CHAPTER 4

PRIMARY ENERGY

Chapter 4 Primary Energy

The purpose is to study energy supply and demand in accordance with the power development plan up to 2025 and in line with the national energy policy subject for preparation of PDP 6^{th} in Vietnam.

4.1 Energy Policy

4.1.1 Current Status of Primary Energy

(1) Actual records of domestic supply and demand

In accordance with the data of IE Study "The study on analytical survey on final energy consumption and establishment of energy balance table, May 2005," total primary energy supply increased from 7,016 kTOE in 1990 to 42,482 kTOE in 2004. Gas products recorded a big growth rate. The average growth rate of primary energy supply during 2000-2004 was about 7.0% as shown in Table 4-1-1.

Table 4-1-1 Primary Energy Supply by Energy Type Unit: kTOE

	2000	2001	2002	2003	2004
Oil products	7,757	8,444	9,493	9,894	10,296
Gas	1,440	1,563	1,953	2,776	5,699
Coal	4,718	4,955	5,206	6,920	7,560
Renewable	14,190	14,399	14,399	14,693	14,734
Hydro	4,314	5,573	5,224	4,418	4,193
Total	***32,419***	***34,934***	***36,275***	***38,701***	***42,482***
Growth rate (%)		7.76	3.84	6.69	9.77

Source: The study on analytical survey on final energy consumption and establishment of energy balance table, IE in May 2005

Most gas resources are used for power generation, while coal and oil production resources are mainly used in the industry sector and transportation sector (refer to Table 4-1-2).

Actual records of primary energy supply and demand are shown in Table 4-1-3 and in Figure 4-1-1. Exploitation, production and supply of energy including crude oil, natural gas, coal and electricity in the economic restructuring to date have been strongly developed and have contributed to the social-economic development.

Table4-1-2 Domestic Final Consumption by Sector Unit: kTOE

	2000	2001	2002	2003	2004
Industry	7,081	7,632	8,187	8,440	10,201
Transportation	3,742	4,050	4,943	5,562	5,896
Agriculture	363	361	411	433	455
Service	965	1,130	1,148	1,107	1,298
Residential	11,882	12,177	12,314	12,991	13,869
Other	137	246	180	205	228
Total	***24,170***	***25,596***	***27,183***	***28,738***	***31,947***
Growth rate (%)		5.89	6.20	5.72	11.16

Source: The study on analytical survey on final energy consumption and establishment of energy balance table, IE in May 2005

Table 4-1-3 Actual Primary Energy Supply-Demand in 2000-2004 Unit: kTOE

	2000	2001	2002	2003	2004
Total supply	32,419	34,934	36,275	38,701	42,482
Total final consumption	24,170	25,596	27,183	28,738	31,947
Fuel supply to Power	8,249	9,338	9,092	9,963	10,535

Source: The study on analytical survey on final energy consumption and establishment of energy balance table, IE in May 2005

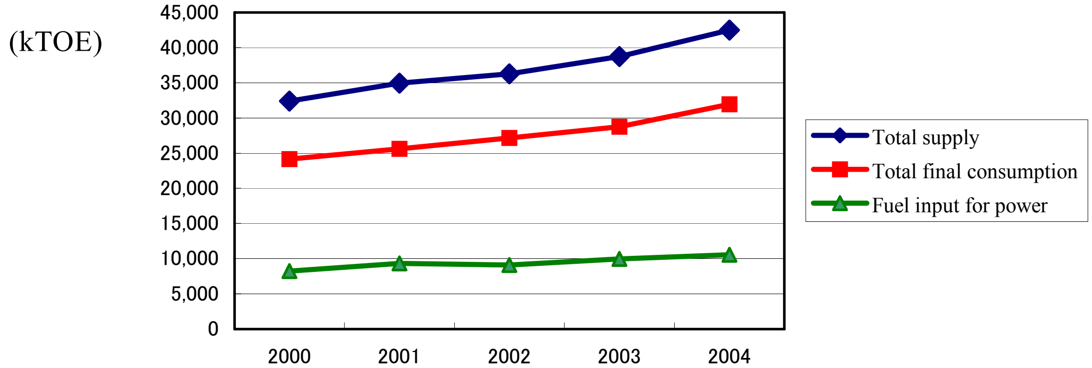


Figure 4-1-1 Energy Supply and Demand : 2000-2004

(2) Production and consumption by energy type

Domestic fossil fuel production in 2000-2004 is shown in Table 4-1-4.

Table 4-1-4 Actual Fossil Fuel Production

Production	2000	2001	2002	2003	2004
Coal (mil. ton)	12.20	14.59	17.08	19.98	27.10
Gas (bil.m3)	1.60	1.73	2.17	3.05	6.33
Crude oil (mil. ton)	15.42	16.83	16.86	17.18	19.50

Source: Report on Vietnam Coal Evaluation, January 2005. Vinacoal. And Strategy on Vietnam Oil and Gas sector Development up to 2015 and orientation to 2025, February, 2005. Petrovietnam.

a. Coal

In the period of 2000-2004, the average growth rate of coal production was 22.0%. In 2004, coal production was 27.10 million tons, of which 10.5 million tons was exported and about 13.5 million tons was supplied to the domestic market.

b. Crude oil and petroleum products

In the period of 2000-2004, the average growth rate of crude oil production was about 6.0%. In 2004, crude oil production was about 19.5 million tons. Since, at present, there are no oil refinery plants in Vietnam, crude oil is almost all exported to the international market.

Meanwhile, major petroleum products such as gasoline, jet fuel, kerosene, DO, FO, LPG and others are imported with an average growth rate of 11.0% per year. In 2004, about 10.75 million tons of petroleum products were imported and supplied to the various domestic sectors.

c. Gas

In the period of 2000-2004, the average growth rate of gas production was 43.3%. In 2004, gas production was about 6.328 billion m3, of which 3.99 billion m3 was consumed domestically and about 3.45 billion m3 was supplied to the power sector and the remaining 0.50 billion m3 to fertilizer plants.

d. Hydropower

In 2004, the total installed capacity of existing hydropower plants including small hydropower was 4,195MW, and the annual generated energy in 2004 was 18 billion kWh, accounting for 21.6% of the economical hydropower potential in the whole country (refer to Table4-1-5).

Table 4-1-5 Hydropower Plant in Operation (2004)

Name	River	Install Capacity (MW)	MW x Unit	2003 Generation Energy (GWh)
Hoa Binh	Da	1,920	240 x 3	8,337
Thac Ba	Lo-Gam-Chay	120	40 x 3	375
Yaly	Se San	720	180 x 3	3643
Vinh Son	Con	66	33 x 2	313
Song Hinh	Ba	70	35 x 2	374
Da Nhim	Dong Nai	167	40 x 7	1,052
Tri An	Dong Nai	400	100 x 4	1,713
Thac Mo	Be	150	75 x 2	604
Ham Thuan	La Nga	300	150 x 2	1,017
Da Mi	La Nga	175	88 x 2	590
Small HPP		35		

4.1.2 National Energy Policy

Energy supply plan to the power sector depends largely on the national energy policy, energy development plan and development target.

In accordance with the Draft Overview on Vietnam Energy Resources and National Energy Policy (summary), MOI, January 2005, the key points of national energy policy are summarized as follows;

(1) Key points of National Energy Policy

- To exploit in diversification, rationing and efficiency the national natural resources, in combination with imports, exports on the basis of reducing primary energy exports, cooperating with foreign countries in energy development and satisfying energy demand for the socio-economic development, ensuring fuel conservation and energy security for the future.
- To develop new projects together with rehabilitation and upgrading of the old ones. To use energy economically and effectively from energy production, transmission and processing to consumption.
- To develop energy resources in parallel with protection of natural resources and environment. To ensure the sustainable development of the energy sector.
- To gradually establish a competitive energy market, and to diversify investment and

business modes in the energy sector. The State shall only secure its monopoly in key items to ensure national energy security.

- To promote the rural energy program. To research and to develop new and renewable energy to meet the energy demand, especially energy demand in isolated and remote areas and islands.
- To develop the energy sector comprehensively and efficiently on the basis of mobilizing internal force in combination with improving international cooperation.
- To develop based on rational and effective consumption of regional energy resources; and to ensure sufficient, constant and safe energy supply for the whole country.
- To encourage economic sectors to join the power generation based on available energy potential of Vietnam, reducing the dependence on energy imports.

(2) Main items of energy development:

- Continue hydropower development;
- Prioritize natural gas exploitation and utilization;
- Improve the efficiency and stability of power supply;
- Prioritize new-renewable energy development (wind, solar, small hydropower, biogas etc.), and increase the share of these energy resources;
- Push the energy program in rural and mountain areas;
- Develop the power generation, electricity network in order to ensure enough supply to satisfy electricity demand and save part for reserve;
- Develop oil refinery factories aiming to sufficiently meet domestic demand;
- Establish the targets and long-term criteria on environmental aspects matching with regional and world criteria and suitable with the national economic condition; and
- Control and mitigate environmental pollution in energy activities.

(3) Main Target of Primary Energy Development

a. Promote discoveries and exploration of energy resources, improving proven reserves:

- Oil and gas: annual increase of reserves is about 200 million m^3 oil equivalent; by 2010, total proven reserves reaches roughly 1.3-1.4 billion m^3 oil equivalent; and by 2020, completion of assessment of the proven reserves of oil equivalent in the whole continental shelf and in economic prerogative zone to depth of 400m and in potential water zones between 400-1000m deep.

- Coal: by 2010, complete the survey and assessment of coal reserves from 300m to 1,100m deep, also complete the survey of a partial coal basin of the Hong River Delta; and by 2015, complete the survey of whole coal basin of the Hong River Delta.
- Hydropower: by 2010, about 10 billion kWh and by 2020, about 15-20 billion kWh will be added.
- Uranium: by 2010, about 8000 ton reserves of U_3O_8 grade C1+C2; by 2020, provide enough reliable data of U_3O_8 reserves of the nation.

b. Sufficiently supply primary energy for domestic demand, by 2010 about 47.4-50 million TOE; by 2020 about 91-100 million TOE, of which:

- Hydropower is to be generated at about 35 billion kWh by 2010, 60-65 billion kWh by 2020 and up to 70 - 80 billion kWh after 2020;
- Coal production should reach 35 - 40 million tons by 2010, about 50 – 60 million tons by 2020 of which part is exploited in Khoai Chau (Hung Yen Province); After 2020, develop the domestic coal exploitation to reduce or stop coal imports and increase coal production up to 200 million tons by 2050.
- Oil and gas exploitability in 2006-2010 will be about 30-32 million TOE, about 31-34 million tons/year in 2011-2015 and about 34-35 million tons/year in the period of 2016-2025.

c. New and renewable energy

Increasing the share from existing negligible share to 2% (0.9 million TOE), 3.4% (3.0 million TOE) and 7% (22.0 million TOE) of total commercial primary energy by 2010, 2020 and 2050.

d. Power generation and network

By 2010, reliability of power supply will be 99.7% (LOLE=24hr/year) and the power network standard will be N-1.

e. Oil refinery

Promote the development of oil refineries to gradually meet the domestic demand on petroleum products. By 2009, Dung Quat oil refinery will have been put into operation; in the period of 2011-2015, the 2nd and the 3rd oil refineries will have been developed in Nghi

Son (Thanh Hoa Province) and in the Southeast region; by 2020 new oil refineries will have been considered for expansion of construction, making the total capacity of domestic refineries up to 25 - 30 million tons of crude oil.

f. Environment

Put forward long-term targets and standards on environment in accordance with international and regional environmental standards and national economic conditions. All energy projects must satisfy the environmental standards by 2010.

g. Nuclear power generation

Get conditions ready to put the first nuclear power in operation by 2020, and increase the share of nuclear energy to 10-11% of total commercial energy consumption by 2050.

h. International cooperation

Develop power network interconnection with voltage up to 500kV by the period of 2006-2010, gas network interconnection in the period 2015-2020 and conduct energy import-export rationally and effectively on the basis of conservation of national energy resources.

(4) Energy Price

a. Principles on Pricing Energy:

・ The State interferes and regulates energy production through the price and tax system
・ Energy price ensures coverage of production cost, import fee and reproduction towards complete self-control in finance of the bodies doing business on energy
・ Aim at pricing under market mechanism towards integrating into international organization such as AFTA, WTO
・ Energy price contributes to promoting diversification of ownership, equitizing state-owned energy enterprise and promoting development of stock market
・ In order not to maintain a uniform energy price over the whole country, regulate price subsidies and tax reduction for easing the gap in energy reception
・ Change the price of energy types in variable energy prices and cost for energy production
・ Foreign currency shares a high ration in energy prices, so energy prices shall be adjusted by period under the inflation rate and exchange rate

b. Energy price policy

i) Coal Price

In the period during which the competitive coal market isn't established, the coal price for heavy industrial consumers (electricity, cement, paper and fertilizer) should be regulated by the State on the basis of being sufficient for covering production cost and rational profits of coal sector. The coal retail price to domestic end-users and export price will be determined according to the supply-demand balance of the market.

Being in line with reform of the coal sector orienting toward the establishment of competitive market, the coal price will be governed by market mechanism. The State with its tax policy (resources tax, import-export tax, etc) will keep control over coal producing utilities as well as import-export activities.

ii) Crude Oil Price

Crude oil for export and for domestic oil refineries will be priced in accordance with international market price.

iii) Petroleum Price

The State stipulates retail price regulations on some main gasoline and oil products, and the enterprises do business on gasoline and oil upon deciding their own retail price.

In case of coping with the drastic change of gasoline and oil price of the world market, the State will apply necessary measures and adjust oriented-price or tax for intervention.

Gasoline and oil prices come to be adjusted by market mechanism.

Oil storage for distributing in order to stabilize gasoline and oil prices is increased.

iv) LPG Price

LPG will be priced by the market mechanism. The State will exert control by tax policies and regulations on minimum reserves for circulation in order to stabilize retail price. The State will not stipulate the retail price of LPG but control by tax.

Apply preferential duties on production enterprises to encourage LPG production, gradually replacing the imported ones.

v) Gas Price

The State will establish the principles of gas pricing, profit, cost allocation, receipts of State etc. each time a gas field is developed

Gas price should be based on minimum gas price (price calculation by producer) and maximum price (acceptable price by end-user). Gas selling price will be negotiated between buyers and sellers within the range of the minimum and maximum price.

In the future, gas price will be regulated by market mechanism. Consumers are able to negotiate to buy gas directly from producers.

vi) Electricity Tariff

Facilitate economic sectors to invest into power development and benefit well; carry out energy resource conservation; utilize new and renewable energy resources that will not cause environmental pollution in the related activities; contribute to the socio-economic development, particularly in the countryside, mountainous areas and islands as well.

Encourage people to use electricity thriftily and efficiently.

Implement rational cross-subsidization among customer groups. Gradually reduce and then remove the cross-subsidization between power tariff for industry sector and power tariff for household use, contributing to the production development and improving competitiveness of enterprises.

Ensure self-determination right of parties involved in the power market in purchasing and selling electricity in accordance with price frame and price list regulated by the State.

Ensure legal rights and benefits of power companies/units and power users.

vii) Energy Subsidy

The State promulgates rational regulations on subsidy for coal, LPG, electricity selling price for rural, isolated and remote consumers. Subsidies will be gradually reduced at the regional growth income, economic rate.

Apply preferential duties and fees to consumers who use low quality coal.

Give minimum subsidy for low-income households and increase electricity price for households with large demand. At present, electricity selling price to rural households has been kept at ceiling price of 700VND/kWh.

4.2 Primary Energy Development Plan

In the period of 1990-2000, GDP growth rate reached an average of 7.5% and kept the same level up to 2004. From 2005 to 2025, average annual growth rate of GDP at 7.5% -7.0% in the base case and 8.5%-8.0% in the high case are expected. And average energy consumption per person in 2005 to 2025 is expected to increase at the average annual growth rate of 3.8%-4.3% in the base case and 4.6%-5.3% in the high case based on social-economic development.

In accordance with the draft national energy policy, sufficient supply of primary energy to national demand is taken into consideration in the energy development plan. Recent development plans by energy resource are described as follows ;

(1) Coal

Coal exploitation planned by Vinacoal in Base Case and High Case as shown in Table 4-2-1. According to the plan, after 2020, the domestic coal exploitation is kept at 50-60 million tones to reduce or stop imports of coal. Meanwhile, Dust Coal 5 used for power plants is estimated to be shortage and needs to be imported by 24 million tons from 2010 at Base Case and 19 million tons from 2011 at High Case. As for the other types of coal, domestic coal demand and coal for export can be met with the domestic coal production plan from 2005 to 2025.

Table4-2-1 Coal Exploitability Forecast (2005-2025)

Coal exploitation	2005	2010	2015	2020	2025
Base case (million tons)	31.25	42.44	50.52	54.39	52.70
High case (million tons)	31.25	48.44	57.32	62.15	54.80

Source: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025, June, 2005, Vinacoal

(2) Oil and Gas

According to the strategy on oil and gas sector development up to 2015 by Petrovietnam, oil production was 20.4 million tons and that of gas was 6.3 billion m3 in 2004. Taking into account the difficulties of exploration in the deep sea and the domestic demand, it is predicted and planned that domestic crude oil exploitation is maintained at the same volume as present level of 18-19 million tons per year until 2012. After 2012, it is necessary to promote exploration for discovering more oil and gas reserves (Table4-2-2).

By following the national policy of prioritizing natural gas exploitation and utilization and forecasting rapid growth of gas consumption, gas exploitation and production are planned to increase from 2015. However, depending on the geological conditions of oil and gas fields, the development plan may be affected by change of investment condition and technical difficulties of exploitation in the deep sea.

Table4-2-2 Oil and Gas Exploitation Plan (2005-2020)

Exploitation	2005	2006-2010	2011-2015	2016-2025
Oil (million tons)	18-20	18-20	19-20	19-20
Gas (billion m3)	6-10	6-10	11-15	15-16

Source: Strategy on Vietnam Oil and Gas Sector Development up to 2015 and Orientation to 2025, Feb.2005, Petrovietnam

(3) Hydropower

Hydropower is a clean and renewable energy resource. Though sizeable up-front costs are needed for development, once operated, this energy is cheap and stable for more than one hundred years and not influenced by exchange rate fluctuation because the fuel cost is zero. Therefore, EVN should properly develop hydropower plants, which have economic rationale.

According to the revised 5th MP, a total of 12,135MW hydropower is developed from 2003 to 2020, of which the north region accounts for 54%, the central 29%, and the south 17%. In the PDP 6th, new hydropower of about 16GW is planned for development by 2025, meaning that most of the feasible hydropower potential with capacity of 20GW is developed.

(4) Nuclear Power Generation

In accordance with the Draft of National Energy Policy by MOI, the first nuclear power plant will be put into operation in 2020. At present, the pre-feasibility study of nuclear power plant construction has been finished, and commissioning of the First Unit with a capacity of 1,000MW is planned in the study. In the PDP 6th, nuclear power plants with a total capacity of 8,000MW will be developed by 2025.

(5) New and Renewable Energy

In 2003, there were small hydropower and small wind power with a capacity of 94.9MW. In accordance with Draft National Energy Policy by MOI, it is planned to develop and increase the share of new and renewable energy at a level of 3% of total power plant capacity up to 2010, as well as 5% up to 2020 and 10% up to 2040 respectively.

(6) Oil Refinery

Since there is no domestic oil refinery currently, oil products are all imported. However, in order to meet the growth of the demand for oil products, oil refineries with total capacity of 25-30 million tons will be developed by 2020 as aforementioned in Section 4-1-2.

At present, Dung Quat oil refinery plant located in central Quang Ngai Province with capacity of 6.5 million tons is under construction. The construction started in 2005, and the plant is expected to put into operation in 2010. The feasibility study on Nghi Son oil refinery and petro-chemical complex (planning capacity 6.5 million tons, operation scheduled in 2015) located in Thanh Hoa Province have been carried out and await approval of F/S by the Government.

The 3rd one is planned to put into operation in 2025 with capacity of 6-10 million tons, and examination has started on its site selection (southeast area expected), scale plan and products.

4.3 Energy Demand and Supply Balancing Plan up to 2025

4.3.1 Preconditions

As well as power demand forecasting, the following economic preconditions and conditions by sector are prepared for the energy demand forecasting study as the following three cases;

<Base case>

The high economic scenario that is mentioned in the social-economic plan is applied to the energy demand forecasting by sector at first, then, power ratio by sector and energy conservation factor are taken into consideration in the energy demand forecasting.

<High case>

Same as Base case

<Low case>

The economic scenario with base economic scenario in social-economic plan is applied for energy demand forecasting

(1) Economic Preconditions

Following preconditions are the same as those for power demand forecasting

- Population growth rate
- Exchange rate
- GDP growth rate
- Crude oil price (WTI)
- Power ratio in Agricultural sector
- Power ratio in Industrial sector
- Power ratio in Transportation sector
- Power ratio in Commercial sector
- Power ratio in Residential sector

(2) Sectional Energy Consumption Ratio

Primary energy is divided into final energy consumption by sector and fuel consumption in the power sector. Fuel consumption in the power sector such as coal, gas and fuel oil etc. cannot be finalized before determining PDP 6^{th}. Meanwhile, final energy consumption can be calculated based on the energy consumption by sector. The preconditions of energy consumption ratio by sector for final energy consumption calculation are as follows;

<Energy consumption ratio in Agricultural sector>

Item	Ratio	2005	2010	2015	2020	2015
Coal demand	%	4.9	3.7	2.7	1.6	0.6
Gasoline demand	%	20.5	21.8	27.4	28.9	17.8
Diesel demand	%	70.0	69.0	62.3	61.2	75.9
Fuel oil demand	%	4.5	5.5	7.5	8.4	5.7
Total	%	100.0	100.0	100.0	100.0	100.0

Applied to all cases

<Energy consumption ratio in Industrial sector>

Item	Ratio	2005	2010	2015	2020	2025
Coal demand	%	37.4	42.4	42.0	41.7	43.2
LPG demand	%	1.2	1.7	2.2	2.4	2.1
Kerosene demand	%	0.1	0.2	0.2	0.2	0.2
Diesel demand	%	9.6	11.9	14.7	15.5	12.9
Fuel oil demand	%	15.5	19.8	24.7	26.2	22.0
Natural gas demand	%	4.7	6.5	9.8	14.1	19.7
Renewable energy	%	31.5	17.5	6.5	0.0	0.0
Total	%	100.0	100.0	100.0	100.0	100.0

<Energy consumption ratio in Transportation sector>

Item	Ratio	2005	2010	2015	2020	2025
Coal demand	%	50.6	56.6	52.3	49.2	52.3
LPG demand	%	3.9	3.4	3.8	4.1	3.9
Kerosene demand	%	41.1	35.4	38.3	40.3	37.4
Diesel demand	%	4.4	4.6	5.6	6.4	6.4
Total	%	100.0	100.0	100.0	100.0	100.0

<Energy consumption ratio in Commercial sector>

Item	Ratio	2005	2010	2015	2020	2025
Coal demand	%	24.4	22.4	23.0	22.2	19.3
LPG demand	%	22.4	22.0	16.5	18.0	24.4
Kerosene demand	%	13.9	9.2	4.8	0.0	0.0
Diesel demand	%	26.5	29.2	34.2	36.2	33.6
Fuel oil demand	%	12.8	17.2	21.4	23.6	22.7
Total	%	100.0	100.0	100.0	100.0	100.0

<Energy consumption ratio in Residential sector>

Item	Ratio	2005	2010	2015	2020	2025
Coal demand	%	6.9	7.2	8.3	9.3	10.1
LPG demand	%	4.7	9.2	12.8	16.5	20.5
Kerosene demand	%	1.3	1.6	1.9	2.2	2.4
Renewable energy	%	87.0	82.0	77.0	72.0	67.0
Total	%	100.0	100.0	100.0	100.0	100.0

Applied to all cases

The above energy consumption ratio is set by consideration of the actual records, future utilization pattern of energy and energy demand forecast by IE model.

(3) Primary Energy Demand Forecasting Formulas by IE

Formulas of IE for calculation of final consumption by sector are as follows.

The results of energy demand forecast calculated by both IE and the Study Team were compared and revised by both parties, and this procedure was repeated. Finally, nearly the same results of energy final consumption by sector and by energy type were obtained and both parties reached agreement on the results.

IE's forecast of final energy consumption by sector was adopted and the forecast of the fuel consumption in the power sector calculated by the Study Team was adopted in the Study.

<Formula for final energy consumption in Agricultural sector>

Dependent variable	Explanation variable
Coal demand	a* (Coal demand (-1)) + b
Gasoline demand	a* (Agricultural GDP) + b
Diesel demand	a* (Agricultural GDP) + b* (Agricultural GDP energy intensity)+c
Fuel oil demand	a* (Agricultural GDP) + b

Note: (-1) means demand of last year
Applied to all cases

< Formula for final energy consumption in Industrial sector>

Dependent variable	Explanation variable
Coal demand	a* (Industrial GDP) + b* (Industrial GDP energy intensity) + c
LPG demand	a* (Industrial GDP) + b
Kerosene demand	a* (Industrial GDP) + b
Diesel demand	a* (Industrial GDP) + b* (Industrial GDP energy intensity) + c
Fuel oil demand	a* (Industrial GDP) + b
Natural gas demand	=1.145*(Natural gas oil demand (-1))
Renewable energy	a* (Industrial GDP) + b* (Industrial GDP energy intensity) + c

Note: (-1) means demand of last year
Applied to all cases

< Formula for final energy consumption in Transportation sector>

Dependent variable	Explanation variable
Gasoline demand	a* (Transportation GDP) + b* (gasoline demand (-1)) + c
Jet oil demand	a* (Transportation GDP)
Diesel demand	a* (Transportation GDP) + b* (Transportation GDP energy intensity) + c
Fuel oil demand	a* (Transportation GDP) + b

Note: (-1) means demand of last year

< Formula for final energy consumption in Commercial sector>

Dependent variable	Explanation variable
Coal demand	a* (Commercial GDP) + b
LPG demand	a* (Commercial GDP) + b
Kerosene demand	a* (Commercial GDP) + b* (Kerosene demand (-1)) + c
Diesel demand	a* (Commercial GDP) + b* (Commercial GDP energy intensity) + c
Fuel oil demand	a* (Commercial GDP) + b

Note: (-1) means demand of last year

< Formula for final energy consumption in Residential sector>

Dependent variable	Explanation variable
Coal demand	a* (Residential GDP) + b
LPG demand	a* (Residential GDP) + b* (Residential GDP energy intensity) + c
Kerosene demand	a* (Residential GDP) + b
Diesel demand	a* (Diesel demand (-1)) + b
Fuel oil demand	a* (Fuel oil demand (-1)) + b

Note: (-1) means demand of last year

(4) Reconditions for Energy Consumption in Power Sector

Energy consumption in the power sector will be decided after preparation of PDP 6th. In this study, energy consumption forecasting model is set tentatively, taking into consideration those factors such as capacity of future power plant, plant factor and energy consumption intensity for calculation of energy consumption at this stage. The preconditions of calculation of all cases are as follows;

<Capacity of future power generation>

Power generation	Unit	2005	2010	2015	2020	2025
Hydro power	MW	4,189	9788	15,167	17,619	19,619
Nuclear power	MW				3,000	8,000
Foreign trade	MW	170	760	1,637	3,544	3,544
Thermal (Coal)	MW	1,547	6,443	8,838	20,838	38,838
Thermal (FO)	MW	960	1,100	624	624	624
Gas-turbine (Gas)	MW	4,251	4,911	8,451	8,451	9,171
Gas steam (Gas)	MW	0	2,040	4,140	6,300	6,300
Diesel generator	MW	153	40	40	40	40
Total	MW	11,269	25,082	38,897	59,816	86,136

Note: Applied to all cases

<Plant factor>

Type	Unit	2005	2010	2015	2020	2025
Hydro power	%	50	50	50	50	50
Nuclear power	%				70	70
Foreign trade	%		100	100	100	100
Thermal (Coal)	%	65	65	65	65	65
Thermal (FO)	%	46	46	46	46	46
Gas-Turbine (Gas)	%	65	65	55	50	50
Gas ST (Gas)	%	65	65	55	50	50

<Energy consumption intensity>

Type	Eff.	kcal	2005	2010	2015	2020	2025
From Thermal (Coal)	30%	5,600	1,953	1,953	1,953	1,953	1,953
From Thermal (FO)	35%	9,910	4,033	4,033	4,033	4,033	4,033
From Gas-turbine (Gas)	48%	9,000	5,023	5,023	5,023	5,023	5,023
From Gas steam	40%	9,000	4,186	4,186	4,186	4,186	4,186
From Diesel	36%	10,150	4,249	4,249	4,249	4,249	4,249

4.3.2 Results of Energy Demand and Supply Balancing Study

The Study Team together with IE counterparts studied the power demand forecast from 2005 to 2025 based upon the statistical data in the period of 1990-2002 (refer to Table 4-3-1).

Table 4-3-1 Power Demand Forecast (GWh)

	2000	2005	2010	2015	2020	2025
Basic case	22,000	46,000	97,000	165,000	257,000	381,000
Growth rate (%)		15.7	16.3	11.2	9.3	8.2
High case	22,000	46,000	101,000	172,000	268,000	399,000
Growth rate (%)		15.7	17.2	11.2	9.2	8.3

Source: JICA/IE study on power demand forecast, Sep. 2005

(1) Domestic Final Consumption

From the study, total domestic energy demand on coal, oil products and gas for domestic final consumption and in the power sector were higher than the forecast by Vinacoal and Petrovietnam.

Total demand of domestic final consumption is forecasted to increase with growth rate of 4.0% per year in Base Case and 5% in High Case by the Study Team/IE as 31,751 kTOE of both Base Case and High Case in 2005, and 70,762 kTOE of Base Case, 91,026kTOE of High Case in 2025 (refer to Table 4-3-2 and Figure 4-3-1 for Base Case, Table 4-3-3 and Figure 4-3-2 for High Case).

