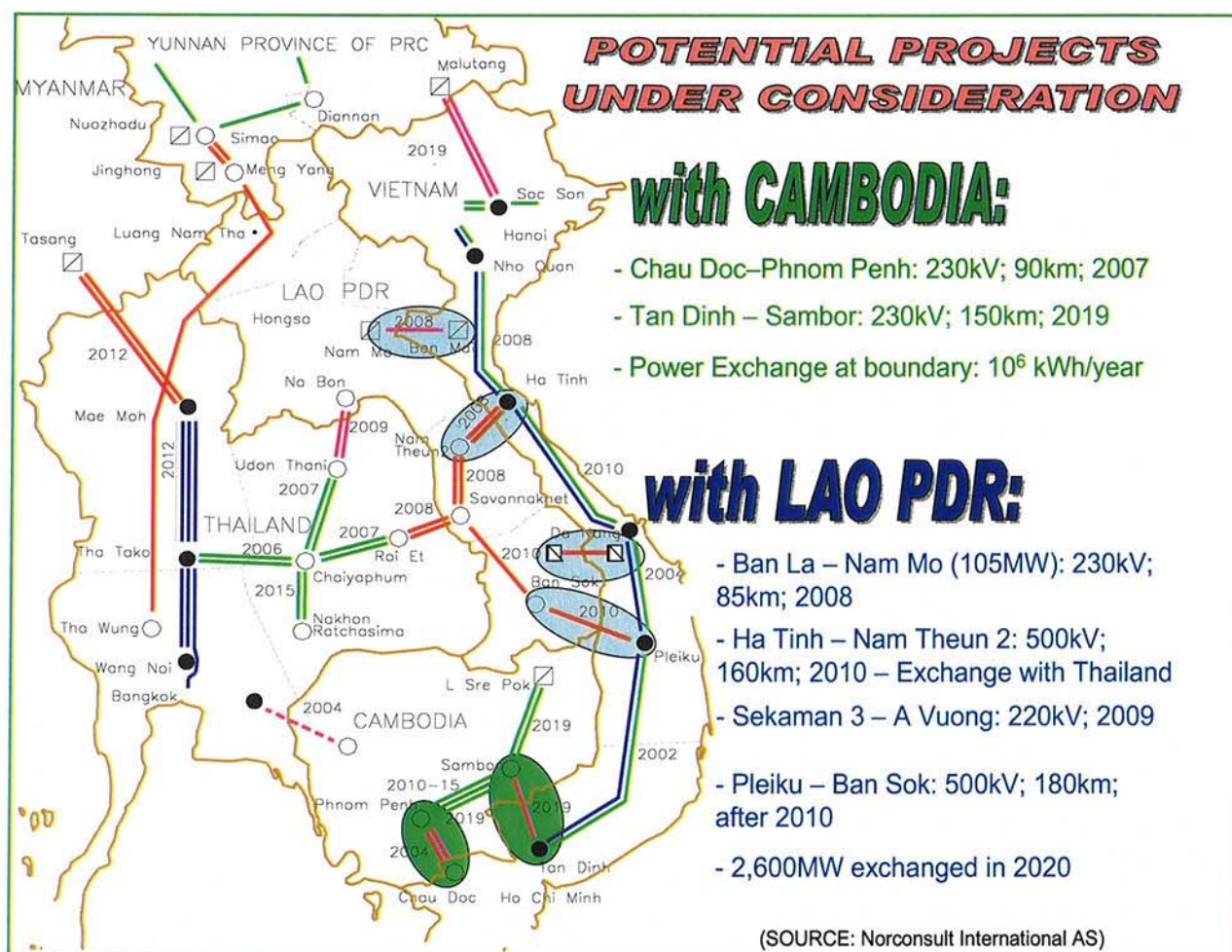


Figure 5.19: Potential interconnections with Cambodia and Lao PDR

5.10 Malaysia

5.10.1 Transmission Grid Planning in TNB is carried out by a section of the System Planning Department. Based on reports from regional and load-forecast section, the section produces/reviews proposals for long term planning on the for TNB Management. The section introduces/proposes system reinforcements such as new injection points, new lines and supply sub-stations.

5.10.2 The Grid Planning Section communicates with generation planning section for details of new plant-up such as locations and capacity, generation scheduling etc. then analyses the effects of generation plant-up or retirements on system (angle, voltage stability, power transport, MVar requirements etc.). The dynamic stability is studied under 2 conditions, steady state or during normal operations and post-disturbance e.g. network conditions after faults occurred and cleared.

5.10.3 **Planning Philosophy and Concept**. 3 methods of planning applied:

- 1) Short term: Remedial actions required to alleviate problems with the existing network
- 2) Medium term: Firm plan for future network plans for future network plans. Minimal changes on the plan during review of load characteristics and load centres.
- 3) Long term: Horizon years approach i.e. long term planning of future network according to future forecast and generation plant-up sitting. Very tentative and subject to changes and reviews. For Horizon year approach, it is based on horizon years according to load characteristics predicted by load forecast.

5.10.4 Planning Methodology comprises of the following steps:

- 1) Set base case with latest system data. Communicate with regional planners and database section.
- 2) Run load flow with PSS/E Power Flow and Faults sub-routine. Check voltages at all buses (load and generator). Do network reinforcements as necessary. Recheck voltages at buses. Repeat until no violations on voltage requirements.
- 3) Run TPLAN to check contingencies conditions with various scenarios. As above, provide network reinforcements as required and repeat simulations runs. Repeats simulations with Power Flow and Faults sub-Routine if necessary
- 4) Set up and initialize base case for dynamic simulation. Run dynamic simulations with varying scenarios in years of study. Provide network improvements as necessary repeat simulations as required.
- 5) Write/review reports of grid system according to results of simulation.

- 5.10.5 As part of Grid Planning Special Technical Studies section has been established to perform analysis on studies/reviews not included in formal description of department.

5.11 Summary of Planning Approaches and Methods

- 5.11.1 Planning approach and method employed by each country depends very much on the criteria adopted. For Brunei and Cambodia providing sufficient generation capacity to meet simple unit outage criteria makes it unnecessary to perform dynamic programming generation expansion studies as employed by Thailand, Vietnam, Indonesia and Malaysia. Both SP PowerGrid of Singapore and Transco of the Philippines are not responsible for generation planning.
- 5.11.2 Methods for transmission planning seem to be uniform throughout ASEAN. Following establishment of load forecast and generation expansion, transmission planning are carried out. Thailand, Indonesia, Lao PDR, The Philippines have presented flow diagrams of their planning steps. These are useful references to benchmark types of analysis to be considered.
- 5.11.3 There seem to be an overall lacking in method and approach towards voltage and reactive power planning in all ASEAN countries.

