JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENERGY
THE SOCIALIST REPUBLIC OF VIET NAM

THE MASTER PLAN STUDY ON ELECTRIC POWER DEVELOPMENT IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

SUMMARY

SEPTEMBER 1995

ELECTRIC POWER DEVELOPMENT CO., LTD.
THE INSTITUTE OF ENERGY ECONOMICS, JAPAN

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Contents

1. INTRODUCTION

(1) In response to the request of the Government of the Socialist Republic of Viet Nam (hereinafter referred to as "Viet Nam"), the Government of Japan has entered an agreement with the Government of Viet Nam to implement the Master Plan on Electric Power Development in Viet Nam in May, 1993. Based on this agreement, the Japan International Cooperation Agency (hereinafter referred to as "JICA") and the Ministry of Energy (MOE) signed, in August, 1993, the agreement of the scope of work, that described the works to be performed in the Study.

(2) The primal objective of the Study is the formulation of power development plan for the period from 1996-2010 in the whole country of Viet Nam. The Study also aims to enhance technical capability of the Vietnamese side with respect to power development plan through transfer of technology.

2. GENERAL DESCRIPTION OF THE SOCIALIST REPUBLIC OF VIET NAM

The Socialist Republic of Viet Nam with an area of 331,111 km^2 is largely divided into three regions, northern, central and southern. The division of the country into three regions is based on the command area under the previous power companies called PC1, PC2 and PC3. The number of provinces is 23 in the northern region, 11 in the central region and 19 in the southern region. The table given below shows area, population (urban and rural) and population density by region.

Table S-1 Area, Population and Population Density by Region

	Area (km^2)	Population (thousands)	Population Density (pers/km^2)	Urban Population (thousands)	(%)	Rural Population (thousands)	(%)
Northern	149,078	33,204	223	4,496	(13.5)	28,708	(86.5)
Central	97,435	10,458	107	2,245	(21.5)	8,213	(78.5)
Southern	84,598	26,275	311	6,906	(26.3)	19,369	(73.7)
Total	331,111	69,938	211	13,647	(19.5)	56,291	(80.5)

About 47% of the country's population concentrates on the northern region. Though the area of southern region is smaller than that of central region, population is more than twice in the southern region than in the central region.

National economy experienced economic recession in the year 1990, GDP in real term (at 1989 constant price) declined from 8.9% to 5.1% in 1990. The economy showed a steady growth rate, 6.0% in 1991, 8.6% in 1992 and 8.0% in 1993. GDP in 1993 is estimated to be Dong 136,571 billion. Per capita GDP in 1993 is estimated to be 1,953,000 Dong (US$180).

Total external debt has gradually increased and amounted to about US$17.9 billion as of 1992. Viet Nam's GDP (Dong 136,571 billion as of 1993) is converted to US$12.6 billion assuming that US$1 is equivalent to Dong 10,810. Total external debt is in the range of 142% of GDP as of 1993.

3. POWER DEMAND AND SUPPLY

(1) Electric power demand (sales power) not including power plant's auxiliaries and system losses increased from 2,670 GWh in 1980, to 6,187 GWh in 1990 and 9,198 GWh in 1994. Growth rate per annum during 1980-1994 of total demand was 9.24%. Growth rates of industrial, non-industrial, transport and residential demand were 7.89%, 8.49%, 6.93%, and 11.01% respectively. Leading drive force of electricity consumption was the rapid increase of residential demand, mainly lighting demand supposedly. These data show that household electrification in urban areas progressed in the 1980's and rural electrification began to improve from the beginning of the 1990's.

(2) Electric power generation increased from 3,559 GWh in 1980, to 8,679 GWh in 1990 and to 12,195 GWh in 1994. Hydropower generation recorded 8,872 GWh accounting for 73% of the total power in 1994 (1,288 GWh, 42% in 1980, 1,472 GWh, 29% in 1985 and 5,369 GWh, 62% in 1990). Such a large increase has been achieved by putting into operation of Hoa Binh hydropower plant (1,920 MW, the Northern region) and Tri An hydropower plant (400 MW, the Southern region). Power generated by thermal power plant decreased from the peak of 4,433 GWh (65.4%) in 1988 to 1,776 GWh (16.6%) in 1993, because of increase in the hydropower generation described above.

(3) The 500 kV transmission line began its 1st stage operation in June 1994, with maximum 300 MW of sending power capability, between Hoa Binh substation in the North and Phu Lam substation in the South with approximately 1,500 km distance. The 2nd stage of the project completed in September 1994 with maximum 500 MW of sending power capability to the South and tapping 2 substations in the Central region (Da Nang and Pleiku). Its operation results in 1994 are as follows.

	Hoa Binh	**Da Nang**	**Pleiku**	**Phu Lam**
Energy (GWh)	990	106	14	770
Max. Power (MW)	574	121	49	418

(4) In 1994, the completion of 500 kV transmission line made it possible to send the surplus power and energy in the North to the South. As the result, regional demand in the South and the Center recorded the growth rates of 21.7% and 19.8% respectively in 1994. The thermal power generation increased again in addition to hydropower in the Northern region. Actually the thermal power generation in the Northern region increased from 636 GWh in 1993 to 1,288 GWh in 1994, and the generation in the Southern region decreased from 1,140 GWh (1993) to 960 GWh (1994). The hydropower generation in the Northern region increased from 5,091 GWh (1993) to 5,834 GWh (1994).

(5) The government decided to develop large scale power projects aiming those commissioning within this decade. They are,

Region	Plant Name	Type	Output	Commissioning Year
North	Pha Lai II	Coal	2 x 300 MW	1999/2000
Center	Yaly	Hydro	720 MW	1999/2000
	Song Hinh	Hydro	70 MW	1997
South	Phu My	Gas	3 x 200 MW	1998/1999/1999
	Ham Thuan/Da Mi	Hydro	472 MW	2000

Note: Yaly and Song Hinh are under construction and Ham Thuan/Da Mi finished detailed design. Others are planning stage.

(6) As for installed capacity, the Northern region has 645 MW of thermal power plants and 28 MW of gas turbines. The Southern region has 205 MW of thermal power plants, 388 MW of gas turbines and 201 MW of diesel units. In the Central region, the least developed area of Viet Nam, the generation plants are composed of widely scattered small diesel units. The installed capacity of approximately 177 MW is supplied by 208 diesel sets of widely varying age, type and condition, reflected in an available capacity 78 MW.

(7) The Northern region has 2,028 MW of hydropower plant comprising Thac Ba (108 MW) and Hoa Binh (1,920 MW). The Southern region has 710 MW of hydropower plant comprising Da Nhim (160 MW), Tri An (400 MW) and recently completed Thac Mo (150 MW) hydropower plant. The Central region had only 3 small hydropower plants before the commissioning of Vinh Son (66 MW) in the late 1994.

PART I DATABASE SYSTEM AND DEMAND FORECAST

4. DATABASE SYSTEM

(1) Vietnamese data used in forecasting electricity demand/preparing electricity statistics have been kept in either form of printed matters or computer-based spread sheets. Based on its first-hand study results, the JICA Study Team recognized two sorts of database necessary, then developed them. They are "database on electricity" and "database on energy/economy."

The "electricity database" is designed to reflect exact situations peculiar to Viet Nam, and technically represents a structure of planning-use database. Therefore, with this database, a special emphasis is put on report-style outputting in technical terms. The "energy/economic database" provides external information necessary for forecasting electricity demand and preparing power development plans, and technically represents a structure of general-purpose database. As a result, with this database, technical priorities are given to how to improve data editing and make information retrieval easier.

(2) Under this study, Vietnamese energy-related organizations introduced a database running on a database management software for the first time. The database is run with a personal computer. The advent of database-based data management is expected to cut open a new stage, in both qualitative and quantitative terms, compared with conventional data processing with word-processors and spread sheet systems. The newly-introduced database also provides a powerful tool in the preparation of master plans (M/P) for various energies as well as power development plans.

Continuously updated data on energy and electricity fields can be an asset common to energy-related sectors all. Institute of Energy, Viet Nam (IEV), once acquiring this database technology, would be allowed to construct its own sophisticated database system to process energy statistics/information. The database, if put to best use, would enable the IEV to act as an energy information center. Also, drafted long-term energy development plans could be submitted to the MOE more promptly than ever. In Viet Nam too, rapid penetration of computers is likely not in the far future, thus enabling the IEV to regularly publish database-based energy statistics. It would also become possible to send energy information at home and abroad through communication circuits. This sort of service is likely to bring about an opportunity of new viable activities.

5. ELECTRIC POWER DEMAND FORECAST

In this study, an econometric approach was employed and economic scenario by region and by sector, each consisting of three cases, were prepared for demand forecasting model building. Vietnamese total GDP grew at an annual average pace of the 5% level during 1980s, and the growth rate has steadily gone up from 1990 onward, 6.0% in 1991, 8-6% in 1992, 8.1% in 1993 and 8.8% in 1994. Future GDP is estimated to be doubled by 2000 and also doubled by 2010 at over 8% annual growth rate of the base case. Following the scenario, GDP scale of Viet Nam will reach Singapore's level as of 1992 around 2000, Malaysia around 2005 and Thailand around 2010. The projected economic level, 754 (US$/head) in 2010, is presumed being as almost similar as those of about 1963 of Taiwan, 1969 of South Korea and 1983 of Thailand.

According to the latest case study, Vietnamese total electric power demand nationwide would increase at average growth rate of 12.8% per year from 8,007 GWh in 1993 to 18,631 GWh in 2000, up 2.3 times over the 1993 value. From 2000 to 2010, the total demand would increase 11.6% per year on the average and reach 55,948 GWh by 2010 (almost sevenfold demand of the 1993) in the base case of economic scenario. In generation (in base case), 10,729 GWh recorded in 1993 is likely to rise to 23,289 GWh by 2000 (up 11.7% per year), and reach 66,600 GWh by 2010 (up 11.1% per year), each representing 2.2 times and 6.2 times over the 1993 record.

In peak load (in base case), 2,803MW in 1993 is expected to reach 4,526MW by 2000 (up 11.7%per year) and 12,550MW by 2010(up 11.1% per year). They represent 2.2 times and 6.0 times over 1993 value, respectively.