Table 4-3-2 Domestic Final Consumption Forecast : Base Case

(Unit: k TOE)

	2000	2005	2010	2015	2020	2025
Oil products	6,760	11,318	17,815	27,245	37,360	43,255
Gas	18	450	818	1488	1,950	2,000
Coal	3,223	5,204	6,177	8,436	10,584	10,985
Renewable	14,191	14,779	14,914	15,415	15,483	14,522
Total consumption	***24,192***	***31,751***	***39,724***	***52,584***	***65,377***	***70,762***
Growth rate (%)		5.59	4.58	5.77	4.45	1.60

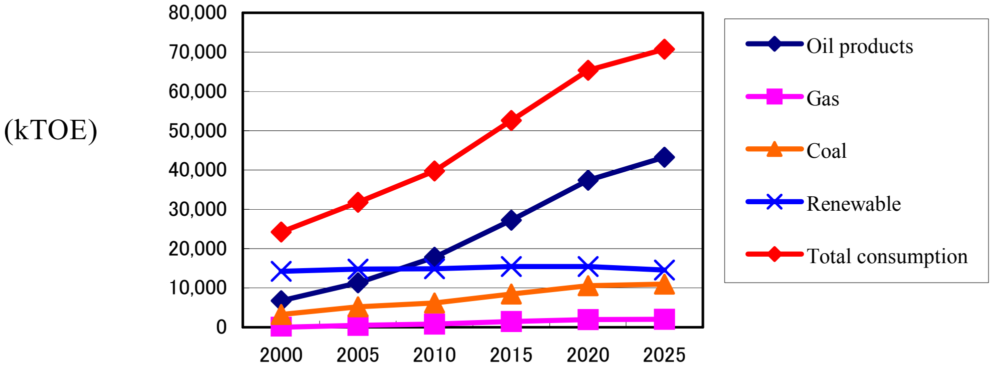


Figure 4-3-1 Domestic Final Consumption Forecast : Base Case

Table 4-3-3 Domestic Final Consumption Forecast : High Case

(Unit: kTOE)

	2000	2005	2010	2015	2020	2025
Oil products	6,760	11,318	18,803	30,879	46,082	56,707
Gas	18	450	886	1743	1,950	2,000
Coal	3,223	5,204	6,444	9,550	13,032	14,232
Renewable	14,191	14,779	15,134	15,985	18,121	18,087
Total consumption	24,192	31,751	41,267	58,157	79,185	91,026
Growth rate (%)		5.59	5.38	7.10	6.37	2.83

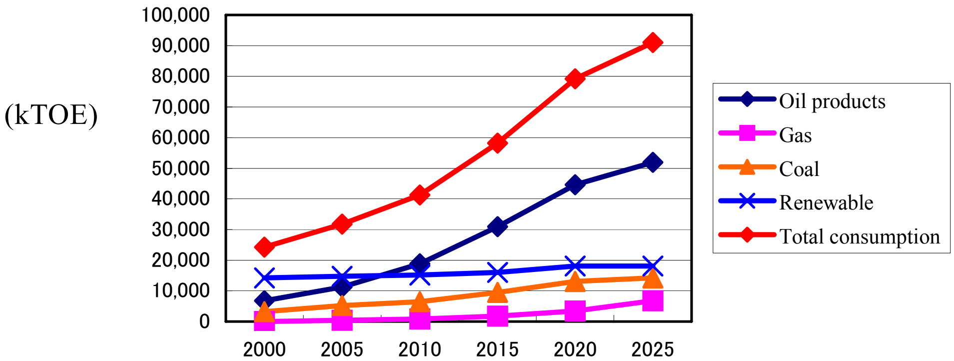


Figure 4-3-2 Domestic Final Consumption Forecast : High Case

(2) Fossil Fuel Consumption in Power Sector

Fossil fuel demand in the power sector is forecasted to increase with annual average rate of 11.99% in Base Case, 12.50% in High Case. Energy consumption in the power sector is estimated as about 6,718 kTOE (Base Case and High Case) in 2005, and 56,846 kTOE (Base Case), 61,012 kTOE (High Case) in 2025 (refer to Table 4-3-4 and Fig.4-3-3 for Base Case, Table 4-3-5 and Fig. 4-3-4 for High Case)

Table 4-3-4 Forecast of Fossil Fuel Consumption in the Power Sector : Base Case

(Unit:kTOE)

	2005	2010	2015	2020	2025
Total Consumption	***6,718***	***12,681***	***21,576***	***35,335***	***56,845***
Coal	1,799	6,138	10,352	23,220	44,297
DO	60.8	13.0	16.0	15.7	15.6
FO	903.5	847.7	591.3	579.21	575.8
NG & AG	3,954	5,682	10,770	11,520	11,957

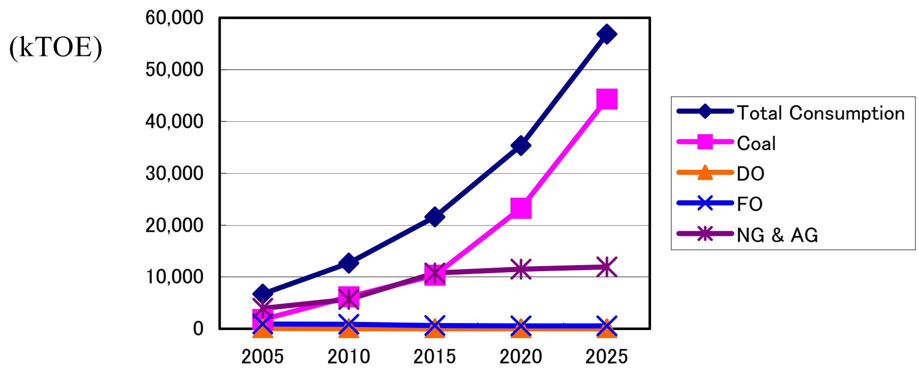


Fig.4-3-3 Fossil Fuel Consumption in Power Sector : Base Case

Table 4-3-5 Forecast on Fossil Fuel Consumption in Power Sector :High Case

(Unit:kTOE)

	2005	2010	2015	2020	2025
Total Consumption	***6,718***	***13,629***	***23,454***	***37,760***	***61,012***
Coal	1,800	6,597	11,160	24,814	47,746
DO	60.8	14.0	17.3	16.8	16.8
FO	903.5	911.1	637.4	618.9	620.6
NG & AG	3,954	6,107	11,639	12,310	12,630

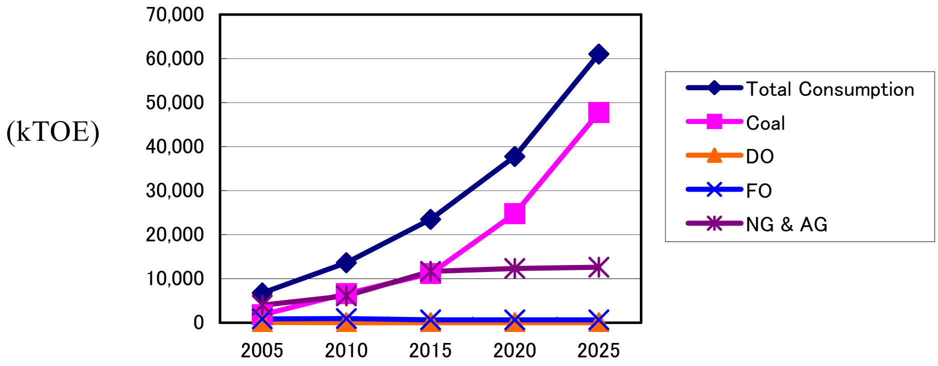


Fig.4-3-4 Fossil Fuel Consumption in Power Sector : High Case

(3) Energy Supply from Vinacoal and Petrovietnam

Concerning domestic fossil fuel supply based upon energy development plan from Vinacoal and Petrovietnam in the period of 2005 – 2025, it is estimated that average annual growth rate is about 6.47% for oil products, 5.17% for gas and 4.39% for coal in Base Case, and 7.06% for oil products, 5.17% for gas, 5.01% for coal in High Case (refer to Table4-3-6 for Base Case, Table 4-3-7 for High Case).

Table4-3-6 Primary Energy Supply Forecast: Base Case

(Unit:kTOE)

	2000	2005	2010	2015	2020	2025
Oil products	7,757	11,402	17,815	20,360	33,289	39,946
Gas	1,440	5,418	9,234	13,500	14,058	14,841
Coal	4,718	8,636	15,726	18,171	19,848	20,381
Renewable	14,191	14,779	14,914	15,415	15,483	14,522
Hydro	4,314	4,292	8,856	14,088	19,320	19,320
Total	***32,400***	***44,526***	***66,545***	***81,534***	***101,997***	***109,011***
Growth rate (%)		6.55	8.37	4.15	4.58	1.34

Source: Coal; Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.and Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam

Table4-3-7 Primary Energy Supply Forecast : High Case (Unit:kTOE)

	2000	2005	2010	2015	2020	2025
Oil products	7,757	11,402	16,200	25,450	37,157	44,588.4
Gas	1,440	5,418	9,234	13,500	14,058	14,841
Coal	4,718	8,776	17,258	21,200	24,138	23,344
Renewable	14,191	14,779	15,134	15,985	18,121	18,087
Hydro	4,314	4,292	8,856	14,088	19,320	19,320
Total	***32,400***	***44,666***	***66,682***	***90,223***	***112,794***	***120,180***
Growth rate (%)		6.62	8.34	6.23	4.57	1.28

Source: Coal; Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.and Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam

(4) Fossil Energy Supply and Demand Forecast

It is forecasted that average annual growth rate of domestic energy supply is about 4.6% for Base Case and 5.1% High Case, meanwhile, average annual growth rate of energy demand is 5.8% for Base Case and 7.3% for High Case. Domestic energy supply and demand can be balanced until 2020. However, after 2020, since supply capacity will be saturated due to limitation of reserves of energy resource, domestic energy supply cannot meet the demand in both cases (refer to Table 4-3-8 and Figure 4-3-5 for Base Case, Table 4-3-9 and Figure 4-3-6 for High Case).

Table 4-3-8 Total Supply-Demand Forecast : Base Case

(Unit: kTOE)

	2000	2005	2010	2015	2020	2025
Total Supply	32,420	44,526	66,545	81,534	101,997	109,010
Total Demand	26,119	38,469	52,405	74,340	100,713	127,608
Balance	***6,301***	***6,057***	***14,140***	***7,194***	***1,2842***	***-18,598***

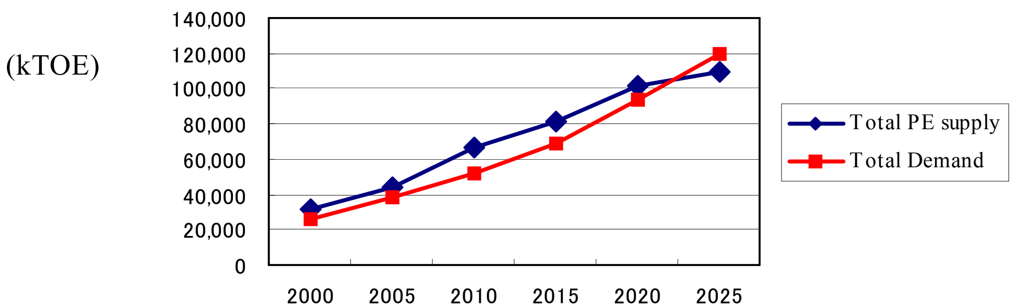


Fig.4-3-5 Total Supply-Demand : Base Case

Table 4-3-9 Total Supply-Demand: High Case

(Unit: kTOE)

	2000	2005	2010	2015	2020	2025
Total Supply	32,420	44,666	66,682	90,223	112,794	120,180
Total Demand	26,119	38,469	54,896	81,611	116,945	152,038
Balance	***6,301***	***6,197***	***11,786***	***8,612***	***-4,152***	***-31,858***

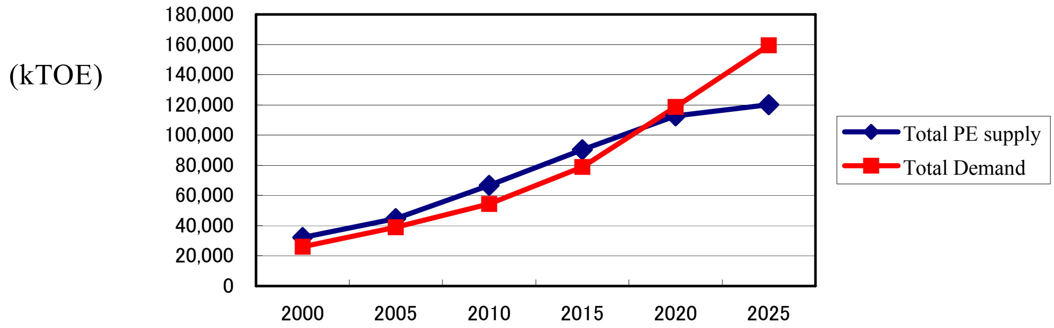


Fig.4-3-6 Total Supply-Demand : High Case

a. Coal

1) Forecast by Vinacoal

According to the Vinacoal report dated 15 June, 2005, coal production is expected to reach 31.25 million tons in 2005, 42.44 million tons (Base Case), 48.44 million tons (High Case) in 2010 and 52.7 million tons (Base Case), 54.8 million tons (High Case) in 2025 with annual growth rate of 2.65% (Base Case), 2.85% (High Case) from 2005 to 2025. After 2020, annual production is expected to hold steady at a level of 50- 60 million tons. Coal supply for domestic sectors including the power sector is forecasted as 19.97 million tons in 2005, 34.65 million tons (Base Case), 38.24 million tons (High Case) in 2010 and 44.25 million tons (Base Case), 48.85 million tons (High Case) in 2025 with annual growth rate of 4% (Base Case), 5% (High Case).

Meanwhile, coal demand of the domestic sector and the power sector is expected 15.42 (Base Case) -15.67 (High Case) million tons in 2005, 32.45 (Base Case) , 37.86 (High Case) million tons in 2015, and 36.40 (Base Case), 41.63 (High Case) million tons in 2025 with annual growth rate of 4.34 (Base Case), 5.0% (High Case). After 2010, in order to meet the coal demand, the shortage of domestic coal supply capacity will be supplemented by reduction of export (refer to Table 4-3-10 for Base Case, Table 4-3-11 for High Case). That is, based on the forecast of domestic coal demand by Vinacoal, the domestic coal supply can meet demand without import up to 2025.

Table 4-3-10 Coal Supply and Demand Forecast by Vinacoal : Base Case

(Unit: 1,000tons)

	2005	2010	2015	2020	2025
Production	31,245	42,440	50,515	54,385	52,700
Total supply	26,699	35,877	42,503	45,994	44,851
Export	11,277	7,794	10,054	10,552	8,449
Domestic supply	15,422	28,083	32,449	35,442	36,402
Consumption in power sector	4,160	15,650	21,525	25,220	25,220
Domestic Final Consumption	11,262	12,433	10,924	10,222	11,182
Domestic Demand	15,422	28,083	32,449	35,442	36,402

Source: Production: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.
Demand: Coal production and consumption, Coal supply-demand forecast, Domestic coal output for power generation and Evaluation on coal import capability. Vinacoal, June 2005

Table 4-3-11 Coal Supply and Demand Forecast by Vinacoal : High Case

(Unit: 1,000tons)

	2005	2010	2015	2020	2025
Production	31,245	48,440	57,315	62,150	54,800
Total supply	26,699	41,018	49,350	55,387	47,582
Export	11,027	10,200	11,493	12,284	5,954
Domestic supply	15,672	30,818	37,857	43,103	41,628
Consumption in power sector	4,160	15,650	21,525	31,920	31,920
Domestic Final Consumption	11,512	15,168	16,332	11,183	9,708
Domestic Demand	15,672	30,818	37,857	43,103	41,628

Source: Production: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.
Demand: Coal production and consumption, Coal supply-demand forecast, Domestic coal output for power generation and Evaluation on coal import capability. Vinacoal, June 2005

However, in the case where coal-fired thermal power plants are constructed on schedule as estimated (5,240MW by 2010 and 8,560MW by 2025), about 2.4 million tons of Dust Coal 5 (5,500kcal/kg) used for coal-fired thermal power plants will run short in 2010, by 6 million tons in 2015 and about 7.7 million tons in 2025 in Base Case. It also runs short by about 1.9 million tons in 2010, and 10 million tons in 2025 for the coal-fired thermal power plants in High Case. Therefore, the fuel coal for coal TPP will be imported from Indonesia and/or Australia.

2) Forecast by Study Team

The Study Team studied on coal supply and demand forecast, and the result showed supply shortage by about 617 kTOE (about 1.1 million tons) by 2015, 13,956 kTOE (about 23.3 million tons) by 2020 and 34,898 kTOE (about 58.0 million tons) by 2025 in Base Case. And shortage by about 13,708 kTOE (about 23.0 million tons) by 2020 and 38,633 kTOE (about 64.0 million tons) by 2025 in High Case. (refer to Table 4-3-12 Base Case and Table 4-3-13 High Case)

Table4-3-12 Comparison of Coal Demand Forecast :Base Case

(Unit:kTOE)

	Data	2005	2010	2015	2020	2025
Domestic Coal supply	Vinacoal	8,636	15,726	18,171	19,848	20,385
Domestic Fuel Consumption	Vinacoal	6,306	6,962	6,117	5,724	6,258
	JICA/IE	5,204	6,177	8,436	10,584	10,985
Consumption in the power sector	Vinacoal	2,330	8,764	12,054	14,123	14,123
	JICA/IE	1,800	6,138	10,352	23,220	44,298
Total demand	Vinacoal	8,419	15,726	18,171	19,848	20,381
	JICA/IE	7,004	12,315	18,788	33,804	55,283
Balance	Vinacoal	217	0	0	0	4
	JICA/IE	1,632	3,411	-617	-13,956	-34,898

Source: Production: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.
Demand: Coal production and consumption, Coal supply-demand forecast, Domestic coal output for power generation and Evaluation on coal import capability. Vinacoal, June 2005

Table4-3-13 Comparison on Coal Demand Forecast :High Case

(Unit:kTOE)

	Data	2005	2010	2015	2020	2025
Domestic Coal supply	Vinacoal	8,776	17,258	21,200	24,138	23,344
Domestic FC	Vinacoal	6,446	8,494	9,146	6,262	5,468
	JICA/IE	5,204	6,444	9,550	13,032	14,232
Consumption in power sector	Vinacoal	2,330	8,764	12,054	17,875	17,875
	JICA/IE	1,800	6,597	11,160	24,814	47,745
Total demand	Vinacoal	8,776	17,258	21,200	24,138	23,344
	JICA/IE	7,004	13,041	20,710	37,846	61,977
Balance	Vinacoal	0	0	0	0	0
	JICA/IE	1,772	4,217	490	-13,708	-38,633

Source: Production: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.
Demand: Coal production and consumption, Coal supply-demand forecast, Domestic coal output for power generation and Evaluation on coal import capability. Vinacoal, June 2005

3) Coal Consumption in Power Sector

According to the report of “Coal production and consumption, coal supply-demand forecast, domestic coal supply for power generation and evaluation on coal import capability” June.15, 2005 by Vinacoal, in Base Case, from 2010-2015 Dust Coal 5 used for the power sector runs short by about 2.3-2.5 million tons in 2010 and 7-8.5 million tons in 2025. In High Case, the shortage is about 2-2.6 million tons in 2011 and 9.5-10 million tons in 2025.

In the Study, coal supply for the power sector is not sufficient in operation of coal-fired thermal power plants after 2010, and runs short by about 1.666 kTOE (about 2.8 million tons) by 2015, 13,956 kTOE (about 22.7 million tons) by 2020, 34,488 kTOE (about 57.5 million tons) in Base Case, and 11,480 kTOE (about 1.9 million tons) by 2020, 35,471 kTOE (about 59.1 million tons) by 2025 in High Case (Table 4-3-14 and Figure 4-3-7 for Base Case, Table 4-3-15 and Figure 4-3-8 for High Case).

Table 4-3-14 Coal Supply-Demand Forecast for Power Sector : Base Case

(Unit : kTOE)

		2005	2010	2015	2020	2025
Coal supply to Power Sector		2330	7,428	8,686	9,598	9,810
Demand	Vinacoal	2,330	8,764	12,054	14,123	14,123
	JICA/IE	1,800	6,138	10,352	23,220	44,298
Balance	Vinacoal	0	-1,336	-3,368	-4,525	-4,313
	JICA/IE	530	1,290	1,666	-13,622	-34,488

Source: Production: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.

Demand: Coal production and consumption, Coal supply-demand forecast, Domestic coal output for power generation and Evaluation on coal import capability. Vinacoal, June 2005

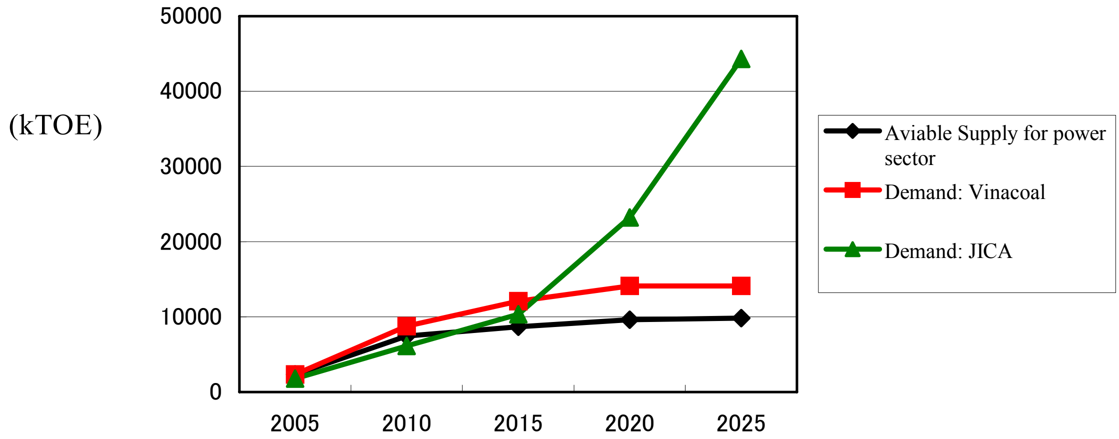


Figure 4-3-7 Coal Supply-Demand in Power Sector : Base Case

Table 4-3-15 Coal Supply-Demand Forecast for Power Sector : High Case

(Unit: kTOE)

Coal supply to power sector		2330	8,764	11,519	13,334	12,274
Demand	Vinacoal	2,330	8,764	12,054	17,875	17,875
	JICA/IE	1,800	6,597	11,160	24,814	47,745
Balance	Vinacoal	0	0	-535	-4,542	-5,602
	JICA/IE	530	2,167	359	-11,480	-35,471

Source: Production: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.

Demand: Coal production and consumption, Coal supply-demand forecast, Domestic coal output for power generation and Evaluation on coal import capability. Vinacoal, June 2005

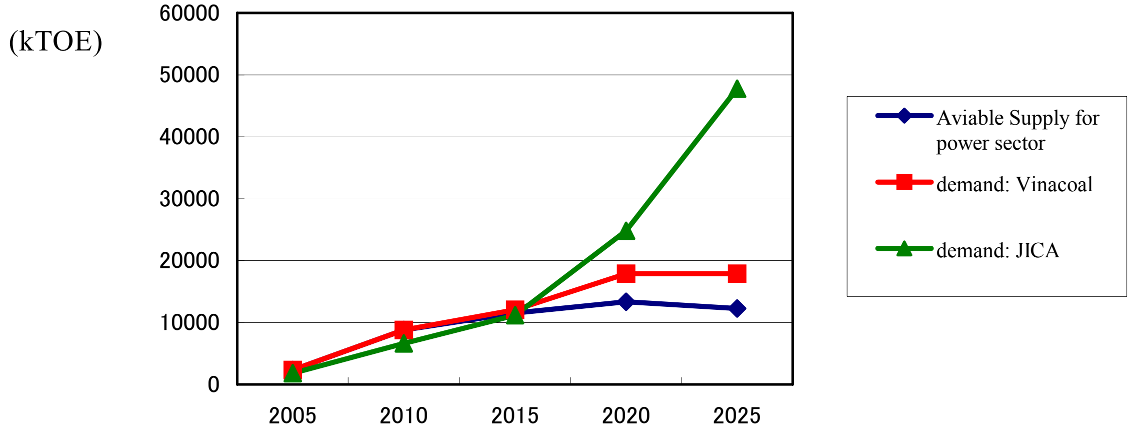


Figure 4-3-8 Coal Supply-Demand in Power Sector : High Case

b. Gas

1) Forecast by Petrovietnam

According to the report of "Strategy on Vietnam Oil and Gas Sector Development up to 2015 and Orientation to 2025" February 2005 by Petrovietnam, gas exploitation volume reached 6.02 billion m3 in 2005. Since then, with annual growth rate of exploitation of 5.16%, exploitation volume is forecasted to increase up to 16.5 billion m3 in 2025 (in both Base Case and High Case). All gas production is consumed domestically.

Around 90% of gas production is used for power generation. Domestic demand of gas is predicted to increase with annual growth rate of 5.97% from 2005 to 2020.

Based on the forecast by Petrovietnam, domestic demand of gas surpasses supply capacity after 2020. It is estimated that the gas runs short by about 2.71 billion m3 in 2025 (Base case), about 2.0 billion m3 in 2020 and about 2.71 billion m3 in 2025 (High Case) as shown in Table 4-3-16 for Base Case, Table 4-3-17 for High Case.

Table4-3-16 Gas Supply and Demand Forecast : Base Case (Unit: billion m^3)

	2005	2010	2015	2020	2025
Exploitation	6.02	10.26	15	15.62	16.49
Total Supply	***6.02***	***8.2***	***11***	***15***	***16.49***
Consumption in power sector	4.50	6.30	8.70	11.15	13.74
Consumption in industry sector	1.52	1.90	2.30	3.00	5.46
Total Demand	***6.02***	***8.2***	***11***	***14.15***	**19.20**
Balance	0.00	0.00	0.00	0.85	-2.71

Source: Strategy on Vietnam oil and gas sector development up to 2015 and orientation to 2025, February 2005, Petrovietnam and Situation of supply and consumption of oil and gas in Vietnam. July 2005, Petrovietnam

Table4-3-17 Gas Supply and Demand Forecast : High Case (Unit: billion m^3)

	2005	2010	2015	2020	2025
Exploitation	6.02	10.26	15	15.62	16.49
Total Supply	***6.02***	***9.6***	***15***	***16***	***16.49***
Consumption in power sector	4.50	7.10	11.02	11.15	13.74
Consumption in industry sector	1.52	2.50	3.98	6.85	5.46
Total Demand	***6.02***	***9.60***	***15.00***	***18.00***	***19.20***
Balance	0.00	0.00	0.00	-2.00	-2.71

Source: Strategy on Vietnam oil and gas sector development up to 2015 and orientation to 2025, February 2005, Petrovietnam and Situation of supply and consumption of oil and gas in Vietnam. July 2005, Petrovietnam

2) Forecast by the Study Team

The domestic final consumption in the power sector is estimated to increase in line with mainly the planned gas-fired thermal power plants in PDP 6th.

On the contrary, since gas supply capability is limited to around 16 million m3, total capacity of gas fired thermal power plant is limited to around 17GW (refer to Table 4-3-18 for Base Case and Table 4-3-19 for High Case).

Table 4-3-18 Comparison on Gas Demand Forecast :Base Case
(Petrovietnam plan and JICA team study) (Unit:kTOE)

	Data	2005	2010	2015	2020	2025
Gas supply	Petrovietnam	5,400	10,080	13,950	14,490	14,400
Consumption in Industry Sector	Petrovietnam	1,368	1,710	2,070	2,700	4,914
	JICA/IE	450	818	1,488	1,950	2,000
Consumption in Power Sector	Petrovietnam	4,050	5,670	11,880	11,790	9,486
	JICA/IE	3,954	5,682	10,770	11,520	11,957
Total demand	Petrovietnam	5,400	10,080	13,950	14,490	14,400
	JICA/IE	4,404	6,500	12,258	13,470	13,957
Balance	Petrovietnam	0	0	0	0	0
	JICA/IE	9964	3,580	1,692	1.020	443

Source: Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam and Situation of supply and consumption of oil and gas in Vietnam. July 2005, Petrovietnam

Table 4-3-19 Comparison on Gas Demand Forecast :High Case
(Petrovietnam plan and JICA team study) (Unit:kTOE)

	Data	2005	2010	2015	2020	2025
Gas supply	Petrovietnam	5,400	10,080	13,950	14,490	14,400
Consumption in Industry Sector	Petrovietnam	1,350	3,690	3,582	6,165	4,914
	JICA/IE	450	886	1,743	1,950	2,000
Consumption in Power Sector	Petrovietnam	4,050	6,390	10,368	8,325	9,486
	JICA/IE	3,954	6,108	11,639	12,310	12,630
Total demand	Petrovietnam	5,400	10,080	13,950	14,490	14,400
	JICA/IE	4,404	6,994	13,382	14,260	14,630
Balance	Petrovietnam	0	0	0	0	0
	JICA/IE	997	3,087	568	230	-230

Source: Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam and Situation of supply and consumption of oil and gas in Vietnam. July 2005, Petrovietnam

3) Gas Demand in Power Sector

Based on the plan of power capacity developed and plant factor of gas-fired power plant in PDP 6th, gas consumption in the power sector is estimated as shown in Table 4-3-20.

Consumption in Base Case is estimated about 4.39 billion m3 in 2005 and 13.29 billion m3 in 2025 with average annual growth rate of 5.69%. In High Case, consumption is estimated 14.03billion m3 in 2025 with annual average growth rate of 5.98% (refer to Figure 4-3-9).

Though total supply capability of gas is increased from 6.0 billion m3 in 2005 to 16.0 billion m3 in 2020 with the average annual growth rate of 5.03%, it is saturated at a level of 16 billion m3 in accordance of the Petrovietnam development and exploitation plan.

Table 4-3-20 Gas Supply-Demand in Power Sector

(Unit: billion m^3)

	2005	2010	2015	2020	2025
Demand Base	4.39	6.31	11.99	12.08	13.29
Demand High	4.39	6.79	12.93	13.68	14.03
Gas supply Base	6.0	11.2	15.5	16.1	16.0
Gas supply High	6.0	11.2	15.5	16.1	16.0

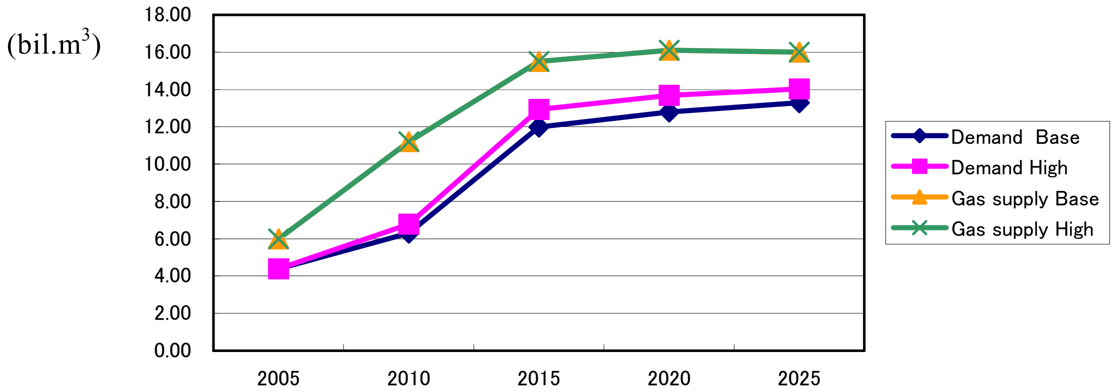


Fig.4-3-9 Gas Supply-Demand in the Power Sector

c. Crude Oil and Oil Products

1) Forecast by Petrovietnam

Until the first refinery plant is put into operation by 2010, all the domestic crude oil is exported to international market and all oil products such as gasoline, kerosene, DO, FO, LNG is imported for domestic consumption. From the viewpoint of energy security, development of domestic oil refinery plants is expected to be completed by 2010 to reduce dependence on import of oil products.

According to the Strategy of Development by Petrovietnam, production of crude oil is planned to maintain the present level until 2025. Meanwhile, demand of oil products is expected to increase with average annual growth rate of 5.5% in Base Case and 6.1% in High Case from 2005 to 2025. Accordingly, based on the forecast, even if planned refinery plants are all completed by 2020, domestic production capability of oil products is still insufficient to meet the demand, and then import of oil products is continuously required.

2) Forecast by the Study Team

Main oil products for power sector will be FO and DO**.** At present in 2004, there are several oil-fired thermal power plants (installed capacity: 1,163MW) in operation and the fuel for the power plants is imported. Since a few oil-fired thermal power plants are planned for development and aged power plants are planned for abolition in PDP 6th, total installed capacity does not change so much (installed capacity in 2025 : around 1300MW).

The fuel demand for those power plants and the domestic final consumption are estimated as shown in Table 4-3-21 for Base Case and Table 4-3-22 for High Case.

Table 4-3-21 Comparison on Oil Products Demand Forecast: Base Case

(Unit:kTOE)

	Data	2005	2010	2015	2020	2025
Oil Products Supply	Petrovietnam	0	6,617	13,743	20,869	20,869
Domestic Final Consumption	Petrovietnam	11,402	17,815	20,360	33,289	33,289
	JICA/IE	11,318	17,815	27,245	37,360	43,255
Consumption in Power Sector	Petrovietnam	0	0	0	0	0
	JICA/IE	1,510.7	868.2	612.4	599.94	596
Total Demand	Petrovietnam	11,402	17,815	20,360	33,289	33,289
	JICA/IE	12,829	18,683	27,857	37,960	43,851
Balance	Petrovietnam	-11,402	-11,198	-6,617	-12,420	-12,420
	JICA/IE	-12,829	-12,066	-14,114	-17,091	-22,982

Source: Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam

Table 4-3-22 Comparison on Oil Products Demand Forecast: High Case

(Unit:kTOE)

	Data	2005	2010	2015	2020	2025
Oil Products Supply	Petrovietnam	0	6,617	13,743	20,869	20,869
Domestic Final Consumption	Petrovietnam	11,402	18,833	25,450	37,157	37,157
	JICA/IE	11,318	18,803	30,879	46,082	56,707
Consumption in Power Sector	Petrovietnam	0	0	0	0	0
	JICA/IE	972	933	660	641	643
Total Demand	Petrovietnam	11,402	18,324	25,450	37,157	37,157
	JICA/IE	12,290	19,736	31,539	46,723	57,350
Balance	Petrovietnam	-11,402	-11,707	-11,707	-16,288	-16,288
	JICA/IE	-12,290	-13,119	-17,796	-25,854	-36,481

Source: Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam

(5) Nuclear power generation

Utilization of nuclear power in line with effective use of hydro and fossil fuel resources is planned for promotion in order to meet the growing power demand,.

In accordance with MOI Draft Energy Policy, the first nuclear power plant with capacity of 1,000MW will be completed by 2020, and power generation by nuclear power plants with total capacity of 8,000MW (assumed to be 490-560 TWh, equivalent to fuel consumption of about 140-160 million tons of coal) is planned for 2025.

4.4 Fossil Fuel Prices for Power Sector

At present, energy prices in Vietnam are evaluated, determined and submitted to the government for approval by the State Price Committee (SPC).

Since all crude oil is exported to the international market, SPC is responsible for setting the crude oil price based on the international market price. Since pricing on natural gas is quite new to the country, SPC sets the associated gas price referred to the international market prices of fuel oil and coal, and it could be based on a negotiated initial price of associated gas.

The domestic coal price is partly determined by market mechanism and is subject to the minimum sale prices set by the Coal Consumers Association.

Table 4-4-1 shows the actual fossil fuel prices in Vietnam

Table 4-4-1 Fossil Fuel Prices in Vietnam

Type	1995	2000	2001	2002	2003
Crude Oil (US$/barrel)	18.41	30.35	25.89	26.09	31.16
Domestic Gas (US$/MMBTU)	1.15*	1.9*	2.0*	2.0*	3.07
Domestic Coal (US$/t)	17.1	18.86	20.1	21.01	21.15

Source: Crude oil; IE data for power demand forecast, 2005
Gas and Coal; Average price IE data from Petrovietnam and Vinacoal
Note: figure with *mark is price of associated gas
Source: Over view of energy pricing practices in the APEC region, 2004. Vietnam

In accordance with the MOI's Draft Energy Policy, in the future, energy prices are determined by the market mechanism. However, for the sustainable development of energy sector and stabilization of energy prices, the State needs to intervene and regulate energy production through the price and tax system.

Vinacoal calculates coal price competitive with minimum gas prices for power generation based on world oil price at 40 US$/barrel in the draft report on "Study on improvement of price mechanism and policy and establishment of tariff for energy in Vietnam" dated March 2004 (refer to Table 4-4-2).

Table 4-4-2 Fuel Price for Power Generation (Estimation)

	Average	2005	2010	2015	2020	2025
Gas (US$/MMBTU)	2.50-3.00	2.6	2.75	3.10	3.25	3.47
4bCoal (US$/ton)	30.0-42.0	23.8-26.3	27.9-29.6	31.6-35.8	35.3-38.4	36.3-40.7

Source: Statistics coal price and coal price forecast in the future. Vinacoal, June, 2005.
Coal Price is at Vinacoal port for Dust Coal 4b

According to the Decree No. 170/2003/ND-CP dated December 25, 2003 of the Government on implementation of price ordinance, coal price is not subject to the State's control and stabilization but is negotiated between coal sector and coal consumers under the market mechanism.