Chapter 6: Financing Issues

6.1 Introduction

6.1.1 With respect to financing issues, the following items were suggested to be discussed:

- 1) Source of funds and requirements;
- 2) Issues on private investments in the power sector and requirements;
- 3) Flexible investment plan;
- 4) Roles of lending agencies and their requirements.

The main objective of discussing the above topics is to find common issues so that experience of one country/utility could be shared with other utilities.

6.1.2 Thailand's presentation addressed all the requested topics while Vietnam and Indonesia identified some of the financing issues they face. For other countries the financing issues are summarized in the following sections.

6.1.3 Brunei Darussalam is 100% self-financing with "the Brunei Government has allocated significant amount of finance resources in the previous and current 5-year National Development Plans, with the following objectives:

- to develop its power infrastructure to provide reliable and continuous electric power for the nation.
- to support the development of industries,
- to allow the population to improve their quality of life.

6.1.4 Cambodian customers are paying very high price for electricity as compared to customers in other ASEAN countries (see figure 6.1). While EdC has established plan for development of the grid, the issue of financing will remain difficult to resolve. The financial could come from international donors as well as multi-lateral lending agencies such as the ADB.

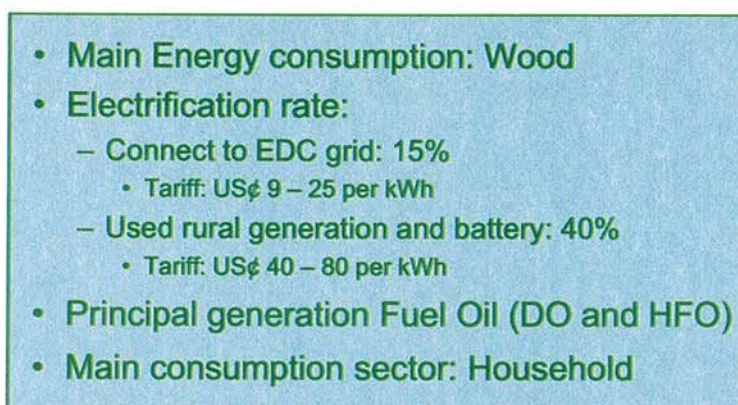


Figure 6.1: Electricity price in Cambodia

6.1.5 No discussion on financing issues was presented by the Philippines and Malaysia.

6.1.6 For Singapore, generation sector is completely privatized and transmission and distribution sector are self-financed.

6.1.7 Generation development for power export Lao PDR is by IPPs. For transmission and distribution development including rural electrification Lao PDR depends of international donors as well multi-lateral lending agencies such as the World Bank.

6.2 Indonesia

6.2.1 For Indonesia, Java-Bali system, the sources of funds for project financing for the Java-Bali are summarized in table 6.1 and for outer islands in table 6.2.

Table 6.1: Financing sources - Java-Bali

	Java - Bali	
	Source of Funds	Players
Generation	Project Financing	Private & PLN Sub.
Transmission	Project Financing	Private & PLN Sub.
	Borrowing	Government & PLN
Distribution	Borrowing	Government & PLN
	Internally Funding	PLN
Rural Electrification	Borrowing	Government

Table 6.2: Financing sources - Outer Islands

	Outer - Islands	
	Source of Funds	Players
Generation	Borrowing	Government & PLN
	Project Financing	Private & PLN Sub.
Transmission	Borrowing	Government & PLN
Distribution	Borrowing	Government & PLN
	Internally Funding	PLN
Rural Electrification	Borrowing	Government

6.2.2 Sources for external funding (borrowing) include:

- Commercial banks
- Development Banks, such as ADB, IBRD etc.
 - In the past, PLN main projects are financed by development bank with the government sovereign guarantees.
- Country-Specific Lending Agencies, such as KfW, JBIC etc.
 - These agencies provide subsidized debt financing for projects that use equipment and services from their country.
- Bilateral Loan or Soft Loan.
- Export Credits and Supplier Credits.
 - Available for projects that will use goods and services from the country that provide the loan. PLN has to provide 15 % of the investment as a down payment.
- Bonds

6.2.3 It must be noted that the government of Indonesia is the borrower of all foreign borrowings and on-lent to PLN through a Subsidiary Loan Agreement (SLA). However, PLN has to bear full foreign exchange risk

6.2.4 With respect to internal funding (self-financing), currently, PLN's major sources of internal funds are from depreciation and consumer connection charges. PLN's ability to internally fund its projects was however limited and the government had provided PLN with the required funds in the form of equity. However, due to budgetary constraint, this fund has now become scarce.

6.2.5 For project financing involving private Sector and public-private partnership, funds are secured essentially solely by revenue-producing contracts. The construction and privately owned power facilities that built on project financing basis are the best ways to expand the power sector without requiring capital outlay from PLN (the Government). These projects are financed solely based on their potential revenues from the project cash flow. Project financing requires a well-design allocation of risks to the party who best able to control the risk. The risks include:

- Completion risk
- Performance risk
- Fuel supply risk
- Market risk etc.

The lenders of these projects request the developers to obtain Power Purchase Agreement, EPC Contract, Operating & Maintenance Contract, Fuel Supply and Transportation Contract, Land Lease Right, and Insurances.

6.3 Thailand

6.3.1 **Source of Fund and Requirement** - Sources of fund of EGAT comprise of local debt , foreign debt and EGAT 's revenue which is also called self-financing. Therefore, project investment of EGAT can be financed with debt and revenue. EGAT's capital expenditure can be acquired from local currency, foreign currency or both. For the part of EGAT's earning which is self financing, it is about 25% of total expenditure.

6.3.2 Sources of fund of EGAT can be categorized as follows :

- Overseas loans
- Domestic loans
- Domestic loans for foreign currency
- Subsidy from Financial Institute

Debts of EGAT are a combination of local debt in terms of Baht (Thai currency unit) and foreign debt in term of foreign currency. EGAT's sources of debt are the follows:-

- Local Debts
 - Public Bond
 - Commercial Banks / Financial Institutions or other sources
- Foreign Debts
 - Foreign Bond
 - Multi-lateral: World Bank
 - Export Credit:
 - Japan Bank for International Cooperation (JBIC);
 - Kreditanstalt Fur Wiederaufbau (KFW)
 - Supplier's Credit :
 - Mitsubishi Corporation
 - Commercial Bank / Financial Institutions etc.

6.3.3 EGAT itself can issue Bond for local sales as well as abroad in terms of Baht or US.\$. Some sources of fund propose loan together with bidding document called 'Financial Offer'. Sometimes EGAT invites commercial banks to propose the loans.