Examinations of by-sector demand in the country show that the industrial sector is likely to record the highest growth, followed by the residential/commercial sector. In the base case, industrial demand is assumed to grow from 3,654 GWh in 1993 to 9,759 GWh by 2000 (up 15.2% per year), and reach 34,572 GWh by 2010 (up 13.4% per year). They are 2.7 times and 9.5 times above the 1993 demand. As a result, the share held by the industrial sector in total demand will be up from 45.5% in 1993 to 52.6% in 2000, and to 61.8% in 2010. Residential and commercial demand is expected to rise from 3,236 GWh in 1993 to 6,689 GWh in 2000 (up 10.9% per year) and to 18,200 GWh in 2010 (up 10.5% per year), standing 2.1 times and 5.6 times each above the 1993 demand. The share in total demand will be down from 40.4% in 1993 to 35.9% in 2000, and to 32.5% in 2010.

Differences in demand structure between the South and North are that the demand for the industrial sector and others will be kept higher in the South than in the North, and that residential and agricultural demand is kept higher in the North than in the South. In other words, the industrial sector and others account for larger shares in region-wide demand in the South than in the North, while weight held by the residential and agricultural sectors in region-wide demand is heavier in the North than in the South.

In comparison with some Asian countries, long-term GDP elasticity of Viet Nam is similar to Malaysia and Thailand. The relationship of power consumption per capita and economic level (GDP/capita), Vietnamese future will be close Indonesia-Thailand lines. In relation between electricity intensity and economic level as well Viet Nam is assumed to decouple from Bangladesh-Viet Nam-Pakistan lines and approach the Indonesia-Thailand ones. By results of factor analysis, economic growth factor has become the primary contributor to power consumption increase in recent years, and Vietnamese by-factor contribution patterns are akin to those of Thailand and Malaysia. Electricity intensity factor is expected to decline gradually from past 30% to around 25% in the future, while the contribution of economic growth factor is expected to have a rising share to 50-60%. Judging from GDP elasticity, power consumption - GDP/capita, factor analysis and electricity intensity, Vietnamese future will follow Thai pattern.

Figure S-1 Power Generation Forecast up to 2010 (JICA Study)

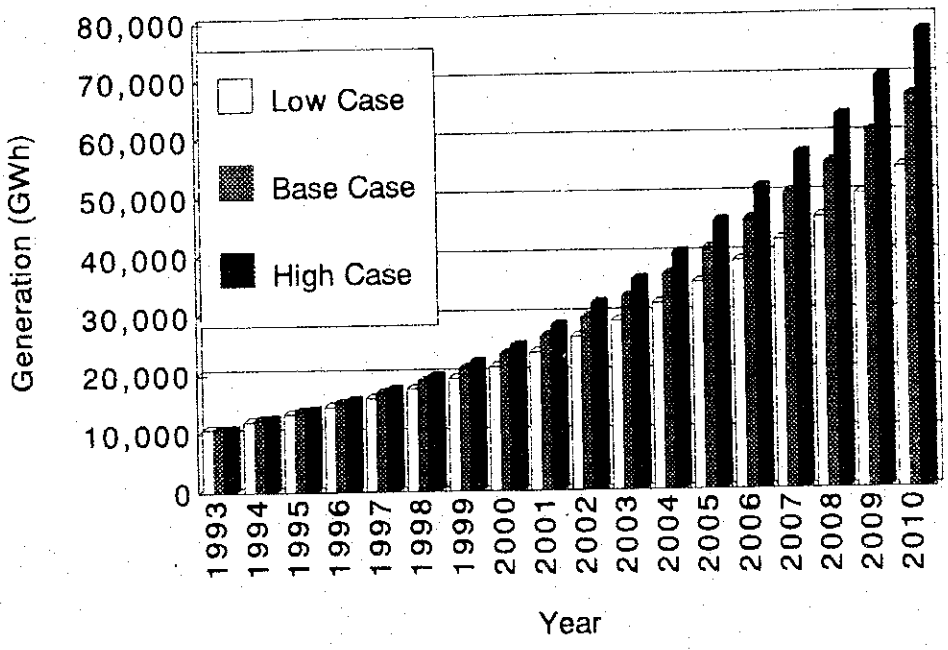


Figure S-2 Peak Load Forecast up to 2010

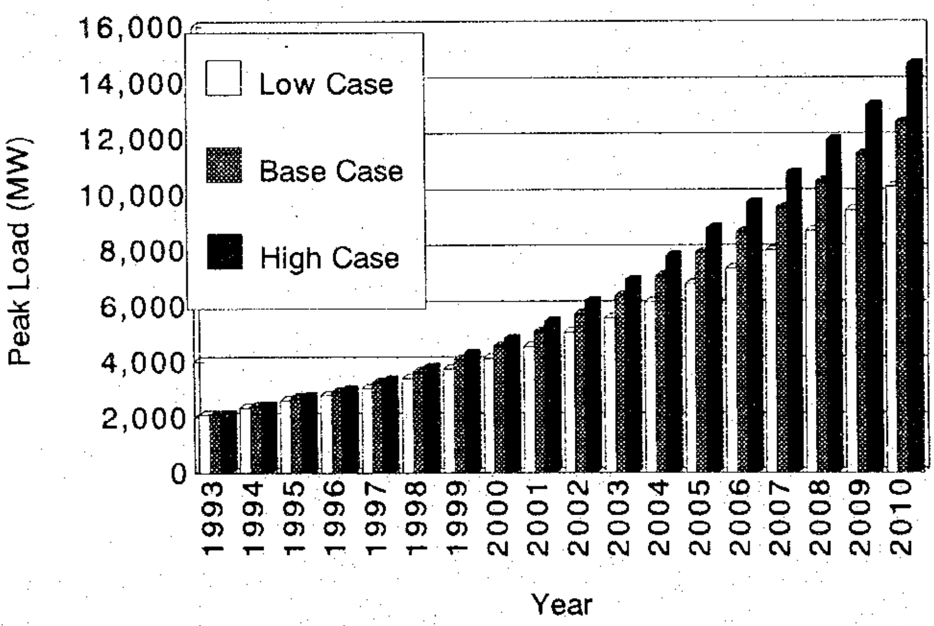


Figure S-3 Power Generation Forecast up to 2010 (Whole Country)

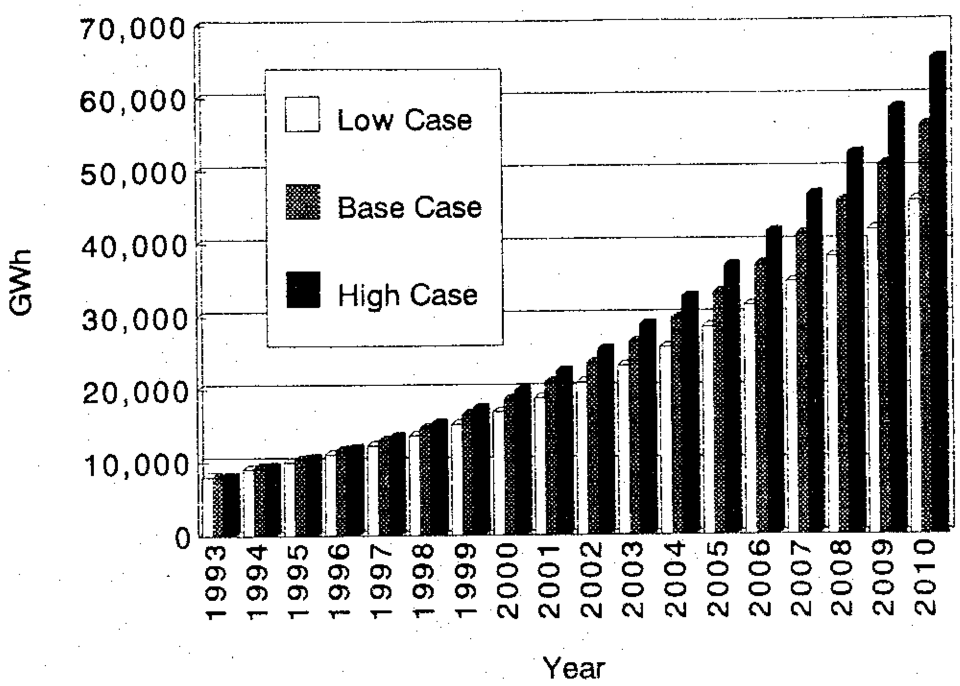
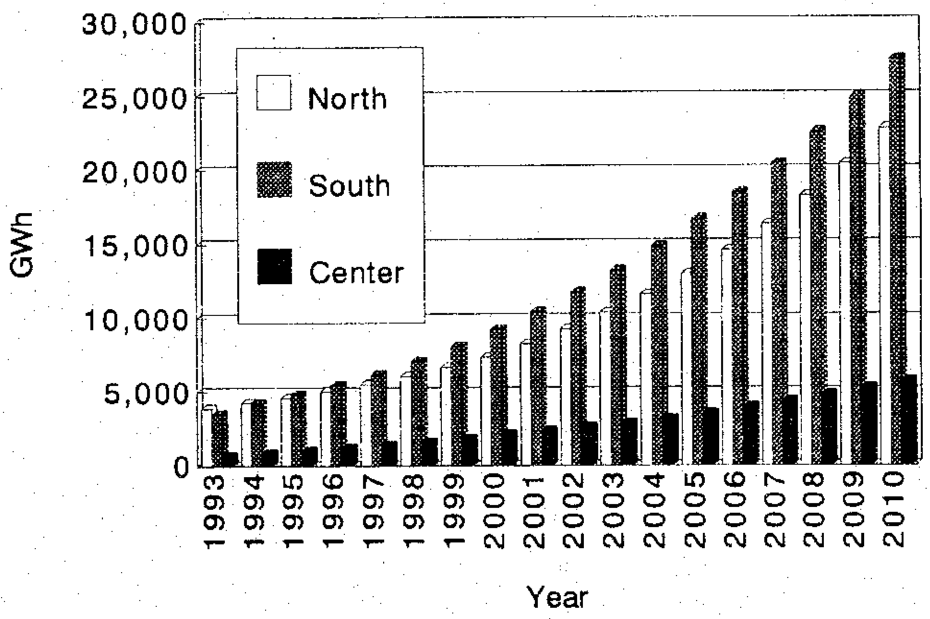


Figure S-4 Power Demand Forecast by Region (Base Case)



PART II STUDY ON POWER DEVELOPMENT PLAN AND IDENTIFICATION OF PRIOR PLANS AND PROJECTS

6. REVIEW AND ASSESSMENT OF POWER DEVELOPMENT PROJECTS

(1) Enormous generating capacities will be required for the long term power development plan up to 2010. Thermal power and hydropower projects to be developed in 2000s are reviewed and assessed, in addition to some projects already scheduled. In the M/P study, two factors which would essentially affect power development plan are taken into account. One is development scale of Son La hydropower project, and the other is development potential of natural gas in the Southern region.