Accordingly, the coal selling price for key consumers, including power sector, is estimated to increase drastically from 2009. Furthermore, since Vietnam plans to become a member of WTO and needs to integrate comprehensively into the region, coal price for power generation is predicted to be the almost same as coal price for export after 2012 (FOB, estimated to be 28-35US$/ton up to 2020) as shown in Table 4-4-3.

Table 4-4-3 Coal Price for Power Generation (Price at Vinacoal's Port)

Unit: $US(2005)/ton

Year	Coal Type	Min.	Max.	Year	Coal Type	Min.	Max.
2006	Dust coal 4b	23.8	26.3	2014	Dust coal 4b	30.9	34.0
	Dust coal 5	22.0	24.3		Dust coal 5	28.1	30.9
2007	Dust coal 4b	24.7	26.9	2015	Dust coal 4b	31.6	35.8
	Dust coal 5	22.8	24.8		Dust coal 5	28.7	32.6
2008	Dust coal 4b	25.5	27.8	2016	Dust coal 4b	32.6	37.6
	Dust coal 5	23.8	25.8		Dust coal 5	29.6	34.2
2009	Dust coal 4b	27.2	29.1	2017	Dust coal 4b	33.2	38.4
	Dust coal 5	24.7	26.5		Dust coal 5	30.2	35.0
2010	Dust coal 4b	27.9	29.6	2018	Dust coal 4b	34.1	38.4
	Dust coal 5	25.4	26.9		Dust coal 5	31.0	35.0
2011	Dust coal 4b	28.6	30.2	2019	Dust coal 4b	34.8	38.4
	Dust coal 5	26.0	27.1		Dust coal 5	31.6	35.0
2012	Dust coal 4b	29.4	30.7	2020	Dust coal 4b	35.3	38.4
	Dust coal 5	26.7	27.9		Dust coal 5	32.1	35.0
2013	Dust coal 4b	30.1	32.3	2025	Dust coal 4b	36.3	40.7
	Dust coal 5	27.4	29.3		Dust coal 5	33.0	37.0

Source: Statistics on coal price and coal price forecast in the future, Vinacoal. June 15, 2005.

When the domestic energy price including export and import of energy is determined based on the market mechanism, changes of international market price influence directly on energy prices in Vietnam. Since energy prices are influenced by various factors such as cost reduction by rationalization of production, increase of transportation cost, market price changed by supply - demand balance and even the political matters, it is difficult to make an appropriate long-term forecast or estimation at this moment.

Referring to the Vinacoal study "Statistics on coal price and coal price forecast in the future" dated 15 June 2005, and Petrovietnam report, the Study Team and IE estimate and predict the fossil fuel prices for power sector, providing crude oil prices in a range of 60-40US$/barrel, escalation rate of about 2% per year for import fuel and about 1% per year for domestic fuel (refer to Table 4-4-4, Figure 4-4-1, Figure 4-4-2 and Figure 4-4-3) . In this estimation, domestic coal prices for South and North include transportation cost of 7US$/ton and 3US$/ton respectively.

Table 4-4-4 Fossil Fuel Prices for Power Sector

Item	Unit	2005	2010	2015	2020	2025
Domestic-Coal	US$/ton	21.4	23.6	26.1	28.8	33.4
South Coal	US$/ton	28.5	30.7	33.2	35.9	39.8
North Coal	US$/ton	24.4	26.6	29.1	31.8	36.4
Import-Coal	US$/ton			51.7	54.31	57.1
DO	US$/ton	398.2	418.5	439.9	462.3	485.9
FO	US$/ton	217.2	228.2	239.9	252.1	265.0
Domestic-Gas	US$/MMBtu	3.14	3.46	3.82	4.22	4.66
Import-Gas	US$/MMBtu	3.37	3.72	4.11	4.54	4.54
Crude Oil	US$/barrel	60.0	40.0	40.0	40.0	40.0

Source: Vinacoal and Petrovietnam reports, Study Team estimates

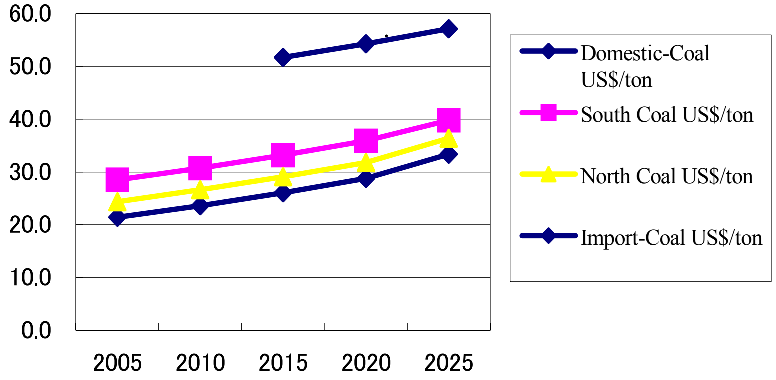


Fig.4-4-1 Coal Price for PDP 6th

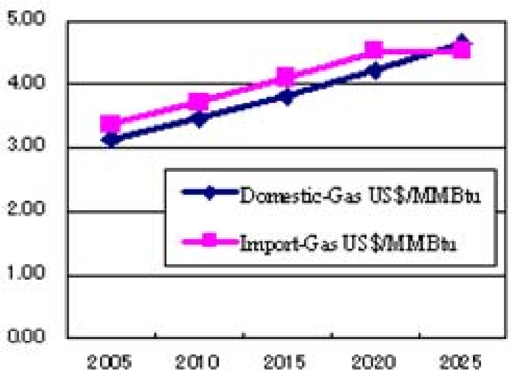


Fig.4-4-2 Gas Price for PDP 6th

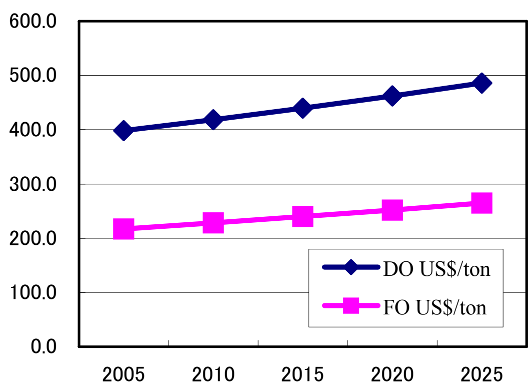


Fig.4-4-3 DO, FO Price for PDP 6th

<Reference>

For reference, fuel prices forecasted by WTI and International Energy Agency (IEA) on imported crude oil and MOF Japan on imported LNG are shown in Table 4-4-5 and Figure 4-4-4. Oil, Gas and Coal prices forecasted by DOE (USA) will be shown in Figure 4-4-5.

Table 4-4-5 Fossil Fuel Price Forecast (Reference)

	2003	2010	2020	2030
WTI Crude Oil (us$/barrel)*	31.2	35	35	35
IEA Crude Oil import (us$/barrel)	27	22	26	29
Japan LNG import (us$/MMBTU)	4.6	3.9	4.4	4.8
OECD Steam Coal import (us$/ton)	38	40	42	44

Source: IEA world energy outlook 2004

Note: Gas price are expressed on the basis of a gross-calorific value and WTI Crude Oil Price: IFS

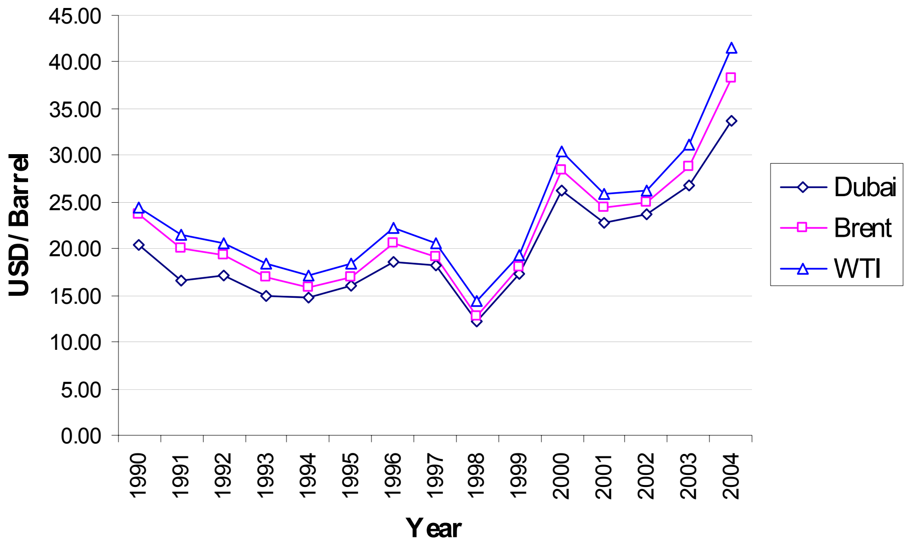
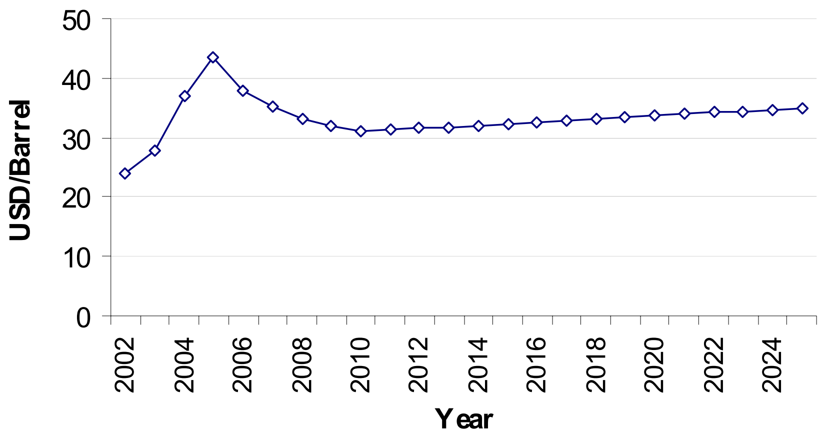
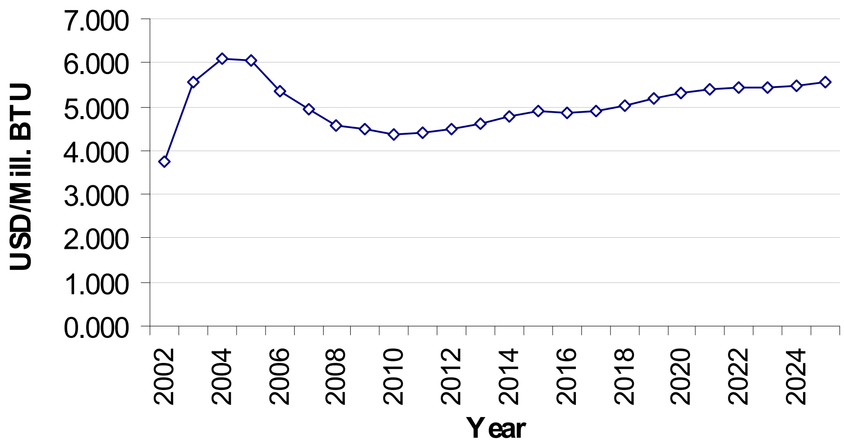


Figure 4-4-4 Crude Oil Price in the Period of 1990-2004 in the Main International Market by DOE/Energy Information Administration (Reference)

Crude Oil



Natural Gas



Coal

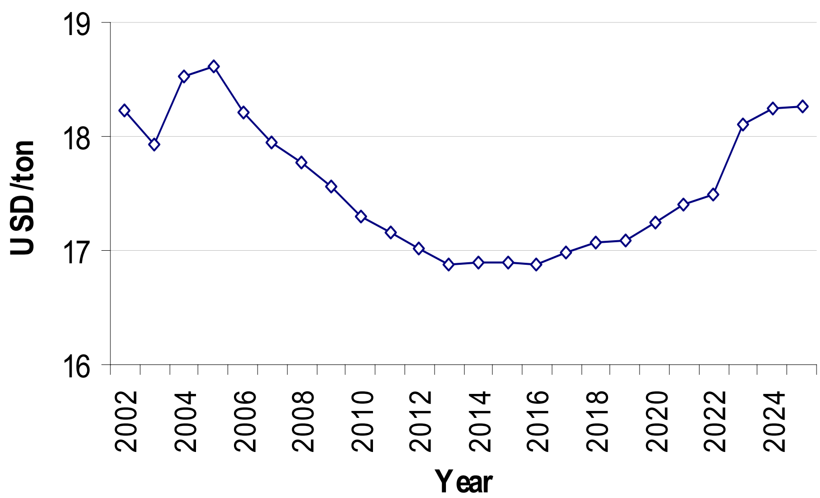


Figure 4-4-5 Forecast of Crude Oil, Natural Gas Prices and Coal Prices in the International Market by DOE/Energy Information Administration, 2005 (Reference)

CHAPTER 5

POWER GENERATION DEVELOPMENT PLAN

Chapter 5 Power Generation Development Plan

5.1 Study Flow of Power Generation Development Planning

For preparing PDP 6th, it is very important to coordinate among various fields such as power demand forecast, primary energy policy, power generation development plan, power system analysis, economic efficiency and environment impact of power plant candidate sites, financial condition and power development policy.

The long term power system development plan is established for the coming 20 years by the least cost planning method. The power plant candidate sites are evaluated from economic and social environmental aspects. The evaluation results are reflected into the power generation development plan.

The power generation development planning is carried out according to the study flow described in Figure 5-1-1 by using PDPAT II and STRATEGIST as planning assistance tools.

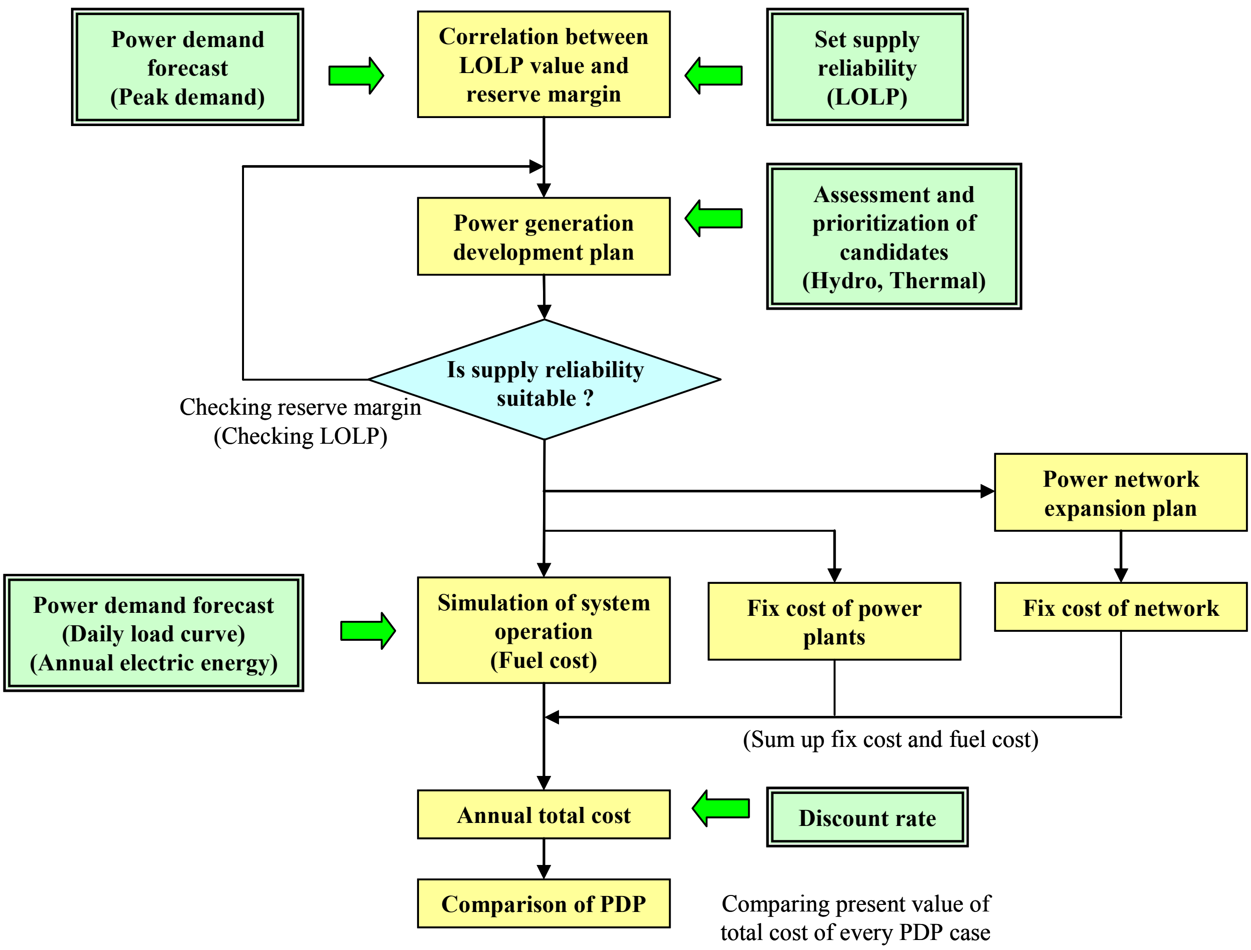


Figure 5-1-1 Study Flow of Power Development Planning

As illustrated in this figure, the power generation development plan should be drafted in harmony with many fields, such as demand forecasts, power system analyses, selection of power plant candidates, financial condition and power development policy. Therefore, the power generation development planning is conducted through close contact and discussions with the counterparts and good coordination among the related working groups.

i) Verification of the data and information of every power plant

The information and data of hydroelectric and thermal power stations (the existing plants and candidate sites for development) required for drafting the power development plan are checked and verified based on the former JICA Study “Master plan study on pumped storage power project and optimization for peaking power generation in Vietnam”, laying stress on changed points. Besides, the following information is collected and put in order.

- Actual records of power generation and system operation,
- List of planned power plants including IPP,
- Plans of power exchange with neighboring countries,
- Plans for abolition and replacement of power plants and so on.

ii) Establishment of the power generation development scenarios

The scenarios of power generation development until 2025 are prepared through a series of discussions with the counterparts. The scenarios are prepared by considering various factors,which may influence the optimization of power generation development plan, as follows:

- Demand forecast scenarios（High, Base, Low）
- Limitation of capacity of 500kV interconnection between North and South systems
- Delay of power development
- Water flow fluctuation
- Conformity with energy resources development and supply plan
- Feasibility of power import
- Power exchange with neighboring countries through interconnections
- Fuel price hike
- Constraint and condition of BOT plant operation

The scenarios are determined based on the analyses and examination of the actual power generation records and the actual demand and supply balance under the constraints and conditions.

Vietnam has to develop eight times as much as existing power plants for the coming twenty years in order to meet the rapidly growing demand. In other words, it is necessary to develop power plants of as much as 4,000MW every year. Therefore, all necessary power plants cannot be invested and owned by EVN. Some of the power plants will need to be developed through other approaches such as IPP (domestic investors) and BOT (foreign investors), and import from neighboring countries, China, Cambodia and Laos, and so on. Since some projects might not be developed in time, the mitigation measures of power shortage due to project delay should be considered in PDP 6th. Generally, the new power plant site should be developed considering room of expansion of the plant in order to cope with the delay of power development and/or the higher than expected growth of power demand.

Fuel price and its hikes are set referring to the Vinacoal and Petrovietnam long-term development plans and international market prices of coal and gas as described in Chapter 4.

The economical power system operation assuming the above-mentioned scenario is simulated. The results of simulation are fed back to the economic, social and environmental consideration study in order to clarify feasibility of each power plant development. The simulation is repeated, changing preconditions based on the results of evaluation of the above preconditions. Thus, the most economical scenario, best fuel mix of power sources, and long-term power generation development pattern are determined through study of the following steps.

iii) Establishment of vision of power generation composition

Before the study of the long-term power generation development plan, an optimum composition of power sources should be determined for the coming 20 years or with 2025 as a target year. The most economical composition is sought for by changing the development ratios of various types of fuel (coal-fired thermal, combined cycle thermal, pumped storage, etc.) with which new development is deemed feasible, and comparing the total annual costs, consisting of fixed costs and variable (fuel) costs, in the various development ratios of each power source. In this study, location of new development plants is not specified and representative annual cost of each power source is applied.

The power generation composition with the least cost operation is determined by finding out the most economical combination of power sources among the various power development scenarios mentioned above, also based on the results of risk study of each scenario.

iv) Consideration of interconnection with neighboring countries

The study on interconnection with neighboring countries was planned for implementation taking into account the study on interconnection plan among GMS countries supported by ADB. However, since the interconnection plan between Thailand and Vietnam was interrupted in the study of ADB, only the effect of interconnection between China and Vietnam was taken into consideration in PDP 6th.

Although the detailed information of power demand and supply balancing plans as well as those of Vietnam concerning interconnected power system is required for the study of interconnection among neighboring countries, the detailed information of the South China power system cannot be collected.

v) Evaluation of power plant candidates

・Selection of sites

The development candidate sites of hydropower and thermal power plants are selected in view of economy and social environmental friendliness. The information for economic evaluation is collected and put in order, such as location, available capacity of units (kW), types of fuel, development period, construction cost, fuel cost and so on.

・Economic evaluation

Comprehensive economic evaluation is carried out by comparing cost of power generation of each development candidate site.

vi) Review of power development scenarios and vision of power generation composition

The power development scenarios and vision of power generation composition are reviewed based on the results of the second WS.

vii) Putting order of priority to the candidates of power development

The candidates are prioritized considering the economic efficiency, diversification and security of primary energies, conditions of existing power plants and interconnection with neighboring countries conducted in the 1st study in Vietnam, and social & environment assessment conducted in the 3rd study in Vietnam.

viii) Establishment of long-term power development plan for the coming 20 years based on the least cost planning method

The least cost power development plan for the coming 20 years is determined according to the study flow in Figure 5-1-1 to achieve the appropriate power source composition or best fuel mix in the year of 2025.

5.2 Necessary Supply Capacity to Secure the System Reliability Criteria

5.2.1 Relationship between LOLE and Reserve Margin

The system reliability situations in 2015, 2020 and 2025 are analyzed based on the demand forecasts (Base Case) and the original power development plan by IE, in the north system and the central & south system respectively. The analysis results are shown in Figure 5-2-1. Power demand forecast applied to the analysis is shown in Table 5-2-1. And the original power development plan by IE is shown by region and by power source in Appendix 5-1(1)-(4). The fuel composition and installed capacity from 2003 to 2025 by region based on the original development plan by IE (Base Case) are shown in Figure 5-2-5.

The relationship between reserve margin and LOLE in the north system does not change significantly. The reserve margin of 7-8% is required to secure the system reliability criteria LOLE 24-hour.

Apart from that, the relationship in the central & south system changes year after year. The forced outage rate of thermal power plants, especially a coal thermal plant, is larger than hydropower plants. The coal thermal power is planned for installation after 2015 in the south system. The increase of composition rate of coal thermal power plant, therefore, leads to the increase of the required reserve margin in order to secure the system reliability criteria. The required reserve margin in the south system increases from 8% in 2015 to 10% in 2025.

The reserve margin, therefore, should be targeted at 7-8% in the north system and at 10% in the central & south system in 2025.

(North System) (Central & South System)

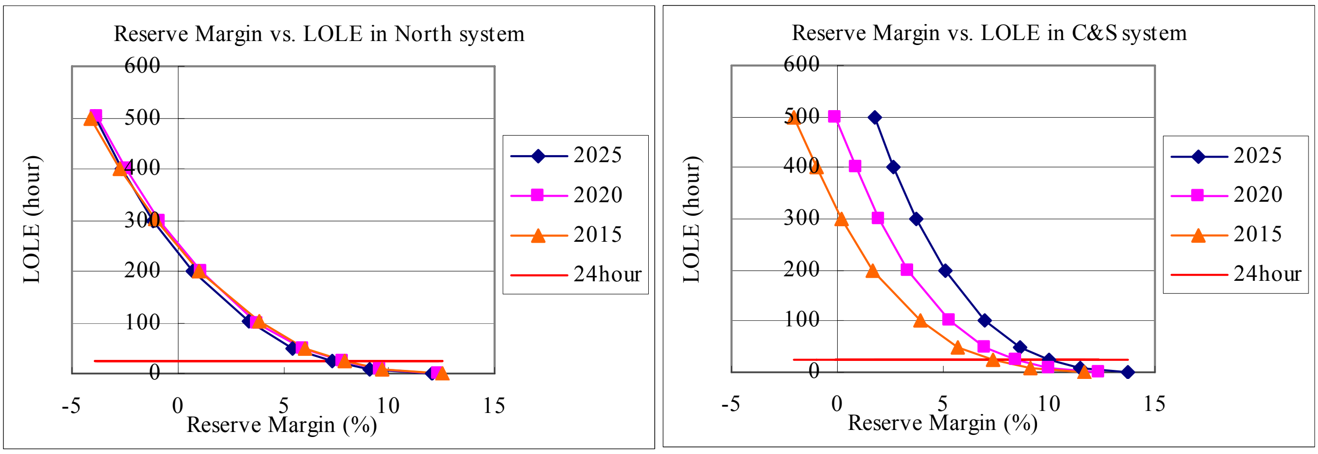


Figure 5-2-1 Relationship between Reserve Margin and LOLE

Table 5-2-1 Power Demand Forecast in the Period of 2005-2025 (Base Case)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
North TC	15,207	17,548	20,601	24,143	28,250	32,678	37,394	42,094	47,045	52,330	58,031	64,233	70,573	77,240	84,540	92,345	100,712	109,382	118,684	128,751	139,166	150,069
North PG	17,513	20,256	23,735	27,763	32,424	37,436	42,758	48,069	53,654	59,604	66,013	72,974	80,045	87,445	95,552	104,204	113,725	123,307	133,567	144,640	156,063	167,961
C&S TC	24,389	28,132	32,984	38,606	45,103	52,170	59,717	67,031	74,654	82,725	91,376	100,728	110,437	120,626	131,811	143,757	156,548	169,728	183,840	199,092	214,765	231,091
C&S PG	28,578	33,003	38,575	45,010	52,423	60,451	68,985	77,243	85,818	94,864	104,531	114,953	125,683	136,872	149,153	162,225	176,775	191,334	206,894	223,662	240,842	258,643
Total consumption	**39,597**	**45,682**	**53,585**	**62,748**	**73,353**	**84,848**	**97,111**	**109,124**	**121,699**	**135,054**	**149,406**	**164,961**	**181,010**	**197,867**	**216,351**	**236,102**	**257,260**	**279,110**	**302,523**	**327,843**	**353,930**	**381,160**
Power Generation	**46,236**	**53,567**	**62,699**	**73,263**	**85,461**	**98,642**	**112,658**	**126,418**	**140,790**	**156,024**	**172,366**	**190,047**	**208,201**	**227,224**	**248,052**	**270,263**	**294,012**	**318,400**	**344,481**	**372,634**	**401,555**	**431,664**
North PL (MW)	*3,494*	*4,013*	*4,668*	*5,421*	*6,287*	*7,207*	*8,174*	*9,126*	*10,116*	*11,161*	*12,277*	*13,480*	*14,681*	*15,926*	*17,281*	*18,715*	*20,285*	*21,994*	*23,824*	*25,799*	*27,837*	*29,959*
C&S PL (MW)	*4,927*	*5,669*	*6,601*	*7,672*	*8,902*	*10,227*	*11,627*	*12,971*	*14,358*	*15,813*	*17,362*	*19,023*	*20,767*	*22,579*	*24,564*	*26,673*	*29,017*	*31,413*	*33,975*	*36,736*	*39,566*	*42,500*
Peak load (MW)	*8,283*	*9,512*	*11,099*	*12,905*	*14,979*	*17,204*	*19,553*	*21,834*	*24,198*	*26,687*	*29,341*	*32,196*	*35,104*	*38,130*	*41,429*	*44,927*	*48,642*	*52,677*	*56,992*	*61,649*	*66,434*	*71,416*

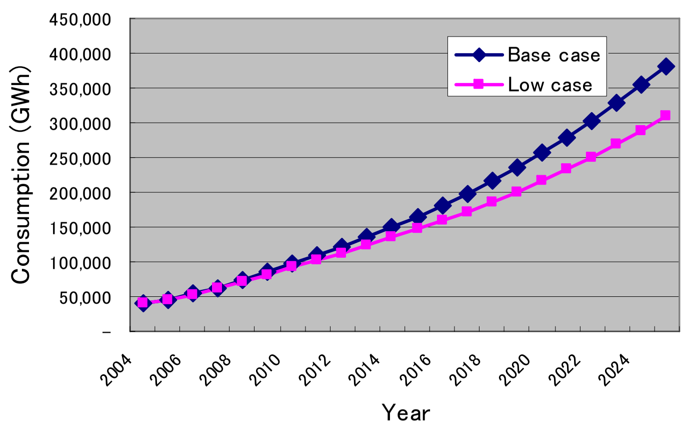


Figure 5-2-2 Electricity Consumption Forecast

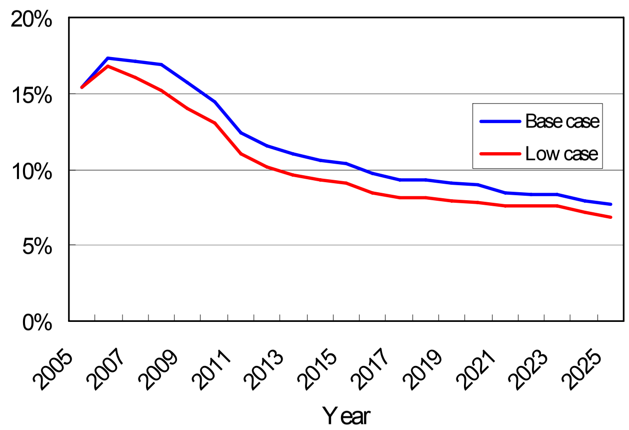


Figure 5-2-3 Growth Rate of Electricity Consumption

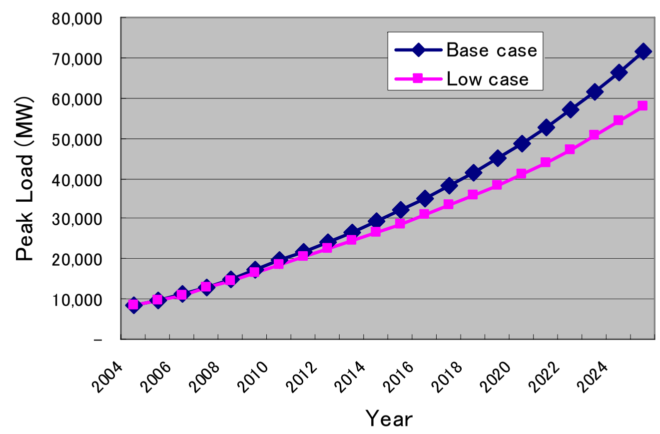


Figure 5-2-4 Annual Peak Load Forecast

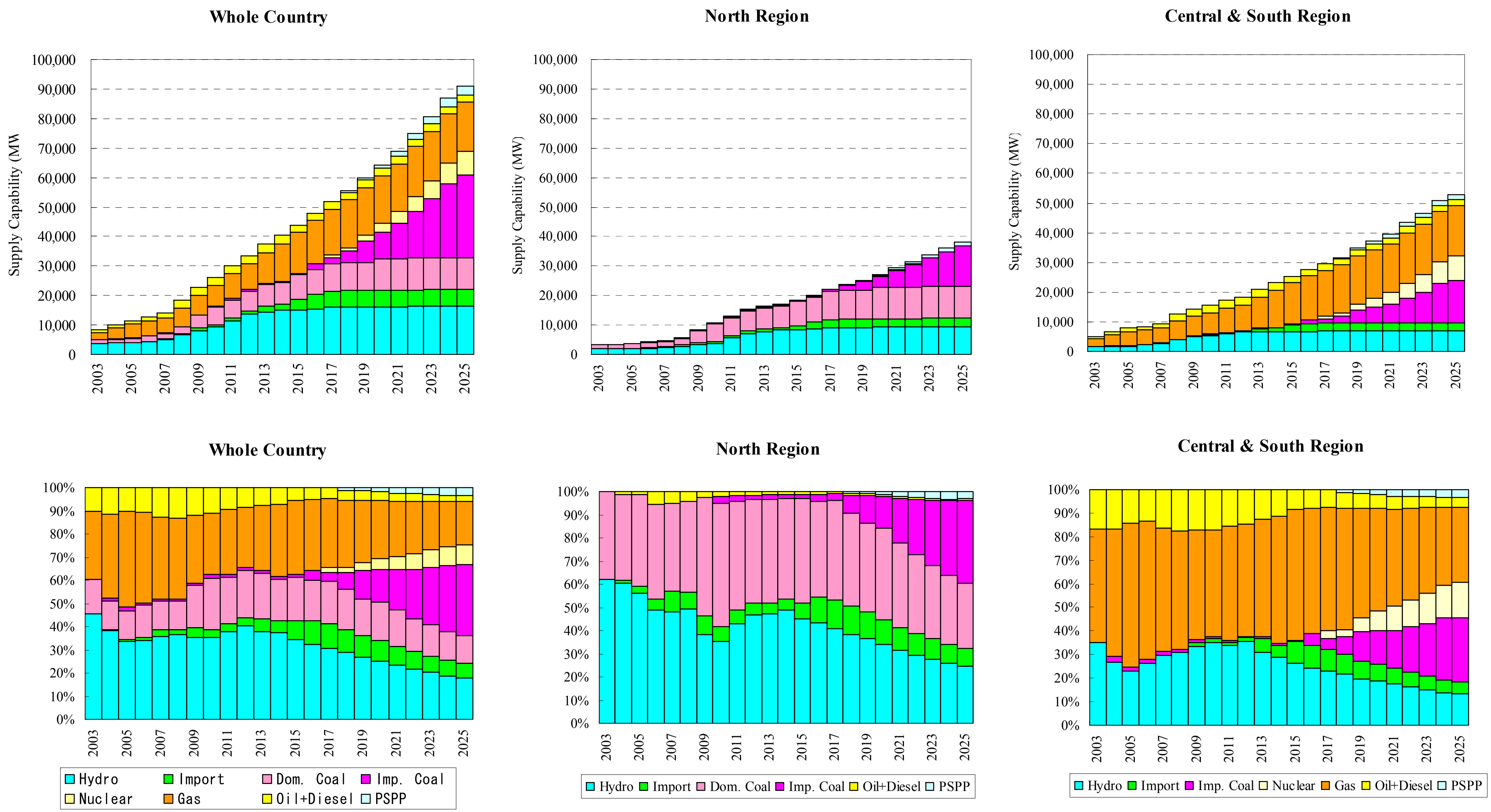


Figure 5-2-5 Installed Capacity and Fuel Composition by Region Based on IE Original Plan (Base Case)

5.2.2 Reliability Situations of PDP by IE

The system reliability LOLE by region is calculated and the results are shown in Figure 5-2-6. The system reliability LOLE criteria, 24hr, in the north system cannot be secured until 2009, but the system reliability in the central and south system can be secured every year until 2025.