6.3.4 **Issues on Private Investments in the Power Sector and Requirement.** The main objectives of the promoting private sector participation in the electricity industry are:

- (a) To increase competition in the energy industry to bring about more efficiency within the industry and the provision of adequate energy at reasonable prices for consumers;
- (b) To reduce the investment burden of the government as well as the public sector debt;
- (c) To Promote the more efficient use of energy;

- (d) To Ensure power users are provided with best possible services, prices and safety standards;
- (e) To Encourage the general public participation in the energy industry development of the country through the development of the capital market

6.3.5 **IPP's and SPP's (Independent Power Producers and Small Power Producers).** The electricity supply industry is now being deregulated to allow for private sector investments in power generation projects, in the form of both IPP's and SPP's, and to sell electricity to EGAT. IPP's can only sell electricity to EGAT but SPP's can sell power directly to consumers located in its vicinity. To date, in accordance with PDP 2004, EGAT has purchased and expected to purchase power from 7 IPP's and its 2 subsidiary companies with a total capacity of 12,601.05 MW.

6.3.6 **Independent Power Producer (IPP's).** The first round of IPP's solicitation was issued in December of 1994 where by EGAT would buy up to 5,800 MW of capacity from IPP's for the period of 1996-2003. Power Purchase Agreements (PPAs) were signed with 7 IPPs. Due to the Baht Floation in July 1997, PPAs were, therefore, amended which significantly helped IPPs to proceed with their projects especially on financing. The economic problems also resulted in re-negotiations for the commercial operation. The main concern of the financial institutions in providing financing for IPPs was related to the ability of EGAT to uphold its commitment under the PPA's as EGAT's financial position could have deteriorated if the economic slow down caused significant slow down in power demand growth resulting in a very high level of reserve margin of the system.

6.3.7 There are 7 IPPs in Thailand which EGAT has purchased and will purchase power from. They are given in table 6.3.

Table 6.3: IPPs in Thailand

<u>Name</u>	<u>MW</u>	<u>Type</u>	<u>Fuel</u>	<u>COD</u>
• Independent Power (Thailand) Co., Ltd. (IPT)	700	Combined Cycle	Gas	Aug 15, 00
• Tri Energy Co., Ltd. (TECO)	700	Combined Cycle	Gas	Jul. 1, 00
• Eastern Power & Electric Co., Ltd. (EPEC)	700	Combined Cycle	Gas	Mar 25, 03
• Glow IPP Co., Ltd. (Bowin)	2x356	Combined Cycle	Gas	Jan 31, 03
• Ratchaburi Power Co., Ltd. (RPC)	2x700	Combined Cycle	Gas	Unit 1: Mar 1, 08 Unit 2: Jun 1, 08
• Gulf Power	2x700	Combined Cycle	Gas	Unit 1: Mar 1, 07 Unit 2: Mar 1, 08
• BLP Power Limited (BLP)	2x673	Thermal	Coal	Unit 1: Oct 1, 06 Unit 2: Feb 1, 07

6.3.8 EGAT has 2 Subsidiary Companies, namely:

• **EGCO**

- Rayong Combined Cycle 1135 MW
- Khanom Combined Cycle 678 MW
- Khanom Barge 678 MW

• **Ratchaburi Electricity Generating Co., Ltd.**

- Ratchaburi Thermal 2x700 MW
- Ratchaburi Combined 3x680 MW

6.3.9 **Small Power Producer (SPP).** SPPs are small power projects that are either c-generators or facilities using renewable energy as fuel, which sell power to EGAT of not more than 90 MW for each project. Since 1991-1992 proposals have been received by EGAT but some projects have been rejected while some have withdrawn particularly after the baht flotation in July 1997. After the baht depreciation in July 1997 the government amended the terms and conditions for the SPPs particularly by indexing a part of the capacity payment to the exchange rate. At the present 79 power purchase agreements (PPA) with EGAT have been signed and another 7 PPAs are under negotiation. If all projects are completed then the total purchase would amount to 2,417 MW (see table 6.4).

Table 6.4: SPP Proposals Accepted Classified by Type of Fuel

	Number of Projects	Generating Capacity (MW)	Sale to EGAT (MW)
Commercial Energy			
Natural Gas	20	2,519	1,473
Fuel Oil	1	10.4	9
Coal	4	392	196
Sub Total	25	2,922	1,678
Renewable Energy			
Bagasse	33	642.9	194.3
Paddy Husk, Wood Chips, Saw dust	24	878.5	500.4
Municipal Waste	1	2.5	1
Biogas	1	19	12
Black Liquor	1	32.9	25
Hydro	1	6.7	6.7
Sub Total	61	1,583	739
Total	86	4,504	2,417

6.3.10 **Power Purchase from Neighbouring Countries.** As with the IPP and SPP program, this initiative will substantially reduce the investment burden of EGAT. The following programs have been implemented:

Lao PDR

A purchase capacity of 1,213 MW is expected by 2009 according to Power Purchase Agreements (PPA) which were been signed for 3 Projects, i.e., Nam Theun Hinboun (187 MW), Houay Ho (126 MW) and Nam Theun 2 (900 MW)

Sale (MW)	Project	Commissioning Date
	Project with PPA	
March 1998	Nam Theun -Hinboun	187
September 1999	Houay Ho	126
COD 2006	Nam Theun 2	900
	Total	1,213

Malaysia

Sale (MW)	Project	Commissioning Date
	Project with PPA	
June 2002	HVDC - Stage 1	300

requirement. The lending agencies that EGAT contacts are multilateral, such as IBRD, Export Credit such as JBIC and many Commercial Banks. For multilateral, it is necessary for the country to have government guarantee for their loans and sometimes the government has to be responsible for 50% of the cost. The advantages of borrowing from multilateral agencies are that the loan has long maturity and it offers technical assistance but it does not tie to exports of a particular country. The disadvantage is that the interest rate is now floating and it is not low as before.

6.3.12

The advantages of borrowing from Export Credit are that the loan has flexible and attractive term. It has long maturity and grace period and also have fixed generally low rate. Disadvantage is that the borrower has to spend the fund buying goods and services from the lender's country only.

6.3.13

13 Terms and condition of the commercial
bank depends on market situation.

6.3.14

14 After contract signing, those lending agencies have to follow up the progress of the projects. They asked EGAT to submit financial projection to make sure that their loans can be paid. Considering EGAT's financial projection, the lender will focus on financial covenants. They require the ratio of Short over Medium Terms Debt being less than 15 %. Debt Service Coverage Ratio is more than 1.3 times. Debt over Equity ratio should be less than 1.5 times and not having Default Clause.

