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ASSESSMENT OF VIETNAM POWER DEVELOPMENT PLAN

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INTRODUCTION

The Power Development Plan (PDP) in general and Master Plan VI in particular, which is the latest plan for the national electricity development in 2006-2015 with the vision to 2025 and submitted for approval by the government, are the two research projects at the national scale, and have significant impacts on the entire economy of Vietnam in 10-15 years and even further. Under the Vietnamese regulations, the Master Plans shall have structure and contents in line with Decision 42/2005/QD-BCN dated December 30, 2005 in terms of the contents, steps and procedures of planning and appraisal of electricity development projects. However, Master Plan VI was set up in a context of many new changes, which should be taken into consideration.

The tendency of international economic development and the place of Vietnam in the international arena should be considered. Entering the 21st century, after 20 years of the Renewal process, Vietnam has got rid of socio-economic crisis, recorded rapid economic growth, initially presented a market economy under the socialist orientation, put forward modernization and industrialization of the country.

To solve global issues such as environmental degradation, energy scarcity and natural resources exhaustion requires cooperation among nations. The 21st century is witnessing many breakthroughs in science and technology. The knowledge economy becomes more important in expanding production forces.

The above international and domestic circumstances pose direct impacts on Vietnam, consequently presenting both new opportunities and new challenges.

Vietnam has become a full member of the World Trade Organization (WTO), which certainly brings about big changes to the Vietnamese economy, including its energy sector, in the international integration.

In this context, planning for the national electricity development should change substantially, which takes into account not only the domestic dynamics but also the aspects of the regional and global integration. Master Plan VI partly considers the above circumstances and offers appropriate solutions. Master Plan VI was set up carefully to address problems with an all-sided approach, with scientific basis and appropriate methodology. It was written in 15 chapters, including the following contents:

- Assessment of the national electricity situation.
- Overview of the socio-economic situation and the energy system in Vietnam.
- Forecast of electricity demand.
- Economic-technical criteria of sources generation projects and electricity grid.
- Assessment of primary energy sources and the possibility of exploitation and import of energy.
- Program on electricity sources and grid expansion.
- Coordination of and information on the Vietnamese electricity system.
- Assessment of environment impacts.
- Program on investment in power development till 2025.
- Financial analysis of electricity development schemes.
- Organizing structure of power administration.

However, Master Plan VI was not able to graduate from the old school of thought. That is reflected in the part of planning, which does not include the restraint of neither investment nor clear financial schemes, or sound calculation of inputs variations and financial and economic analysis. The construction of Master Plan VI does not state clearly how and where to mobilize capital and investment, nor provide financial options. In addition, input data are not reliable.

Therefore, under the Vietnam Union of Science and Technology Association (VUSTA) umbrella and with the sponsorship of the Ford Foundation, a study group was formed with experts and specialists from the Center for Development Assistance (CDA), the Institute of Energy Research under the Academy of Science and Technology and the Institute of Water and Irrigation to assess the feasibility and the suitability of Master Plan VI, taking the following issues into consideration:

1- Description and comments on load forecast;
2- Description and comments on the power sources development;
3- Description and comments on hydro power development and risk assessment;
4- Assessment of renewable energy and recommendations;
5- Policy recommendations on power development plan.

I. LOAD FORECAST

1.1. Methodology and basis of demand forecast

1.1.1. Some results on electricity demand forecast used in planning the national power development in Vietnam:

By 2006, Vietnam already had six Master Plans. Below are some forecasts of electricity demand in the latest three Master Plans.

Table 1-1: Electricity demand addressed in Master Plan IV for the period 1996-2000 with vision to 2010 (written by the Institute for Energy in September 1995)

	1995	2000	2005	2010
Low scenario (billion kWh)	11,4	22	39,7	66,4
Base scenario (billion kWh)	11,4	24,5	45,4	77,4
of which:				
- Industry %		50-51	55-56	60
- Services %		9,5	10	10
- Household %		36	30	25
Consumption per capita (KWh/person/year)				
High scenario (billion kWh)	11,4	26,9	51,0	87,5

Table 1-2: Electricity demand addressed in Master plan V for the period 2001-2010 with vision to 2020 (written and revised by the Institute for Energy in October 2002)

	2000	2005	2010	2020
Base scenario (billion kWh) - Produced power - Power for sale	 26,6 22,4	 53,4 45	 96,1 82,9	 201,4 178,4
of which:				
- Industry %	40,6	48,4	51,9	63,7
- Services %	4,8	4,9	5,2	5,1
- Household %	49	41,3	38,5	27,1
Consumption per capita (KWh/person/year)	341	636	1064	1977