(2) Eighteen (18) hydropower projects identified were considered possible to be developed for the period of power development plan. The study was made on annual energy generation, review of construction costs and economic viability assessed by benefit-cost ratio (B/C). Results of the studies are summarized below.

(a) Annual energy generated from power projects is calculated by taking into account of increase/decrease of energy bringing to existing power plants downstream for three river basins, Da, Se San, and Dong Nai. The results show that all of the figures are somewhat increased except Thuong Kontum hydropower project, comparing with that studied by Vietnamese side.

(b) Results of the study on construction cost of the projects show some differences between the figures estimated by Vietnamese side and the Study Team. However, it is considered to be reasonable on the whole, since total amount of construction cost of all of planned projects is estimated within approximately 7% difference by both side.

(c) Both dam site and development scale of Son La hydropower project were not clearly determined in pre-feasibility study. Two scenarios of development scale are prepared for the PDP with installed capacity of 3,600 MW (Son La Large) and 2,400 MW (Son La Small). Results examined by duration time of peak on B/C values of "Son La Large" and "Son La Small" show that the former is positioned for middle/base load and the latter is for middle/peak load.

(3) Regarding thermal power projects, coal-fired (anthracite) thermal power plant should be chosen in the Northern region because of abundant domestic coal resources . However, the Southern region has options of fuel for power generation, either gas fired/combined cycle or coal (domestic/imported). Levelized unit cost of thermal power plants by plant type is estimated as an indicator for economic evaluation.

7. FUEL FOR POWER GENERATION

(1) Coal resources distributing in the Northern region are estimated to be approximately 3 billion ton and minable one to be over 500 million ton. Current production capability is 10 million ton in raw coal and 8 million ton in clean-coal, annually. Possibility of investment requirement in 2000s for production increase would depend on coal consumption in the power sector.

(2) Natural gas is currently produced as associated gas, by-product of crude oil in Bach Ho field, but being flared. Associated gas was estimated to be 20 billion m^3. Its utilization will be started after completion of gas pipeline to Ba Ria-Vung Tau area for power generation within 1995. 8.2 billion m^3 of associated gas was also proven in Ron and Dai Hung oil fields. Approximately 60 billion m^3 of natural gas resources non-associated gas) was reported by BP/Stat oil group being developed in Lan Tay and Lan Do gas fields, but is not proven yet. Higher price of the resources in these gas fields is expected due to those location far from the shore (approximately 270 km and in deep depth).

(3) At present stage it is too early to judge possible natural gas resources for utilization in the future, since natural gas exploration is energetically being developed. Careful studies should be implemented for exploitation of natural gas resources as fuel for power generation. Coal resources is more reliable than natural gas resources in terms of minable amount.

8. POWER DEVELOPMENT PLAN

(1) The least cost method was employed for formulation of an optimal power development plan, given a constant power supply reliability. The base year is determined to be 1993. All project costs (capital, fuel and O & M) during the planning horizon were discounted to estimate present value of those costs at 1993 price level.

(2) Two essential factors were taken into account for formulation of power development plans. One is the development scale of the Son La hydropower project (Large/Small, hereafter called SL/SS). The other is development potential (Large/Small, hereafter called GL/GS) of natural gas production. Four scenarios were formulated by a combination of two factors. The term GS is defined as associated gas of about 28.2 billion m^3 for power generation, while GL is defined as the sum of associated and non-associated gas (about 57.0 billion m^3) for power generation. In order to justify implementation of the Son La hydropower project, the power development plans without the Son La (called NS) in combination of both cases of GL and GS were also taken into account. Each scenario is arranged in the order of the least-cost.

Table S-2 Development Priority Among the PDP Scenarios

Order	1	2	3	4	4	6
Senario	SS/GL Son La (S) Gas (L)	SS/GS Son La (S) Gas (S)	SL/GL Son La (L) Gas (L)	SL/GS Son La (L) Gas (S)	NS/GL Son La (N) Gas (L)	NS/GS Son La (N) Gas (S)
Costs (US$ billion)	14.36	14.73	14.74	14.98	14.98	15.43

The least-cost scenario is identified to be SS/GL (US$ 14.36 billion). The difference of costs is US$ 0.62 billion between SS/GL and SL/GS, and US$ 1.07 billion between SS/GL and NS/GS.

The analyses of PDP simulation can be summarized with respect to cost performance in the following way.

(a) Power expansion costs of the scenarios without Son La turn out to be higher than those of the scenarios with Son La. Implementation of the Son La hydropower project is justifiable in terms of cost effectiveness.

F/S of the project should be implemented as early as possible to clarify on this matter, since determination of the Son La hydropower project scale would be changeable depending on input data of the project.

(b) The scenarios under the case of GL turn out to be cost effective rather than those under the case of GS. This is mainly because the former scenarios will be benefited owing to less unit cost of combined cycle instead of coal thermal, which improves cost performance of the scenarios under the case of GL.

Nevertheless, cost performance of coal thermal would be perhaps better than that of combined cycle depending on price level of coal and natural gas. The consideration should be given to price prospect of energy resources and energy potential for power generation in order to formulate thermal power general plan in the Southern region.

(3) The 500kV interconnected transmission line is planned as an alternative to independent power development project in the process of identifying the least-cost power expansion plan. As shown in Annex-1, annual mean interconnected energy is about 2,200Gwh in the scenario of SS/GS. Annex-2 shows generation dispatch of SS/GL by region.

(4) Annex-3 shows implementation schedule and features of power projects by scenario. Installed capacity to be required for power development during 1996-2010 is estimated to be 12,500-13,000 MW.

(5) Sensitivity analyses can be summarized as follows

(a) **Economic Viability of Son La (S) Scenarios**

The order of cost effectiveness of Son La (S) scenarios remain unchanged irrespective of high and low cases of power demand.

(b) **Less Constrained LOLP**

LOLP indicating power supply reliability was firstly assumed to be constant within 1 % after 1998. The condition of power supply reliability is made less-constrained by changing LOLP from 1% to 3%. Total costs can be saved by 3 % in the scenario of SS/GS in base case of demand. Benefits to be expected by changing LOLP from 1% to 3% will be.

- Saving of two units of coal thermal in the South in around 2010.
- Commissioning years of scheduled projects can be postponed by one or two years.

(c) **Commissioning year of Son La hydropower project**

Provided that the commissioning year of the Son La will delay by two years, total costs will increase by US$ 0.25 billion in the scenario SL/GS, and by US$ 0.29

billion in the scenario of SS/GS. Implementation of the Son La is desirable as originally scheduled (the year of 2007)

9. OPTIMAL POWER DEVELOPMENT PLAN

(1) In the chapter of 8, economic viability of six scenarios is assessed in terms of cost effectiveness. In order to formulate on optimal power development plan, the following evaluation criteria are taken into account in addition to cost effectiveness.

- Power system operation
- Fuel resources for power generation
- Socio-environmental consideration
- High case of power demand
- Influence of delay in Son La implementation schedule.

(2) The analyses of power system operation are as follows

(a) Ban Mai and Dai Thi hydropower projects in the Northern region, and all hydropower projects in the Central region are expected to start operation until the year of 2007. As a result, inter-regional power supply from Central region can be realized. The Southern region will continue to be in a position of importing power from Central and Southern regions in the decade from 2000 to 2010.

(b) Since coal thermals in the Northern region operate for peak load, annual plant factors of them will be not high . On the other hand, combined cycle plants designed for base load operation will have high plant factor.

The Southern region will continue to import power through a day (24 hours).

(c) Annual mean interconnected energy supply will reach to about 2,000 GWh from north to south , and the range of 1,500 to 2,500 GWh from central to south in the period between 1996 and 2010.

(3) Fuel consumption for power generation in the latter half of 2000s is shown in the following table with conclusions given below.

(a) Attention should be paid to annual coal consumption of the scenarios under the case of GS (NS/GS, SS/GS, SL/GS). Annual coal consumption in 2010 is estimated to be 11 million tons in NS/GS, 8.8 million tons in SS/GS and 6.9 million tons in SL/GS. Taking into account the current clean coal production of about 8.0 million tons per year, expansion of coal production will be required for three scenarios. Implementation of the Son La hydropower project will contribute to reduction of incremental coal production.

Table S-3 Simulation Results for Fuel Consumption of Coal and Natural Gas

Case	Fuel	Unit	2000	2005	2007	2008	2009	2010
SL/GL	Coal	10^6t	1.3	2.6	3.4	3.0	2.8	2.8
	Gas	10^9 m^3	0.6	2.5	3.3	3.6	4.2	4.5
SL/GS	Coal	10^6t	1.3	3.4	4.2	4.8	5.6	6.9
	Gas	10^9 m^3	0.6	2.1	2.3	2.4	2.4	2.4
SS/GL	Coal	10^6t	1.3	2.7	3.0	2.9	3.0	3.4
	Gas	10^9 m^3	0.6	2.5	3.0	3.3	4.0	4.6
SS/GS	Coal	10^6t	1.3	2.9	4.6	5.7	7.1	8.8
	Gas	10^9 m^3	0.6	2.1	2.3	2.4	2.4	2.4
NS/GL	Coal	10^6t	1.3	2.6	3.8	4.1	5.2	6.8
	Gas	10^9 m^3	0.6	2.2	2.8	3.4	4.0	4.5
NS/GS	Coal	10^6t	1.3	3.5	4.8	6.1	8.7	11.2
	Gas	10^9 m^3	0.6	2.2	2.3	2.4	2.4	2.4

(b) The case of GL where natural gas for power generation extends to non-associated gas will contribute to reduction of incremental coal production as well as stable power supply. The scenario of SL/GL would be the most desirable power development plan with respect to the reduction of coal production to be nearly developed. Nevertheless, development potential of non-associated gas is entirely owed to gas demand in consumption sectors including power sector. At present, the possibility of GL case seems to be low.

(4) Power development projects were examined from standpoints of environmental impact

(a) Construction costs of de-sulphurization and de-nitrification facilities were not involved in coal-fired thermal power development plan, because low sulfur coal is to be supplied and air quality around plants can clear the air quality standard of Viet Nam.