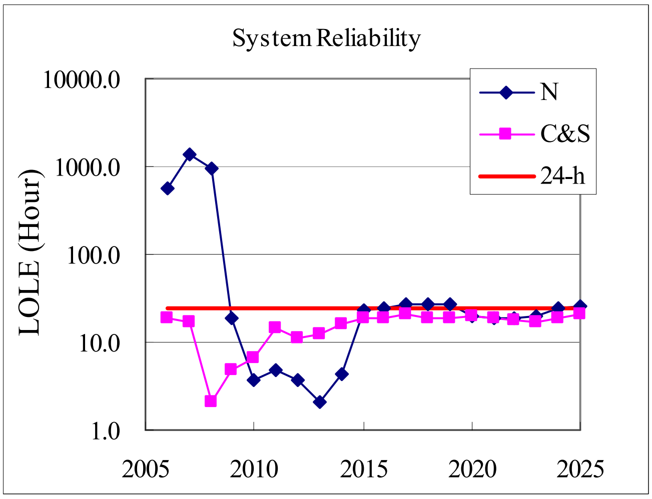


Figure 5-2-6 System Reliability Situation in IE's PDP

The reserve margin in the north system is minus value until 2009 and after that it can keep more than 7%. In the south system, the reserve margin can keep around 10%.

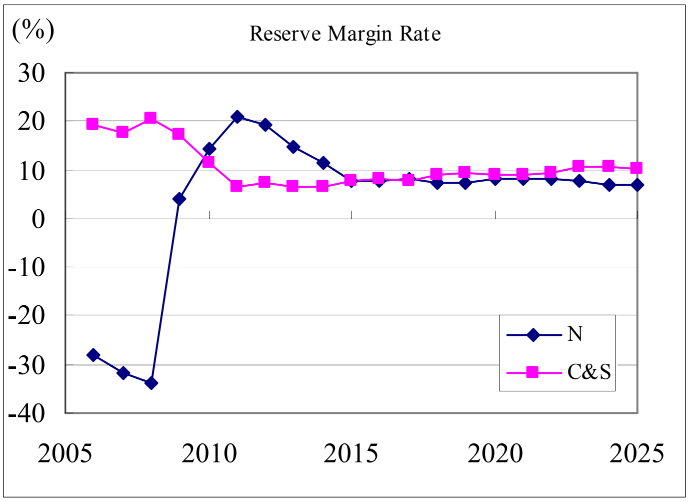


Figure 5-2-7 Reserve Margin in IE's PDP

As shown in these figures, the original PDP by IE has too much system reliability during 2010 to 2014, in other words, it is better to delay the power development during 2010 to 2014 for one or two years.

5.2.3 Conditions of Simulation of Power Demand and Supply Balance

(1) Thermal power characteristics

Coal thermal PP over 300MW unit can operate daily start and stop (DSS) in the IE simulation condition. However, in our experience, the investment cost increases if the DSS function is equipped. Since the incremental costs have not been known and estimated in the construction cost, DSS function should not be considered in the simulation.

(2) 500kV Interconnection capacity

The capacity is set at 1000MW in the IE simulation condition during the considered years. This capacity does not meet N-1 criteria before 2015.

The capacity of two circuits of 500kV Interconnection is 800MW to meet N-1 criteria. After installation and reinforcement of another circuit between the Central system and the South system, the capacity will increase up to 1300MW according to the results of system stability analysis.

(3) BOT

Current BOT scheme has a constraint of operation because the plant factor of 75% is conditioned in the power purchase contract. There are two existing BOT projects of Phu My 2.2 and Phu My 3.

5.2.4 Simulation Results

The results of simulation based on the original PDP by IE are shown in Figure 5-2-8 in the North and in Figure 5-2-9 in the Central & South. The results show no critical problems for operation.

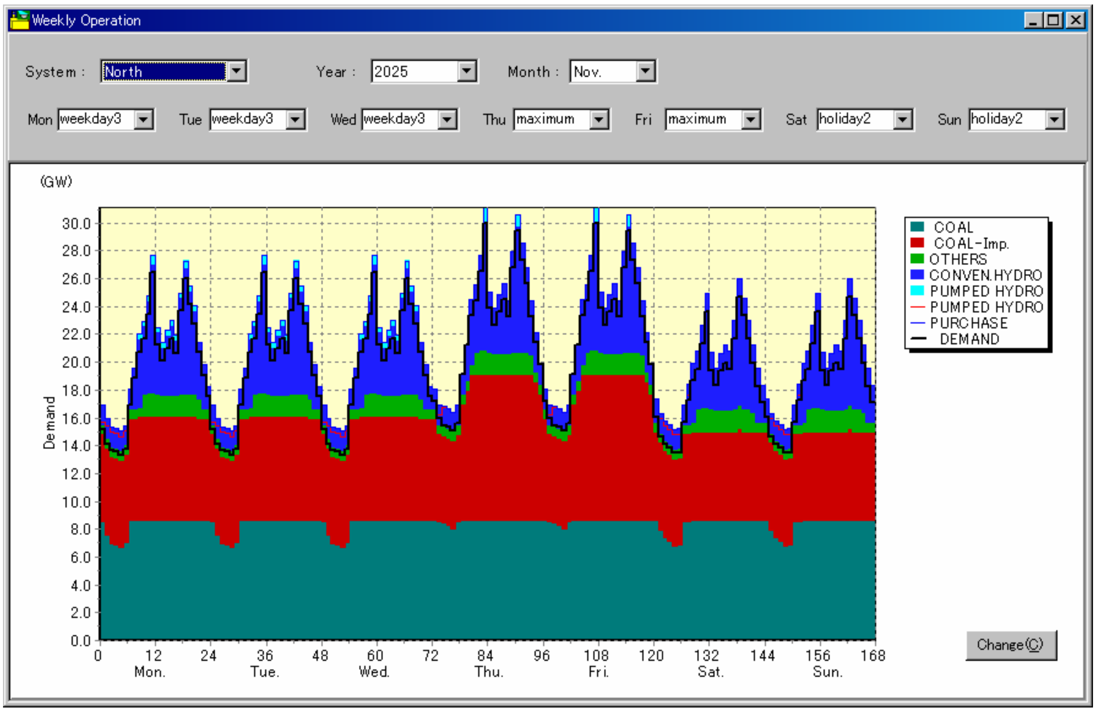


Figure 5-2-8 Result of Simulation in the North in November 2025

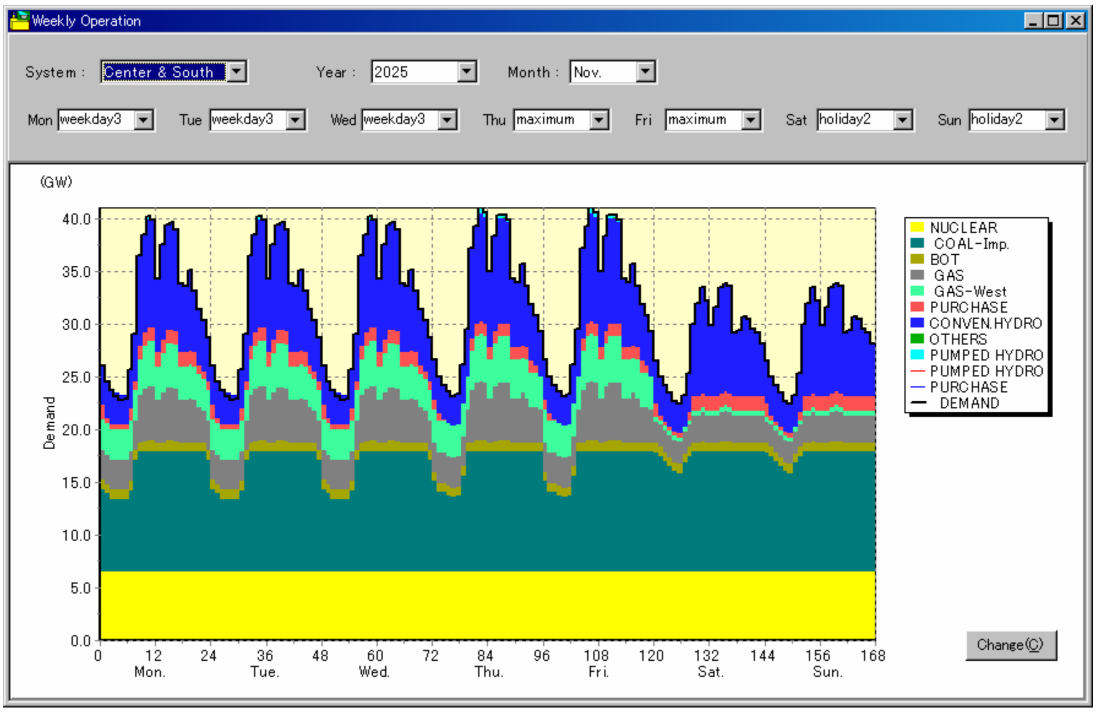


Figure 5-2-9 Result of Simulation in the Central & South in November 2025

5.2.5 Relation between Capacity of Interconnection and Reserve Capacity Reduction

The relation between the amount of reduction of reserve capacity and North and South interconnection capacity is analyzed. The increase in the interconnection capacity brings out possibility of reduction of reserve capacity in the whole power system because demand diversity among interconnected systems enhances the mutual generation utilization [1]. The amount of reduction of reserve capacity by interconnection in 2015, 2020 and 2025 is calculated by RETICS as a tool of system reliability analysis (refer to Figure 5-2-10).

The amount of reserve capacity reduction is saturated at approximately 900MW, when the interconnection capacity is 2000MW. The difference of reserve capacity reduction between 1,000MW and over 2,000MW is only 140MW, which means there is little advantage in investing in reinforcement of interconnection facility more than 1,000MW. The most economical capacity of interconnection is necessary to be examined considering fuel cost savings by the economic operation through the interconnection with a simulation analysis of the demand-and-supply balance. However, the capacity more than 1000MW is not rational, when the reinforcement cost of interconnection line is taken into consideration. Thus, the interconnection capacity for the PDP simulation is set around 1000MW from the viewpoint of efficiency of the system reliability improvement.

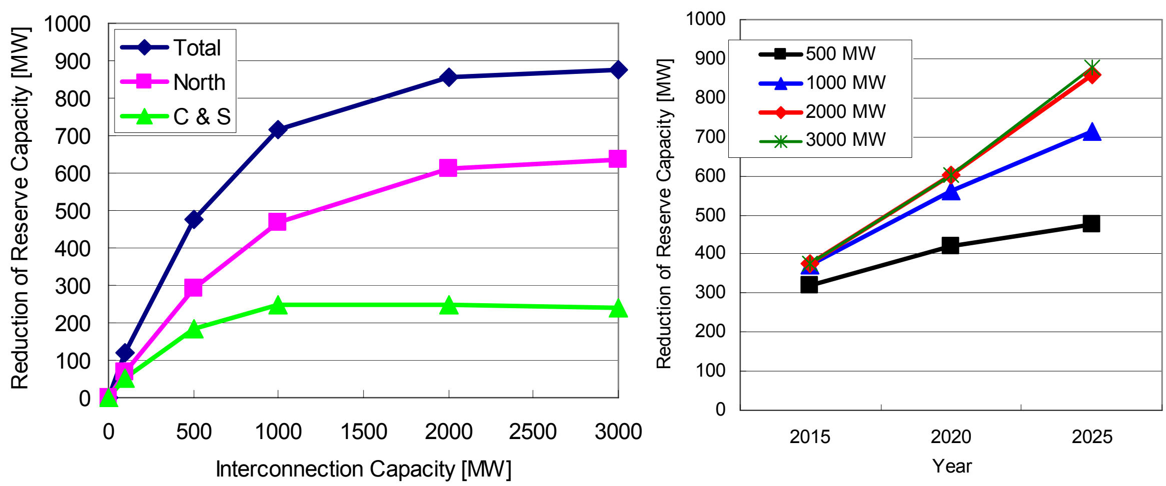


Figure 5-2-10 Relation between Amounts of Reduction in Power Development and Interconnection Capacity in 2025

[1] That Characteristic of a variety of electric loads whereby individual maximum demands usually occur at different times due to time deference and weather condition difference. When a system has peak demand, it is likely that the other systems do not have peak demands. Therefore, the system can use extra generation through interconnections. The interconnected systems can reduce their reserve margin.

5.3 Vision of Power Generation Composition in 2025

5.3.1 Comparison of Generation Costs of Power Sources

The screening curve analysis of generation cost by type in 2015 is conducted for preparation of the development scenarios in Vietnam.

Annual generation cost comprises fixed costs, which consist of depreciation, interest and O&M costs, and variable costs which correspond to mainly fuel costs. Here, the gross efficiency of pumping for PSPP is assumed at 70% and coal thermal generation energy are applied for pumping energy. The discount rate of 10% is applied. Conditions for screening curve analysis are shown in Table 5-3-1.

Table 5-3-1 Conditions for Screening Curve Analysis

Plant type	Capital cost (USD per kW)	Heat efficiency (%)	Fuel cost (dollars)	Lifetime (years)	O&M cost factor	Capital recovery factor	Calorie	Station service rate (per kWh)
Gas fired combined cycl	660	48	4.66per mmBtus	25	4.5%	11.02%		2.5%
Coal fired in the north	980	40	36.4 per ton	25	2.0%	11.02%	5500kcal/kg	7.0%
Coal fired in the south (coal from the north)	1100	40	39.4 per ton	25	2.0%	11.02%	5500kcal/kg	7.0%
Coal fired in the south (imported coal)	1100	40	63 per ton	25	2.0%	11.02%	6500kcal/kg	7.0%
Gas Turbine	400	37	4.66per mmBtus	20	5.0%	11.75%		5.0%
Diesel	800	38	466 per ton	25	2.0%	11.02%	10150kcal/l	5.0%
Pumped storage PP	750	70		40	1.0%	10.23%		0.5%
Nuclear	1700	33	0.124cent/10^3kcal	25	5.0%	11.02%		5.0%

Note:Discount rate of 10%.
Note:Capital costs of coal fired in the south and nuclear power include construction cost of its own port.
Note:All generation costs are culicurated at sending end

The results of screening are shown in Figure 5-3-1 and Figure 5-3-2. These figures are calculated at the sending end of power station taking into consideration own use energy.

As shown in these Figures, pumped storage PP and gas turbine are suitable for the peak supplier, gas fired C/C are suitable for the middle supplier, and coal fired thermal PP is suitable for the base supplier. Although nuclear power plant can be more economical than coal thermal power using imported coal in the south under the condition of over 85% capacity factor in 2025, it is hard to achieve more than 85% capacity factor due to scheduled outage of 50 days per year from the experience in Japan. Therefore, it can be said that nuclear power plant is less economical than any type of coal fired thermal power plant until 2025.

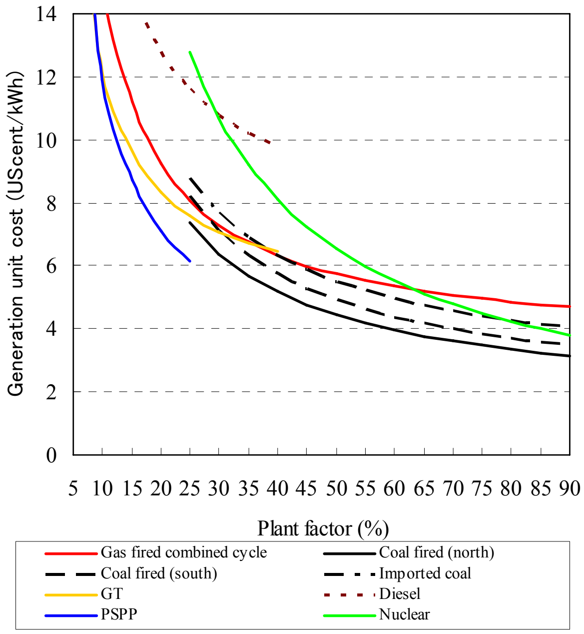


Figure 5-3-1 Generation Costs vs Capacity Rate in 2025 (Pumping Energy; Coal Case)

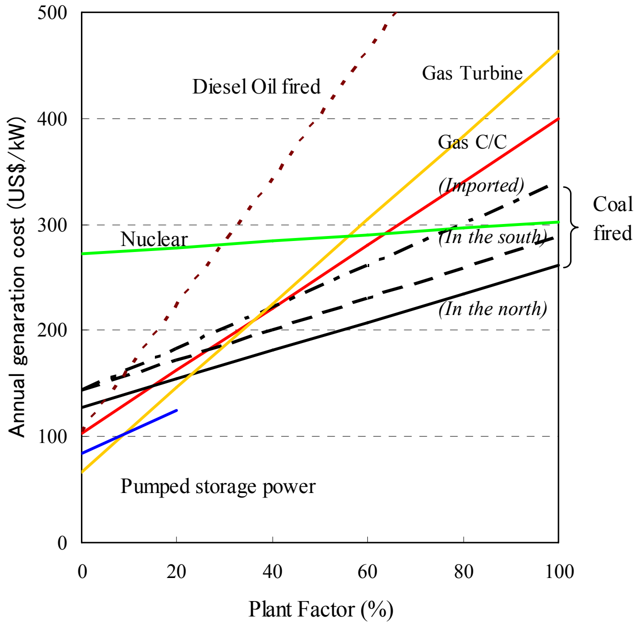


Figure 5-3-2 Annual Costs in 2025 (Pumping Energy; Coal Case)

5.3.2 Least Cost Development Plan Study

(1) Alternation of Coal Thermal vs. Gas CC in the Center & South System

The Study Team conducts the analysis of the appropriate composition of power generation in the year 2025 as a target year. The analyses are made by PDPATII by changing the composition of power sources.

Since there are no alternatives in the North system except for hydropower and coal fired thermal but there are alternatives in the Central & South system, the Study Team carries out simulation of system operation in 2025 with various cases of composition of coal thermal and gas C/C and compares the total annual generation cost of the whole system.

The results of analysis indicate that the 6000MW of gas combined cycle power plants replaced by the coal thermal from IE original plan is the most economical as shown in Figure 5-3-3. In this case, then the total annual cost of 160 million USD can be reduced. The least cost composition of power generation in 2025 is the case in which coal thermal accounts for 37% and gas thermal power accounts for 24% .

In Figure 5-3-3, the original point is the case of IE original development plan and plus value of X axis means increase of coal thermal development and decrease of gas C/C development.

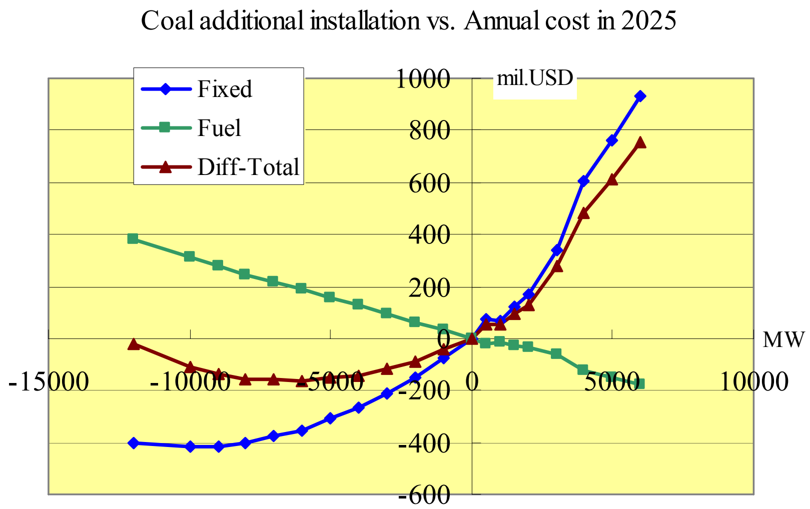


Figure 5-3-3 Alternation of Coal Thermal vs. Gas CC Development

The fuel consumption of gas and coal in the least cost plan is that the gas consumption is 18 BCM per year and the coal consumption is 66,000 ton per year (refer to Figure 5-3-4). However, the gas supply capability according to the latest Petrovietnam master plan is limited to 14 BCM per year. The least cost composition has a shortage of gas of 4 BCM per year. When the gas supply capability is taken into consideration, alternation from coal thermal to gas CC is also limited to 2000MW. That is, the gas of 14 BCM per year is consumed and the coal is consumed at 74,000 ton per year.

The most economic composition of power generation is the case in which coal thermal accounts for 45% and gas C/C accounts for 18% in the whole system.

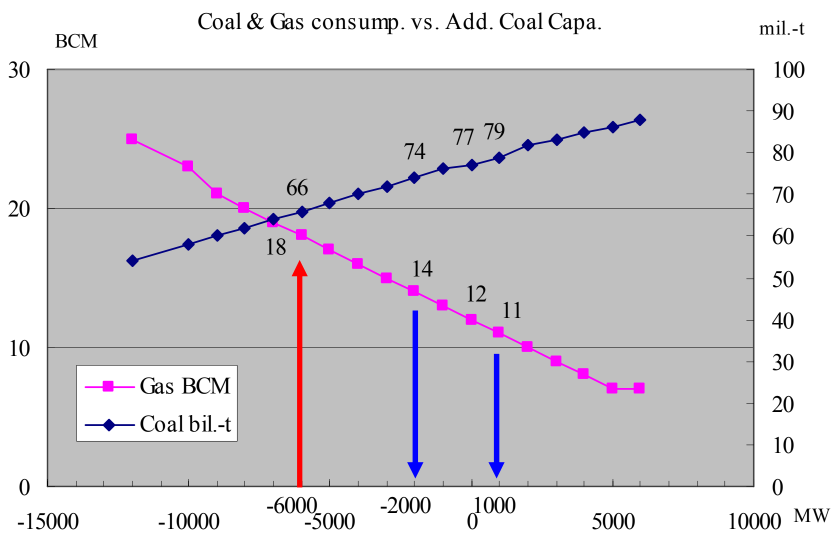


Figure 5-3-4 Fuel Consumption by Coal Thermal and Gas CC Capacity

(2) Appropriate Development Amount of PSPP in the Central & South System

The economical power generation composition is studied in the previous section. The vision of power generation composition has a larger share of coal thermal PP than that of least cost composition due to the limitation of gas supply capability. Next, the Study Team analyzes the availability of economical operation of PSPP by utilizing the surplus amount of coal thermal PP. In other words, the most economical development amount of PSPP is studied the same as in the previous section study.

PSPP capacity in the South vs. total annual cost difference of each system is shown in Figure 5-3-5.

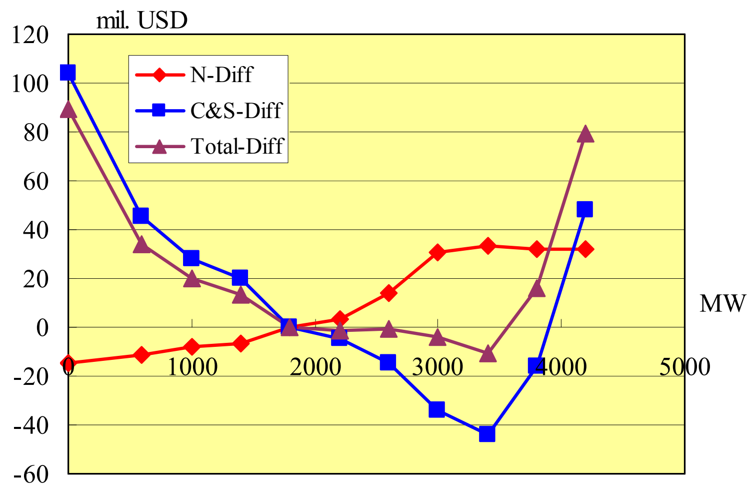


Figure 5-3-5 PSPP Capacity in South System vs. Total Annual Cost Difference in 2025

PSPP capacity in the south system is 1800MW in the original power development plan by IE.

Annual cost reduction cannot be seen in the case of additional PSPP installation in the Central & South system. Because the marginal cost of imported coal thermal is higher than that of the north domestic coal thermal, imported coal thermal cannot increase output at the off-peak time for pumping energy, in which case the pumping energy for additional PSPP in the Central & South system is supplied from the north system.

Furthermore, the capacity of transmission lines between the north and south systems have limitation up to 1300MW in 2025. Therefore, the surplus pumping energy cost and fixed cost reduction are balanced between 1800MW and 3000MW of PSPP installed capacity. The total annual generation cost increases over 3000MW of PSPP installed capacity because gas thermal has to generate to supply pumping energy. Accordingly, the original PSPP capacity of 1800MW in the Central & South system is appropriate.

(3) Appropriate Development Amount of PSPP in the North System

The most economical development amount of PSPP in the North system is studied the same as in the previous section study. PSPP capacity in the North vs. annual cost difference of each system is shown in Figure5-3-6.

PSPP capacity of 1200MW is planed for development based on the original power development plan by IE. The bottom of the total annual generation cost can be seen at the PSPP capacity of 2000MW. Accordingly, additional PSPP of 800MW is recommended for development in the North system from the viewpoint of the least cost development plan.

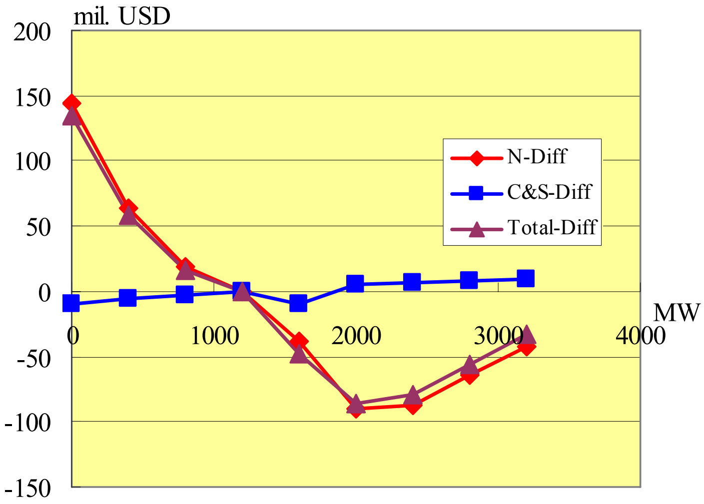


Figure 5-3-6 PSPP Capacity in North System vs. Total Annual Cost Difference in 2025

(4) Conclusion

It is more economical to substitute 2000MW of coal thermal power to gas combined cycle thermal power in the south system, and to increase 800MW of PSPP in the North system and decreasing equivalent amounts of coal thermal power from the IE original plan.

The additional gas combined cycle thermal power is expected to reduce total annual generation cost by 90 million US$ per year. The additional PSPP installation is expected to reduce cost by 85 million USD per year. Totally the annual generation cost of 175 million US$ can be reduced from the original development plan by IE.

Moreover, nuclear power is less economical than imported coal fired thermal power plant until 2025 as mentioned in the screening study.

Accordingly, the vision of power generation composition from the viewpoint of the least cost development plan in 2025 is as illustrated in Figure 5-3-7. The share of coal thermal power increases from 23% in 2015 to 54% in 2025. On the other hand, the share of hydropower including PSPP decreases from 39% to 23%.

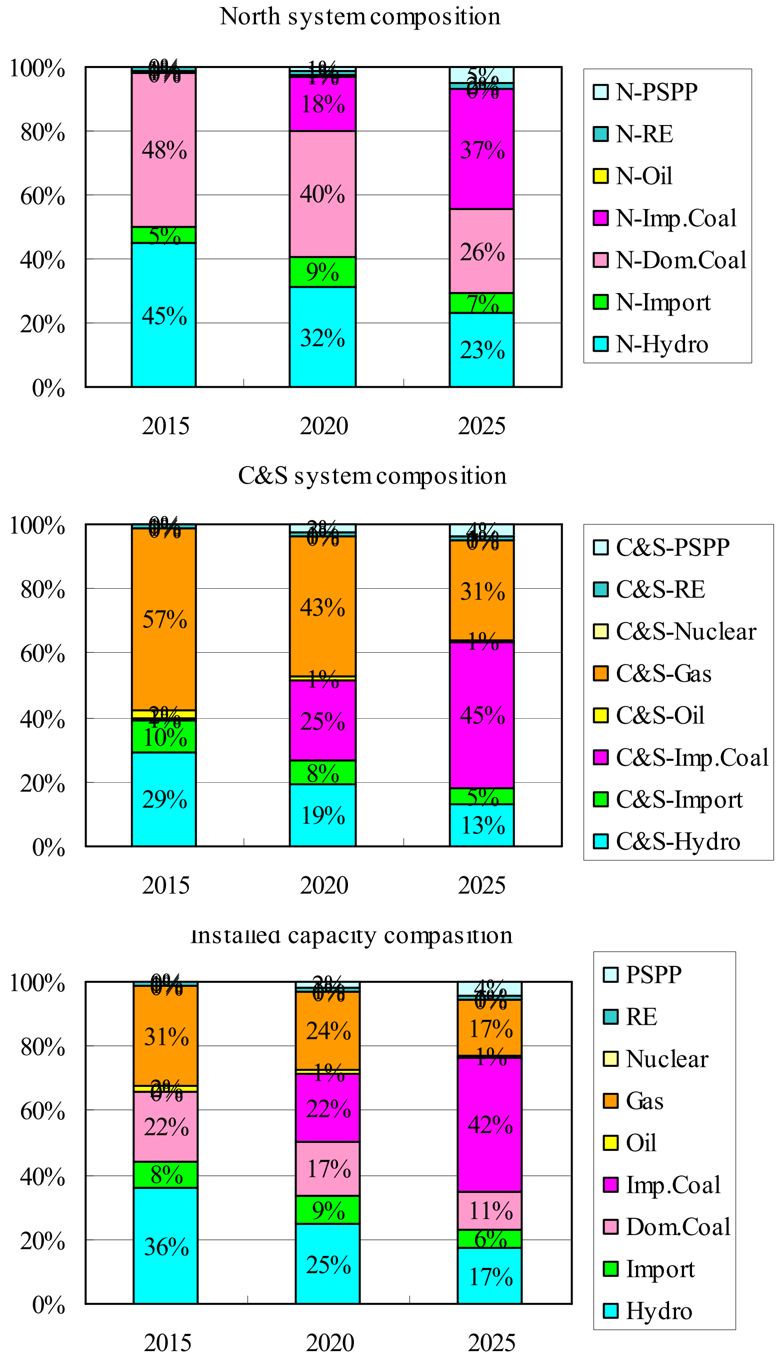


Figure 5-3-7 Optimum Power Generation Compositions by the Least Cost Power Development Planning

However, the daft of energy policy states that the first unit of nuclear power is to be put into operation by 2020. Furthermore, nuclear power has several advantages in that the amount of carbon dioxide emissions is small and it has fuel stock effect (once the nuclear fuel is installed, it can continue to generate for around 1.5 year). Therefore, the Study Team agrees on the installation of nuclear power up to as much as 8000MW of IE original development plan by 2025 from the viewpoint of national energy security.

The vision of power generation composition in 2025 taking into account installation of nuclear power is as illustrated in Figure 5-3-8.