P max (million kW)	4,9	9,6	17,8	40,3
High scenario (billion kWh) - Produced power - Power for sale	 26,6 22,4	 55,7 47	 105,0 90,5	 250,0 221,8

Table 1-3: Electricity demand addressed in Master plan VI for the period 2006-2015 with vision to 2025 (written by the Institute for Energy in June 2006)

	2005	2010	2015	2020	2025
Low scenario (billion kWh) - Produced power - Power for sale	 53 45,6	 106,6 91,9	 169,2 146,8	 227,3 216,4	 349,4 308,5
Pmax (million kW)	9,2	18,1	28,0	40,0	53,4
Base scenario (billion kWh) - Produced power - Power for sale	 53 45,6	 112,6 97,1	 190,0 164,9	 294,0 257,2	 421,8 381,4
of which:					
- Industry %	46,7	47,7	49,4	50,9	52,3
- Services %	4,7	6,35	6,4	6,7	7,2
- Household %	43,5	39,2	36,2	33,3	31,2
Pmax (million kW)	9,2	19,1	31,5	47,6	68,4
Consumption per capita (KWh/person/yr)	548	1106	1174	2629	3703
High scenario (billion kWh) - Produced power - Power for sale	 53 45,6	 117,3 101,1	 198,5 172,3	 305,7 267,3	 446 394,4
Pmax (million kW)	9,2	19,9	32,9	49,5	70,8

1.1.2. Description of forecast methodology

The below analysis focuses on the latest Master Plan – the 6th one.

(i) Methodology of electricity demand forecast

Many models of electricity demand forecast have been introduced and used in Vietnam. Besides traditional and simple ones such as direct model, recurrent model, energy elasticity model, some other models should be mentioned, as follows:

- MEDEES was introduced by France and transferred to the Institute of Energy for the period 1985-1990.
- MAED included in the ENPEP program was transferred to the Vietnam Institute for Atomic Energy in the mid 1990s.
- The DDAS model included in the ETB program was transferred by the United Kingdom to the Ministry of Planning and Investment in 1995 via the project on Enhancement of planning capacity.
- In 2005, the Vietnam Electricity Corporation (EVN) imported the STRAEGIST software from the United States, including the electricity demand forecast module.

However, for many objective and subjective reasons, the full utilization of those models has been faced with many challenges. Therefore, forecast of electricity demand has been mainly based on the direct model and energy elasticity model.

Electricity demand forecast is an essential part of the Master Plan on electricity development. The results of the forecast have big references to the program of development of electricity sources, grid and investment.

However, in the Institute of Energy's Master Plan IV in 1995, Mater Plan V in 2000 and revised in 2002, Master Plan VI in 2006, the methodology was poorly described. For instance, in the version of Master Plan VI built in June 2006, three models of electricity demand were introduced as follows:

- The direct model
- The indirect model (calculation of electricity consumption capacity and intensity in different areas)
- The recurrent model (projection of the future relationship between electricity demand and economic growth from the current and previous ones)

Those models were poorly described, lacked necessary analysis and data sources. The report presented the forecast results, which made it difficult to evaluate and reason.

In fact, those models can only be used for short-term forecasts. The above advanced models have not been used.

In 2006-2010, the demand is forecasted with the direct model without mentioning specific basic loads in demand. That merely put together demand forecasts from various localities. As a result, the demand in 2010 doubles from one in 2005, or electricity production is projected of 112 billion kWh vs. 53 billion kWh, respectively without proper reasons.

(ii) Procedures of electricity demand forecast in Vietnam

In building the Master Plan for national electricity development of Vietnam, the Institute for Energy under the umbrella of EVN, Ministry of Industries, has always been assigned to consult with other relevant agencies and map out the plan drafts. Then, final draft is submitted to the appraisal committee formed by the Ministry of Industries. Based on the advisory of the committee, the Institute revises the plan, which is sent by the Ministry to relevant ministries. The ultimately revised plan is submitted to the government for approval.

The period for the national master plan is 10 years, which shall take into consideration of the following 10 years. It shall be revised after every 5 years, in which demand forecasts will be recalculated.

The above procedure proves to be suitable, follows suit the new law on electricity in 2005 (article on electricity planning).

However, the Institute for Energy falls short of coordination and cooperation with other relevant agencies in making the master plan, thus coming short of making full use of the data sources and human resources from relevant institutions.

(iii) Database for forecasts

There has not yet had a database on energy-economic-environmental-social information in general and one for electricity demand forecasts in particular.