As environmental concern and measures are changeable with advancing of socio-economical situation, final decision for the measures should be done based on site-survey and Environmental Impact Assessment at site selection stage.

Speaking of the cost of desulphurization facility the cost is considered to be held 10 -15% of total cost in general. This is an additional cost and push up unit cost for generation. Weight of coal-fired thermal power in Case-GS is heavier than one of Case-GL. Taking cost estimation including de-SOx and de-NOx facilities, cost difference between Case-GL and Case-GS will be still wider.

(b) Socio-environmental consideration for all hydropower projects identified was studied in the form of compensation costs estimated by the ratio of construction costs. The share of compensation costs is more or less judged to be reasonable in the M/P. However, the Son La hydropower project accompanying a huge reservoir area (580 km^2 in Son La Large, 275 km^2 in Son La Small) is expected to have negative impacts on environment, resulting in larger compensation costs and bigger negative impacts than expected in the M/P.

In general, Son La (S) is superior to Son La (L) since negative impacts is less in Son La (S) than in Son La (L), it is recommended that a comprehensive feasibility study (F/S) should be made with respect to technical, economic and environmental aspects in order to determine development scale of the Son La hydropower project. (refer to Annex 4)

(5) Sensitivity analyses are summarized as follows

(a) High demand case reveals that total costs is by US$ 0.5 billion higher in SL scenarios than in SS scenarios. It is concluded that Son La (S) performs better than Son La (L) in terms of cost effectiveness.

(b) Influence of delay (two years) in the Son La implementation schedule was also examined. Total costs will increase by U$0.25 billion in SL/GS, and by U$0.29 billion in SS/GS. Implementation of the Son La is desirable as originally scheduled.

(6) Overall evaluation was conducted with respect to the criteria shown below in order to formulate an optimal power development plan.

Table S-4 Evaluation of Selected Optimal PDP Senario

Evaluation Criteria	SL/GL	SL/GS	SS/GL	SS/GS	NS
Cost Effectiveness	○	△	◎	○	×
Power System Operation	○	○	○	○	○
Fuel Resources for Generation	×	◎	×	○	×
Socio-environmental Consideration	×	×	△	△	○
Cost Effectiveness in High Demand Case	△	△	○	○	△
Influence of Delay in Implementation Schedule	△	△	△	△	-
Overall Evaluation	×	×	○	◎	×

Note: ◎ = Recommendable; ○ = Desirable; △ = Possible; × = Uncertain

The following criteria are considered to be uncertain factors giving low priority to the scenarios.

- Natural gas production for power generation
- Expansion of coal production for power generation
- Socio-economic consideration for Son La(L)

Overall evaluation is summarized as follows.

(a) It is desirable to develop the Son La hydropower project.

(b) The recommendable power development plan at the stage of this M/P is the scenario of SS/GS.

(c) The scenario of SS/GL was identified to be the least-cost power development plan. If the case of GL can be realized with reasonable price, the choice of scenario would shift from SS/GS to SS/GL, which improves cost performance of power expansion program.

(d) Son La (S) was identified to be recommendable in the M/P.

(e) Early execution of the Son La F/S including environmental survey is strongly recommended.

10. POWER SYSTEM EXTENSION PLAN

(1) The Vietnamese power system is consist of three regional systems of Northern, Central and Southern, and the nation-wide inter-connection with 500 kV transmission line. Power flow analyses are made for the nation-wide 500/220 kV. Power system on the conditions of PDP scenario, Case SS/GS (Son La, 2,400 MW; Natural gas production, Small), as already studied in Chapter 8 and Chapter 9. (3 stages in 2000, 2005 and 2010).

(2) As a result of the studies, it is recommended to each region, that the size of transmission line conductors should be determined taking into account possible increase of power flow in the near future.

Planned 220 kV northern power system to 2005 seems to have enough capacity to meet the demand up to 2010. Planned 220 kV central power system will be adequate to meet the demand to 2005. In the period of 2006 to 2010, the second circuit will be required for the sections of Da Nang - Hoa Khanh - Hue and Plei Ku - Qui Nhon.

Reflecting expected rapid growth of the southern demand, and too much concentration of demand in the Ho Chi Minh area (exceeding a half of the southern demand), fundamental modification of the existing and already planned system will be required by 2010.

(3) Plans for 500 kV system extensions are made by the JICA Study Team based on the results of power flow analyses, since particular plans for the study period are not clarified in the Vietnamese fourth M/P.

- Addition of the second 500 kV line between Hoa Binh and Plei Ku was found not essential till 2010.
- Installation of Ha Tinh transformers will be required just after 2000 for stable operation of the very long 220 kV line from Hoa Binh to Dong Hoi.
- Construction of the second 500 kV line between Plei Ku and Phu Lam will be required to send the generated power of Yaly and other succeeding hydropower plants around Plei Ku to Ho Chi Minh area.
- A 500 kV line between Phu Lam and Thot Not will be required to increase power transfer capability to meet the growing demand after 2000 in the Mekong delta area.

(4) Transmission and distribution lines required in the study period is summarized as 500 kV, 2,170 circuit-km; 220/110 kV, 17,626 circuit-km; MV/LV lines; 336,000 circuit-km. Investment requirement is estimated to be US$8,450 million.

PART III FORMULATION OF BASIC STRATEGY AND POLICY FOR EFFECTIVE POWER SUPPLY AND POWER DEVELOPMENT

11. ASSESSMENT OF ENERGY CONSERVATION POTENTIALS

As essential indicators to energy conservation in the electric power sector, the share held by primary energy input (PEI) into the electric power sector in total primary energy supply (TPES), the ratio held by generated output to primary energy, and the ratio by final electricity consumption (end-use consumption) to primary energy input are usually used.

These indicators in comparison with selected Asian countries are shown below.

Table S-5 Energy Index 1992 Records of Selected Asian Countries

(Unit: %)

	PEI/TPES	Generation/PEI	End-use Consumption/PEI
Viet Nam	49.5	24.6	17.7
Thailand	35.7	38.8	33.5
Malaysia	23.2	38.7	35.0
Philippines	40.9	26.6	23.0
Indonesia	17.3	36.3	28.3
South Korea	26.6	37.2	32.4
Taiwan	40.9	37.8	33.3

Note: Viet Nam; 1990 value, Other countries; 1992 value

Source: Estimated from IEV's energy balance tables and IEA's energy statistics and balances of Non-OECD countries

In Viet Nam, primary energy consumed in the electric power sector amounted to some 50% of total supply. It means that energy conservation in the electricity sectors will be in a position of vital importance, because the electric power sector is responsible for half of total energy consumption.

Of the indicators above, generation/PEI represents generating efficiency in macro terms, and gaps between generation/PEI and end-use consumption/PEI show gaps in total loss ratio. With these situations of electric power in energy sector, assessment of energy conservation potentials and measures to be improved were examined.

(1) Thermal Power Plant

(a) Thermal power plants being operated in 1995 are expected to be Pha Lai, Ba Ria new GT (gas turbine) and Thu Duc new GT plants. Nin Binh, Uong Bi and Thu Duc power plants (oil) will decrease those power and energy generated. Entering 2000s, only three power plants of Pha Lai, Thu Duc new GT and Ba Ria GT can be expected for electric power supply. New gas turbine plants can be converted to combined cycle power plants, which will be effective measures from a view point of energy conservation. However, contribution of Pha Lai to energy conservation is not so much expectative, because the supply capability will be decreased by commissioning of Pha Lai II.

(b) Energy efficiency in thermal power plants is an effective indicator from a standpoint of energy conservation. By the results of simulation study, the annual averaged efficiencies are estimated as below.

Year	1995	2000	2005	2010
Efficiency (%)	27.0	37.5	40.5	37.1

Main points obtained from above figures are as follows.

- New thermal power plants will be operated as supply capability of base and peak with hydropower and with high plant factor. Cost-effective power source composition will be able to attain from standpoints of total power system and energy conservation.

- Coal thermal power plants in the Northern region will be operated with lower plant factor through 2000s. It is desirable to take into consideration of daily start/stop operation mode in the designing stage of the power plants.

(2) Transmission and Distribution System

(a) The principle of "the lower, the better" is self evident for the T & D loss. However, every loss reduction measure will cost a certain amount, and there must be a certain limitation in actual execution. For final decision of each individual measure, an economical justification must be confirmed for each case. However, taking into account the actual situation of similar developing countries, it is considered to set a target to reduce the T & D loss within the study period from the present 20% to around 10%, a half of the present loss and roughly corresponds to the present Thai value.

In Japan, during the period from 1951 to 1960 the average T & D loss of the power companies had decreased from 25.3% to 11.4%, less than a half, due to the raising of HV distribution voltage from 3.3 kV to 6.6 kV, use of insulated wires for the distribution lines and resultant increase in sectional area of conductor, and other improvements.

(b) Taking the present situation into account, the following measures are conceived to be appropriate.

- The two distribution system improvement measures, application of the 20 kV distribution voltage nation-widely to MV lines and stringing of insulated wires on LV lines, which are now being under execution, are expected to significantly contribute to the loss reduction.

- Power loss in long 110 kV transmission lines can be reduced by converting to the 220 kV supply. In extension of the 220 kV system to load centers supplied with 110 kV lines, proper procedures such as power flow studies, economical justification, etc. are necessary.

- The most appropriate conductor size for a line shall normally be determined as the result of economic evaluation, so as to minimize the overall cost through the entire life time. The loss value is evaluated in MW and MWh with a typical generation cost of thermal power plant. A cost increase for a larger conductor is usually not much compared to evaluated cost by ohmic loss reduction, which is in inverse proportion to the sectional area of conductor. Such a study tends to selection of relatively large conductors.

- The operating power factor of the Vietnamese power system is low, being 80 to 85% at the outgoing points of 110 kV feeders. Flow of low power factor power in line cause not only large power loss but also significant voltage drop.

For power system management, it is more preferably to improve power factor at the distribution ends at consumers. It is not practical to install capacitors at small general consumers, and it is recommended to request large consumers to install capacitors so as to improve the receiving power factor to 90 to 95%. As a policy, it is desirable to promote use of high power factor appliances by attaching static capacitor and other means.

(3) Final Consumption Sector

(a) Electric power consumption in Viet Nam centers on the industrial and residential/commercial sectors. Of 1994 records (9,198 GWh), industrial demand occupied 44%, and residential/commercial demand 41%. Thus, major targets for energy conservation are the industrial sector in the first place, and the residential/commercial sector in the second. If an electricity conservation target is set at 10% of electric power demand projected this time (base case) and successfully achieved, conserved electricity would amount to 1,863 GWh as of 2000, and 5,595 GWh as of 2010.