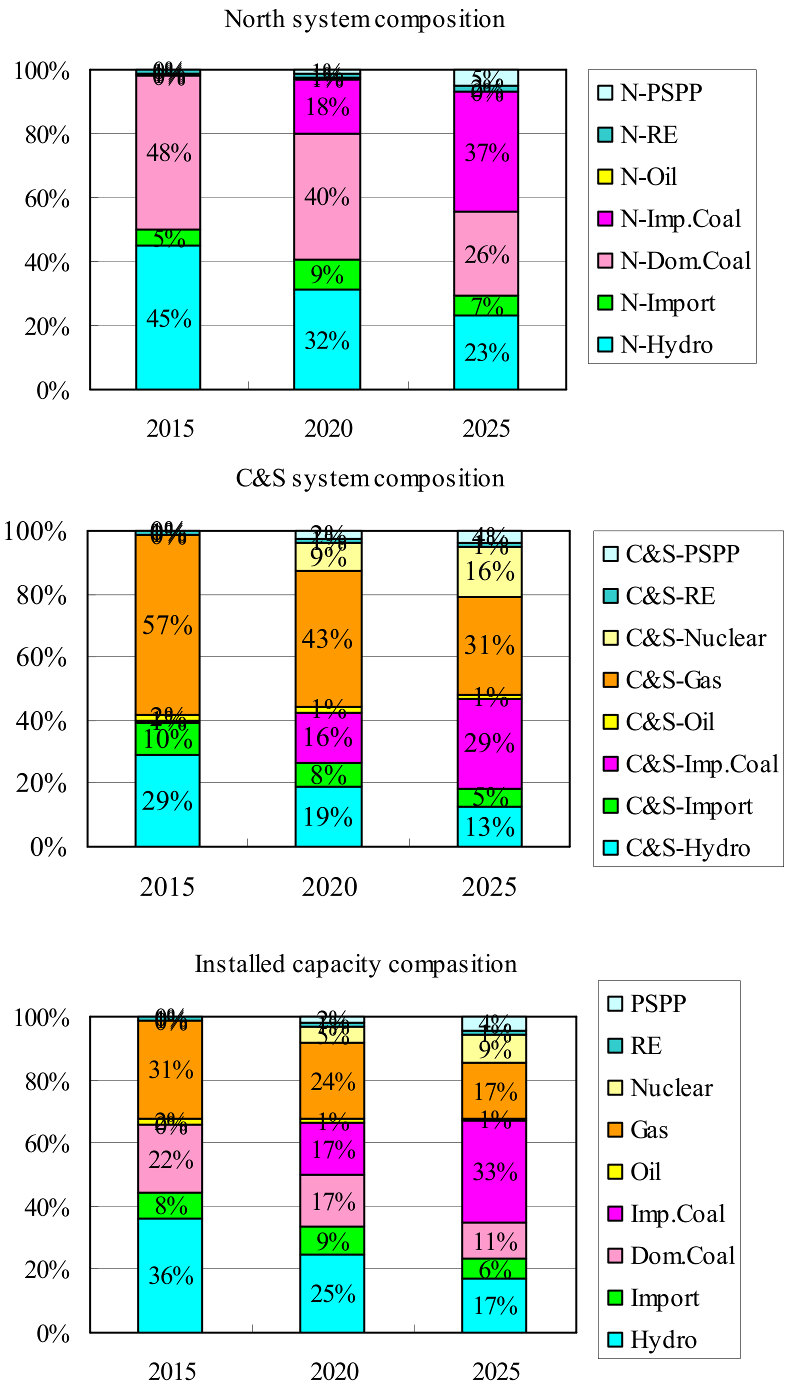


Figure 5-3-8 Power Generation Compositions Taking into Account Nuclear Power

5.4 Power Generation Development Plan up to 2025

An example of Power Generation Development Plan including nuclear power arranged to achieve the vision of power generation composition described above is illustrated in Figure 5-4-1. The power development capacity of every year is arranged to secure the required reserve margin at 7-10% by region.

(Unit: MW)

Fiscal Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
North Region		Coal-Import 600									
		Coal 200									
		Trung Son 310	Coal 1200								
		Ban Uon 80	Bac Me 280	PSPP 200		PSPP 200			PSPP 200		
	Coal 1000	Import from Laos 400	Small Hydro 100	Coal-Import 1200		Coal-Import 1800	PSPP 200	PSPP 200	Coal-Import 2000	PSPP 200	PSPP 800
	Import from China 500	Import from China 500	Import from China 500	Import from China 250	Coal-Import 1200	Small Hydro 100	Coal-Import 1600	Coal-Import 2000	Small Hydro 100	Coal-Import 2000	Coal-Import 1000
PDP N total	1,500	2,090	2,080	1,650	1,200	2,100	1,800	2,200	2,300	2,200	1,800
N Peak Demand	13,480	14,681	15,926	17,281	18,715	20,285	21,994	23,824	25,799	27,837	29,959
N Supply	14,521	15,845	17,237	18,526	20,086	21,960	23,836	25,799	27,767	29,787	31,876
RM	7.7%	7.9%	8.2%	7.2%	7.3%	8.3%	8.4%	8.3%	7.6%	7.0%	7.0%
Center & South Region											
						PSPP 200		CCGT-Gas 720		PSPP 200	
	CCGT-Gas 1440	CCGT-Gas 720	CCGT-Gas 720	PSPP 400	PSPP 200	Coal-Import 1000	PSPP 400	Coal-Import 2000	PSPP 200	CCGT-Gas 1000	PSPP 200
	Import from Laos 490	Coal-Import 1200	Nuclear 1000	CCGT-Gas 720	Coal-Import 2000	Nuclear 1000	Coal-Import 1000	Nuclear 1000	Coal-Import 2000	Coal-Import 2000	CCGT-Gas 1000
	Import from Cambo 375	Import from Cambo 429	Small Hydro 100	Coal-Import 1000	Nuclear 1000	Small Hydro 100	Nuclear 1000	Small Hydro 100	Nuclear 1000	Nuclear 1000	Nuclear 1000
PDP C&S total	2,305	2,349	1,820	2,120	3,200	2,300	2,400	3,820	3,200	4,200	2,200
C&S Peak Demand	18,856	20,584	22,381	24,493	26,597	28,934	31,323	33,878	35,723	38,466	41,306
C&S Supply	20,241	22,157	24,003	26,582	28,934	31,405	34,013	36,897	39,381	42,450	45,503
RM	7.3%	7.6%	7.2%	8.5%	8.8%	8.5%	8.6%	8.9%	10.2%	10.4%	10.2%
PDP Total	3,805	4,439	3,900	3,770	4,400	4,400	4,200	6,020	5,500	6,400	4,000

Fiscal Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Peak Demand	32,196	35,104	38,130	41,429	44,927	48,642	52,677	56,992	61,649	66,434	71,416
Supply Capacity	34,762	38,002	41,240	45,108	49,020	53,365	57,849	62,696	67,148	72,237	77,379
Reserve Margine	8.0%	8.3%	8.2%	8.9%	9.1%	9.7%	9.8%	10.0%	8.9%	8.7%	8.3%

Figure 5-4-1 An Example of Power Development Plan Based on the Least Cost Power Development Plan (2015-2025)

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5.5 Risk Study of Power Development Plan

(1) Drought Effect on Supply Capability of Hydropower

There are big differences between actual records from 1996 to 2004 and plan of output of Hoa Binh hydropower plant at the daily peak demand hour as shown in Table 5-5-1. And the difference between dry season and rainy season is 205MW. There is difference of 1.5 times of standard deviation (SD) of the actual output at the peak demand hour between average actual output and planned available capacity of 90% probability in dry season. The difference from the planned available capacity of 50% probability is 2.4 times of SD of the actual output.. On the contrary, the differences between actual and planned output in rainy season are within one SD of actual output.

Table 5-5-1 Difference of Actual and Planned Outputs between Dry and Rainy Season

Unit: MW

	Dry	Rainy
Periods	Jan.-May, Dec.	Jun.-Nov.
Average	1394	1599
SD	218	196
Plan 90%	1713	1655
Diff.	319	56
×SD	1.5	0.3
Plan 50%	1920	1775
Diff.	526	176
×SD	2.4	0.9

The average actual output at the daily peak demand hour in dry season is 1,400MW and the one in rainy season is 1,600MW as shown in Figure 5-5-1. The actual output of 90% probability at the daily peak demand hour in the dry season is 1,100MW and that in the rainy season is 1,350MW based on the actual operation records as shown in Figure 5-5-2.

The reason why the available capacity in dry season becomes dormant is because there is not enough water volume in reservoirs to operate at an available capacity for current peak duration time of 4 hours a day.

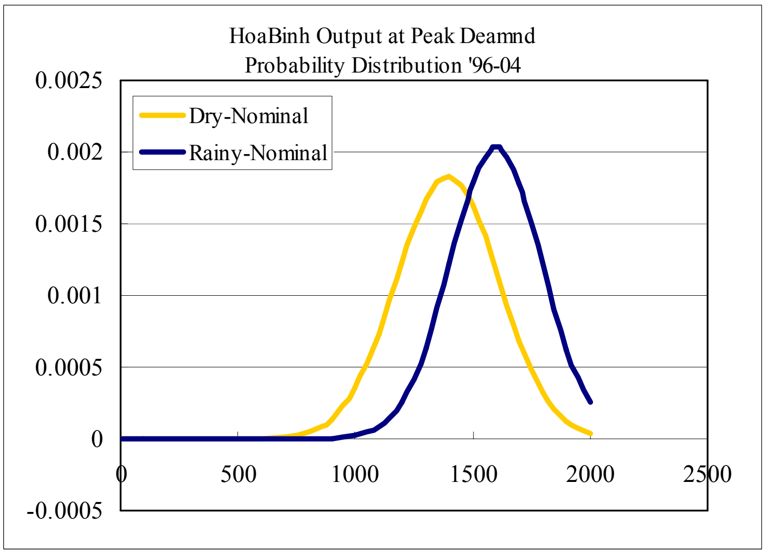


Figure 5-5-1 Estimated Nominal Distributions of Hoa Binh Outputs from 1996 to 2004

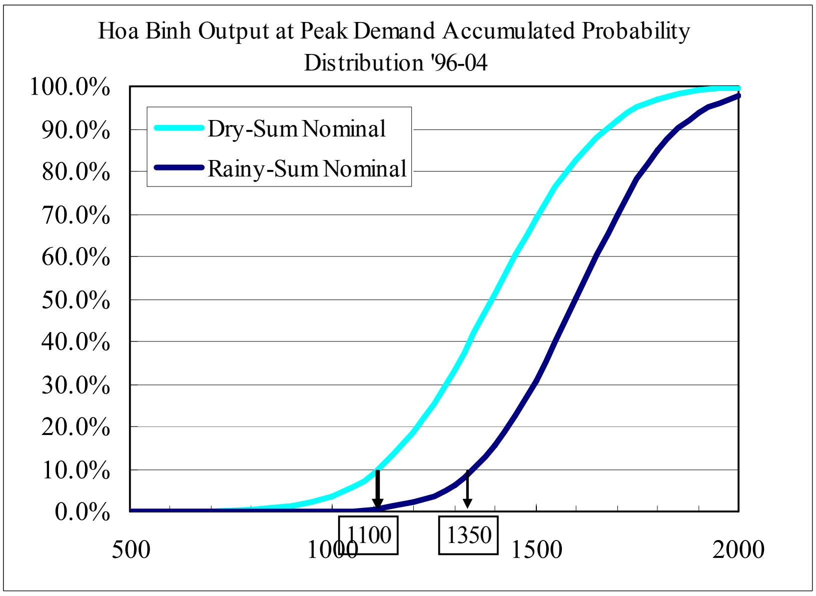


Figure 5-5-2 Accumulated Probability of Hoa Binh Outputs from 1996 to 2004

The Hoa Binh Dam is a multipurpose dam for irrigation, food control, tap water, and power generation. Besides, Hoa Binh Dam operation will change in line with development in the Da river system such as Son La Dam in the future. Since the capacity of hydropower plants in the Da river system is large, operation of those hydropower plants will greatly affect the demand supply balance in the north system during the dry season. Therefore, the drought effects should be analyzed carefully. The distribution of the hydropower output fluctuation is estimated as shown in Figure 5-5-3. The average of distribution in drought year is shifted 200MW from that in normal year.

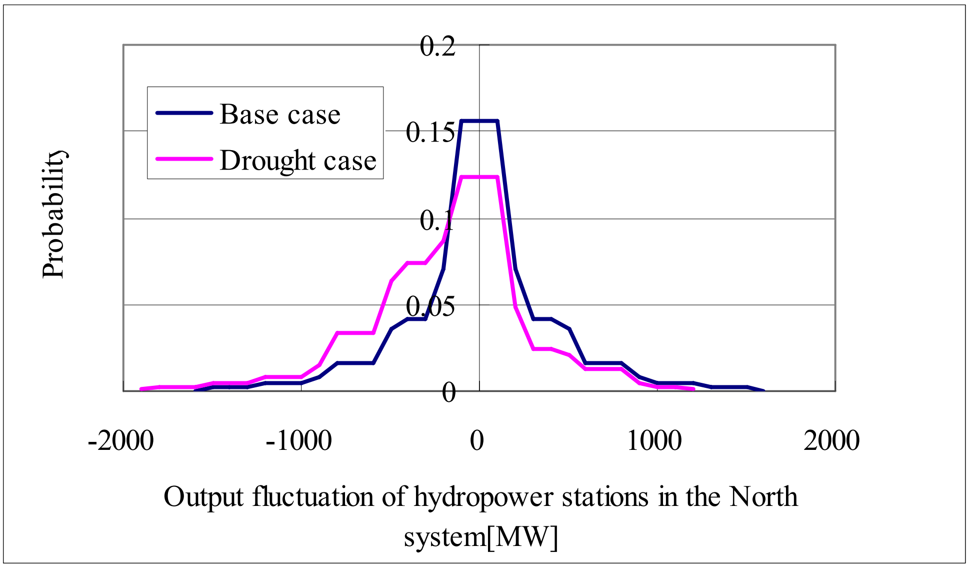


Figure 5-5-3 Hydropower Output Distributions in Drought Year and in Normal Year

The effect is evaluated from the system reliability aspect in 2015, 2020 and 2025. The hydropower outputs from new hydropower plants are assumed as planned. The necessary reserve margins in the north system are affected crucially by the above mentioned fluctuation of hydropower supply capability and increase 1-3% from 7-8% to 8-10% as shown in Figure 5-5-4. The difference of necessary reserve margins between drought year and normal year becomes small in the future in line with decrease in the composition ratio of hydropower.

(Normal Year) (Draught Year)

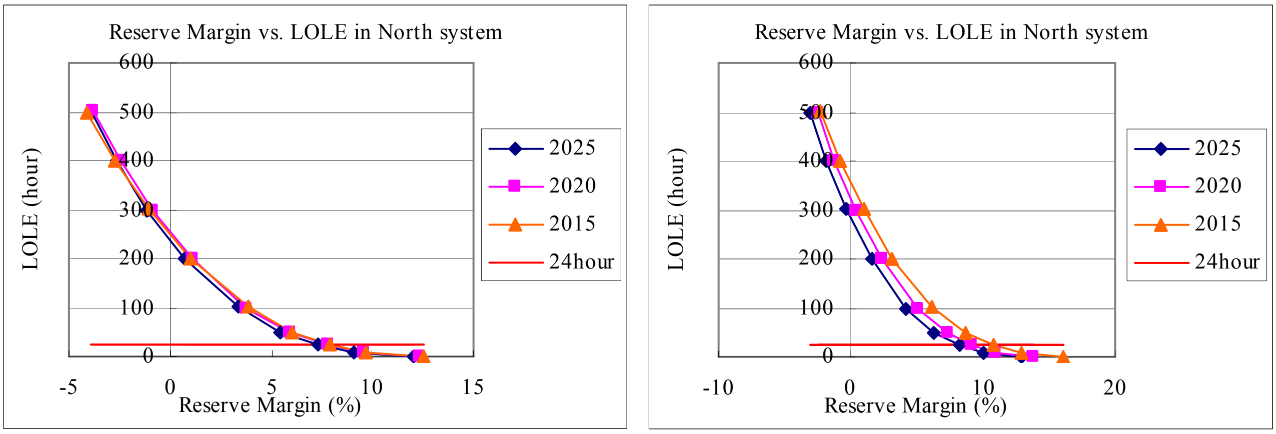


Figure 5-5-4 Reserve Margin in the North System in Drought Year and in Normal Year

On the contrary, the necessary reserve margins in the C&S system do not change, as shown in Figure 5-5-5, because there is little difference between actual record of output and planned output.

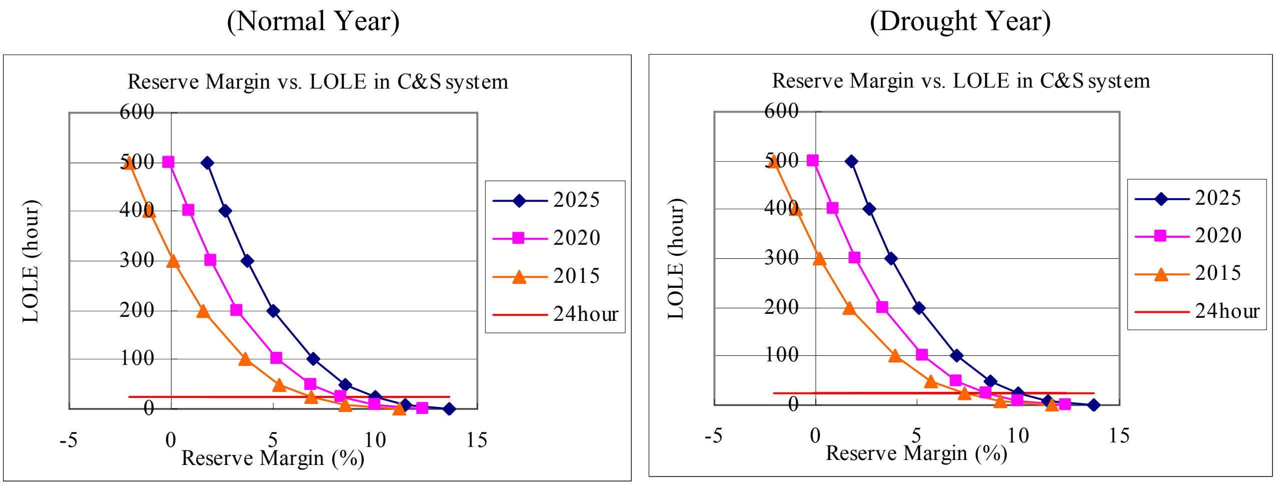


Figure 5-5-5 Reserve Margin in the C&S System in Drought Year and in Normal Year

Accordingly, it is strongly recommended to review and update the metrological data and monthly supply capability of all hydropower plants (existing and planned) in the North. Especially, when revising monthly firm peak capacity, the required peak duration time should be set at **7** hours.

(2) Power Import from Neighboring Countries

The effects on the annual generation cost caused by the limitation of imported power from neighboring countries are simulated. The annual costs in the north system are varied from minus 40 to plus 156 million US$ in comparison with the Base Case. The annual cost in the north system decrease 40 million US$ in 2020 without the power import from China. On the other hand, the annual costs in the north system increase 156 million US$ in 2025 without the power import from Laos (refer to Figure 5-5-6).

The annual costs in the C&S system are also fluctuated from minus 4 to plus 100 million USD in comparison with the Base Case. The annual cost in the C&S system decreases a little or nothing without power import from Laos. The annual cost in the C&S system increases 72 million US$ in 2020 and 76 million US$ in 2025 without the power import from Cambodia (refer to Figure 5-5-7).

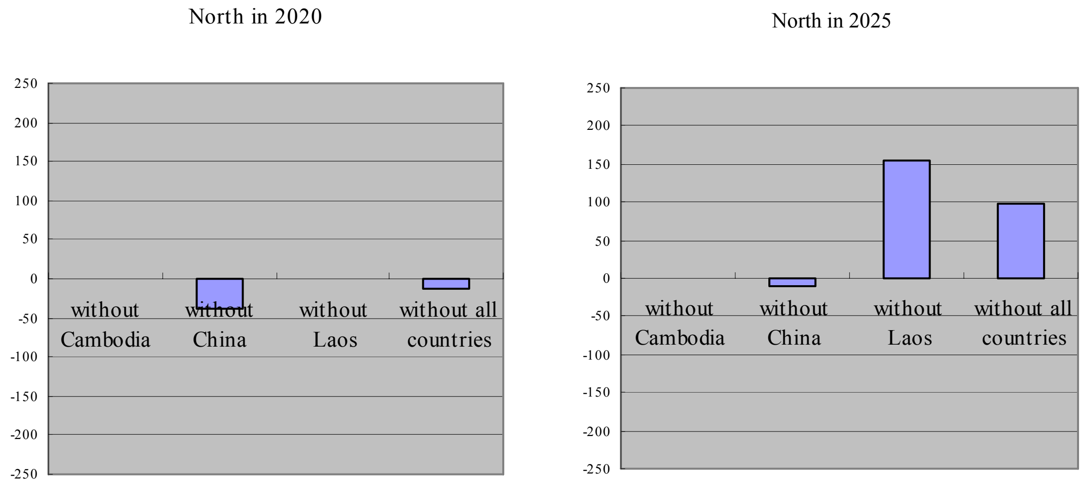


Figure 5-5-6 Effects of Limitation of Power Import from Neighboring Countries in N System

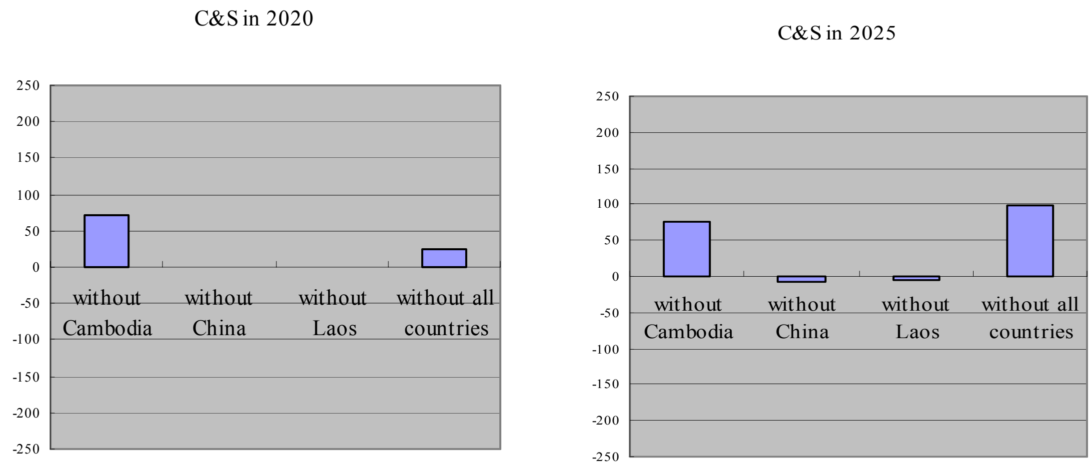


Figure 5-5-7 Effects of Limitation of Power Import from Neighboring Countries in C&S System

Power import from China is not economical until 2025 in this study, because the purchase price is assumed at 4.5 cent/kWh. When price of power purchase from neighboring countries is higher than the marginal cost of the power system in Vietnam, the development of North system coal thermal power plants using domestic coal should be made the first priority. On the contrary, power import from Laos and Cambodia becomes economical, because the generation cost of gas thermal power plants is more expensive than the power purchase price planned.

In conclusion, from the viewpoint of least cost power development planning, it is necessary to compare the price of power import from neighboring countries with the marginal costs in Vietnam.

(3) Fuel price hike

Effect of the fuel price hike is analyzed in two cases. Fuel costs of imported coal and oil are hiked at 1.5 and 2 times the escalation rate of the Base Case. Another case is that all fuels including domestic production are hiked at 1.5 and 2 times the escalation rate of the Base Case as shown in Table 5-5-2.

Table 5-5-2 Preconditions of Calculation of Fuel Price Hike

(Base Case)

		Unit	2005	2010	2015	2020	2025
Import	DO	US$/ton	398	418	439	462	485
	FO	US$/ton	217	228	240	252	265
	Coal-Imp.	US$/ton			51.7	57.1	63.0
Domestic	Coal (N)	US$/ton	24.4	26.6	29.1	31.8	36.4
	Coal (C&S)	US$/ton	28.5	30.7	33.2	35.9	39.8
	Gas	US$/MMBtu	3.14	3.46	3.82	4.22	4.66

(1.5 times of escalation rates of Base Case)

		Unit	2005	2010	2015	2020	2025
Import	DO	US$/ton	398	439	460	494	529
	FO	US$/ton	217	234	252	270	289
	Coal-Imp.	US$/ton			56.4	64.5	73.3
Domestic	Coal (N)	US$/ton	24.4	27.7	32.4	35.5	42.4
	Coal (C&S)	US$/ton	28.5	31.8	35.6	39.6	45.5
	Gas	US$/MMBtu	3.14	3.62	4.16	4.76	5.42

(Double escalation rate of Base Case)

		Unit	2005	2010	2015	2020	2025
Import	DO	US$/ton	398	460	480	526	572
	FO	US$/ton	217	239	263	287	313
	Coal-Imp.	US$/ton			61.0	71.8	83.6
Domestic	Coal (N)	US$/ton	24.4	28.8	33.8	39.2	48.4
	Coal (C&S)	US$/ton	28.5	32.9	37.9	43.3	51.1
	Gas	US$/MMBtu	3.14	3.78	4.50	5.30	6.18

The incremental fuel cost in the imported fuel price hike case leads to increase of generation costs at the maximum 0.4 cent/kWh in 2025 in the both systems as shown in Figure 5-5-8

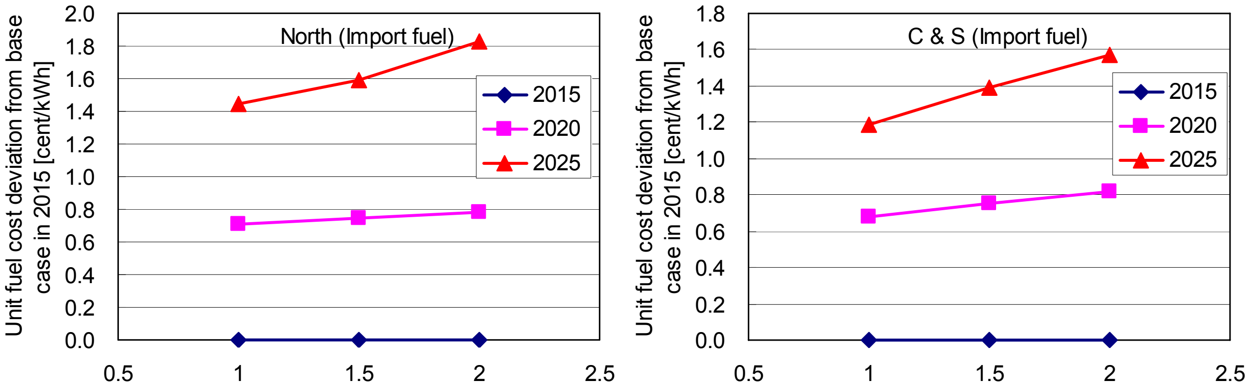


Figure 5-5-8 Effects of Import Fuel Price Hike

The incremental fuel cost leads to increase of generation costs at the maximum 0.7 cent/kWh in 2025 in both systems as shown in Figure 5-5-9.

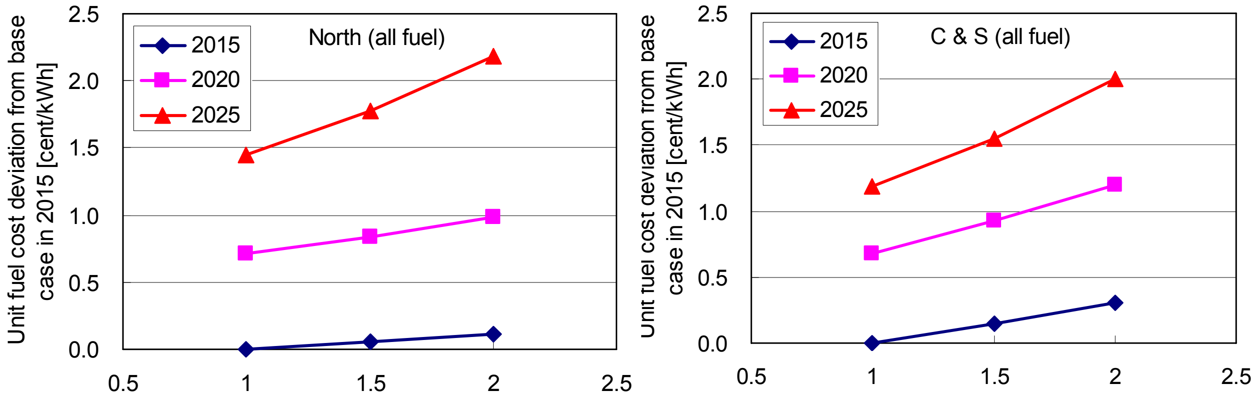


Figure 5-5-9 Effects of All Fuel Price Hike

Annual Costs vs. Capacity Factor for every type of power plant of Base Case and Double escalation rate of Base Case are shown in Figure 5-5-10 and in Figure 5-5-11 respectively. As evidenced by these Figures, in the case that escalation rate of fuel prices is double that of the Base Case, since nuclear power becomes more economical than coal fired thermal power plant in the range of the large capacity factor, the composition ratio of nuclear power development should be increased form the viewpoint of least cost development planning.

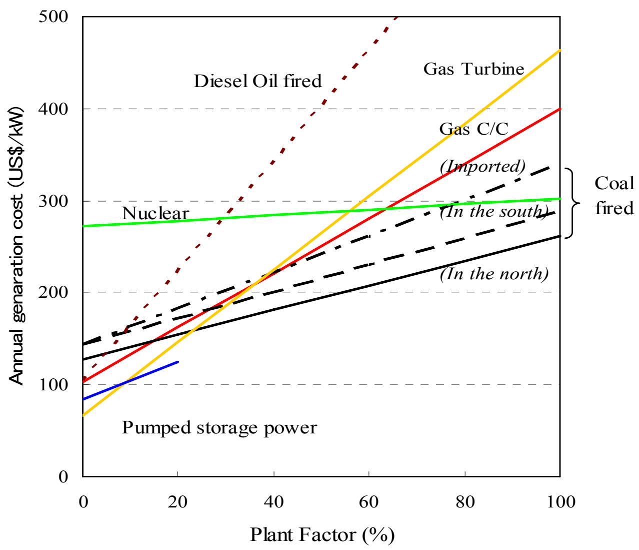


Figure 5-5-10 Annual Costs in 2025

(Base Case)

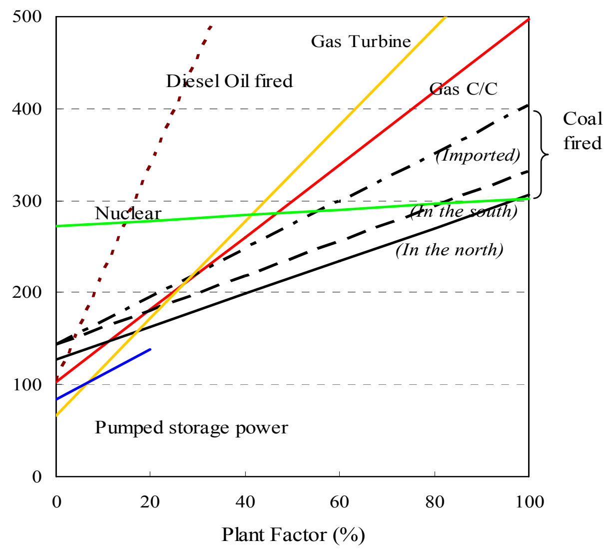


Figure 5-5-11 Annual Costs in 2025

(Double Escalation Rate of Base Case)

(4) BOT operation constraints

BOT scheme has a constraint of operation because the plant factor of 75% is made conditional in the power purchase contract. The limitation of BOT scheme is analyzed from the limitation of gas supply of 14BCM per year. The following three cases are set and analyzed. Base case is that where the existing BOT projects, Phu My 2.2 and Phu My 3 with total capacity 1440MW, have the constraint of operation of a BOT. Case No.1 is that where Phu My 2.2, 3, 4 and O Mon 3,4,5, with total capacity of 3990MW, have the constraint as a BOT scheme. Case No.2 is that where Phu My 2.2, 3, 4, O Mon 3,4,5 and New Gas C/C plants, with total capacity of 9,030MW, have the constraint of a BOT scheme.

Case No.1 consumes the gas amount of 14.5 BCM in 2025, which is 0.5 BCM over the planned gas supply volume. However, the volume of 0.5 BCM is supposed to be acceptable. Case No.2 consumes the gas amount of 15.7 BCM in 2025, which is 1.7 BCM over the planned gas supply volume, that is, not enough gas volume to operate them can be supplied . That means the constraint of 75% capacity factor of BOT scheme cannot be maintained in Case No.2.

The results of least cost operation simulation indicate that the annual costs are not greatly affected by BOT installations. The installation of gas C/C is limited to Case No.1 in which Phu My 2.2, 3, 4 and O Mon 3, 4, 5 are executed as BOT scheme.

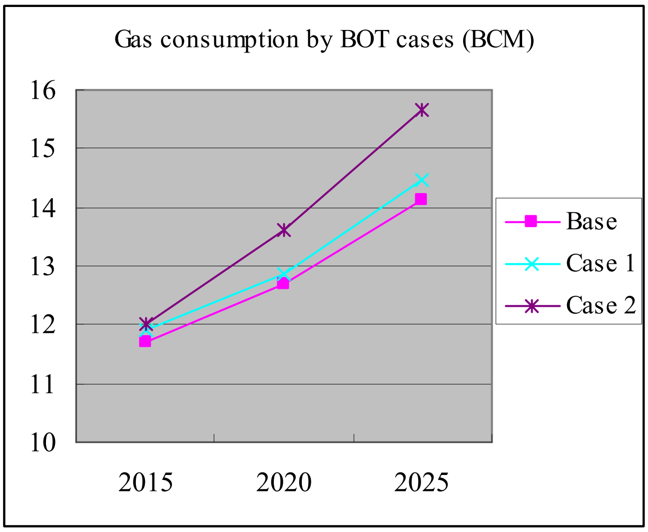


Figure 5-5-12 Effects of BOT Installation to Gas Consumption

Besides, the installation of BOT plants makes the capacity factor of gas C/C and coal thermal plants owned by EVN decrease. The capacity factor of EVN's thermal plants decreases from 67% in the Base Case to 52% in Case No.2 as shown in Figure 5-5-13 and Figure 5-5-14. If the capacity factor of BOT gas thermal plants is constrained as 75% in Power Purchase Agreement, EVN thermal power plants have to play the role of middle and/or peak supplier because BOT power plants become a base supplier. That is not an efficient and economic method of system operation. . Furthermore, in this case, installation capacity of gas fired thermal power plants has to be reduced, due to limitation of gas supply of 14 BCM.