Data on energy caps for various industries and data on new technologies are found scattering, incomprehensive and inaccurate.

Data mainly provided by the Institute of Energy, including information on electricity production provided by EVN, lack objectivity. In the forecast, direct and accumulative calculation is subjective and dependent on the person who does it.

Data on energy consumption and efficiency for each period of consumption are not available, thus preventing it from using the above models, such as MEDEES, MAED…

One issue always faced when forecasting electricity demand in Vietnam is that long-term economic development planning is always delayed, only information on the general socio-economic development orientations is provided by the state planning agencies. Therefore, in energy forecast, energy experts and economists must tentatively project economic development targets, such as growth rates, industrial structure…

That reveals the weakness in economic development planning, which should be enhanced.

(iv) Electricity saving programs

It is found in Master Pan VI an overview, analysis on the implementation of the demand side management (DSM), including some forecasts on efficiency of DSM. It is expected that by the end of 2007, it will be able to cut 120MW peak loads and save 0.5 billion kWh thanks to DSM. The potentials for the following period of time have not been calculated. Therefore, it fails to fully assess the efficiency of DSM and the impacts of DSM on the forecasts.

(v) Technology advancement and energy saving

Technological progresses in production and consumption of energy play an immense role in reducing energy demands. Electricity consumption per a production unit tends to fall. Therefore, energy saving should be considered in the demand forecasts.

Because of the rough forecasts, which do not take into account the utility of electricity, the factor of technological progresses and energy saving is left out in the forecasts. Consequently, the electricity demand is always projected high.

As a result of researches and assessment in energy saving projects in Vietnam, good management of electricity utility can save up to 4-5% total utility, and long-term technology remodel and replacement can save up to 7-8% total utility. The national program on saving and effective use of energy for the period 2006-2015 is currently implemented toward those goals.

(vi) Forecasts

GDP growth rates forecasts

These are significant data, which help the accuracy of electricity demand forecasts.

GDP growth rates are projected in 3 scenarios: slow growth, base growth and rapid growth (Table 1-4).

Table 1-4: GDP growth rates forecasts (%)

Scenario	2006 – 2010	2011 – 2020	2021 – 2030
Slow development	6,2	7,0	7,0
Base development	7,5	7,2	7
Rapid development	8,5	8,5	8,0

Forecasts on electricity demand for production

The demand is also projected in 3 scenarios:

- Light load: based on the base growth scenario of GDP growth.
- Base load: based on the rapid growth scenario of GDP growth.
- Heavy load: based on the rapid growth scenario of GDP growth with higher rates of electricity growth.

Table 1-5 shows the base scenario taking into consideration of heavy load scenario.

Table 1-5: Forecasts on electricity demand for production (%)

Period	Low scenario	Base scenario	High scenario
2006 – 2010	14.8	16	17
2011 – 2015	9.7	11	11.1
2016 – 2020	7.9	9.1	9
2021 – 2025	7.2	8	7.9
2006 – 2025	10.4	11.6	11.8

Forecasts on the trend of the graphs of electricity loads

In Master Plan VI, the graphs of electricity loads are projected as follows:

- Daily load: the graph goes up and becomes flatter with a gradual increase of Pmin/Pmax from 0.511 in 1996 to 0.639 in 2005. The graph has 2 peaks: the first peak appears at about 11:00AM and the second (max) peak at about 19:00-20:00PM, which tends to shift from 19:00PM to 20:00PM.
- Monthly load: the graph remains from year to year with basic characteristics as follows:
    - The high peak months are found in the summer from April to August. In the North and the Central, the high peak months are July, August. In the South, it is May.
    - The low peak months are January, February.
    - The gap between the high peak and low peak is 1.4 times.

1.2. Comments

1.2.1. GDP growth rates

Vietnam has been able to record high growth rates at about 7% for a long time. Yet, the country stays in low development level compared with the region. Therefore, it is expected that in the decades to come, the growth rates as projected by the base scenario are feasible with utmost efforts in the economic management. If the squandering and losses in many economic sectors remain and the corruption prevails, it is difficult to realize those goals and targets.

1.2.2. Growth rates in electricity for production development

According to the scenarios on electricity for production development, the elasticity is projected as in Table 1-6.