(b) In order to achieve energy conservation, effective measures are required in all the fields concerned, including the industrial and commercial/residential sectors. Then, comprehensive conservation policy measures are needed based on detailed fact-finding survey on actual state of energy consumption like " M/P for energy conservation."

(c) Preparing Demand Side Management programs appear effective not merely in leveling of peak power but in prompting energy conservation itself. For instance, it is worthy to consider the introduction, into the industrial sector, of an "electricity supply/demand adjustable contract system," which evaluates load leveling-off efforts through load control while peak hours and/or load shifts, well-planned equipment operations/repairs, heat-storage-based operations, etc. A discriminating electricity tariff system "by time zone" to have price-induced effects is a viable option as well.

(d) Promotion of energy conservation moves through mass-media can contribute to energy saving. An energy conservation campaign must be in advance with utmost care. For instance, fluorescent lamps, priced at 10,000-20,000 Dong a piece, are much expensive than electric bulbs available only for 400-2,800 Dong a piece. A system needs to be established to enable users to evaluate worthiness of fluorescent lamps from a wide range of elements from electricity rate to light-source efficiency and the number of useful years, along with information/PR provision.

12. EXAMINATION OF ENVIRONMENTAL PROTECTION PLAN

In consideration of features of M/P Study as well as to examine the entire situation of environmental protection plan of the country, the following items have been studied under this chapter. Based on results of the study, recommendations are provided for making improvements in future by concerned organizations of the country.

- Environmental policy and institutional framework of the country
- Nature and social environments of the country
- Present situation of environmental considerations under hydropower projects
- Present situation of environmental considerations under thermal power projects
- Findings and recommendations for enhancement of environmental protection in future

Through the study, the following issues are found and necessary recommendations are also provided:

(1) Basic environmental laws and regulations have already been established, pending how these laws and regulations could be implemented as intended.

(2) Forest area has been decreased to about 25% of total land area and afforestation becomes now a critical issue of the country. On the other hand, there are 53 groups of ethnic minority people living mainly in mountainous and high land areas of the whole country. Therefore, protection of the livelihood of the ethnic people to be affected by power plant development projects is also an important issue.

(3) Facility performance of existing thermal power plants has been much degraded due to insufficient maintenance work. Enhancement of maintenance activity is needed from viewpoints of both environmental protection and energy conservation. In addition, environmental protection equipment shall be installed in future as needed for both existing plants and new projects.

(4) People resettlement issue of hydropower projects has not yet been resolved well. It is strongly recommended that this issue shall be resolved well by project owners and planners. For a new project, an integrated and practical resettlement program shall be established under the EIA during its F/S stage. Project owner/planner shall be fully responsible for the program.

Finally, it is concluded that obtaining technical assistances from qualified consultants should be beneficial to the country for improvement of environmental considerations under various new socio-economic establishment projects now being actively implemented or planned.

13. FORMULATION OF BASIC POLICY STRUCTURE

(1) The Vietnamese government intends to raise the average price level from the current 500 Dong/kWh to 770 Dong/kWh (7 ¢ /kWh) until 2000, which would be barely in the price range of other countries like Thailand and Indonesia in Asia. This price level should be regarded as the upper limit to compete with those countries with respect to introduction of foreign capital on commercial principles.

(2) The reform of current tariff system is recommended to be as follows.

(a) The difference between residential and industrial charge is small, which implies that the residential charge is set below actual cost. A practical method to adjust the residential charge to a higher level is to increase the levels of second and third step charges (600 and 800 Dong/kWh).

(b) The economic policy should aim at keeping industrial electricity tariff as low as possible to help increase the cost advantage of Vietnamese industries.

(c) The introduction of capacity charge, particularly for industry is a major step to modernize the current electricity tariff system.

(d) The time-of-use (TOU) tariff would contribute to reduction of peak load.

(3) Electricity price is determined based on cost including rate in most of industrial countries. Average cost is defined as unit cost that cost plus rate is divided by energy sales, while marginal cost is defined as unit cost that incremental cost is divided by incremental energy demand. The former indicates price level attaining financial cost recovery, while the latter does price level at which economic benefit is maximized. Although both approaches to price determination have advantages and disadvantages, the Vietnamese government intends to raise electricity price from the current level to Long Run Marginal Cost (LRMC). In general, high LRMC-based price guarantees financial viability of a BOT style private financing, but high prices would lead to consumers' complaint. Marginal cost is only used in case of fine adjustment of each classified tariff.

(4) When the cost is constantly increasing, it is requested to build some cost reduction incentives in the electricity tariff system. In pursuing measures to promote continuous cost reduction, it is recommended to introduce Quality Control (QC) activities in which dedication and participation of all employees belonging to power industry deserves serious consideration.

(5) The average tax rate accounts for more than 10 % of total costs. From a macro economic perspective, the government may better levy a tax on value added of industrial products rather than on raw materials. It would be better to keep electricity price level low for the sake of industrial competitiveness and to get tax revenue from industries which are producing more value added.

(6) Accounting System

New accounting system was introduced in Viet Nam to replace the old system in the process from centrally planned economy to the market economy. New system was applied to the Electricity of Viet Nam (EVN) established in January 1995.

(7) There would be many advantages resulting from the new EVN. The financial and technical capability will be strengthened and the close coordination with central government will become possible with respect to the long-term national development plan. Under EVN there are many companies which have independent accounting system. Together with EVN, five regional distribution companies will provide distribution services, each serving the area of Hanoi, Ho Chi Minh City, PC1 (excluding Hanoi), PC2 (excluding Ho Chi Minh City) and PC3 respectively. These companies will operate as regional

monopoly by purchasing electricity from EVN. Wholesale price will be decided by negotiation between EVN and regional distribution companies.

As often stated, the most important management technic is human resource development. Human resource should not be treated as mere labor force. Rather, it should be viewed as a source of creating added value. Typically Japanese management practice is famous for its emphasis on human resource management, which is often characterized by group work, lifetime employment or middle-management driven (unlike top - down) management. The essential point of this management style is that an organization as a whole can create a new value (new product, high quality, cost reduction, etc.) by fully utilizing employee's knowledge and experience.

(8) Rural Electrification

The development of rural energy, electricity in particular, is the important task to develop rural economic infrastructure and to improve peoples' standard of living. As a whole, 416 of 491 districts (85%) and 4,942 of 9,005 communes (55%) are electrified in Viet Nam. By 1993, electricity supplied to rural area had reached 1,243 Gwh, 16% of total electricity consumption in Viet Nam.

The Vietnamese government now has the target of achieving 70% electrification at household level by the year of 2010. However the following problems are contemplated.

(a) Financial Issues

There is no policy on electricity tariff and/or tax for RE, which means only insufficient funds are available for implementing RE programs. In general, the cost of supplying electricity to small and dispersed loads tends to be high and the return on investment is relatively low. Therefore, electric utility companies, either state-owned or private, has little economic incentive to invest in rural electrification.

(b) Technical Issues

There are many kinds of technical problems which make operation and maintenance of RE equipment difficult and costly. Such problems include low reliability of equipment, high electricity loss in distribution grid and low load factor of power plants. The existing rural electricity network built and managed primarily by local people is usually of poor quality and does not satisfy safety standard.

Taking into account the major constraints and regional development pattern of RE (i.e. effective use of micro/small hydro in central region), it is recommended to implement M/P of RE in the whole country. The study area of RE M/P would be less-developed or mountainous areas where extension of the existing distribution lines will be hardly expected. Viet Nam, especially central region is endowed with rich renewable energy resource (small hydro). The potential of micro hydro is about 2,500 sites with a total capacity of around 100--200 MW. As a result, the objective of RE M/P is defined as RE development with the maximum utilization of micro/mini hydropower potential in less-developed area.

The scope of works of RE M/P are as follows.

Phase I : Selection of Study Area
Phase II : Undertaking of Pre-F/S
Phase III : Policy and Institutional Issues

The followings are contemplated to be other programs for accelerating RE.

- Standardization of equipments
- Technical guidance on RE projects where local people are participated
- Licensing and permission system and institutional framework for independent power supply (micro hydro, diesel and others)

14. ASSESSMENT OF FUTURE INVESTMENT PLAN

(1) Total investment requirements are estimated to be US$23,025 million during 1994-2010. Annual mean investment during 1994-2010 is estimated to be about Dong 14,700 billion which corresponds to 10.8% of GDP in 1993. The power investment plan is shown in the following table. About 73% (US$16,848 million) of total investment will be disbursed after 2000 onwards.

Table S-6 Composition of Foreign and Local Finance

(US$ million)

	1994-2000		2001 - 2010		1994 - 2010		
	Foreign	Local	Foreign	Local	Foreign	Local	Total
Generation	2,981	1,421	7,478	2,771	10,459	4,192	14,651
500 kV T.L.	18	15	392	256	410	271	681
220 kV T.L.	232	67	305	196	537	263	800
110 kV T.L.	153	93	610	390	763	483	1,246
M.V. Distribution	153	525	612	2,184	765	2,709	3,474
L.V. Distribution	140	379	460	1,194	600	1,573	2,173
Total	3,677	2,500	9,857	6,991	13,534	9,491	23,025

(2) Capital sources of power investment are classified into those for EVN and PCs respectively.