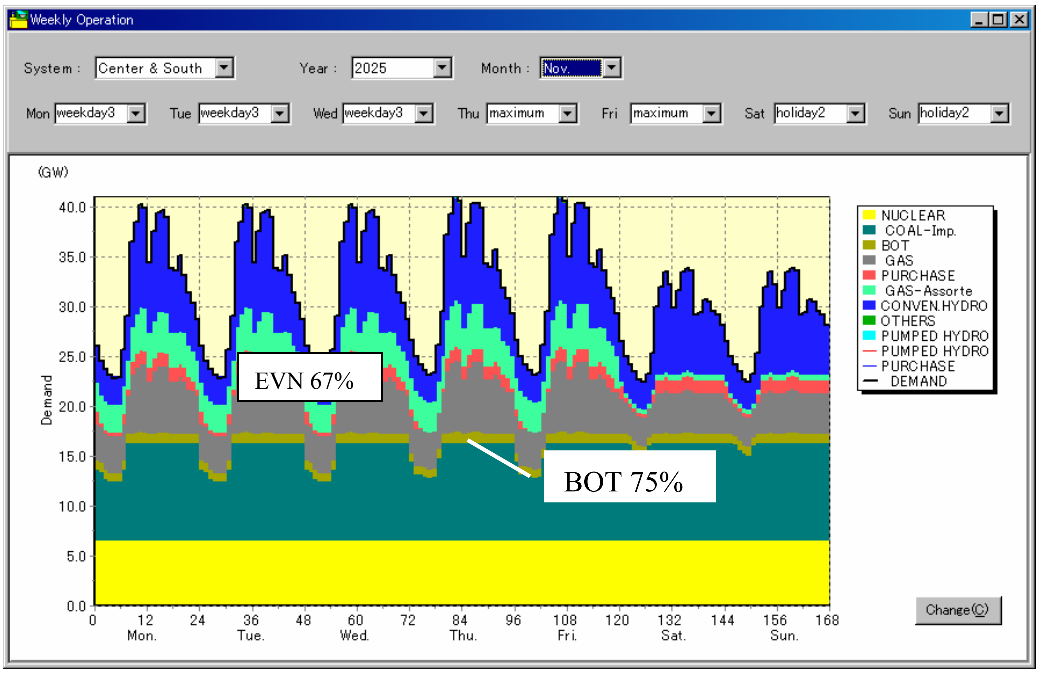


Figure 5-5-13 Capacity Factors of BOT and EVN Gas Thermal Power Plants in 2025 (Base Case)

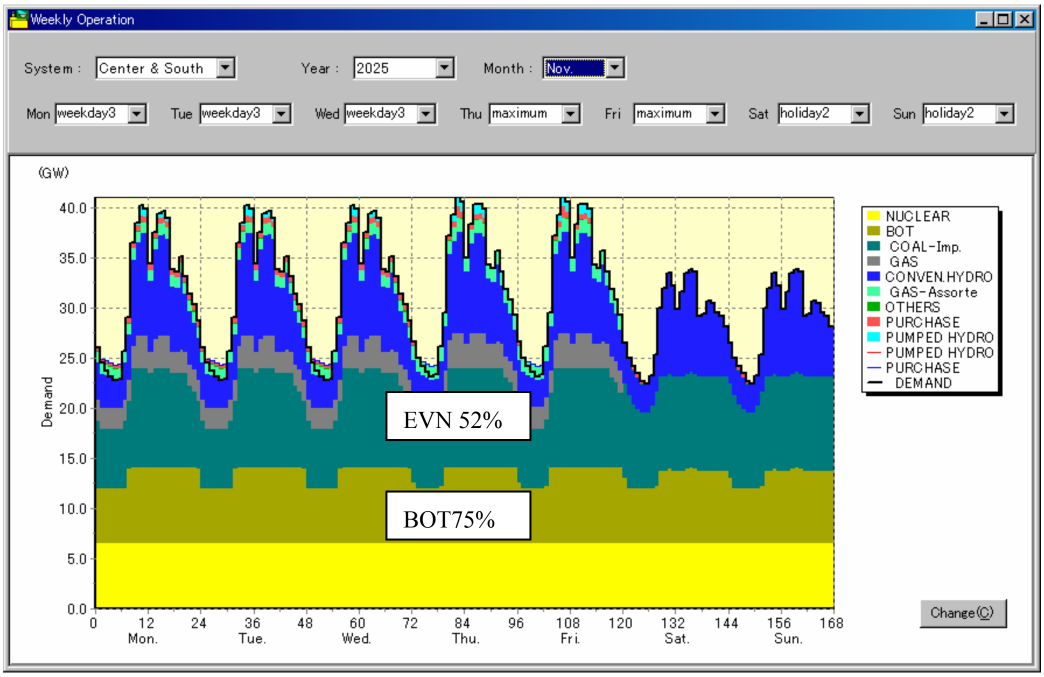


Figure 5-5-14 Capacity Factors of BOT and EVN Gas Thermal Power Plants in 2025 (Case2)

5.6 Power Generation Development Plan as of January 2006

Referring to the above mentioned study results by the Study Team and based on the changed conditions such as feasibility of power import, etc., IE reviewed and revised its original power generation development plan.

The power development program of PDP 6th (Base Case) as of January 2006 is shown in Appendix 5-2(1)-(5). The fuel composition and installed capacity by power source up to 2025 based on the PDP6th as of January 2006 are shown in Figure 5-6-1, Figure 5-6-2 respectively, and those by region are shown in Figure 5-6-3.

Furthermore, power demand - supply balance in the PDP 6th as of January 2006 during 2015-2025 is shown in Table 5-6-2.

Table 5-6-1 Installed Capacity by Power Source in the PDP 6th (Base Case) as of January 2006

(Unit: GW)

		Hydro	Import	Coal	Nuclear	Gas	Oil	RE	PSPP	Total
Whole Country	2005	4.0	0.2	1.5	0.0	4.1	1.0	0.1	0.0	10.8
	2010	9.4	0.7	6.5	0.0	7.5	1.7	0.5	0.0	26.2
	2015	15.3	2.7	9.2	0.0	12.5	1.3	1.1	0.0	42.0
	2020	16.0	5.0	20.8	3.0	13.9	1.3	1.7	0.6	62.2
	2025	16.0	5.0	36.2	8.0	16.1	1.3	2.4	4.2	89.1
North	2005	2.0	0.2	1.4	0.0	0.0	0.0	0.0	0.0	3.6
	2010	3.5	0.4	6.3	0.0	0.0	0.1	0.3	0.0	10.7
	2015	8.1	0.6	9.0	0.0	0.0	0.1	0.4	0.0	18.2
	2020	8.8	2.5	14.4	0.0	0.0	0.1	0.7	0.6	27.1
	2025	8.8	2.5	23.8	0.0	0.0	0.1	0.9	1.8	37.9
Center & South	2005	2.0	0.0	0.0	0.0	2.2	0.8	0.0	0.0	7.2
	2010	6.0	0.2	0.2	0.0	7.5	1.6	0.1	0.0	15.6
	2015	7.3	2.1	0.2	0.0	12.5	1.1	0.6	0.0	23.8
	2020	7.3	2.5	6.4	3.0	13.9	1.1	0.9	0.0	35.2
	2025	7.3	2.5	12.4	8.0	16.1	1.1	1.4	2.4	51.2

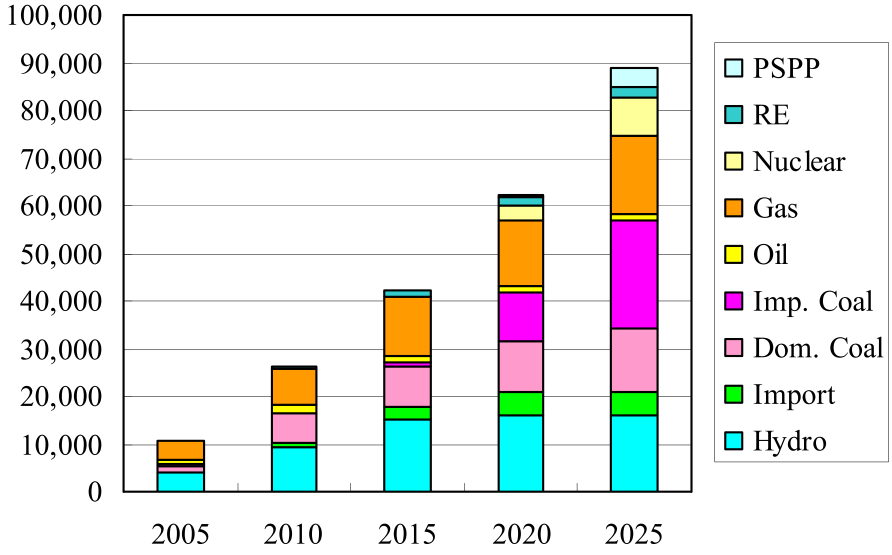


Figure 5-6-1 Installed Capacity by Power Source in the PDP 6th (Base Case) as of Jan. 2006

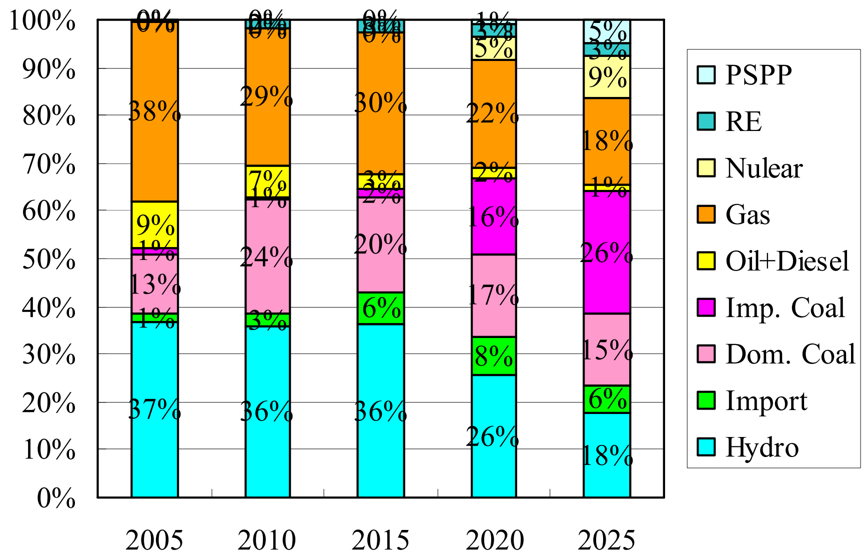


Figure 5-6-2 Fuel Composition in the PDP 6th (Base Case) as of Jan. 2006

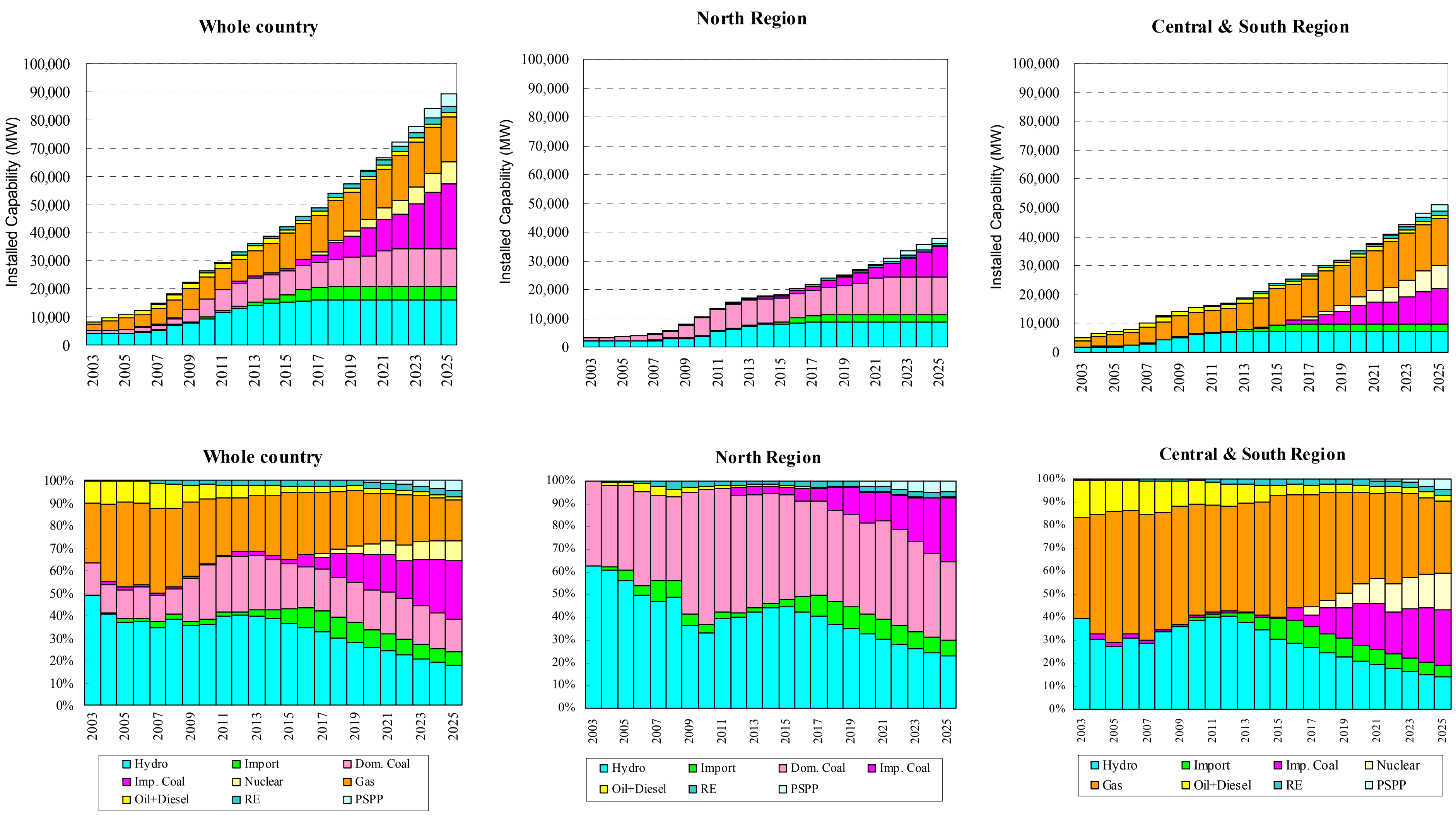


Figure 5-6-3 Installed Capacity and Fuel Composition by Region in the PDP 6th (Base Case) as of Jan. 2006

Table 5-6-2 Power Demand - Supply Balance in the PDP 6th (Base Case: 2015-2025) as of Jan. 2006

(Unit: MW)

Fiscal Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
North Region		Coal 800									
		Small Hydro 100									
	Nho Que 140	Trung Son 310	Coal 600								
	Khe Bo, Ta Thang 115	Ban Uon 80	Bac Me 280			PSPP 600		PSPP 600			
	Small Hydro 100	Import from Laos 382	Small Hydro 100	Coal 1800		Coal 1200	Wind 100	Coal-Import 1000	PSPP 300	PSPP 300	
	Import from China 250	Import from China 500	Import from China 500	Import from China 500	Coal 1200	Small Hydro 100	Coal 1800	Coal 600	Coal-Import 2000	Coal-Import 2000	Coal-Import 2000
PDP N total	605	2,172	1,480	2,300	1,200	1,900	1,900	2,200	2,300	2,300	2,000
N Peak Demand	13,480	14,681	15,926	17,281	18,715	20,285	21,994	23,824	25,799	27,837	29,959
N Supply	14,802	16,494	18,137	20,020	21,567	23,245	25,071	27,072	29,069	31,241	33,453
RM	9.8%	12.3%	13.9%	15.8%	15.2%	14.6%	14.0%	13.6%	12.7%	12.2%	11.7%
Center & South Region											
										Wind 50	Wind 100
	Small Hydro 100		Wind 50			Wind 50			PSPP 300	PSPP 900	PSPP 900
	CCGT-Gas 2160		CCGT-Gas 720		Wind 50	Coal-Import 2000	PSPP 300		Coal-Import 1800	Coal-Import 2000	CCGT-Gas 1000
	Import from Laos 617	Coal-Import 1200	Nuclear 1000	CCGT-Gas 720	Coal-Import 1000	Nuclear 1000	Coal-Import 1200	CCGT-Gas 2160	Nuclear 1000	Nuclear 1000	Nuclear 1000
	Import from Cambo 375	Import from Cambo 429	Small Hydro 100	Coal-Import 2000	Nuclear 1000	Small Hydro 100	Nuclear 1000	Nuclear 1000	Small Hydro 100	Small Hydro 100	Small Hydro 100
PDP C&S total	3,252	1,629	1,870	2,720	2,050	3,150	2,500	3,160	3,200	4,050	3,100
C&S Peak Demand	18,856	20,584	22,381	24,493	26,597	28,934	31,323	33,878	35,723	38,466	41,306
C&S Supply	20,102	22,037	23,967	26,393	28,717	31,285	33,894	36,607	38,875	41,934	45,011
RM	6.6%	7.1%	7.1%	7.8%	8.0%	8.1%	8.2%	8.1%	8.8%	9.0%	9.0%
PDP Total	3,857	3,801	3,350	5,020	3,250	5,050	4,400	5,360	5,500	6,350	5,100

Fiscal Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Peak Demand	32,196	35,104	38,130	41,429	44,927	48,642	52,677	56,992	61,649	66,434	71,416
Supply Capacity	34,904	38,531	42,104	46,413	50,284	54,530	58,965	63,679	67,944	73,175	78,464
Reserve Margine	8.4%	9.8%	10.4%	12.0%	11.9%	12.1%	11.9%	11.7%	10.2%	10.1%	9.9%

5.7 The Final PDP 6th

According to the comments by the relevant Ministries and Organizations such as EVN and Ministry of Industry, IE revised again the above described Power Generation Development Plan as of January 2006.

The power development program in the Final PDP 6th (Base Case) as of May 2006 is shown in Appendix 5-3(1)-(5). The fuel composition and installed capacity by power source up to 2025 based on the Final PDP 6th are shown in Figure 5-7-1, Figure 5-7-2 respectively, and those by region are shown in Figure 5-7-3.

Furthermore, power demand – supply balance in the Final PDP 6th during 2015-2025 is shown in Table 5-7-2.

The Final PDP 6th was rather improved in comparison with the PDP 6th as of January 2006. Main revised points and required further study items are listed as follows.

- Total power generation capacities during year of 2009 and 2015 are reduced at around 1GW every year. In the PDP 6th as of January 2006, the reserve margin during 2009 and 2015 were set at around 20%, while required reserve margin is around 10%, taking into account the risk of progress of some projects behind schedule. The reserve margin during 2009 and 2015 were revised at around 10% and this revised plan can secure appropriate supply reliability. The plan need to be continuously reviewed and revised as needed in line with change of growth rate of power demand and change of progress of each project after completion of the study on PDP 6th.

- While the Draft Final Report of the JICA study was made, total capacity of nuclear power plants of 8,000MW was planned to develop by 2025, the development capacity was reduced to 4,000MW because nuclear power plant is not so economical than imported coal TPP by 2025 and there remains critical issues such as radioactive waste disposal and public acceptance. Upon introducing nuclear power plants, deliberate and comprehensive study on such as nuclear fuel cycle, radioactive waste disposal and decommissioning of reactor need to be continuously carried out.

- In line with the review of production plan of the coal sector, the fuel of Vung Anh coal TPP in the North was changed from imported coal to domestic coal, and the development time of the first unit of imported coal TPP in the North, which unit size is 1GW, was postponed from 2022 to 2023 and total number of units was also reduced from 7 to 5. Accordingly, the total capacity of imported coal TPP developed by 2025 in the North reduced from 10.5GW to 5.0

GW. It is desirable that exploration of coal reserve and improvement of exploitation technology are continuously furthered in view of security of energy supply and restraint of increase of annual generation cost.

Table 5-7-1 Installed Capacity by Power Source in the Final PDP 6th (Base Case)

(Unit: GW)

		Hydro	Import	Coal	Nuclear	Gas	Oil	RE	PSPP	Total
Whole Country	2005	4.0	0.2	1.5	0.0	4.1	1.0	0.1	0.0	10.8
	2010	9.2	1.0	5.0	0.0	8.2	1.1	0.5	0.0	25.0
	2015	14.2	2.1	10.2	0.0	12.7	0.5	1.4	0.0	41.1
	2020	16.2	4.9	19.9	2.0	14.9	1.2	1.9	1.2	62.3
	2025	16.4	4.9	39.1	4.0	15.7	1.2	2.3	4.8	88.5
North	2005	2.0	0.2	1.4	0.0	0.0	0.0	0.0	0.0	3.6
	2010	3.5	0.7	4,8	0.0	0.0	0.0	0.2	0.0	9.8
	2015	7.3	0.8	8.2	0.0	0.0	0.0	0.4	0.0	16.7
	2020	8.9	2.4	13.1	0.0	0.0	0.0	0.6	0.6	25.6
	2025	9.1	2.4	21.7	0.0	0.0	0.0	0.8	1.8	35.8
Center & South	2005	2.0	0.0	0.0	0.0	4.1	0.8	0.0	0.0	7.2
	2010	5.7	0.3	0.2	0.0	8.2	1.1	0.3	0.0	15.7
	2015	6.9	1.3	2.0	0.0	12.7	0.5	1.0	0.0	24.4
	2020	7.3	2.5	2.8	2.0	14.9	1.2	1.3	0.6	36.7
	2025	7.3	2.5	17.4	4.0	15.7	1.2	1.5	3.0	52.6

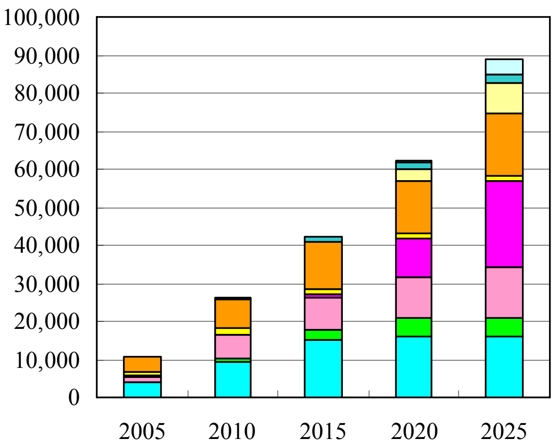


Figure 5-7-1 Installed Capacity by Power Source in the Final PDP 6th (Base Case)

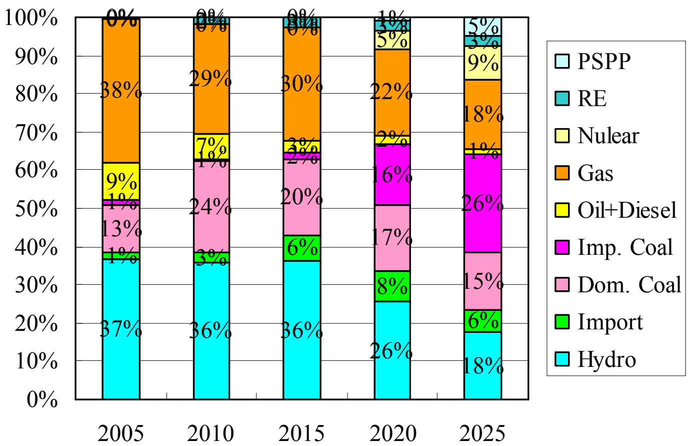


Figure 5-7-2 Fuel Composition in the Final PDP 6th (Base Case)

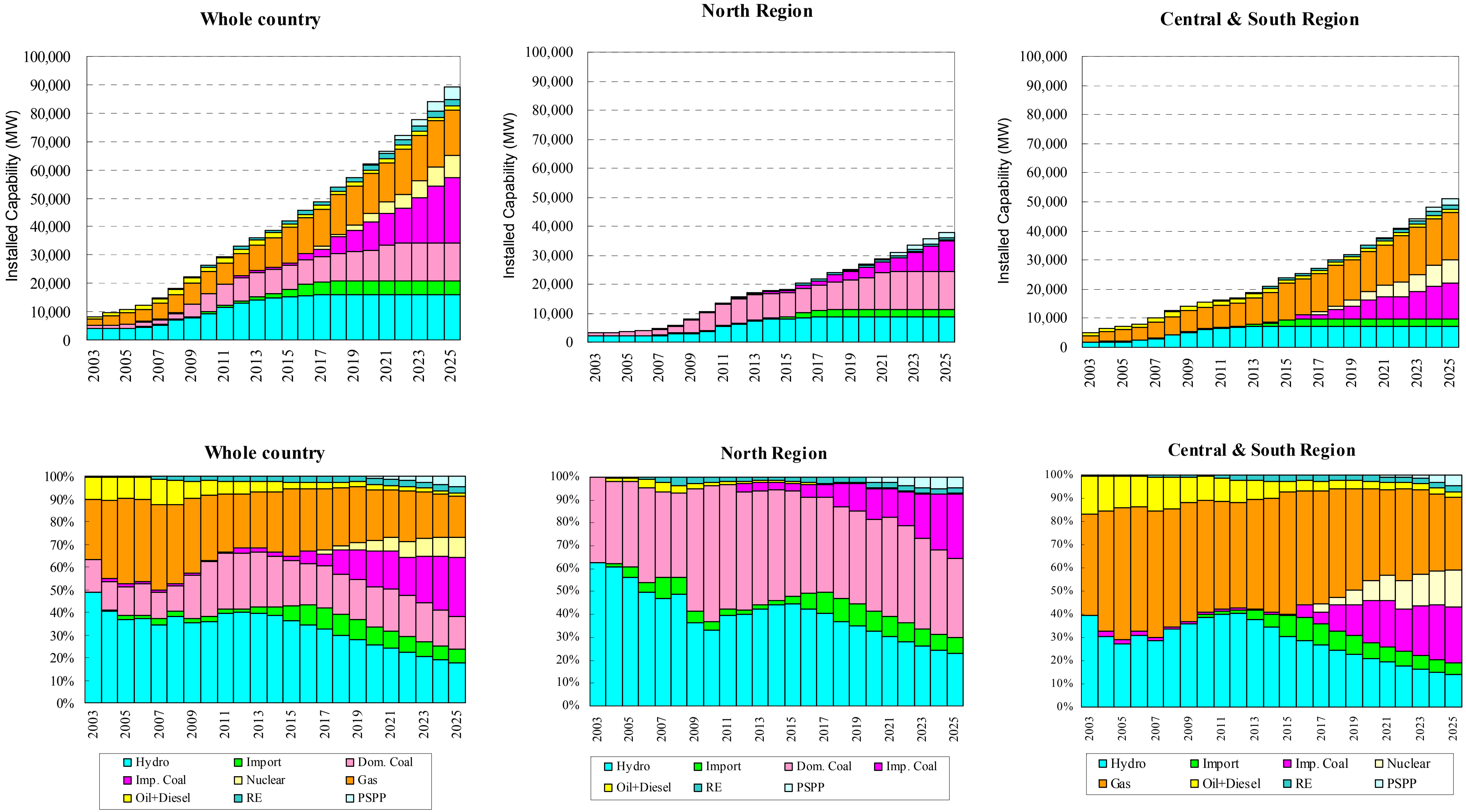


Figure 5-7-3 Installed Capacity and Fuel Composition by Region in the Final PDP 6th (Base Case)

Table 5-7-2 Power Demand - Supply Balance in the Final PDP 6th (Base Case: 2015-2025)

(Unit: MW)

Fiscal Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
North Region	Coal										
	500										
	Coal	Coal	Coal								
	500	500	600								
	Hua Na	Nho Que 3	Hoi Xuan		PSPP						
	140	140	96		300		Wind 100				
	Lai Chau #1,#2	Song Hieu,Ta Tang	Trung Son	Coal	Coal	PSPP	PSPP	PSPP			
	600	100	250	800	600	300	300	600			
	Khe Bo	Lai Chau #3,#4	Small Hydro	Bac Me	Coal	Coal	Nam Na	Small Hydro	Coal	PSPP	
	96	600	100	70	600	600	200	100	600	300	
	Small Hydro	Small Hydro	Import from Laos	Bao Lac	Coal	Coal	Coal	Coal	Coal	Coal-Import	Coal-Import
	100	100	382	190	600	600	600	600	600	1000	1000
	Import from China	Import from China	Import from China	Import from China	Nho Que 1,2	Small Hydro	Coal	Coal	Coal-Import	Coal-Import	Coal-Import
	250	750	250	250	110	100	600	600	1000	1000	1000
PDP N total	2,186	2,190	1,678	1,310	2,210	1,600	1,800	1,900	2,200	2,300	2,000
N Peak Demand	13,480	14,681	15,926	17,281	18,715	20,285	21,994	23,824	25,799	27,837	29,959
N Supply	14,167	16,034	17,384	19,074	20,668	22,196	24,249	25,992	28,194	30,276	32,641
RM	5.1%	9.2%	9.2%	10.4%	10.4%	9.4%	10.3%	9.1%	9.3%	8.8%	9.0%
Center & South Region		Coal-Import									
		600	Wind 50					Wind 50			
		CCGT-Gas	Coal-Import					Small Hydro			
	Wind 50	750	600					100			
	Song Bung 2	Vinh Son, Dak Mi	Song Bung 5					PSPP			
	108	320	85					600	Wind 50		
	Small Hydro	Duc Xuyen	Small Hydro	Coal-Import	CCGT-FO	PSPP		Coal-Import	PSPP	PSPP	PSPP
	100	52	100	600	330	600		600	600	600	600
	CCGT-Gas	Small Hydro	CCGT-Gas	Coal-Import	Coal-Import	CCGT-FO	PSPP	Coal-Import	Coal-Import	Coal-Import	Coal-Import
	1500	100	750	600	600	330	600	600	1000	1000	600
	Import from Laos	Import from Laos	Import from Laos	Coal-Import	CCGT-Gas	Coal-Import	Coal-Import	Coal-Import	Coal-Import	Coal-Import	Coal-Import
	464	405	240	600	750	600	600	600	1000	1000	1000
	Import from Cambo	Import from Cambo	Import from Cambo	Coal-Import	Nuclear	Nuclear	CCGT-Gas	Coal-Import	Coal-Import	Nuclear	Nuclear
	207	222	375	600	1000	1000	750	1000	1000	1000	1000
PDP C&S total	2,429	2,449	2,150	2,400	2,680	2,530	1,950	3,550	3,650	3,600	3,200
C&S Peak Demand	18,856	20,584	22,381	24,493	26,597	28,934	31,323	33,878	35,723	38,466	41,306
C&S Supply	20,296	22,069	24,134	26,219	28,477	30,915	34,099	36,925	39,705	42,649	45,589
RM	7.6%	7.2%	7.8%	7.0%	7.1%	6.8%	8.9%	9.0%	11.1%	10.9%	10.4%
PDP Total	4,615	4,639	3,828	3,710	4,890	4,130	3,750	5,450	5,850	5,900	5,200

Fiscal Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Peak Demand	32,196	35,104	38,130	41,429	44,927	48,642	52,677	56,992	61,649	66,434	71,416
Supply Capacity	34,463	38,103	41,518	45,293	49,145	53,111	58,348	62,917	67,899	72,925	78,230
Reserve Margine	7.0%	8.5%	8.9%	9.3%	9.4%	9.2%	10.8%	10.4%	10.1%	9.8%	9.5%

CHAPTER 6

POWER NETWORK DEVELOPMENT PLAN

Chapter 6 Power Network Development Plan

6.1 Method of Study of System Reliability

In PDP 6th, the optimum network development program that would meet the requirements in terms of both system reliability and economic efficiency should be planned. It is necessary to take into account of the stabilization of whole transmission system spread over Vietnam, power trading flows from the neighboring countries through interregional transmission lines, and existence of large national economic power exchange brought by the various types of power sources.

The power network planning of the 6th MP was carried out based on the 5th MP including updated demand forecast and power sources development program. The planning scope of the power network in PDP 6th covers 110 kV, 220 kV and 500 kV systems up to 2015 and 220 kV and 500 kV systems up to 2025.

In general, system reliability and stability can be confirmed through the study of the system with peak demand. The reliability and stability of the network with the one-directional power flow from power sources to a demand center can be checked through the study mainly at the peak demand time. On the other hand, the power flow between the north and the south of Vietnam does not always take the maximum value at the peak demand time, therefore, the studies should be carried out for some cases such as dry/wet seasons or peak/off-peak times.

For 220 kV and 110 kV systems, the network plans can be made in consideration of regional peak demand. Figure 6-1-1 shows the procedure of the system planning process.