Table 1-6: Forecast of the elasticity of the growth in electricity for production

Period	**Elasticity = Produced power growth rate % / GDP growth rate %**		
	Low scenario	**Base scenario**	**High scenario**
2006 – 2010	2.39	2.13	2
2011 – 2015	1.39	1.53	1.31
2016 – 2020	1.13	1.26	1.06
2021 – 2025	1.03	1.14	0.99

From Table 1-6, the elasticity figures are very much different in every 5-year plan and in the first 5-year plans; electricity grows much more rapidly than in the later plans. The reasoning for picking those figures is unclear. Why the elasticity for the period 2006-2010 is above 2 while staying around 1 for the period 2010-2025 is questionable. May it be because the shrink of the elasticity for the period 2006-2010 may lead to a reduction of necessary capital investment while that investment comes mainly from borrow from abroad?

For the period 2006-2010, the elasticity should stay around 1.8 for the three scenarios, so that the changes in elasticity over every 5-year plans will be smooth and reasonable. One of the measures to bring the elasticity down is to prioritize the development of the efficient economic sectors with low electricity consumption, such as tourism – a highly potential sector somehow in short of investment and marketing.

1.2.3. Graphs of loads

In the past, the graphs of loads tended to be sharper, thus making way for a rapid spread of the pumped storage hydro stations to balance the gap between Pmax and Pmin. It is found contrary in Vietnam with flatter graphs of loads. How to explain that contradiction: is it because EVN makes it that way?

According to monthly load graphs, the heavy load months are from May (in the South) to July, August (in the North and the Central). That is helpful for a hydropower weighted system of energy since those months are in the flooding season, thus bringing hydropower plans into full run. That is also in line with the EVN regulation that states the running time for any hydropower machine shall not exceed 4,200 hours. The utility is the lowest during January and February, which are also the drying months.

Studying combined daily and monthly graphs of loads, it shows that in the conditions of Vietnam, building pumped storage hydro stations is inappropriate. Covering peaks in daily graphs using reservoir hydropower plants is possible. If necessary, the plant capacity can increase, the running time can decrease, and water is reserved for peak hours.

Raising hydropower plans' capacity and using it during peak time instead of building more pumped storage hydro stations has 2 advantages:

- Reduction of energy losses since it costs twice as much energy to pump up and store water and to release to run the turbine, while the efficiency of the pump is always below that of the turbine.
- Reduction of investment costs in building the pumped storage hydro stations and reduction of losses due to floods over the reservoir.

1.2.4. Models used in forecasts

Models used in the forecasts in Master Plan VI are common ones, whose accuracy however depends on the process of the input data: statistics and expected coefficients such as elasticity, energy intensity, paces in each period. From the other countries' experiences, these data are also the basis for the future projections. Statistics data depend on the settings of each country. In Vietnam, the demand-supply relationship has been broken due to 2 factors:

- The state remains control over electricity prices, which is against the demand-supply principle.
- The electricity price chart in Vietnam was set up almost a century ago on the basis of single element – electricity utility, now remains unfair. Nowadays, countries no longer use single-element price chart. They use two-element price chart, instead, while remain using one-element prices for small households and small enterprises. Thailand

has long been introducing two-element price chart and applied prices per using time since 1992 to households exceeding 2,000 kW of utility because the price chart offers users low average prices, against the using time of maximum load, which shows in the following formula:

$$g = \frac{g_P}{T_{\max}} + g_A$$

Whereas,
g: average electricity price (VND/kWh)
g_P: price of electricity power (VND/kW/month)
g_A: electricity price (VND/kWh)
Tmax: utility time at maximum load in the month

The single-element price chart has users pay no attention to the power but only to electricity current. Consequently, the ratio between the average power and maximum power (or load coefficient) remains since the introduction of prices per daily utility time.

The changes of the load coefficients are shown in the following table:

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0,6	0,61	0,61	0,63	0,63	0,64	0,63	0,63	0,64	0,65	0,66

(Source: Master Plan VI and statistics of the electricity regulating agency)

As a result, investment in generating sources further increases to meet the demand of load. However the investment efficiency remains low. To elaborate, compare the current statistics of Vietnam and those of Thailand in 1992, with the same electricity production but different installation and maximum power.

Table 1-7: Comparison between Vietnam (2005) and Thailand (1992)

Item	Unit	Vietnam (2005)	Thailand (1992)
Installed capacity	MW	11.298	11.033
Pmax	MW	9.255	8.876

Power for sale	GWh	45.603	50.727
Produced power		53.462	56.020
Loss	%	12%	9,7%
Self-consumption	%	2,7%	4,14%
Loss from self-consumption	%	14,7%	13,85%
Load coefficient (Tmax)		0,66	0,72
Reserve coefficient	%	22%	24,3%

(Source: Master Plan VI and the electricity power development of Thailand for the period 1992-2001)

It should be notice that Thailand has for long introduced the two-element price chart, and used prices per utility time since January 1990 for small enterprise exceeding 2,000kW of utility, which was introduced to enterprises in Vietnam since 1992) (see appendix for the advantages of the two-element price chart).