(a) **1st Stage (1994 - 2000)**

Table S-7 Investment Plan - 1st Stage

(US$ million)

	Local		Foreign		Total
EVN	Long-term domestic fund	(1,443)	ODA with ordinary loan conditions	(3,291)	4,734
PCs	Government subsidy	(365)	ODA with concessionary loan conditions	(1,078)	1,443

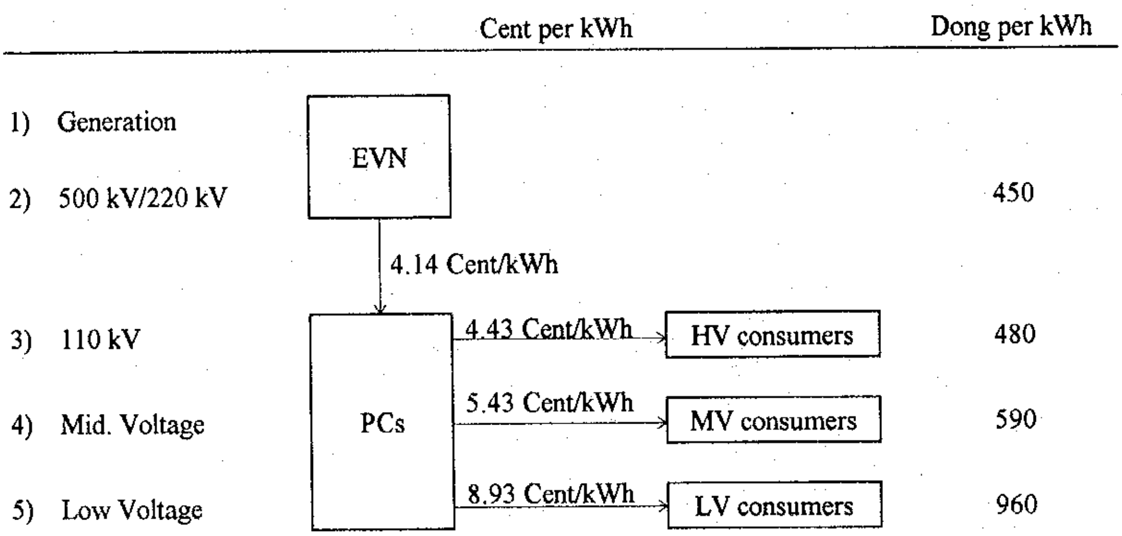
(b) **2nd Stage (2001 - 2010)**

Table S-8 Investment Plan - 2nd Stage

(US$ million)

	Local		Foreign		Total
EVN	Long-term domestic fund	(1,565)	ODA with ordinary loan conditions	(8,175)	11,398
	Own funds	(1,658)			
PCs	Government subsidy	(1,078)	ODA with concessionary loan conditions	(1,682)	5,450
	Long-term domestic fund	(2,690)			

(3) Electricity price is firstly forecast based on LRMC (average incremental cost) per kWh until the years of 2000 and 2010 respectively. The structure of electricity prices for EVN and PCs based on LRMC until 2000 is given below.



Secondly, the strict LRMC-based prices are adjusted by taking into account capacity-to-pay for electricity in household and coincidence factor during peak time. Price forecast is shown in the following table.

Table S-9 Electricity Price Forecast

(Dong/kWh)

	1995	2000	2005	2010
EVN	400	450	500	500
PCs				
110 kV	480	530	530	530
Mid. Voltage	500	590	590	590
Low Voltage				
Household	500	770	850	960
Commercial	960	960	960	960
Average	580	680	690	700

(4) The following items are assumed for preparation of financial statements of both EVN and PCs.

(a) Income tax (25%) and tax on net fixed assets are taken into account.
(b) Depreciation is accounted by the straight-line method.
(c) Power plants and equipments are valued at original costs. Revaluation of assets is not taken into account because of long-term evaluation period.
(d) The government capital is financed to PCs as equity funds.

Financial statements consist of income statements, fund flow statements and a part of balance sheets (formation of net fixed assets). Net income plus interest expense as a percentage of net fixed assets is defined as the rate of return (ROR). The self-financing ratio is defined as internal generation as a proportion of the capital expenditure.

Table S-10 ROR of EVN and PCs

(US$ million)

	1995	2000	2005	2010
EVN				
Income after income tax	133.7	104.7	103.8	395.9
Interest expense	15.0	334.9	626.9	656.4
Net fixed assets	2,399.6	6,330.8	12,448.7	13,760.4
ROR (%)	6.2	6.9	5.9	7.6
PCs				
Income after income tax	5.9	58.9	-69.7	34.7
Interest expense	0	20.9	140.5	251.0
Net fixed assets	699.0	1,875.0	3,396.0	5,432.0
ROR (%)	0.8	4.3	2.1	5.3

ROR of EVN will decline in the period from 2000 to 2005 due to a massive investment of power investment, but rise again towards the year of 2010. The projected ROR of EVN is more or less within the acceptable range of ROR in comparison with about 8 % in ASEAN countries and 10 % in Korea and Singapore. RORs of PCs are low compared to those of EVN. The projected ROR will gradually rise up from 1995 onwards. The self-financing ratios of PCs are estimated to be constant (around 35%) during investment plan period.

15. FORMULATION OF SUPPORTING PROGRAMS

In order to make the smooth implementation of power development plan the following supporting programs are formulated as action plans.

- Establishment of electric power statistics
- F/S of Son La hydropower project
- Reform of power utilities on commercial principles

(1) Establishment of Electric Power Statistics

(a) In this study, it was highly recognized that data availability and reliable database on socio-economy, industrial activities and electric power supply/demand structure for the formulation of power development plan. In order to establish database system, reliable data collection is firstly required. Data collection is considered to be proceeded step by step as:

1) from simple data to integrated data
2) from supply side to demand side
3) from urban area to rural area

(b) Data gathered can be stored in a database software. The function of database consists of 1) retrieving system, 2) data collection system and 3) data processing/formulation of secondary data. For the establishment of database described just before, the following process is needed.

1) Arrangement and analysis of data
2) Concept design
3) Function design
4) Detailed design
5) Coding
5) Test run
7) Application and operation

(c) As for data collection system, delivering/recovering method by use of questionnaire sheet prepared and using of communication control system are considered. In order to advance the data communication network, the following process is supposed to be realistic.

1) Mail system by use of floppy disc
2) Remote Job Entry System (RJE)
3) Real time processing system

(d) Action programs for electric power database are supposed to be as follows.

1) Official meeting of inside MOE
2) Selection of IEV staffs for training programs
3) Preparation of S/W for training programs
4) Execution of training programs
5) Establishment of Power Statistics Division under MOE

(2) Feasibility Study of Son La Hydropower Project

The scope of works for Son La hydropower project is largely classified into those for technical and environmental studies.

(a) Technical Study

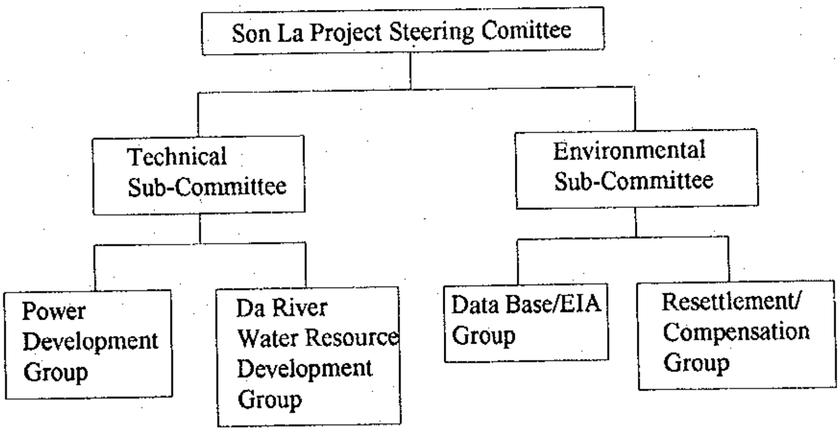
1) Geological study of dam sites
2) Basic dimensions of reservoir (sedimentation, LWL, HWL)
3) Water resource development in Da river (inland water, flood control, water demand)
4) Optimization of effective storage capacity

5) Evaluation of Son La power development with respect to economic viability of the project (hydropower generation) and analysis of the Son La hydropower project in power development alternative plans
6) Implementation schedule

(b) Environmental Study

Environmental study consists largely of Resettlement and Compensation, and Data Base and EIA. The S/W of the former component covers not only estimation of local people to be resettled including compensation costs, but also the recommendation of how to make a sustainable livelihood in resettled area. The second recommendation issue is derived from lessons that the government should take a consistent care of resettled people. The purpose of the latter component is to acquire collect informations about economic value of production, infrastructure, and minority peoples' culture/relics to be lost due to implementation of the project.

In order to conduct the smooth implementation of the Son La hydropower project, the government is requested to establish the following Steering Committee.



The Steering Committee would have two sub-committees under which the working groups will be established. The principal duty of the working groups is preparation of Terms of Reference for respective scope.

(3) Reform of Power Utilities on commercial Principles

"The Charter of the Organization and Operation of the General Company of EVN "was issued on January 27, 1995 in the form of the government decree. EVN was made public as the authority and regulatory organization of power utilities in place of the Ministry of Energy. The provision of the Charter is the first step to reform power utilities on commercial principles. In order to undertake the step-wise reform of power industries towards the market economy, the government will be required to take the further action of implementing management/financial study.

The supporting programs will be recommended to be undertaken in the following steps.

First Step	Study or Reinforcement of Corporation
	↓
Second Step	Execution of Training Programs
	↓
Third Step	Action Programs of Privatization

Prior to management/financial study, it is recommended to establish the Working Committee. The major duties of the Working Committee will be the preparation of TOR and selection of a consulting firm to undertake the management/financial study. The training Programs Committee is also proposed to establish inside EVN. This committee will take the responsibility of training plans, program operation and reporting.