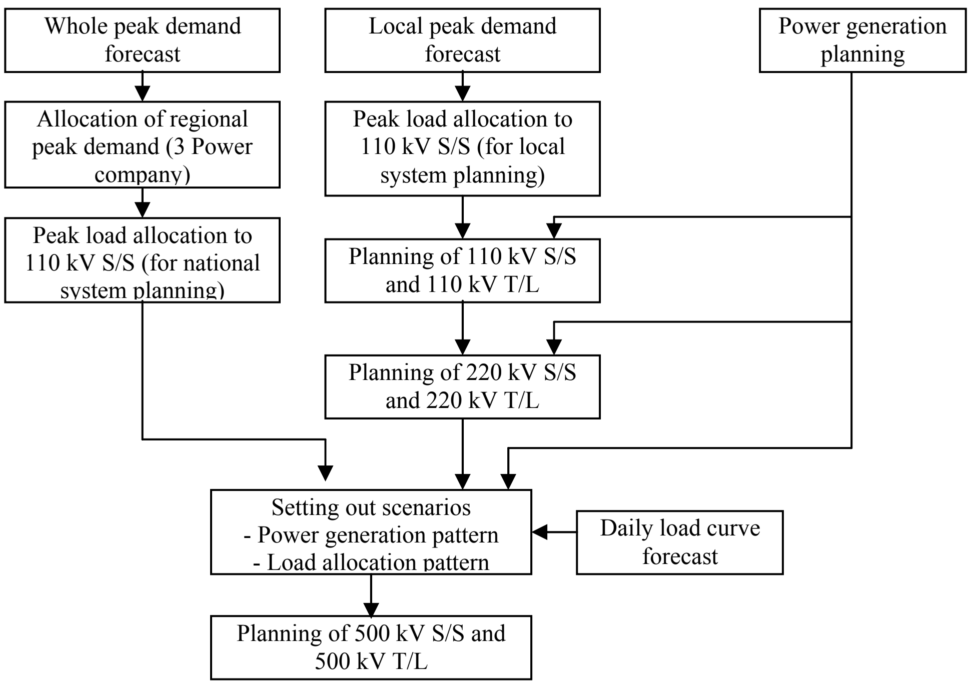


Figure 6-1-1 Procedure of System Planning

The PSS/E developed in USA is used as system analysis software in the PDP 6th in the same manner as in the 5th MP. Figure 6-1-2 shows the study flow of power network development planning.

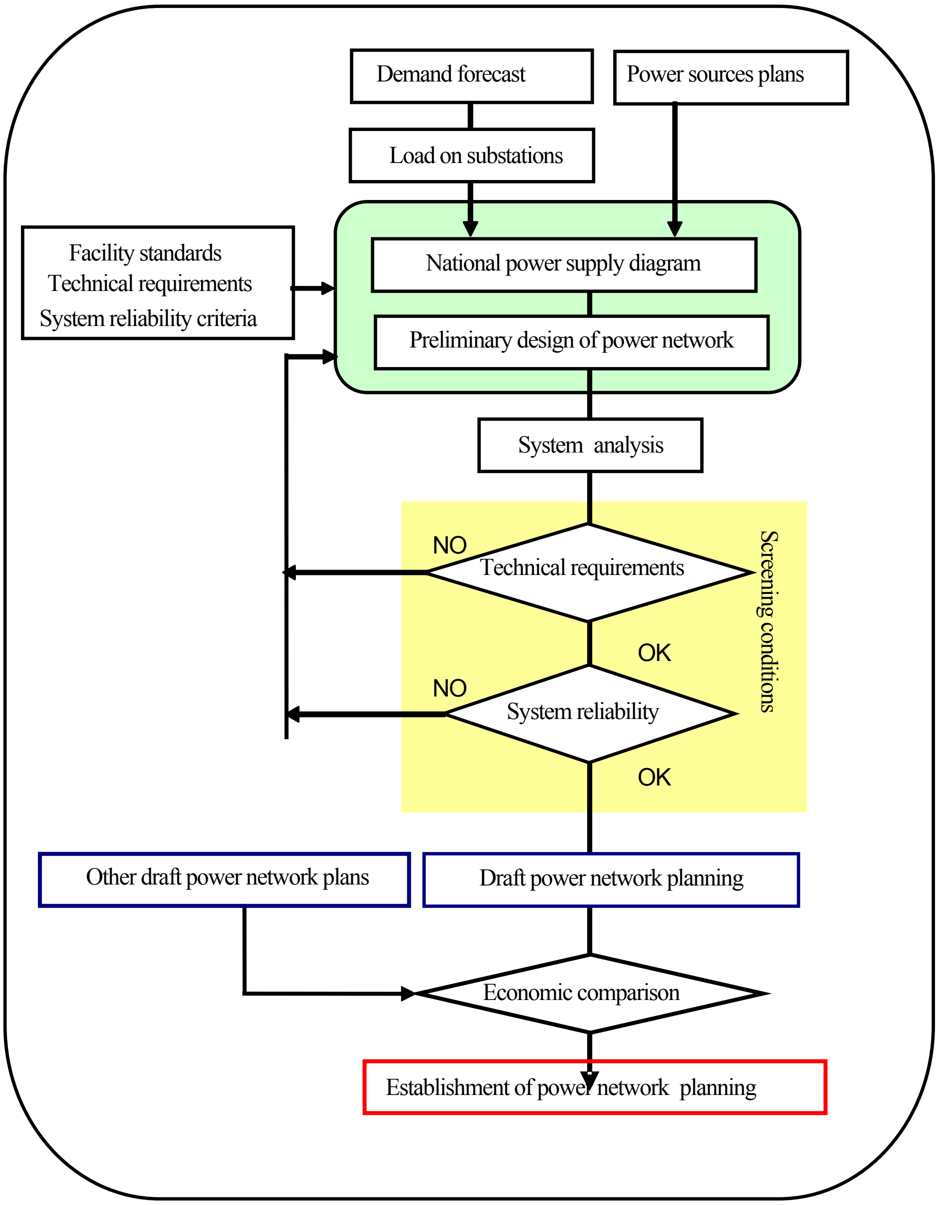


Figure 6-1-2 Study Flow of Power Network Development Planning

Firstly, the preliminary power network development plan up to year 2025 is set out and analyzed concerning power flow, stability and fault current so as to meet the system reliability criteria in several cases such as power demand increasing, power demand changing by each season, night and day, generator power adjustment for economic operation and change in power trade through interconnection transmission lines from neighboring countries. Special attention should be paid to the stability of large distance power transmission. Referring to planning criteria, it is confirmed whether or not the results of the studies satisfy the technical conditions and reliability criteria. When the results do not satisfy them, the preliminary plan is revised partly or completely.

The check is made mainly on whether or not the following problems are solved.

- Power flow and voltage analysis: occurrence of overload and over-voltage
- Fault current analysis: occurrence of over fault-current
- Stability analysis: instability of operation of power generation

This report focused on the power network planning of 500 kV transmission lines in 2020 and 2025 from the viewpoints of importance of long term plan of future bulk power network system.

6.2 Main Study Conditions

The study conditions are determined through the discussion with IE. The main study conditions regarding 500 kV and 220 kV systems are considered to be as follows.

Power network should be planned in order to realize the stable and continuous power transmission of power outputs of generators to substations. Stable and continuous power transmission is required even in case of a lack of one unit of power system facilities due to faults or scheduled outages. However, all the phenomena occurring in widespread power systems cannot be incorporated into the planning. Therefore, assuming a lack of one unit of facilities such as power transmission lines or substations, power systems are usually made in order to transmit power stably and continuously as much as possible even in such a case. This planning criterion is called N-1 criterion.

In case of a lack of one unit of facilities during the peak demand time, overloading or load-switching is often permitted because of the tentative situation.

System reliability criteria suitable for PDP 6th considered from the existing criteria applied to the Japanese power sector are expected as follows:

- Power flow through transmission lines should be under the nominal current of conductor used for remaining lines in case of a fault of a circuit;
- In case of drop of a transformer, remaining transformers are to be burdened under 120 % of their nominal capacity. Switching of some 220 kV substations to other 500 kV substations is permissible;

- For evaluating static stability, in systems using two or more circuits, the system should be stable even on single circuit sections; and
- For evaluating dynamic stability, in systems using two or more circuits, the system should be stable in three-phase short circuits. However, if necessary, the same phase ground fault in double circuits, route contingency, or unsuccessful circuit breaking should be studied for avoiding expansion of severe contingency.

The confirmation of power stability analysis will be based on the criteria that the stability is kept with 3LGO. That means the system should be kept stable even with open circuit breakers after three-phase fault occurrence. IE is now considering the stability with 1LG-O-C-1LG-3O as evaluation of stability of the 500 kV system (In case of a single-phase ground-fault, single-phase reclosing is not succeeded and after that three -phase opened). This condition seems to be a little bit more severe than 3LG-O and allows high reliability system planning. However, the process of simulation is complex. In general, the evaluation is often made with 3LG-O. Japanese power utilities often take 3LG-O as a typical fault for confirming the system dynamic stability. Regarding the fault current analysis for the system in Vietnam, the study condition is that a three-phase short circuit and a single-phase ground fault both do not exceed the maximum permissible fault currents as shown in Table 6-2-1.

Table 6-2-1 Maximum Permissible Fault Currents and Fault Clearing Times

Voltage level	Maximum fault current	Maximum fault clearing time
500 kV	40 kA	80 ms
220 kV	40 kA	100 ms
110 kV	31.5 kA	150 ms

Concerning interconnection transmission lines with foreign countries, only power lines are taken into account. The way of transmission lines through Laos has been planned to connect the North to the Center of Vietnam in framing of GMS interregional power trade system, however, there is a risk that the construction is not realized. Therefore, only power lines from neighboring countries are considered.

The demand used for power network planning should be peak demand. However, if severe situations arise in off-peak demand time, study should be carried out for the off-peak demand.

The plans are made in consideration of the following issues.

- Power Supply to Inside and Outskirts of the Big Cities

The conductors used for the 500 kV transmission lines with large length such as several hundred kilometers should be 4xACSR 330, however, in the case where short transmission lines and large capacities are economical, the alternatives should be examined.

4 x ACSR 330 mm2 used for Vietnamese 500 kV transmission lines has the thermal capacity of around 2,500 MW per circuit. In the case of power transmission through the lines of several hundred km, for example, through the existing north to south 500 kV transmission lines in Vietnam, the limited capacity from the viewpoint of stability is less than its thermal capacity. In such a case, 4 x ACSR 330 mm2 can be said to have enough capacity.

However, in the case of power transmission with rather short length, the limitation required by stability is not so much and this size of conductor does not have enough capacity.

The 500/220 kV transformers applied for Hanoi or Ho Chi Min systems have usually 450 MVA and the maximum number of transformers in a substation is two, which is a small number. The plans of conductor sizes of 220 kV transmission lines and capacities of 220/110 kV transformers might be uneconomical in the future for Hanoi and Ho Chi Min cities, which are predicted to have huge power demand densities like present big cities in southeast Asia, because the standards of the former Soviet Union are applied and too many facilities have to be installed. For example, the 500/275 kV substations around Tokyo have loads in the range from 2,000 MW to 4,000 MW in one substation, meanwhile, most 500/220 kV substations were planned to have loads only in the range around 1,000 MVA in the 5th MP in Vietnam.

The 275 kV transmission lines around Tokyo sometimes have the capacity of more than 1,000 MW per circuit, meanwhile, the 220 kV transmission lines planned in Vietnam usually have less than half of this capacity. Even in consideration of the different voltage levels, the present specifications on the system are considered to be too small for the future bulk power system in Vietnam.

Although the existing standards have been suitable and economical for the long distance power transmission with small demand densities, the standards need to be improved for the future Hanoi and Ho Chi Min systems, which will have high demand densities and limited land space for installation.

The 500 kV network systems around big cities in Southeast Asia are often planned to configure multi-ring shaped systems like Tokyo or Shanghai. From the ring-shaped 500 kV system to load center, power is supplied by lower voltage systems. For the configuration of power systems in Hanoi and Ho Chi Min City, the multi-ring shaped system configuration is targeted.

Table 6-2-2 shows the main specifications of the 500 kV substations applied for 6th MP.

Table 6-2-2 Standard 500 kV Substations Applied for the PDP 6th

Voltage (kV)	Capacity	Number of Transformers
500/220	900, 600 ,450	1-3
220/110	250, 125, 63	1-3

The capacity of TEPCO's 500/275 kV transformers is 1,500 MVA. It is about 3-5 times of 275 kV usual transformers.

Vietnam uses 250 MVA transformers as usual in 220 kV system. Therefore, 1200 MVA also seems adequate as the capacity of 500/220 kV transformers.

Table 6-2-3 shows the standard conductor of 500 kV and 220 kV transmission lines applied for PDP 6th.

When large substations are applied such as 220 kV: 250 MVA x 3 or 4, 500 kV: 1200 MVA x 3 or 4, some intervals in grid are heavily loaded. Large-size conductors should be considered for economical system configuration.

Table 6-2-3 Standard Conductor Applied for the PDP 6th

Voltage (kV)	Type	Number of Conductors
500	410, 610	4
220	610, 810	2

- Power flow from north to center and south regions

Around year 2020, since the north region has a lot of base power suppliers such as hydro power plants and/or coal thermal power plants, and the power flow from Ha Tinh to Center and South regions has a tendency to increase, the power flow is sometimes over the limitation based on N-1 criteria between Ha Tinh and Da Nang according to the distribution of power sources in Vietnam.

In this case, the following alternatives are to be considered.

- To reinforce the transmission lines between Ha Tinh and Da Nang to meet various power generation patterns
- To limit power generation patterns in north and south in order not to exceed the limitation of the power flow from north to center/south, or to open inter-regional connection between North and Center & South
- To change location of power plants

In this power network planning, the power flow between north and center is planned to be within about 1,000 MW. However, the comparative study of above-mentioned counter measures should be continuously carried out in line with optimum power development planning and power system operation planning for the long term.

The following points should be paid attention in the optimization study of power network development plan for years 2020 and 2025. In the case that large power flow is allowed between the north and the south, investment cost of power network increases, however, power generation with cheap generation cost can be made use of widely. And when generator stops due to accidents, the power exchange from other regions is expected and then the reserve-margin by region can be reduced. On the other hand, when power supply and demand are balanced in each region, the enhancement costs of transmission lines are reduced and power network stability is improved. That is, the optimum power transmission system between the North and the South is determined in consideration of the cost and the reliability of the whole system including power plants and capacity of power transmission to be a parameter. In concrete terms, the studies on whether or not the number of the circuits from north to south, which has two circuits now, should be increased are carried out.

For example, coal-fired power plants installed in the north region can generate cheaper power than in the South region because coal is produced mainly in the North region as shown in Figure 6-2-1. However, the case requires an increase in the capacity of transmission lines from the north to the south and the construction cost of transmission lines is increased.

Furthermore, the large distance power transmission may decline system reliability. On the other hand, Coal-fired thermal power plants installed in the South region may reduce the construction cost of power transmission lines even though they may bring higher generation cost due to long-distance fuel transportation from north to south.

The power loss from north to south can reach about 10% at most and about 6% on the average.

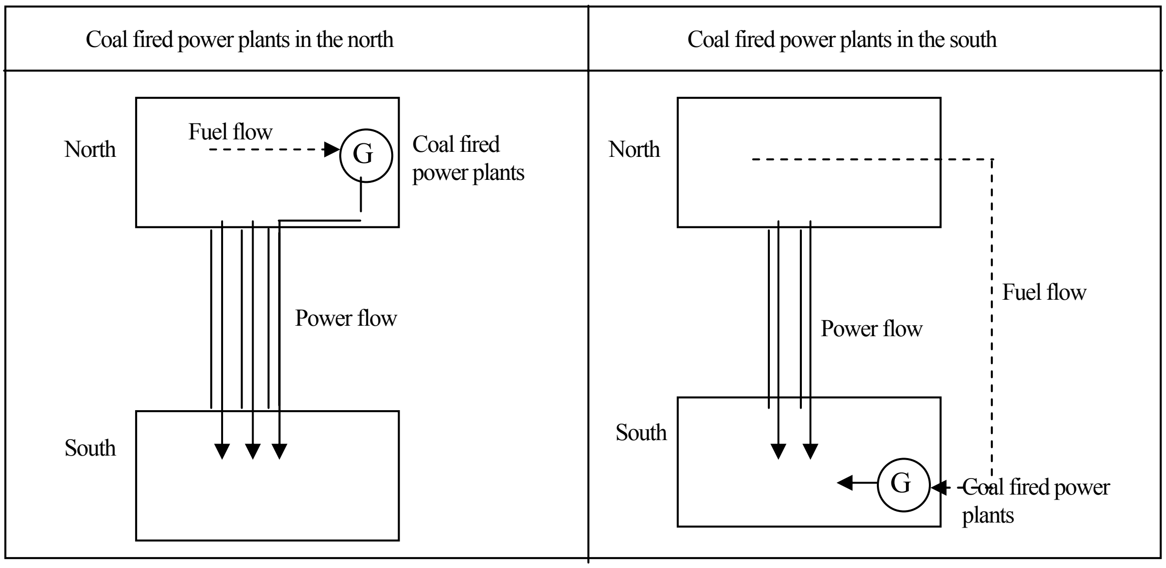


Figure 6-2-1 An Example of Study-Scenario about Locations of Power Plants and Reinforcement of Power Transmission Lines

- Power flow from the Center to the South region

From the Center to the South coast, there are development plans for nuclear power plants, large coal thermal power plants and power import from large hydro power plants in Laos. The power flow from the Center to the South exceeds the capacity limitation of N-1 criteria between Plei Ku and Than Dinh. Thus, the large-scale reinforcement of 500 kV transmission lines is required between the Center and the South.

In Japan, when the large reinforcement of 500 kV system with many circuits was predicted for the future, the introduction of 1,000 kV system was examined and steel towers for 1,000kV were actually designed and constructed. Now in China, such a ultra high voltage AC transmission system is also examined. For the Vietnamese power network system, it would be necessary to study such an alternative in the future.

- Voltage maintenance

Vietnam power network system spread over 1,500 km from the North to the South causes large change in power flow through optimal operation of power plants. In large power demand areas such as Hanoi and Ho Chi Min city, the large difference in voltage between day and night or season by season may occur, which is difficult to be adjusted only by static reactive power facilities. In the future, automatic controllers for adjusting reactive power will be required such as automatic switching operation of capacitors or shunt reactors, SVC (thyristor controlling reactive power sources) and synchronous condensers. The precise planning of reactive power facilities requires precise reactive load forecast, however, the long-term reactive load forecasting is difficult. The reactive power facilities should be studied and planned annually by system calculation for the next year.

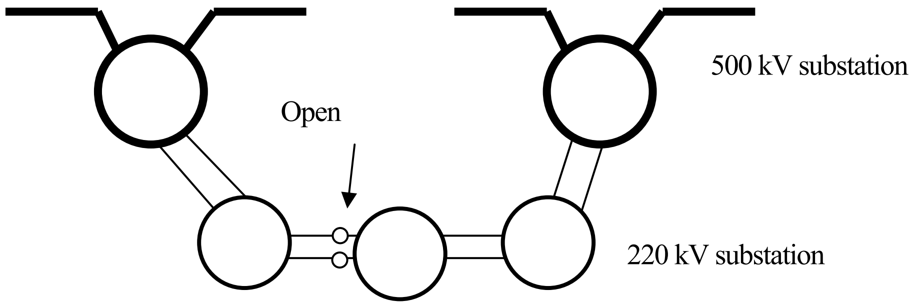
- Increase in fault current

One of the common issues of the system in/around the Asian large cities such as Tokyo, Shanghai and Taiwan is increase in fault current. Increase in demand density requires many transmission lines connected with large-scale power plants, which threaten the fault-breaking ability of circuit breakers.

The following countermeasures against increases in fault current can be considered.

- To split operation of the system
- To adopt circuit breakers with high fault breaking ability
- To apply high impedance transformers

One of the ways of split operation system is as shown below. Circuit breakers in the 220 kV system are opened at some intervals and fault currents are suppressed.



- Series capacitors

Installation of series capacitors causes electrical series resonance with low frequency levels. When the frequency becomes equal to the frequency of turbine mechanical resonance of nuclear power plants or thermal power plants, power generators vibrate and have a possibility of dropping from the system, which leads to black out. If many series capacitors are installed, it is difficult to grasp the resonance frequencies. Therefore, series capacitors should be limited to installation in the north – south transmission lines.

- Stability consideration for planning year 2025

Stability calculation is usually complicated and not easy, but important. When rough estimation of stability is required for network planning on “white papers”, the following considerations are convenient.

- 500 kV transmission lines have about 0.1 %/km reactance not depending on conductor sizes.

  500 kV transmission line is said to be able to transmit power up to 5,000 MW through 100 km in stable operation with a single circuit (Almost the same as the maximum power with double circuit under N-1 criteria)

  For example, if length is 200 km, maximum power would be about 2,500 MW with single circuit (Under N-1 criteria, the maximum power is about 2,500 MW with double circuit).

  Approximate stable power flow = Remaining number of circuit x 5,000/("Length of a transmission line" (km) / 100 (km))

- "Length of a transmission line" is calculated as shown below.

  For example, Vietnam's first 500 kV transmission line has 1,500 km with 60 % compensation. Thus the length of the line is deemed 600 km (40% of 1500km).

  When substituting 600 to "length of a transmission line" in the above-mentioned formula, stable power flow can be obtained as 833 MW, and it would give good approximation.

  For another example, take the north-south transmission line with double circuits from Ha Tinh to Plei Ku (with second, third and fourth intervals). Stable power flow, in the case that a single circuit drops at an interval, can be calculated as follows.

  "Length of each interval" is 1500*0.4(by series capacitor compensation)/4 = 150 km

  "Length of the transmission line" is 150 (dropped single circuit) + 150/2 (double circuits) + 150/2 +150/2 = 940 km

  When substituting 940 to length of a transmission line, stable power flow can be obtained as 1333 MW.

The results of the above rough estimation have to be checked by precise system stability analysis.

6.3 Optimization Study of Power Network System in 2020 and 2025

The Study Team prepares data for the Vietnam power system including the 500 kV and 220 kV systems based on the information as of Sep 2005 and discusses with IE. At present, IE are updating and analyzing the data with PSS/E software program. The 500 kV power network plan is determined on the basis of the following system analysis.

- Power flow
- Stability
- Fault current

The regional descriptions of power plants and power load forecast at 220 kV substations are as follows. However, the figures in the tables represent the capacities of power plants (maximum power generations) and maximum loads and difference between capacities and loads are not equal to regional surplus or shortage of power at the peak demand time.

(1) North East Area

North East Area has power development plans of Mong Duong and Quang Ninh coal thermal power plants connected to the 500 kV system. Hai Phong and Uong Bi coal thermal power plant are connected to the 220 kV system. On the other hand, the total load in this region is smaller than output of those power plants. Since there is large power flow from this area to Hanoi, about three circuits by 2020 and four circuits by 2025 of the 500 kV system are required.

Table 6-3-1 Power Stations and Loads at 220 kV Substations in North East (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Mong Duong	2000		2000	
Uong Bi		105		105
Uong Bi MR1&2		600		600
N.Duong		100		100
C.Ngan		100		100
ND Hai Phong		1200		1200
ND Cam Pha		600		600
ND Quang Ninh	900	300	900	300
Son Dong		400		400
Mao Khe		400		400
New Imp. Coal #4			1000	
New Imp. Coal #5			1000	
New Imp. Coal #6			1000	
	2900	**3805**	**5900**	**3805**

Substation	2020	2025
	220 kV	220 kV
BacCan	159	220
BacGiang1,2	575	800
CaiLan	232	400
HoanhBo	290	400
UongBiMR	145	300
CamPha	159	300
TrBach	400	400
DongHoa	400	400
VatCach	400	400
NDHPhong	200	400
DinhVu	400	600
DoSon	200	400
BacSongCam	200	400
CaoBang	142	200
LangSon	336	500
	4239	**6120**

(2) North West Area

North West Area has power development plans for large sized hydropower plants such as Son La and Lai Chau and pumped storage power plants. The surplus power output of this area of 4,000 MW at maximum by 2020 and 3,000 MW at maximum by 2025 is transmitted to Hanoi.

Table 6-3-2 Power Stations and Loads at 220 kV Substations in North West (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Thac Ba		108		108
Tuyen Quang (Na Hang)		342		342
Thai An		44		44
Na Le		90		90
Nam Mu		11		11
Na Loi		9		9
Van Chan		35		35
Ngoi Bo		35		35
Minh Luong		22		22
Nam Dong-Suoi Sap		22		22
Ban Ve (Ban La)		300		300
Khe Bo		68		68
Song Hieu		53		53
Coc San		40		40
Chu Linh		30		30
Seo Chung Ho		22		22
Ban Chat		200		200
Huoi Quang		560		560
Cua Dat		97		97
Nam Chien		210		210
Nho Que		140		140
Son La	2400		2400	
Lai Chau	1200		1200	
Bac Me		280		280
Thuy dien nho mien Bac moi		100		100
Thuy dien tich nang	600		600	
	4200	**2818**	**4200**	**2818**

Substation	2020	2025
HBinh220	350	500
LaoCai	478	700
LChau220	200	300
HaGiang	165	250
TXSonla	203	300
SLa220	70	100
LuuXa	400	600
ThNguyen	400	500
TQuang	246	400
YenBai	276	404
	2788	**4053**

(3) Hanoi Area

This area has large existing power plants such as Hoa Binh hydropower plant and Pha Lai coal thermal power plant. On the other hand, the load is far larger. Therefore, large power flows into this area from other areas.

Table 6-3-3 Power Stations and Loads at 220 kV Substations in Hanoi (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Nhap khau TQ	1500		1700	
Pha Lai I		400		400
Pha Lai 2		600		600
Hoa Binh		1920		1920
	1500	**2920**	**1700**	**2920**

Substation	2020	2025
BacNinh1,2	600	1000
BacNinh500	400	400
PhaLai	400	400
HDuong1	400	600
HDuong2	300	600
TrangBach cap	100	100
XuanMai	400	600
HaDong	400	400
SonTay	250	400
HoaLac	400	600
TayHN	580	600
Chem	400	600
MaiDong	507	700
AnDuong	580	700
VanTri 1,2	580	1200
SSon220	300	400
DongAnh	400	600
SaiDong	400	600
PhuLy	300	400
HaNam	300	400
PhoNoi	400	400
PhoNoi500	150	400
PhoCao	300	400
PhuTho	319	400
VTri220	400	600
PhucYen	250	400
VinhYen	400	550
	10215	**14450**

(4) South Area of Hanoi

This area has power development plans such as Thoi Bonh coal thermal power plant by 2025. The difference between power demand and supply in this area until 2025 is not so large.

Table 6-3-4 Power Stations and Loads at 220 kV Substations in South Hanoi (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Ninh Binh		100		100
Ninh Binh MR		300		300
New Imp. Coal #1- Thoi Bonh				600
New Imp. Coal #2- Thoi Bonh				600
New Imp. Coal #3- Thoi Bonh				600
	0	**400**	**0**	**2200**

Substation	2020	2025
NinhBinh	350	400
NBinhMR	200	400
NamDinh1,2	400	600
TXuyen	250	400
ThaiBinh	577	844
	1777	**2644**

(5) North Central Coast Area

This area has power development plans of two large coal thermal power plants, Ngi Son and Vung An. Total power output of these two plants reaches 6,000 MW connected to the 500 kV system. On the other hand, loads will be far smaller than power output. Therefore, the large power flows into Hanoi from this area, and more than three 500 kV lines are required.

Table 6-3-5 Power Stations and Loads at 220 kV Substations in North Central Coast (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Hua Na		180		180
Ban Uon		80		80
Trung Son		310		310
Nhac Han, Ban Coc, Huong Son		100		100
L1. Nam Mo		95		95
Import from Lao (Nam Theun		382		382
Nghi Son I-220kV		600		600
Nghi Son II-500kV-Import coal	2400		2400	
Vung Ang I	1200		1200	
Vung Ang II- Import coal	2400		2400	
	6000	**1747**	**6000**	**1747**

Substation	2020	2025
	220 kV	220 kV
HTinh220	300	400
ThachKhe	200	200
Vungang	100	200
QuynhLuu	400	400
DoLuong	200	200
Vinh1,2	400	800
BimSon	300	400
ThanhHoa1,2	600	800
Tay ThanhHoa		300
NghiSon	400	400
	2900	**4100**

Figure 6-3-1 shows the power supply/demand balances of above-mentioned five regions at peak demand time and outlines of power flow. There is power flow from the surrounding areas to Hanoi.

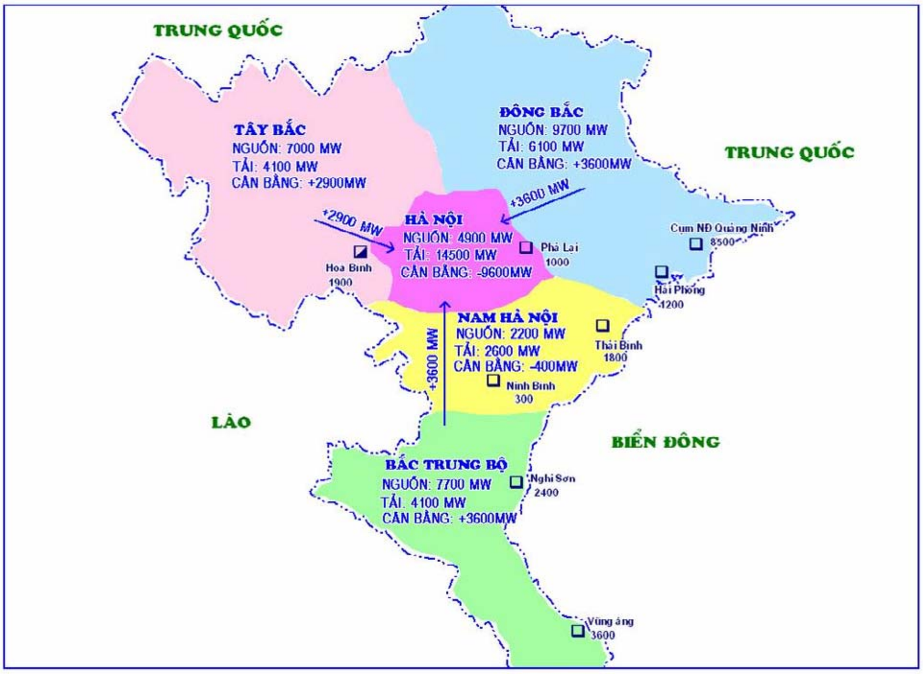


Figure 6-3-1 Power Demand/Supply Balances at Peak Demand Time and Power Flow

(6) South Central Coast Area

Quang Tri coal thermal power station is constructed by 2020, however, total load of this area is larger than power output. Da Nang coal thermal power station is constructed by 2025 and surplus power output is transmitted to the South region.

Table 6-3-6 Power Stations and Loads at 220 kV Substations in South Central Coast (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
New Imp. Coal #7-Quang Tri			1000	
New Imp. Coal #8-Quang Tri			1000	
New Imp. Coal #9-Quang Tri			1000	
New Imp. Coal #10- Dà Nang			1000	
New Imp. Coal #11-Dà Nang			1000	
New Imp. Coal #12-Dà Nang			1000	
Thuy dien nho mien Trung		200		200
A Vuong		210		210
Quang Tri (Rao Quan)		64		64
DakDrinh		100		100
Plei Krong		100		100
Thuong Kon Tum		220		220
Song Con 2		70		70
Dak Mi 4		210		210
Dac Mi1		210		210
Song Boung 2		108		108
Song Boung 4		165		165
Song Boung 5		85		85
ND Khi mien Trung				720
	0	1742	6000	2462

Substation	2020	2025
HoaKhanh1	250	360
LienChieu	150	200
DNang220	400	600
Quan3	140	200
BaDon	200	250
DongHoi	210	350
TamKy	300	400
ChuLai1,2	400	550
DSoi220	300	400
ThDpDQ	190	300
Qngai	200	320
DongHa	250	350
VinhLinh	200	330
Hue1	400	550
Hue2	300	400
Hue3		260
	3890	5820

(7) South Northern East Area 1

There is a development plan for Tuy Hoa coal thermal power plant by 2025.

Table 6-3-7 Power Stations and Loads at 220 kV Substations in South Northern East 1 (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Song Ba Ha		220		220
South Coal #8 (Tuy Hoà)			1000	
South Coal #9 (Tuy Hoà)			1000	
South Coal #10 (Tuy Hoà)			1000	
An Khe-Ka Nak		163		163
Song Hinh		70		70
Vinh Son		66		66
	0	**519**	**3000**	**519**

Substation	2020	2025
QuiNhon	477	752
NTran220	450	709
CamRanh	327	515
TuyHoa	245	387
	1500	**2362**

(8) South Northern East Area 2

This area has large power output with development plans of Dong Nai hydropower, Binh Thuan combined cycle power plant, nuclear power plants and pumped storage power plants. More than 6,000 MW by 2020 and more than 10,000 MW by 2025 flows into Ho Chi Min city area and more than several circuits are required from this area to Ho Chi Min city.

Table 6-3-8 Power Stations and Loads at 220 kV Substations in South Northern East 2 (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Dien gio, NL moi,...		100		100
Da Nhim		160		160
Ham Thuan		300		300
Da Mi		177		177
Dai Ninh		300		300
Dong Nai 3		180		180
Dong Nai 4		340		340
Dong Nai 2		78		78
Dong Nai 5		173		173
Duc Xuyen		52		52
Thuy dien tich nang	800		800	
New CC #4 (Binh Thuan 1)		720		720
New CC #5 (Binh Thuan 2)		720		720
DNT #1	1000		1000	
DNT #2	1000		1000	
DNT #3	1000		1000	
DNT #4	1000		1000	
DNT #5			1000	
DNT #6			1000	
DNT #7			1000	
DNT #8			1000	
	4800	**3300**	**8800**	**3300**

Substation	2020	2025
PhanTh	500	800
DucTrong	100	200
DaLat	150	250
DaiNinh	80	100
BaoLoc	150	200
LNhom	200	200
HamThuan	80	100
ThapCham	204	293
DNgTu220	54	78
DaNhim	82	117
	1600	**2339**

(9) Central Highland Area

This area has Plei Ku substation and Yali hydropower station. Surplus power output including imported power from Lao hydropower sources is transmitted to the South regions through North-South 500 kV transmission lines.