6.3.15

The lenders also require feasibility study, pre and post evaluation of the projects. They focus on financial return of the projects, economic return in the form of economic welfare, environmental friendly and create less impact for the society which can be acceptable.

6.4 Vietnam

6.4.1 For Vietnam, the financial requirements to implement power development project up to year 2010 is indicated in figure 6.2. Generation sector requires 68% while transmission and distribution are at 13% and 19% respectively. There is large amount of investment required in the generation sector. To meet the financial requirement EVN has been making financial arrangement as shown in figure 6.3

FINANCIAL DEMAND DURING 2003-2010 BASED ON THE 5th PDP (billion USD)				
	GENERATION	NETWORK		TOTAL / % TOTAL
		TRANSMISSION	DISTRIBUTION	
EVN	10.01	2.44	2.58	15.03 / 77.08
OTHERS	3.26	0	1.21	4.47 / 22.92
TOTAL	13.27	2.44	3.79	19.50 / 100
% TOTAL	68.05	12.51	19.43	100

Figure 6.2: Financial requirements for EVN

FINANCIAL ARRANGEMENT BASED ON THE 5th PDP (million USD)			
TOTAL DEMAND		21,080	
NET INVESTMENT	15,033		
REPAYMENT	6,047		
BALANCED SOURCES		21,080	
STATE BUDGET		136	
SEFT INVESTMENT		10,473	
• DEPRECIATION	5,697		
• DEVELOPMENT FUND	532		
• TARIFF INCREMENT & CAPITAL FEE	4,223		
LOAN		10,470	
• ALREADY ARRANGING	2,973		
• SEARCHING	7,497		

Figure 6.3: Financial arrangement undertaken by EVN

6.5 Summary of Financing Issues

- 6.5.1 Brunei is 100% self-financing its power sector development. Singapore generation sector is completely market driven and therefore additions are based on price signals and financing arrangement by the generation companies themselves while transmission and distribution are self-financed.
- 6.5.2 Cambodians are paying high price for electricity (only about 20% grid-connected). The country requires large amount of financial assistance for power sector development. Since the country has only recently (late 1990's) recovered from war, many issues related to foreign investments, regulations and trades have to be resolved. However, steady assistance from multi-lateral agencies such as the World Bank are beginning to help in accelerating required development.
- 6.5.3 Lao PDR has established a strategy for sustainable development of its large hydro potential for export and some proportion of the output for domestic use to complement small hydro development. Large hydro development for export is left to the private developers to make the financial arrangement - it must be noted Lao PDR Government through EdL takes some stakes in those large hydro companies. For the development of domestic power infrastructure, EdL depends on assistance from international donors as well as multi-lateral lending agencies.
- 6.5.4 Indonesia depends on borrowings, project financing and very limit amount of self-financing for power sector development. With respect to external borrowings there are several sources including, development banks such as the ADB, soft loans and bonds. All external borrowings are government guaranteed. PLN's ability for self-financing is however becoming limited and scarce.
- 6.5.5 Thailand's source of financing for power sector development includes local debt, foreign debt and self financing (25% for EGAT). Local debts include public bonds, commercial bank and financial institutions. With respect to foreign debts the sources are; foreign bonds, multi-lateral agencies like the World Bank, Export Credit and Supplier's Credit.
- 6.5.6 Vietnam requires massive investment in power sector development particularly generation sector. Presently to finance its power sector development, Vietnam has to depend on foreign loans.

Chapter 7: Specific Technical Issues

7.1 Introduction

7.1.1 Each participating utilities was also requested to present and discuss specific issues under the following topics:

- 1) Containment of Short-Circuit Levels
 - a. Available methods and technologies;
 - b. Experiences of developed countries;
- 2) Applications of New Technologies
 - a. FACTS and their roles;
 - b. Cost effectiveness of new technologies;
 - c. Operation and maintenance issues;
- 3) Planning Against System Collapse
 - a. Cost of blackout/system collapse;
 - b. Tools used;
 - c. Planning of system islanding;
- 4) Network Configurations
 - a. Network configurations used;
 - b. Planning in anticipation of embedded generation;
- 5) Embedded/Dispersed Generations;
 - a. Embedded generation experience;
 - b. Issues related to connections of embedded generations
- 6) Voltage Stability and Reactive Compensation
 - a. Voltage stability problems;
 - b. Reactive power forecasting;
 - c. Load models;
 - d. Reactive compensation

7.1.2 Only EGAT of Thailand presented some the above issues at the workshop and these are discussed in the next section.

7.2 Thailand

7.2.1 EGAT in their planning had identified increased fault level problem in their Eastern system as shown in figure 7.1. After considering several options for **short-circuit containment** including back-to-back HVDC and taking reliability into consideration, the cost-effective method is bus-splitting as shown in figure 7.2.