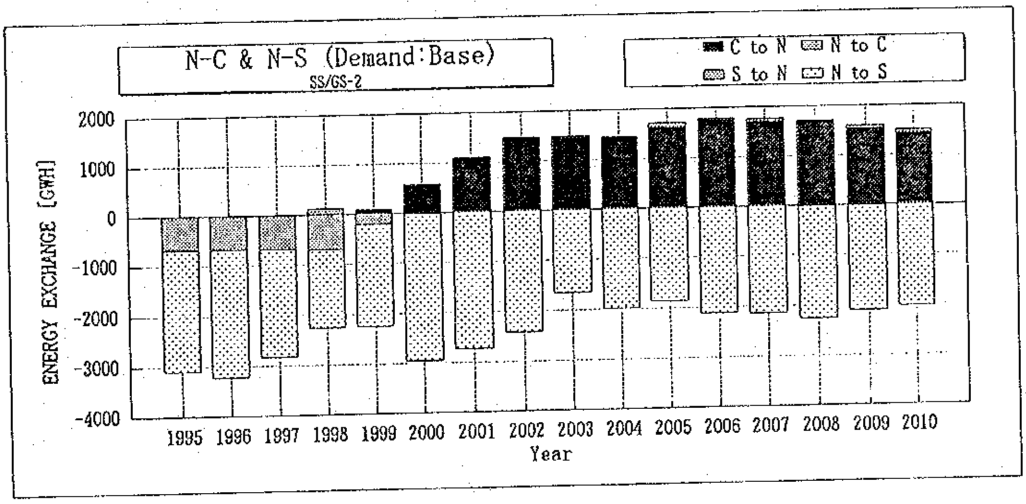
Energy flow on inter line N-C & N-S

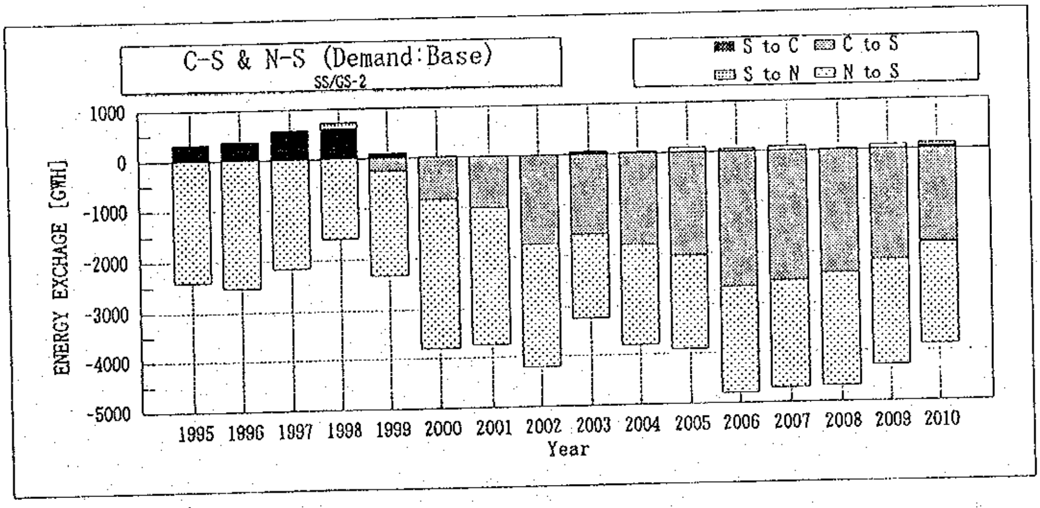
Year	energy-transfer (GWh		energy-transfer (GWh	
	N to C	N to S	C to N	S to N
1995	684.0	2405.0	0.0	0.0
1996	685.0	2533.0	0.0	0.0
1997	681.0	2150.0	0.0	0.0
1998	695.0	1581.0	0.0	126.0
1999	199.0	2062.0	85.0	18.0
2000	5.0	2947.0	587.0	0.0
2001	0.0	2730.0	1102.0	0.0
2002	0.0	2428.0	1477.0	0.0
2003	0.0	1667.0	1444.0	42.0
2004	3.0	1979.0	1446.0	13.0
2005	0.0	1872.0	1616.0	96.0
2006	0.0	2133.0	1732.0	51.0
2007	0.0	2149.0	1687.0	74.0
2008	6.0	2257.0	1685.0	13.0
2009	11.0	2104.0	1524.0	77.0
2010	2.0	2034.0	1424.0	74.0
Total	2971	35031	15809	584

Energy flow on inter line C-S & N-S

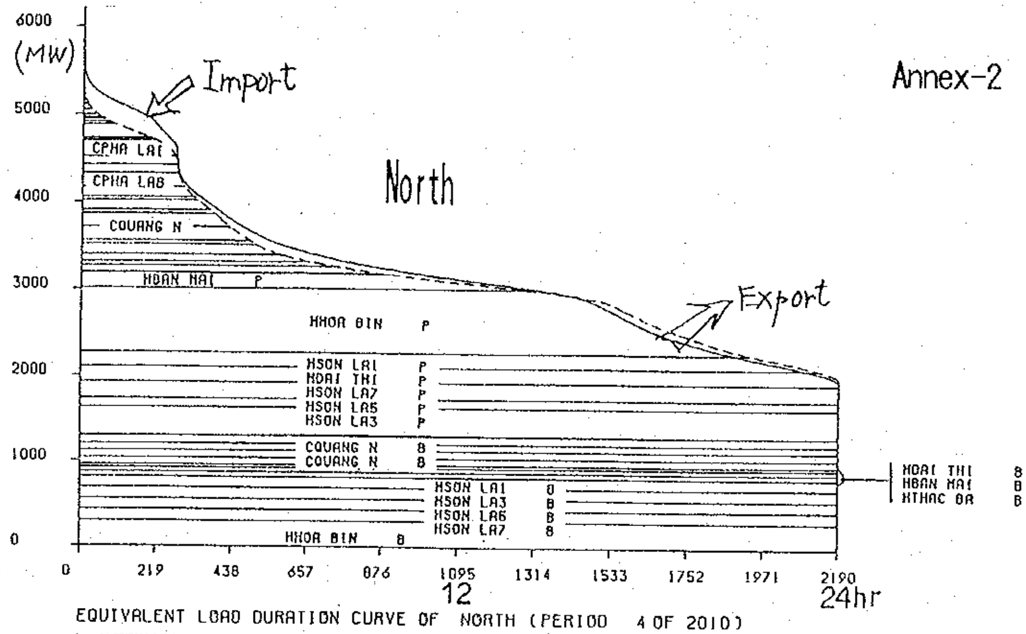
Year	energy-transfer (GWh		energy-transfer (GWh	
	C to S	N to S	S to C	S to N
1995	0.0	2405.0	317.0	0.0
1996	0.0	2533.0	369.0	0.0
1997	0.0	2150.0	574.0	0.0
1998	1.0	1581.0	595.0	126.0
1999	258.0	2062.0	90.0	18.0
2000	847.0	2947.0	24.0	0.0
2001	1004.0	2730.0	4.0	0.0
2002	1760.0	2428.0	0.0	0.0
2003	1577.0	1667.0	0.0	42.0
2004	1807.0	1979.0	14.0	13.0
2005	2035.0	1872.0	0.0	96.0
2006	2668.0	2133.0	0.0	51.0
2007	2555.0	2149.0	11.0	74.0
2008	2414.0	2257.0	5.0	13.0
2009	2167.0	2104.0	5.0	77.0
2010	1840.0	2034.0	38.0	74.0
Total	20933	35031	2046	584

EPDC

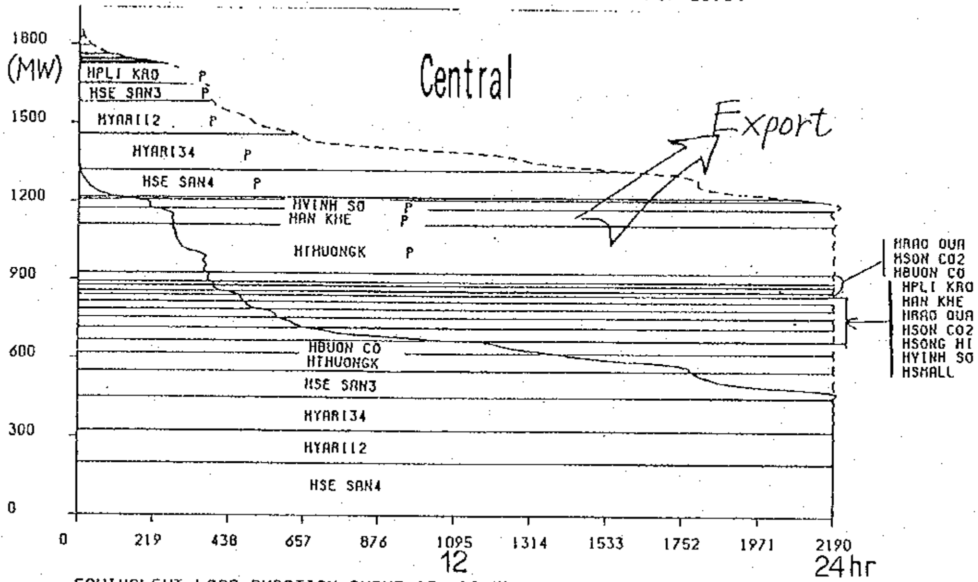




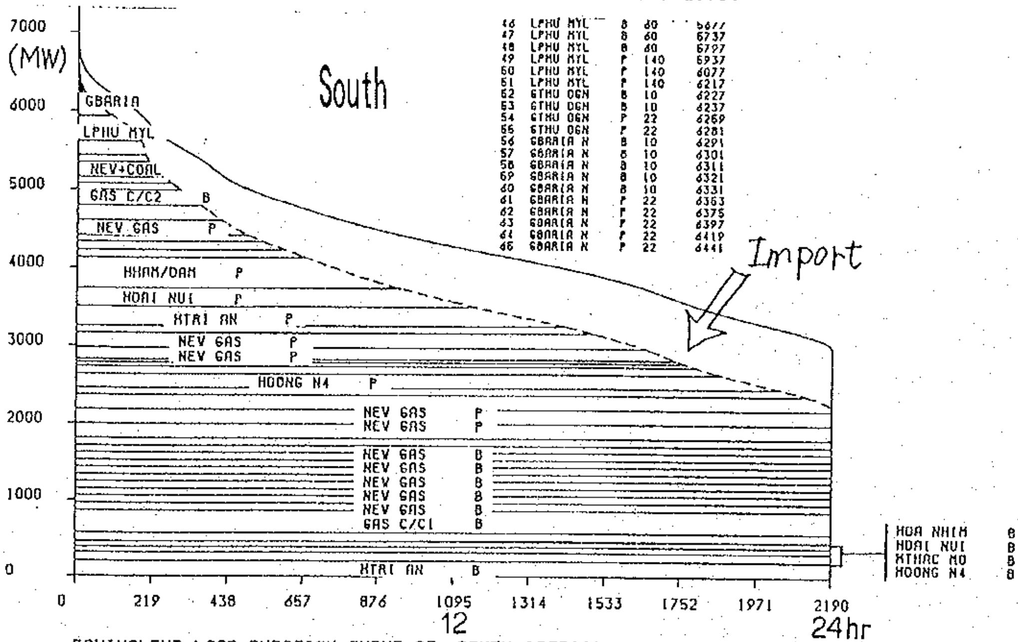
Annex-1 Energy Exchange Case-SS/GS (Base Case)



EQUIVALENT LOAD DURATION CURVE OF NORTH (PERIOD 4 OF 2010)



EQUIVALENT LOAD DURATION CURVE OF CENTER(PERIOD 4 OF 2010)



EQUIVALENT LOAD DURATION CURVE OF SOUTH (PERIOD 4 OF 2010)

Annex-2 Generation Dispatch Nov. 2010 (SS/GL)