Table 6-3-9 Power Stations and Loads at 220 kV Substations in Central Highland Area (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Yaly		720		720
TDN Tay Nguyen		100		100
Se San3		260		260
Se San3A		108		108
Dak Rtih		72		72
EaKrong Hnang		65		65
Buon Kuop		280		280
Dam Bri		72		72
Song Tranh		160		160
Buon Tua Srah		85		85
Serepok 3		220		220
Serepok 4		28		28
Se San 4		360		360
L4. Xekaman 3		248		248
Xe Kaman 1	396		396	
L6. Sekong 4	464		464	
L3. Nam Kong 1	229		229	
L7. Sekong 5	388		388	
Nhap khau CPC (H.Sosan 3)		375		375
	1477	**3153**	**1477**	**3153**

Substation	2020	2025
KrongBuk	314	494
BMThuat	150	172
Daknong	100	200
PleiK220	423	637
KonTum	161	242
	1148	**1744**

(10) Ho Chi Minh City Area

Ho Chi Min city has large existing power plants such as Tri An hydropower, Phu My gas fired thermal power plant and a development plan of Nhon Trach gas fired thermal power plant. On the other hand, total load is quite large. There is large power flow from other areas to this area.

Table 6-3-10 Power Stations and Loads at 220 kV Substations in Ho Chi Minh City (Year 2020 and 2025)

Power Station	2020		2025			Substation	2020	2025
	500kV	220kV	500kV	220kV				
Tri An		400		400		PhuMy220	400	400
Phu My 2-1		430		430		MyXuanA	300	400
Phu My 2-1 MR		450		450		KCNPhuMy2	100	400
Phu My 4	450		450			BaRia	200	300
Phu My 1		1090		1090		VungTau	300	400
Phu My 2.2	720		720			XuanLoc	400	600
Phu My 3	720		720			SMay220	400	600
Ba Ria		386		386		LThanh1,2	600	800
Formosa		300		300		AnPhuoc	400	600
Amata+Vedan+Bourbon		109		109		LongBinh	400	400
Nhon Trach II #1 CC		330		330		BienHoa	400	600
Nhon Trach II #2 CC		330		330		TamPhuoc	600	600
GT-GE - Nhon Trach		428		428		LongKhanh		400
CC-GE I (2x117+100MW)-Nhon Trach		330		330		TriAn	200	400
CC-GE II (2x117+100MW)-Nhon Trach		330		330		NTrac220	400	400
ND +TBK Thu Duc		278		278		TDBac220_1,2	600	1200
Hiep Phuoc		375		375		HoaBinhPhuoc	400	650
						HMon220	600	650
						CatLai	600	650
						ThuDuc	400	650
						NhBe220	600	650
						TaoDan	600	650
						BChanh1,2	400	1200
						PLam220	600	650
						TanBinh	600	650
						NamSGon	400	650
						VinhLoc	400	650
						TangNhonPhu	400	650
						CuChi	400	650
						Taybac CuChi	400	650
						Quan2	400	650
						HiepPhuoc	300	300
	1890	**5566**	**1890**	**5566**			**13200**	**19100**

(11) West Ho Chi Minh Area

This region has existing hydropower plants such as Thac Mo, and some development plans formiddle-scale hydropower plants. On the other hand, total load isquite large, therefore, there is large power flow from other regions.

Table 6-3-11 Power Stations and Loads at 220 kV Substations in West Ho Chi Minh (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
Thac Mo		225		225
Can Don		72		72
Srok Phu Mieng		51		51
Bac Binh		35		35
Import Cambodia 3(LoSrepok2)		222		222
		605	**0**	**605**

Substation	2020	2025
TDinh220	600	600
BinhHoa	600	600
UyenHung	400	600
ThuanAn	400	600
MyPhuoc	400	600
BenCat	200	600
LaiUyen	400	600
PhLong	200	400
BPhuoc	200	400
TrangBang	400	400
TayNinh	476	800
	4276	**6200**

(12) South Ho Chi Minh Area

A gas combined cycle power plant is planned in Tien Giang. Demand and supply is well balanced.

Table 6-3-12 Power Stations and Loads at 220 kV Substations in South Ho Chi Minh (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
New CC #1 (Tien Giang I)		720		720
New CC #2 (Tien Giang II)		720		720
	0	**1440**	**0**	**1440**

Substation	2020	2025
LongAn	400	400
BenLuc	400	400
TanAn		400
MyTho1,2	800	800
GoCong		330
	1600	**2330**

(13) South Southern West Area

This region has O Mon thermal power plant and plans for large coal thermal power plants in Soc Tran and Tra Vinh. Power flow of about 6,000 MW will occur from this region to Ho Chi Min city by 2020.

Table 6-3-13 Power Stations and Loads at 220 kV Substations in South Southern West Area (Year 2020 and 2025)

Power Station	2020		2025	
	500kV	220kV	500kV	220kV
ND +TBK Can Tho		150		150
O Mon I		600		600
O Mon II	720		720	
O Mon III		660		660
O Mon IV (New CC3)	720		720	
O Mon V (New6)	720		720	
Ca Mau		1440		1440
New CC #7 (Cai Lay 1)		720		720
New CC #8 (Cai Lay 2)		720		720
South Coal #1 (Soc Trang1)		600	600	600
South Coal #2 (Soc Trang2)	600		600	
South Coal #3 (Tra Vinh 1)	1000		1000	
South Coal #4 (Tra Vinh 2)	1000		1000	
South Coal #5 (Tra Vinh 3)	1000		1000	
South Coal #6 (Soc Trang 3)			1000	
South Coal #7 (Soc Trang 4)			1000	
	5760	**4890**	**8360**	**4890**

Substation	2020	2025
ChauDoc	340	489
LXuyen	299	430
BacLieu	439	642
BenTre	326	469
CaMau	420	614
OMon220	250	300
TraNoc	286	400
CanTho	450	600
CamPuch	200	200
CaoLanh	272	400
SaDec	190	350
ThotNot	180	263
HonDat	408	587
Kluong	245	400
SocTrang	580	830
TraVinh	399	583
CaiLay1,2	435	800
VinhLong	272	391
	5990	**8749**

Apart form the abovementioned power station, coal thermal power plants of total 5,000 MW are planned in south regions.

6.4 Draft Power Network Development Plan of 500kV up to 2025

Based on the description about the regional generation planning and demand forecast in 6.3, applying the study condition and the basic specification to power network system described in 6.2, the 500 kV power network plans are made.

The following tables show the draft planning of 500 kV network system retaining possibility of revision through more precise studies. However, as preliminary levels, they are adequate.

500 kV Transmission Lines 2006-2015

Name		Conductor	No. Of line	x	km
Starting point	Ending point				
Quang Ninh	Thuong Tin	ACSR4x330	2	x	151
Quang Ninh	Soc Son	ACSR4x330	1	x	140
Quang Ninh	Mong Duong	ACSR4x330	2	x	25
Son La	Soc Son	ACSR4x330	2	x	200
Son La	Hoa Binh	ACSR4x330	1	x	180
Son La	Nho Quan	ACSR4x330	1	x	240
Son La	Huoi Quang	ACSR4x330	2	x	25
Son La	Lai Chau	ACSR4x330	2	x	180
Phu Lam	O Mon (to Long An)	ACSR4x330	1	x	25
Branch Hoc Mon	Hoc Mon	ACSR4x330	2	x	10
Song May	Thu Duc	ACSR4x330	2	x	20
Phu My	Song May	ACSR4x330	2	x	63
Song May	Tan Dinh	ACSR4x330	1	x	40
Branch Nhon Trach		ACSR4x330	4	x	3
Mon Duon	Qung Ninh		2	x	25
Vung An	T off		2	x	20
Nghi Son	T off		2	x	40

Total 2,155 km

(No series capacitor assumed.)

500 kV Transmission Lines 2015-2020

Name		Conductor	No. Of line	x	km
Starting point	Ending point				
PSPP north	Pai taking		2	x	20
Ngi Son	Thai Binh		1	x	80
Thai Binh	Thuong Tinh		1	x	80
Doc Soi	Na Trang		1	x	300
PSPP south	Di Linh		2	x	85
Nuclear PP	Tan Dinh		2	x	280
Nuclear PP	Di Linh		1	x	70
Nuclear PP	Na Trang		1	x	60
Nuclear PP	New CC		1	x	130
New CC	Song May		1	x	150
Tra Vinh	My Tho		2	x	150
Soc Trang	O Mon		2	x	100
Thuong Tinh	Dong An		2	x	20
Dong An	Soc Son		2	x	20
West HCM taking					

Total 2,220 km

(Doc Soi – Na Trang assuming series capacitors.)

500 kV Transformers up to 2020

(MVA)

	2005			2015			2020		
Hoa Binh	450	x	2	450	x	2	450	X	2
Ha Tinh	450	x	1	450	x	2	450	X	2
Plei Ku	450	x	1	450	x	1	450	X	1
Nho Quan	450	x	1	450	x	2	450	X	2
Thuong Tin	450	x	1	450	x	2	1200	X	2
Quang Ninh				450	x	2	450	X	2
Soc Son				1200	x	1	1200	X	2
Viet Tri				1200	x	1	1200	X	1
Son La				450	x	1	450	X	1
Lai Chau				450	x	1	450	X	1
Dong Anh							1200	X	1
Thai Binh									
Da Nang	450	x	2	450	x	2	450	X	2
Dung Quat				450	x	2	450	X	2
Nha Trang				450	x	1	450	X	1
Phu Lam	450	x	2	1200	x	2	1200	X	3
Phu My	450	x	2	450	x	2	450	X	3
Nha Be	600	x	2	600	x	2	600	X	4
Tan Dinh	450	x	1	450	x	2	1200	X	1
Song May				1200	x	1	1200	X	2
Thu Duc				1200	x	1	1200	X	2
Hoc Mon				1200	x	1	1200	X	1
Di Linh				450	x	1	450	X	1
O Mon				450	x	2	450	X	2
My Tho							1200	X	1
West HCM 1							1200	X	2
West HCM 2									
Total Capacity	**7,050**			**2,0850**			**33,900**		

Note

Besides the above, Nam Teun (Laos) - Ha Tinh and Ban Soc (Laos) - Plei Ku are planned up to 2015 and China – Soc Son is planned up to 2020 as inter-regional transmission lies.

Figures 6-3-2 and 6-3-3 show the outlines of preliminary 500 kV power network plans by 2020 and 2025. Figures 6-3-4 and 6-3-5 show the power flow in 2025. Though, there is possibility that the power network plan will be revised in line with revision of power generation planning and more precise power system analysis as mentioned before, the plan seems to be appropriate as a preliminary level.

It can be seen that multi-circuits of 500 kV transmission lines with several hundreds kilometers are needed from nuclear power stations in the Center region to the South region.

In such a case, ***1,000 kV transmission lines*** should be considered for economical system configuration through reducing the number of lines.

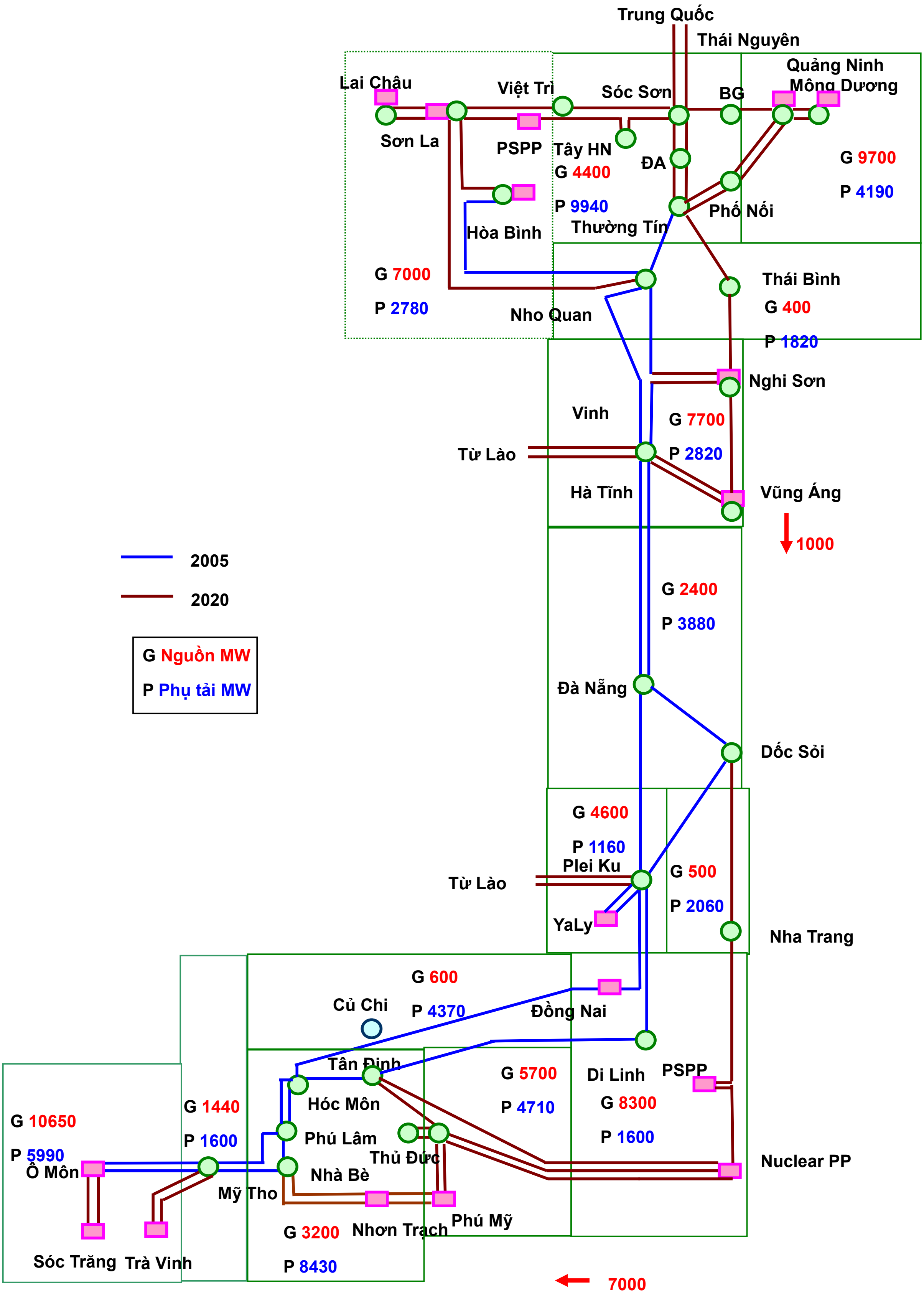


Figure 6-4-1 Draft Plan of 500 kV System in 2020 as of Jan. 2006

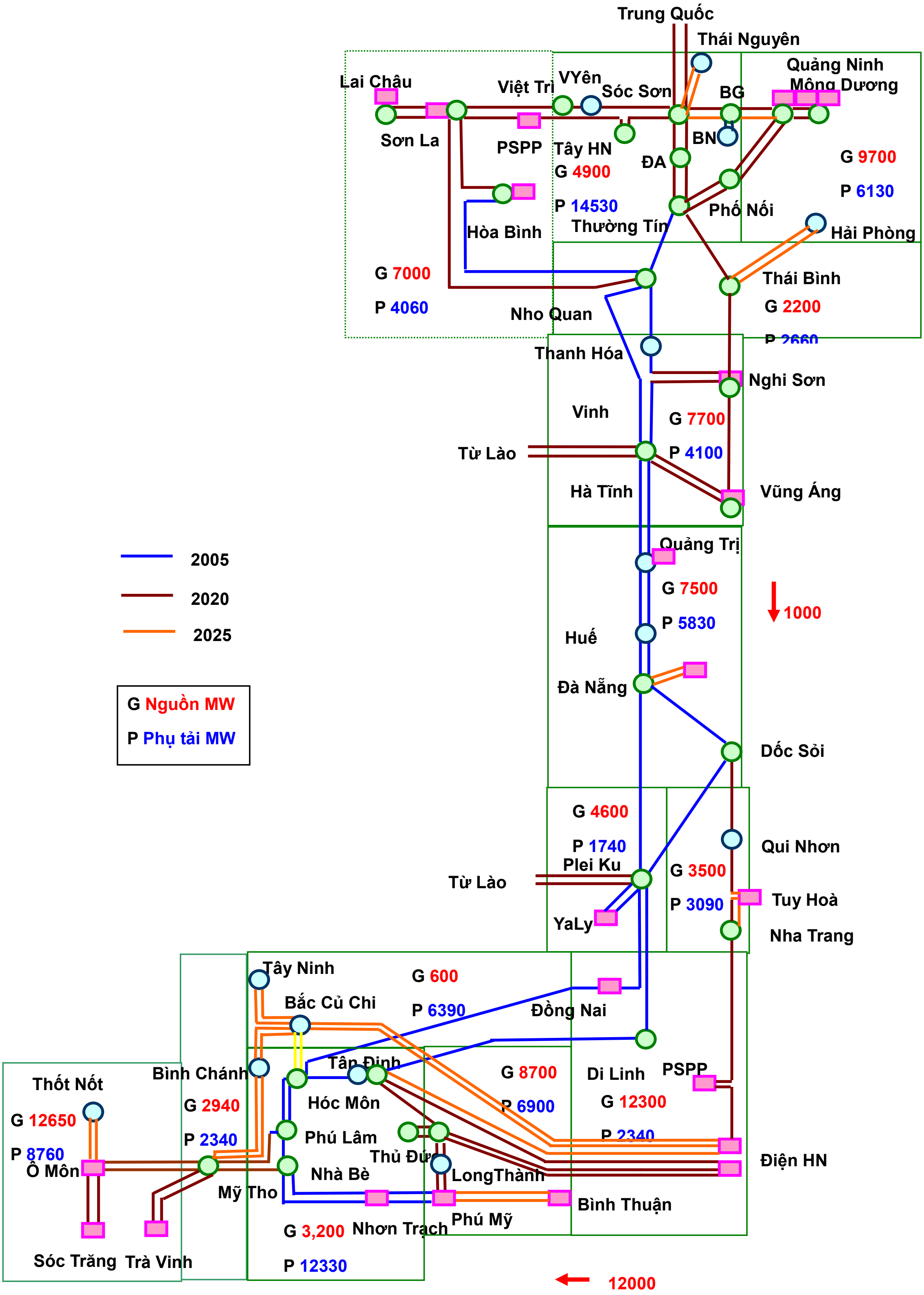


Figure 6-4-2 Draft Plan of 500 kV System in 2025 as of Jan. 2006

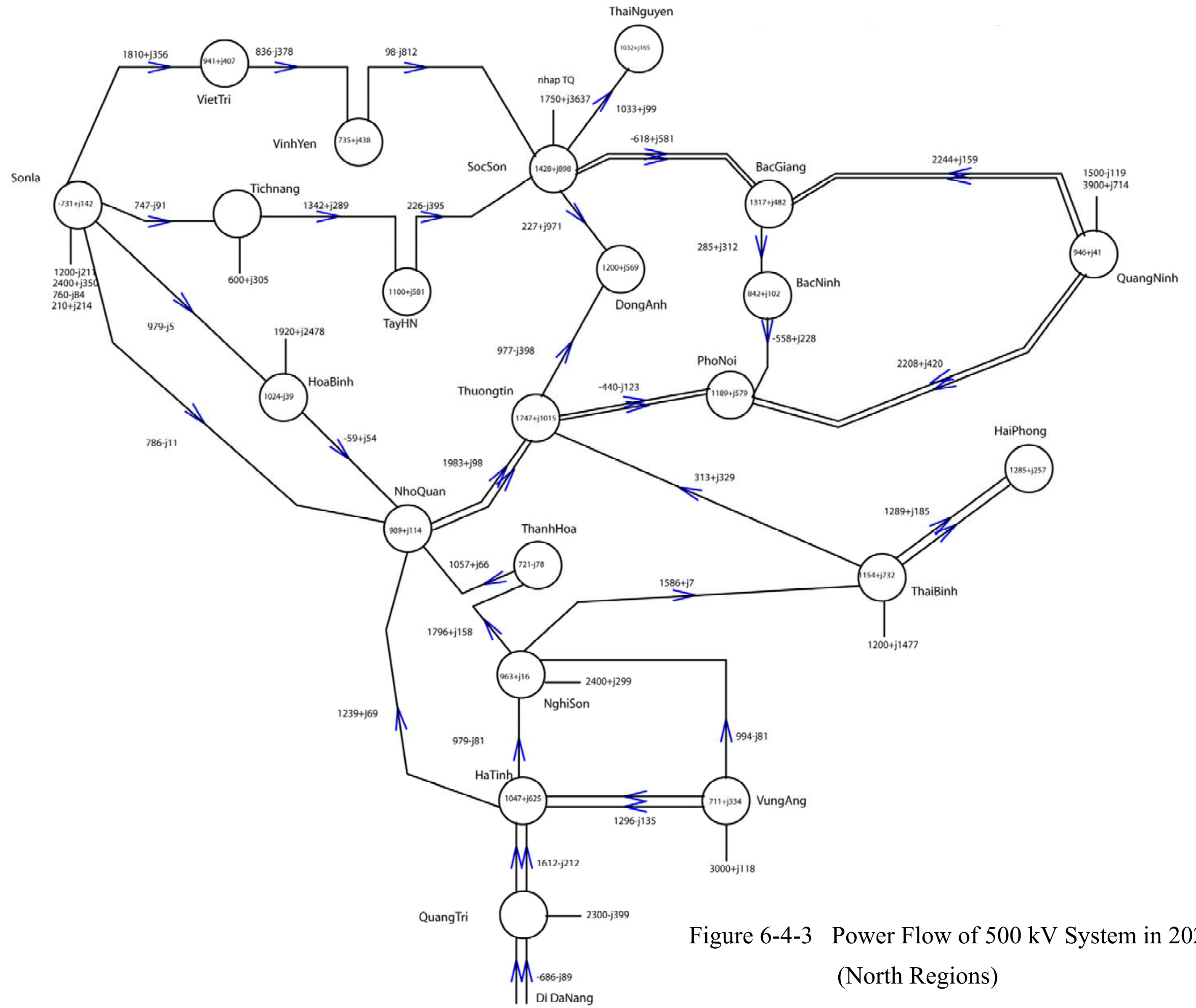


Figure 6-4-3 Power Flow of 500 kV System in 2025 (North Regions)

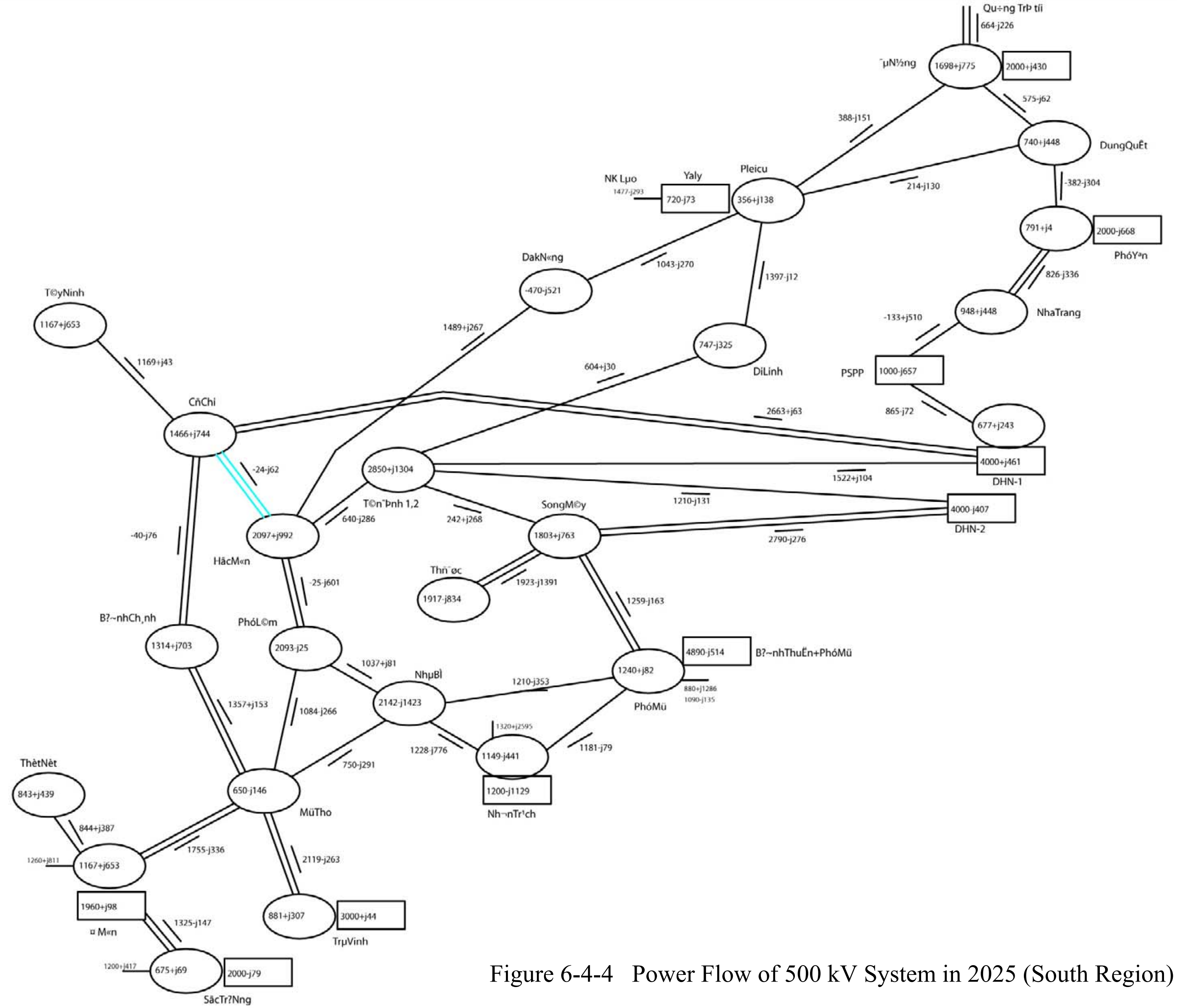


Figure 6-4-4 Power Flow of 500 kV System in 2025 (South Region)

6.5 The Power Network Development Plan as of January 2006

Referring to the above-mentioned study results by the Study Team and taking into consideration the changed conditions such as feasibility of power import, etc., IE reviewed and revised the Power Network Development Plan.

The PNDP of 220kV and 500kV systems as of January 2006 is shown in Appendix 6-1.

The changes from the preliminary network plan were the transmission lines for a north pumped storage hydro power plant, the newly planned sites of Than Hoa and Vinh, and the increase in the number of circuits from south nuclear power plants to Ho Chi Min city. However, the basic system configuration was not changed.

The continuous revisions are necessary from now on through detailed checks about system reliability. Making a reliable long-term master plan applicable for the next 20 years and showing a clear target for system configuration, efficient construction of a power network will be realized.

System reliability depends on system operation such as power output of generators, fault patterns and change in loads, therefore, it is necessary to check the system reliability with system analysis such as fault current, stability and voltage stability in consideration of the system operation.

Especially, since the fault current levels in Hanoi and Ho Chi Min city seem to threaten the capacities of circuit breakers, the study of countermeasures against such huge fault currents needs to be carried out.

Because of the single AC system widespread in the whole country, stability of the connected generators should be confirmed and the study on the voltage stability corresponding to increase in demand should be carried out.

It would be preferable to study the application of 1000 kV transmission from the technical and economical aspects for the interval from the south nuclear power stations to Ho Chi Min city due to the large number of circuits of 500 kV transmission lines.

6.6 The Latest Power Network Development Plan

According to the comments by the relevant Ministries and Organizations such as EVN and Ministry of Industry, IE revised again the above described Power Network Development Plan as of January 2006. The latest plan of 500 kV System in 2025 as of May 2006 is outlined in Figure 6-6-1.

Construction of a power network system takes a long time and a system component in the power network affects each other. If the power network were planed based on just a short term prediction, there would be risks with constructing excessive and duplicated facilities or with insufficient amount of system. Therefore, making a long term plan is required in order to develop highly reliable and efficient power network system to meet its rapidly growing power demand.

Noteworthy points and or necessary further study items are listed as follows.

- While the Draft Final Report of the JICA study was made, the power network development planning had been carried out on the condition that nuclear power plants with total capacity of 8,000 MW would be developed by 2025. Therefore, study of 1,000 kV transmission lines had been recommended. According to the Latest PDP 6th, the total capacity of nuclear power plants developed by 2025 was reduced to 4,000 MW, therefore, it no longer need to carry out the study on introduction of 1,000 kV transmission line. On the other hand, the number of circuits of the 500 kV transmission lines from the coal thermal power plants of 3,000 MW in Tra Vinh, coal thermal power plants of 1,200 MW in Soc Trang to Ho Chi Min City and the methods of power transmission from new large coal thermal power plants of 5000MW developed in such as Da Nang and Doc Soi need to be continuously studied including power system stability after completion of the study on PDP 6th that have suggested the direction of such kind of studies

- Against the increase in power demand in the future, the adoption of the large sizes of 500 kV transformers, the duplicated supplies to 220 kV substations around Hanoi and Ho Chi Min city and the ring shaped configuration of 500 kV power system were clearly described in the PDP 6th. Those countermeasures can be considered adequate to lead efficient power network configuration. The countermeasures against the increase in fault currents in around Ho Chi Min city and other places can be considered to have several alternatives, which are listed in the Report, and should be studied continuously. The configuration of 220 kV system operation with open points on the way of the system is considered on of the adequate alternatives.

- The Report describes the required capacity of the shunt capacitors. Moreover, it is necessary that the methods of their regulation and control be studied continuously because the system voltage would be largely changed day and night and season by season.

- The Report recommended that the limit of installation of the series capacitors that have a possibility with causing turbine-vibration, the consideration with the effective exciter system of large power plants and the installation of synchronous condensers against the instability caused by the faults around Son La hydropower plant and an interregional connection to China. Each countermeasure can be effective.

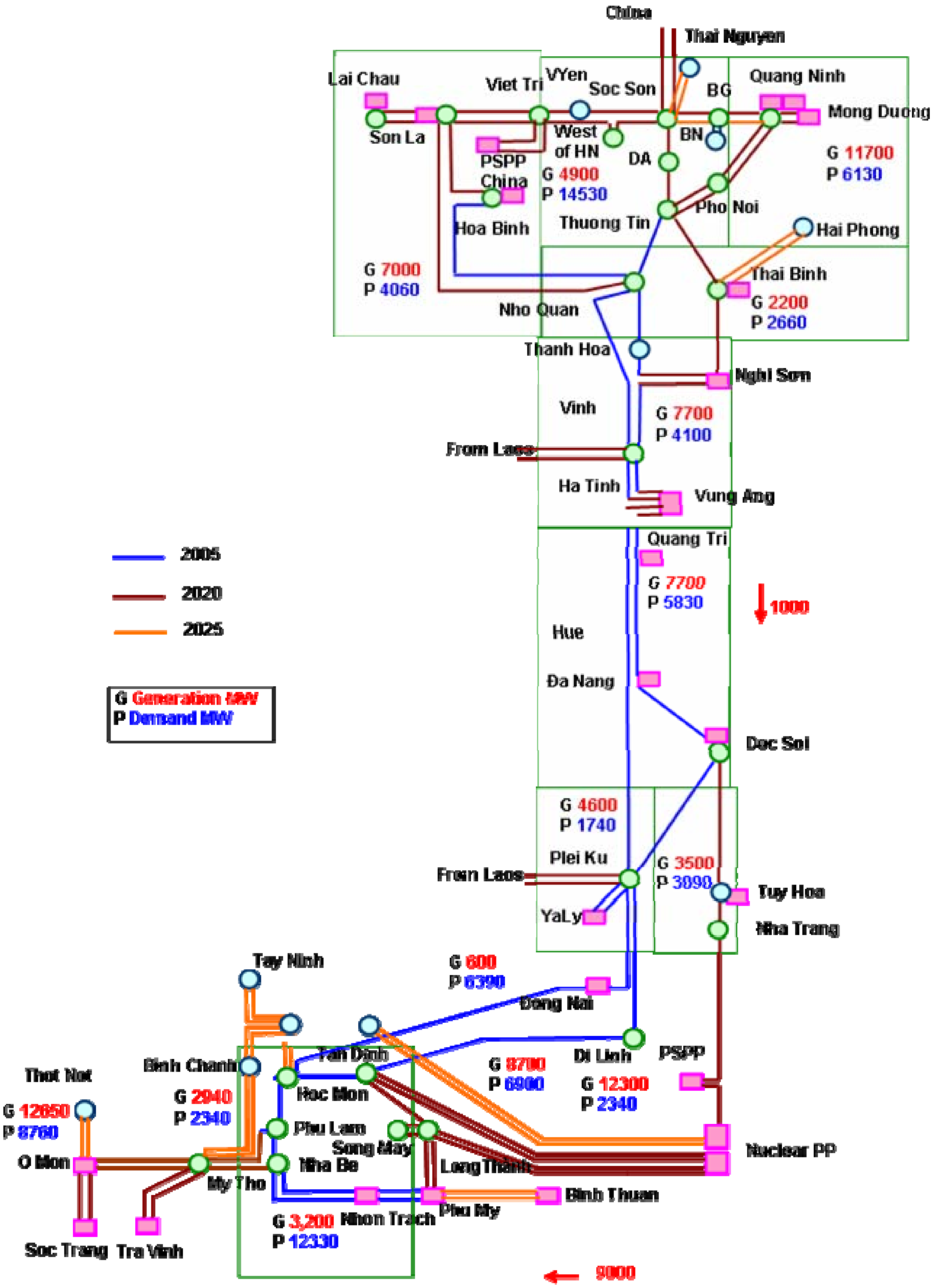


Figure 6-6-1 Latest Plan of 500 kV System in 2025