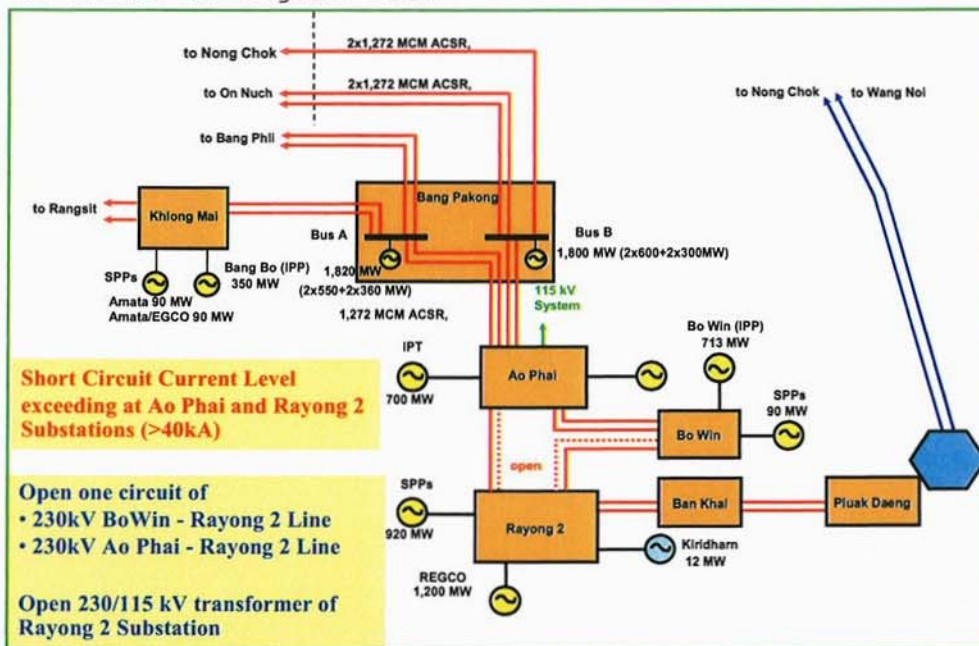


Figure 7.1: Fault level problem in EGAT's Eastern region

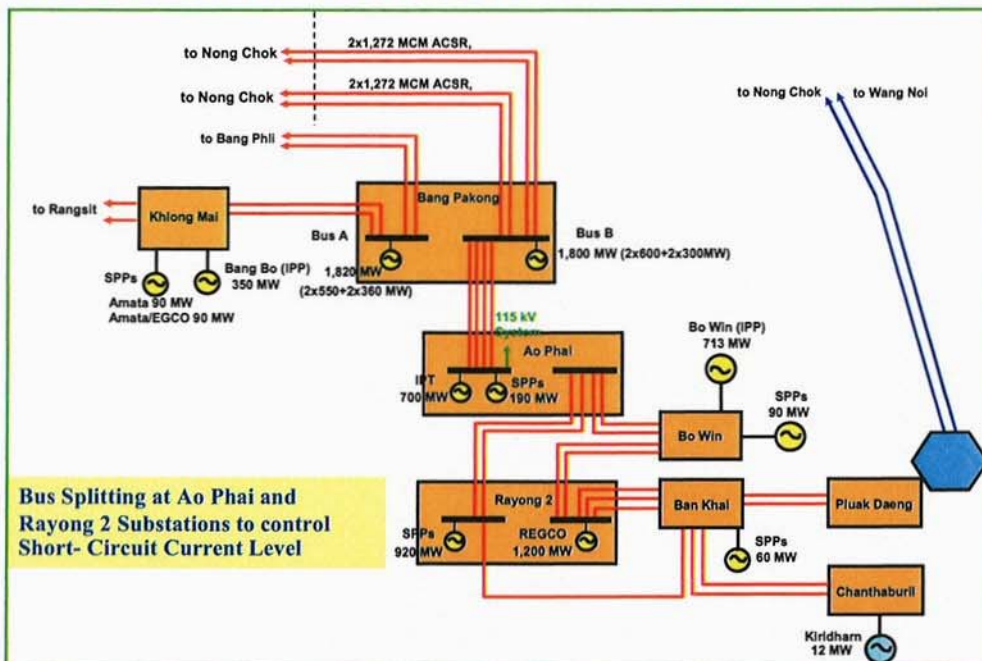


Figure 7.2: Bus-splitting solution, cost-effective

7.2.2 On issue of planning against system collapse, EGAT has experienced to address mitigation measures due insufficient installed generating capacity in Northeastern of Thailand. Through (N-1) and loss of unit contingency analysis, power transfers may need to be limited. Methods that have been employed to limit power flows include:

- Defining generation dispatch in the Northeastern region
 - Ex. Nam Phong Power Plant is a base load generation
- Load Shedding

7.2.3 For connection of SPPs (Disperse Generation), Thailand has established the following requirements:

• **Small Power Producer (SPP) is planned according to the suitable area**

Ex.

	<u>Generation Capacity</u>	<u>Voltage Level</u>
- Distribution:	less than 10 MW	22kV
- Transmission:	60 - 90 MW	115kV

7.2.4 On the subject of reactive compensation EGAT indicated that their practice is to use power system analysis software to help in defining the size and place to install shunt capacitor equipment in the system. Transmission system reinforcement projects are normally complemented with reactive power compensation.

7.2.5 For load modeling, EGAT uses the followings:

- Constant MW
- Defined Power factor

<u>System Year</u>	<u>Power Factor</u>
2001 - 2004	0.875 lagging
2005 -->	0.900 lagging

7.3 Summary of Specific Technical Issues

- 7.3.1 Only EGAT of Thailand responded to items under specific technical issues. We believe that other countries/utilities have or are addressing the listed issues. For reasons of limited time and resources, those issues could not be presented at the August 2004, Bangkok Workshop.
- 7.3.2 EGAT, in addressing increasing short-circuit level has examined several methods including the use of new power electronic devices and concluded that, the traditional method remained cost-effective.
- 7.3.3 EGAT, in planning against possible system collapse in the Northeastern region has applied both security constrained dispatch and load shedding.

Appendix A - List of Contributions at the Workshop, 3rd - 4th August, 2004.

The following contributions in the form of PowerPoint presentations are provided the CD.

No	Country	List of contributions
1	Brunei Darusslam	cigre- Brunei.ppt
2	Cambodia	Cigre_Cambodia.ppt
3	Indonesia	Environment.ppt Generation.ppt TRANS PLAN CIGRE 01.ppt
4	Lao PDR	CIGRE Workshop Lao PDR.ppt
5	The Philippines	HAPUA Presentation Bangkok.ppt
6	Malaysia	Country Paper-Msia2004-Presentation.ppt
7	Singapore	Spore CIGRE Workshop 3 to 4 Aug 04 rev 3.ppt
8	Thailand	CIGRE - Thailand-Transmission.ppt CIGRE_LoadForecast.ppt CIGRE_PDP2004.ppt CountryPaper_Thailand2.doc NEW Financing Issues Revised.ppt
9	Vietnam	Vietnam-CIGRE_03Aug2004.ppt

Appendix B - Contribution by NGC on "A Summary of Recent International Comparisons of Planning Criteria"

INTRODUCTION

- This appendix describes three surveys conducted relatively recently, which compare different aspects of a number of overseas utilities with those of NGC. The first survey was conducted by CIGRE, the second by NGC and the third by Ontario Hydro.
- The reader should note that, for ease of reference and where convenient, the text of this appendix often identifies the different overseas utilities being compared by the name of the country in which it is located.

CIGRE COMPARISON

- In November 1992 CIGRE published a review of "Adequacy Standards for Generation and Transmission Planning"[29], prepared by Study Committee 37 (SC37), which provides useful comparative information for this Review. This survey compares the key standards, requirements, criteria or limits used by transmission planners in twenty-four utilities including NGC.