Annex-3 Power Development Scenarios (Whole Country) (1/2)

Year	Demand (MW)	SL/GL					SL/GS					SS/GL					SS/GS				
		Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)	Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)	Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)	Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)
		Hydro	Thermal				Hydro	Thermal				Hydro	Thermal				Hydro	Thermal			
1996	2,911				4,470	53				4,470	53				4,470	53				4,470	53
1997	3,228	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54
1998	3,628		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48
1999	4,064	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58
2000	4,526	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc, Ba Ria	1,132 ▲ 60	7,528	66	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲ 60	7,528	66	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲ 60	7,528	66	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲ 60	7,528	66
2001	5,067	Plei Kron (120)		120 ▲ 100	7,548	49	Plei Kron (120)		120 ▲ 100	7,548	49	Plei Kron (120)		120 ▲ 100	7,548	49	Plei Kron (120)		120 ▲ 100	7,548	49
2002	5,690	Buon Cuop (81) Se San 3 (220)		301	7,849	37	Buon Cuop (81) Se San 3 (220)		301	7,849	38	Buon Cuop (81) Se San 3 (220)		301	7,849	37	Buon Cuop (81) Se San 3 (220)		301	7,849	38
2003	6,328	Ban Mai (350)	Phu My C/C #3	650	8,499	37	Dai Thi (250)	Phu My C/C #3	550	8,399	33		Phu My C/C #3 Phu My C/C #4	600	8,449	37		Phu My C/C #3 Phu My C/C #4	600	8,449	42
2004	7,049	An Khe (116) T. Kontum (260)	Q. Ninh #1 Phu My C/C #4	976	9,475	33	An Khe (116)	Q. Ninh #1 Phu My C/C #4 Phu My C/C #5	1,016	9,415	33	An Khe (116) T. Kontum (260)	Q. Ninh #1 Phu My C/C #5	976	9,425	34	Ban Mai (350) T. Kontun (260) Au Khe (116)	Q. Ninh #1 Phu My C/C #5	1,326	9,775	38
2005	7,879	Son Con 2 (60)	Phu My C/C #5 N. Trac #1 N. Trac #2	960	10,435	32	Dai Ninh (300) Son Con 2 (60) T. Kon Tum (260)	O Mon #1	920	10,335	32	Dai Thi (250) Son Con 2 (60)	N. Trac #1 N. Trac #2	910	10,335	31	Dai Ninh (300) Son Con 2 (60)	O Mon #1	660	10,435	32
2006	8,620	Se San 4 (366) Dong Nai 4 (200)	Q. Ninh #2 Q. Ninh #3	1,166 ▲ 150	11,451	33	Ban Mai (350) Se San 4 (366)	Q. Ninh #2 Q. Ninh #3	1,316 ▲ 150	11,501	33	Se San 4 (366)	Q.Ninh #2 Q. Ninh #3 N. Trac #3	1,266 ▲ 150	11,451	34	Dong Nai 4 (200) Se San 4 (366)	Q. Ninh #2 Q. Ninh #3	1,166 ▲ 150	11,451	32
2007	9,481	Rao Quan (80) Son La #1, 2 (600)	Q. Ninh #4 N. Trac #3 N. Trac #4	1,580 ▲ 100	12,931	36	Rao Quan (80) Son La #1, 2 (600)	O Mon #2, 3 P. Thiet #1, 2	1,880 ▲100	13,281	40	Son La #1, 2 (480) Ban Mai (350) Rao Quan (80) Dai Ninh (300)	Q. Ninh #4, 5	1,810 ▲ 100	13,161	39	Rao Quan (80) Son La #1, 2 (480)	Q. Ninh #4,5,6 O Mon #2,3	2,060 ▲100	13,411	41
2008	10,422	Son La #3, 4 (600)	N. Trac #5	900 ▲ 150	13,726	32	Son La #3, 4 (600)	Q. Ninh #4	900 ▲105	14,076	35	Son La #3, 4 (480) Dong Nai 4 (200)	N. Trac #4	980 ▲ 105	14,036	35	Son La #3, 4 (480)	P. Thiet #1 P. Thiet #2	1,080 ▲105	14,386	38
2009	11,408	Son La #5, 6 (600)	N. Trac #6 N. Trac #7	1,200	14,926	31	Son La #5, 6 (600) Dang Nai 4 (200)	P. Thiet #3 P. Thiet #4	1,400	15,476	35	Son La #5, 6 (480)	Q. Ninh #6 N. Trac #5, 6	1,380	15,416	35	Son La #5, 6 (480)	P. Thiet #3,4	1,080	15,466	36
2010	12,550	Son La #7, 8 (600) Dai Ninh (300)	O Mon #1 O Mon #2	1,500	16,426	31	Son La #7, 8 (600)	P. Thiet #5 P. Thiet #6 P. Thiet #7	1,500	16,976	35	Son La #7, 8 (480)	N. Trac #7 O Mon #1 O Mon #2	1,380	16,796	34	Son La #7, 8 (480)	Q. Nihn #7 P. Thiet #5, 6, 7	1,680	17,146	37
Addition 1996-2010				12,471 ▲ 310					13,021 ▲ 310					12,841 ▲ 310					13,191 ▲ 310		
Addition 2011-2013		Qua Dat (105) Son La (1,200) Dai Thi (250)	Coal Thermal 3,900 (N=900) (S=3,000)	5,455			Son La (1,200) Cua Dat (105)	Coal Theraml 3,300 (N=1,200) (S=2,100)	4,605			Son La (480) Huoi Quang (800)	Coal 3,600 (N=600) (S=3,000)	4,880			Dai Thi (250) Son La (480) Huoi Quang (800)	Coal Thermal 300 (N=900) (S=2,100)	4,530		

Note 1: Unit capacity of thermal power project is assumed to be 300MW each.
2: Margin is calculated on the installed capacity basis.
3: ▲ shows retirement of the plant.

Annex-3 Power Development Scenarios (Whole Country) (2/2)

Year	Demand (MW)	Case NS/GL Projects: Hydro	Case NS/GL Projects: Thermal	Case NS/GL Capacity (MW)	Case NS/GL Installed Capacity (MW)	Case NS/GL Margin (%)	Case NS/GS Projects: Hydro	Case NS/GS Projects: Thermal	Case NS/GS Capacity (MW)	Case NS/GS Installed Capacity (MW)	Case NS/GS Margin (%)
1996	2,911				4,470	53				4,470	53
1997	3,228	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54
1998	3,628		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48
1999	4,064	Yaly (360)	Pha Lai II #1 Phu My #2,3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2,3 (400)	1,060	6,456	58
2000	4,526	Yaly (360) Ham/Da Mi (976)	Pha Lai II #2 Tra Noc, Ba Ria	1,132 ▲60	7,528	66	Yaly (360) Ham/Da Mi (976)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲60	7,528	66
2001	5,067	Plei Kron (120)		120 ▲100	7,548	49	Plei Kron (120)		120 ▲100	7,548	49
2002	5,690	Se Sans (120) Buon Cuop (81)		301	7,849	38	Se San 3 (220) Buon Cuiop (81)		301	7,849	38
2003	6,328	Dai Ninh (300)	Phu My C/C #3	600	8,449	34	Dai Ninh (300)	Phu My C/C #3	600	8,449	33
2004	7,049	Ban Mai (350) T. Kontum (260)	Quang Ninh #1 Phu My C/C #4	1,210	9,659	37	T. Kontum (260)	Q. Nihn #1 Phu My C/C #4	860	9,309	32
2005	7,879	An Khe (116) Son Con 2 (60)	Phu My C/C #5 N. Trac #1	776	10,435	32	An Khe (116) Son Con 2 (60)	Quang Ninh #2,#3 Phu My C/C #5	1,076	10,385	31
2006	8,620	Se San 4 (366)	Quang Ninh #2, #3 N. Trac #2	1,266 ▲150	11,551	34	Dong Nai 4 (200) Se San 4 (366)	Q. Ninh #4 O Mon #1	1,166 ▲150	11,401	32
2007	9,481	Dong Nai 4 (200) Huoi Quang (400)	Quang Ninh #4 N. Trac #3	1,200 ▲100	12,651	33	Rao Quang (80) Ban Mai (350) Huoi Quang (400)	O Mon #2 O Mon #3	1,430 ▲100	12,731	34
2008	10,422	Huoi Quang (400)	Quang Ninh #5 N. Trac #4,#5	1,300 ▲105	13,846	33	Huoi Quang (400)	Q. Ninh #5 Phan Thiet #1,#2	1,300 ▲105	13,926	34
2009	11,408	Rao Quang (80)	Quang Nin #6, #7 N. Trac #6, #7	1,280	15,126	33		Q. Ninh #6, #7, #8 Phan Thiet #3, #4	1,500	15,426	35
2010	12,550		Quang Ninh #8, #9, #10 O Mon #1, #2	1,500	16,626	32		Q. Ninh #9 Phan Thiet #5,#6, #7	1,200	16,626	32
Addition 1996-2010				12,671 ▲310					12,671 ▲310		
Addition 2011-2013		Cua Dat (105)	Coal Thermal 4,500 (N = 1,500 S = 3,000)	4,605			Cua Dat (105)	Coal Thermal 4,800 (N = 1800 S = 3000)	5,200		

Note: 1. Unit capacity of thermal power project is assumed to be 300 MW each.

Annex-4 Comparison on Environmental Factors between Son La (L) and Son La (S)

Environmental factor	Unit	Son La (large)	Son La (small)	(L)/(S)	Rermarks
1. Area of submerged cultivated land	ha	14,500	7,251	2.0	
2. Area of submerged forest	ha	47,850	21,800	2.2	
3. Length of submerged roads	km	415	170	2.44	
4. Number of submerged villages	number of villages	233	183	1.27	
5. Resettlement of people					Population in the year 1990 at HWL:
(1) In the year 2000 (estimated)	households	24,190	17,786	1.36	1) In case of Son La (L):
	persons	142,860	105,170	1.36	106,530 persons (17,652 households)
(2) In the year 2010 (estimated)	household	32,950	24,185	1.36	2) In case of Son La (S)
	persons	185,550	137,300	1.35	77,900 persons (12,845 households)
6. Compensation amount (estimated)	x 10^6 US$	298.45	161.56	1.85	
7. Remarks					
(1) Surface area at HWL	km^2	508.0	275.0	1.85	
(2) Max. power output	MW	3,600	2,400	1.50	

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