Countries/Utilities Selected for Comparison

- Tabulation of data relating to transmission planning, based on a synthesis of earlier papers presented to Study Committee 37, were circulated to all SC37 members with a request that they provide updated figures.
- Data on systems with nominal voltage greater than or equal to 220kV were returned by the following 24 countries/utilities:-

European (14)	
Belgium/CPTE	Norway/NWR&EA
Denmark/ELKRAFT	Portugal/EDP
Finland/IMATRAN	Romania/ICEMENERG
France/EDF	Slovenia/Milan
Vidmar Elec Inst	
Ireland/ESB	Spain/FECSA
Italy/ENEL	Sweden/VATTENFALL
Netherlands/DEGB	UK/NGC
Non-European (10)	
Australia/SECV	Ivory Coast/CIdE

	Brazil/ELECTROBRAS	Japan/CRIEPI
	Canada/Ontario Hydro	Jordan/JEA
	China/EPP&EInst	South
Africa/ESKOM		
	CIS/Acad of Sciences	USA/AEP

- Data received are mainly of 1991 origin and may be assumed to be referring to 1990.

Results Summary

- The following paragraphs set out some of the main findings of the CIGRE (SC37) report in the area of transmission planning.
- The report, in effect, gives a 'snapshot' picture of adequacy criteria for the 24 countries. Figures F.1 to F.4, which have been included at the end of this appendix have been reproduced from the CIGRE report. These provide a useful graphical summary of the survey findings. The following paragraphs list some of the similarities and differences between the countries in the area of transmission planning.

Similarities in Transmission Planning

- The report identified the following similarities for the 24 countries surveyed:-
 - most countries study peak, some off-peak periods and the minimum demand condition
 - most countries use merit order ranking of installed generation, but only a few countries use this method alone
 - all countries use deterministic study techniques. In addition about half use, or have available, probabilistic techniques. Spain, South Africa and Denmark are working towards new or greater use of probabilistic techniques. None of the countries use probabilistic methods alone
 - in general, countries that use an N-2 outage criterion do not also consider the outage of a busbar; those that consider the outage of a busbar generally use an N-1 outage criterion
 - most countries plan for transmission system voltages in the range of +5% to -10% of nominal.
 - most countries take transmission losses into account when evaluating alternative transmission reinforcement options, but less than half of the 24 countries compare generation production costs or include an assessment of the cost of unserved energy
 - more than half of the countries study stability at peak demand. Far fewer study stability for off-peak conditions

- o in most of the countries surveyed, a three phase fault is used as a stability test in planning studies, even if it is considered to be a very low probability event.

Differences In Transmission Planning

- The CIGRE report identified the following differences:-
 - o not all countries allow short-time overloads of transmission system components to be used at the planning stage
 - o to allow for uncertainty, about half of the countries increase the planned power transfer capability above the nominal requirement identified in planning studies.

Trends and Current Thinking

- It is worth noting that in the 1992 CIGRE SC37 report three countries said they were moving towards new or greater use of probabilistic planning methods.

COUNTRY COMPARISON

- A more recent and, in some respects, a more detailed survey was conducted by NGC. This survey covered a wider range of transmission aspects than the CIGRE Study and compared NGC's transmission system with those of ten overseas utilities in the following three respects:-
 1. system performance;
 2. operational standards; and
 3. planning standards.

Countries/Utilities Selected For Comparison

- For meaningful comparisons with NGC, it was important that in the first place the countries/utilities selected possessed certain similarities with NGC; whether size, structure or some other characteristic. Ideally such a utility would have, amongst other things, similar obligations to NGC, namely:-
 1. to develop, maintain and operate an efficient, coordinated and economical transmission system;
 2. to facilitate competition in the generation and supply of electricity; and
 3. to mitigate the effects of developments on the environment.
- Most utilities worldwide are vertically integrated and their obligations are similar to (i) above although they also include generation and distribution functions. Few yet have a duty to facilitate competition in generation and supply, although there is an increasing movement worldwide towards unbundling of utilities, towards third party access and towards encouragement of Independent Power Producers[31].

- However comparisons need to extend beyond legal obligations and include customer expectations, financial and environmental constraints and transmission system characteristics (eg. demand profile, plant margin, plant availability and utilisation).
- On the one hand, customer expectations and financial and environmental constraints are broadly comparable in developed countries. On the other hand, transmission system characteristics vary widely according to geography, climate, demography and availability of energy sources.
- These considerations led to the selection of the following four Western European countries:-

European (4)

France/EDF

Spain/RED Electrica

Germany/RWE

Italy/ENEL

- However, of these, only Spain is organisationally structured in a similar way to NGC in that, like NGC, it is solely a transmission company.
- Although most other developed countries worldwide have vertically integrated electricity supply industries, a review of CIGRE, UNIPED and IEE literature shows that several utilities are actively assessing their planning and operational security procedures, practices and performance. This consideration led to the selection of the following six non-European countries/utilities:-

Non-European (6)

Australia/SEVCV

Canada/Ontario Hydro

Japan/Chubu EPCo

New Zealand/TRANSPower

South Africa/ESKOM

USA/AEP

- NGC also had useful discussions with the Scottish companies, namely, Scottish Hydro-Electric and ScottishPower, although these were not included in the '10 country comparison'.

Survey Procedure

- The survey was conducted in three stages, namely:-
 - 1) a questionnaire was sent to planning functions in each of the above ten countries
 - 2) in the light of the responses to the questionnaire, further discussion (by telephone) took place between NGC and each of the ten countries; and

- 3) a supplementary questionnaire, tailored to take account of the earlier responses and discussions was sent to each of the ten countries in August 1993.
- Naturally, the discussions and information exchanged with the ten countries do not cover every aspect of overseas operational performance, operational standards and planning standards. Nevertheless the information obtained is considered sufficiently robust to identify NGC's position relative to comparable utilities in developed countries with stable economies.
 - Where necessary, information (particularly on system performance of the 10 countries) was supplemented by further published information for these countries given in an August 1992 CIGRE paper on "Update of the Disturbance Performance of Bulk Electricity Systems"[32] prepared by Study Committee 39 (SC39).
 - The following paragraphs summarise the findings of NGC's survey. The comparison focuses on the three key areas of system performance, operational standards and planning standards.

System Performance

- There are currently numerous indices available to enable utilities to compare each other's system performance. In the future, a degree of harmonisation is likely to occur which will gradually lead to standardisation of indices.
- In the context of the CIGRE SC39 survey, 'disturbance' means loss of supply and is measured in System Minutes = $\frac{\text{MW lost} \times \text{minutes of interruption}}{\text{Annual Peak Demand MW}}$
The Degrees of Severity are:-
 - Degree 1: an event with a security between 1 and 9 System Minutes
 - Degree 2: an event with a security between 10 and 99 System Minutes
 - Degree 3: an event with a security between 100 and 999 System Minutes.
- Comparing CEGB/NGC data with information in CIGRE SC39 paper show that:-
 - 1) for 'Degree 1' (minor) and 'Degree 2' disturbances:
 - NGC's performance is better than the average for all utilities surveyed, but below the average relative to those utilities most like NGC
 - 2) for 'Degree 3' (major) disturbances:

- NGC's performance is better than the average for all utilities surveyed and average relative to those utilities most like NGC.
- The survey shows a trend towards improving performance, particularly for 'Degree 1' events, and especially for North American utilities.
- Conclusions consistent with the above mentioned CIGRE SC39 work are that:-
 - networks in the centre of an interconnected system experience the least number of disturbances. Those on the periphery of an interconnected system fare worse, but isolated systems experience the most disturbances
 - stability limited systems experience more disturbances than thermally limited systems
 - the frequency and type of disturbance does not vary markedly with system size; and
 - approximately 3 out of 4 disturbances arise from contingencies which exceed the system design criteria.
- Whilst the NGC system is highly integrated within itself, it has only one point of interconnection with the main European system. In this context, therefore, it can be regarded as comparatively isolated and consequently displays a statistically higher risk of disturbance than for a similar sized system interconnected with many neighbouring systems. Accordingly, to offer a similar level of disturbance performance as that found in countries such as France, Germany, Italy and USA, it could be argued that NGC's system would need to be designed and operated to higher standards than the interconnected countries.
- At present, power flows on the NGC system are usually, though not solely, constrained by thermal and voltage limits rather than by stability. As system utilisation increases, stability constraints will increase bringing with it an increased risk of a greater number of disturbances.

Operational Standards

- For utilities in the USA, operational requirement may be set out in the Regional Reliability Council requirements rather than the utility documentation.
- The power pools established in the USA enable each utility to benefit from the interconnection with adjacent utilities. This benefit is reinforced by the Regional Council requirement for utilities to provide minimum levels of operating reserve, allowing adjacent utilities to contract for a part of the pooled reserve thereby minimising their own reserve costs.
- Remedial Action Schemes or Special Protection Systems offer facilities for automatic control and optimisation of the system under abnormal conditions in the USA. More than one country studies 'disaster scenarios', beyond normal operational conditions, to allow provision for emergency facilities to be considered.
- From the evidence currently available, deterministic criteria are still primarily employed by most of the ten utilities in their operational security standards for the main transmission network. The increasing interest internationally in probabilistic planning suggests that this will feature more prominently in future security assessments.
- An N'-D operational security criterion is specified in operational standards of most utilities, together with an obligation to consider the cost relative to the cost of N'-1 security. In practice the operators in some overseas utilities do take account of generation costs to allow relaxation to N'-1 security on occasions. Italy is considering using meteorological data as an input to a risk assessment model for operational security assessment.
- The utilities in Scotland adopt an N'-1 operational criterion under normal and outage conditions. However, this N'-1 criterion is tightened when there is evidence of a significant risk of a double circuit overhead line fault, for example due to adverse weather conditions, when a double circuit loss criterion is used. In addition, where large sections of the Scottish system are at risk, transmission outages are planned such that the system may be operated to the double circuit criterion.
- The control of generation plays a significant role within the security criteria of the various utilities. Generator outages are fully coordinated with transmission to minimise system risks during circuit outages and in most cases the security

procedures allow for out of merit running to avoid significant consequences such as instability or system split risks. Most of these also feature in NGC's activities although outage co-ordination is of course easier to achieve in a utility which owns both generation and transmission.

- An important aspect, which is clearly evident in some utilities and which from the supporting documentation appears to suggest the trend for the future, is the role of customer choice in the extent of security provided to them. In the United States there is an increasing trend towards Least Cost Planning including extensive demand management which has a cost reducing impact on supply-side planning thereby minimising outturn cost to the customer without jeopardising the security of the system. NGC has some load demand contracts in place and is actively looking to extend this option.

Planning Standards

- Generator To System Connections
 - Five of the ten countries (Australia, Canada, France, Spain and South Africa) allow single circuit connection of generation to the system (transmission or distribution). For all except Canada, the maximum generation connected on a single circuit is less than or equal to the output of the largest set on the system. In Spain there are only two such connections of up to 350MW, with a largest unit size on the system of 994MW.
 - The use of double circuit lines to connect generation occurs in 8 of the 10 countries (America, Australia, Canada, Germany, Italy, Japan, New Zealand and Spain). Maximum generation connected on a double circuit has typically about twice the output of the largest unit on the system.
 - Six of the ten countries (France, Germany, Italy, Japan, New Zealand and South Africa) use double busbar substations for connection of generation to the system. Two of these also use alternative connection arrangements - Germany also allows 'T' and 'H' connections; New Zealand also uses 1½ switch and single busbar arrangements.
 - Three (America, Australia and Spain) of the four countries that do not use double busbar substations use 1½ switch arrangements. This design allows circuits to stay in service during circuit breaker maintenance but the greater number of circuit breakers used means higher capital cost. Canada (Ontario Hydro) uses a 11/3 switch design with generation connected to the centre section of a busbar coupling diameter containing 4 switches, and transmission lines connected to the outer two sections.

- Connection Performance & Customer Choice
 - Levels of performance for availability and reliability of connections are agreed with customers in four of the ten countries, namely; America, Australia, France (below 225kV) and New Zealand and in two of these countries, America and New Zealand, the transmission businesses/utilities may suffer financial penalty for not meeting the agreed levels of performance.
 - In three of the ten countries (Australia, New Zealand and Germany), the customer may currently opt for a type of connection below what would otherwise be the normally accepted level. This may also happen in Canada in the future.
- Use of Intertripping as a Planning Tool
 - Four of the ten countries (Australia, Canada, New Zealand and South Africa) also allow intertripping of demand to temporarily defer capital investment. The amount to be intertripped varies from 70MW in New Zealand up to 1500MW in Canada.
 - Five of the ten countries (America, Australia, Canada, New Zealand and South Africa) allow intertripping of generation to temporarily defer capital investment. The amount of generation intertripped can vary from 100MW to as much as 3000MW, again in New Zealand and Canada respectively, figures which of course reflect the size of the respective systems.
- Busbar Faults
 - All but Australia study the effect of busbar faults for the purposes of determining reinforcement investment. Four utilities, like NGC, consider the effect of both three phase faults and single phase faults, three consider only three phase faults and one considers only single phase faults.
- Stability Criteria
 - Five of the ten countries (America, Australia, Canada, France and South Africa) deplete the system with a typical or known outage pattern before applying faults in stability studies. In Scotland, the planning standard requires the system to be stable for three phase faults but permits this to be relaxed to two phase to earth faults if this would avoid what the planner considers to be excessive cost. NGC are presently required to ensure the system is stable, following a three phase fault or double circuit outage, throughout the annual demand cycle. The system is therefore depleted as necessary to reflect the maintenance/construction outage pattern that would occur at any particular time of year.

- Single-Pole Auto-Reclosing (SPAR)
 - High speed three phase auto-reclosing can cause severe stress to and life reduction of generator shafts and consequently its use can offer significant risks. However, high speed Single-Pole Auto-Reclosing (SPAR) does not have this drawback and can significantly reduce the impact of single phase faults in terms of stability. SPAR is used widely in six of the ten countries (France, Germany, Italy, Japan, Spain and South Africa), and occasionally in a further three (America, Australia and New Zealand). The historically developed circuit configurations of the NGC system (eg. transformers banked with lines) make SPAR unsuited for use on NGC's system where many breakers currently have a common drive to the interruptions of all three phases.
- Value of Lost Load
 - The value of lost load (or cost of energy not supplied) is a good primary indicator of the integrity of a country's transmission system and relative wealth of its customer base. Various papers have commented on the value of lost load and have suggested that it is dependent on many factors including:-
 - a. time of day, season, duration
 - b. type of lost supply (domestic, commercial or industrial)
 - c. location of interruption (urban or rural)
 - d. how widespread is the interruption
 - e. direct and indirect losses (comparison of direct losses such as loss of production to those associated with loss of reputation/esteem etc).
 - Six of the ten countries (Australia, Canada, France, Italy, New Zealand and South Africa) consider the value of lost load when determining the need for transmission capital expenditure, but in three of these countries this is only done occasionally or to establish priorities.
 - The value assigned to lost load, or unserved energy, varies between US\$0.7/kWh (for domestic load in Australia) to US\$10 (for commercial load in Australia), but the 1992 CIGRE survey shows that Australia, Canada, France, Italy, South Africa and Spain only use values in the range US\$1.5-6 for generation planning. The value of £2.345 presently used in England and Wales falls within this range at around US\$1.52 (at £1=US\$1.54).

Trends and Current Thinking

- In Italy, ENEL uses weather forecast data as an input to risk and operational security assessment.

- From discussions with ScottishPower and Scottish Hydro-Electric it was noted that relaxation of their standard is used to enable certain circuit outages to be taken which would reduce the security of load in some areas below N'-D. Their weather criteria classified approximately 50% of the year as being fair and thus suitable for security relaxation.

NORTH AMERICAN REPORT

- Although some North American utilities were included in both the CIGRE Comparison and the 10 Country Comparison above, a further report by Ontario Hydro on "Transmission Planning and Cost Allocation Practices Used by Electric Utilities"[30] published in February 1993 relates specifically to the trends in the North America. The following information is taken from this report which is based on six Canadian utilities, twenty-one US utilities and two US Power Pools:-
 - o a high proportion of North American utilities are relying on demand management to meet system demands in the planning timescale
 - o 20 of 29 (20/29) respondents would consider the use of special protection systems as an interim measure, and 9/29 would adopt this as a permanent measure
 - o 17/29 indicated that compensation would be given to demand management schemes for reducing demand to allow reinforcement to be deferred
 - o allocation of costs/benefits is an issue which a number of utilities see as being of prime importance now and in the future. Using appropriate methods for determining the cost/benefit of transmission capacity and losses are chief among the concerns. Ontario Hydro hold the view that current methods are not entirely satisfactory, and that re-assessment and examination of other approaches is required
- The most interesting issue raised above is the acknowledgment by Ontario Hydro, that whilst a cost-benefit approach is seen as being of prime importance for the immediate future, there are difficulties with present methods and that other methods will need to be examined. This view aligns very closely with those of the UK utilities.

SUMMARY OF FINDINGS

- General conclusions derived in the areas of performance, operational and planning standards and future thinking, are summarised below.

System Performance

- Against a wide range of international utilities, NGC's disturbance performance (ie. loss of supply) is better than average and about average when compared with those utilities which are most like NGC (paragraph F30). Comparison of transmission system performance in terms of investment and operational costs could not be undertaken as data availability was limited by its commercial sensitivity. Relative to other European utilities, NGC may be regarded as comparatively isolated and as such it could be argued that, to offer a similar level of disturbance performance, the NGC system would need to be designed and operated to a relatively higher standard.
- Stability limited systems experience more disturbances than thermally limited systems. Power flows on the NGC system are usually constrained by thermal and voltage rather than stability considerations. As NGC's system utilisation increases stability constraints will increase with a consequent increased risk of a greater number of disturbances.

Operational Standards

- The security contingencies covered by utilities, other than NGC, primarily aim to ensure that no major consequence such as system instability or system splitting would result following credible events. In NGC, operation of the main transmission system requires the operator to secure against double circuit contingencies. This approach compares readily with that in the USA where the operator is required to secure not only for double circuit outages but also for multiple circuits in the same 'right of way'.
- NGC does not have direct control of generator outage programming. However, Generators are required to provide NGC with data regarding their planned outage requirements in an interactive process which commences five years ahead and extends down to two days ahead. With regard to generation scheduling, the present England and Wales Pool Rules require generators to be 'constrained-on' or 'constrained-off' where transmission security is at risk.
- Operational practice in vertically integrated utilities allows greater flexibility and firmer co-ordination of outages than presently exists for NGC. When combined with the study of 'disaster scenarios' and emergency automatic protection

schemes, as in USA, then this may contribute to the good (and improving) operational performance reported for the USA utilities.

- One aspect which is apparent from the existing information is that allowance is provided at the long term planning stage for discrepancies between forecasts and actual outturns and degrees of operator flexibility are provided at the operational stage to enable any variations to be managed. This can be in the form of emergency equipment ratings or control of generation scheduling to ensure the system is not put at contingency risk.

Planning Standards

- The procedures of other utilities will sometimes result in outage criteria more severe than NGC's N-2. For example, for connections to large generating stations modelling busbar outages or depleting the system with typical or known outage patterns before applying faults is common.
- The deterministic planning standards presently used by NGC are comparable with those used in the other countries, but several countries supplement 'baseline' deterministic standards with a risk-based economic assessment (Spain is working towards using probabilistic planning studies as a standard). This is done in order to prioritise projects and to target expenditure.
- For stability analyses, three phase faults are commonly considered although recognised as having a low probability of occurrence. For NGC, this approach will remain valid whether NGC were to move towards probabilistic criteria or not. This is because, on the NGC system, it is likely to remain the case that the type of fault is not the determining factor as far as system stability is concerned.
- The ability of the customer to influence the standard of connection is greatest in Australia and New Zealand; there is no evidence that this has caused poor technical or operational performance.