In 2003, total installation power in Thailand reached 25,422MW, in which hydropower accounted 11.5%, thermal power 23.7%, combined gas turbine 20%, gas turbine and other sources 3.1%, IPP projects 41.7% (including imports), no pumped storage hydro power. Total electricity production recorded 116.7 TWh, of which power for sale was 110.7TWh; Pmax: 18,121MW, load coefficient: 0.735, which is equivalent to the high scenario of Vietnam in 2010 and the base scenario in 2011, when the load coefficient of Vietnam is only 0.67. That means Vietnam needs another 1,000MW to meet the same load as in Thailand.

1.2.5. Forecast of load demand

Forecast of load demands poses great impacts on the development orientations, which should be notice as follows:

- Forecasts of load demands are unclear, primitive and unreasonable. The annual growth of electricity for the period 2006-2010 is 16.3% in the base load scenario, 17.2% in the heavy load scenario with 8.5% annual GDP growth rate. The forecast of demands tends to be high, which is 112 billion kWh in the base scenario for 2025 or 2 times of that in 2005, 190 billion kWh in 2015, 294 billion kWh in 2020 and 431 billion kWh in 2025. The growth rate of demand is twice as much as that of GDP, which is unreasonable. The energy intensity in Vietnam has always been higher than in other countries, will even increase if adding the surplus for the period 2006-2010, which will do harm to Vietnam. It is necessary to find solution to improve this situation.

The annual load growth rate for the period 2011-2020, especially 2011-2015 when experiencing a big drop in the growth, will stay at 11.2% while the GDP growth rate is 8.5%, which is unreasonable.

- There is a gap of 5-6% between the forecast of demand in the low and the base scenario in Master plan 6, while almost no difference between the base and the high scenario. The average growth rates in the base and the high scenario are 11.6% and 11.8%, respectively. That also reflects the impropriation of the forecasts, since if there is almost no difference between the base and the high scenario, why it was needed to introduce the high scenario.
- Structures of electricity utility mentioned in the recent master plans are incorrect. Industries' and construction's utility was projected at high level of 55-60%, but in fact stays at 40.6 % and 48% in 2000 and 2005, respectively. Services' utility was projected lower and households' utility was projected higher than in the previous periods. In general, all forecasts were proceeded unreasonably, as follows:
    - In reality, it turned out that industries were not developing and using as much electricity as projected.
    - Classification of sectors and branches was impropriate, without adequate supporting statistics. In Master Plan IV, households' utility was projected

- Demand-side management (DSM), which reflects the energy efficiency, has not been taken into account. In the DSM chapter, only expected outcomes (outputs) of the DSM program are projected without considering the investment in the program (inputs). It should be clarified of the inputs for the DSM program as well as its result in a reduction of investment in sources.
- The forecasts only sum up accruing outcomes and are based on projected growth rates, which fail to identify technologies and load elements involved in the future. The high and the base scenario are nearly identical with the average rates of 11.6% and 11.8%, respectively.

In short, the forecast of electricity demand in Master Plan VI, as well as in the previous ones, was conducted with primitive models and inaccurate data, along with objective projection regarding the lack of power and weakness in management. Therefore, the forecast outcomes tend to be high, which poses impacts on the source and grid development program, and leads to an increase in investment.

1.3. Some recommendations

In the framework of the Ministry of Industry's key program on energy in the period 2001-2005, the project "Research on master plan on efficient exploitation and utilization various sources of energy in Vietnam" is conducted by the Vietnam Academy of Sciences and Technologies with a goal of forecast energy demands in general and electricity demands in particular in Vietnam to 2030.

The project has joined experts from the Strategy Institute of the Ministry of Planning and Investment in proposing a number of scenarios for economic development in Vietnam to 2030, in which the base and the high scenarios are not different from those in Master Plan 6. Namely, the growth rates in the base and the high scenario are 7-7.5% and 8-8.5%, respectively.

In forecasting power demands, the Model for Analysis of Energy Demand (MAED) was taken based on the optimization of MEDEES.

The project uses a lot of data to calculate upon MAED, including:

- Data on population growth
- Classification of economic activities and income generation
- Energy intensity of power utility processes in various economic sectors
- Industrial development forecast
- Technological progresses projected from studying energy consumption/power ratios in various processes.

Power demand is briefly forecasted in the following tables:

1. *Demand in Vietnam to 2030*

Produced power (billion kWh)	2005	2010	2015	2020	2025	2030
High scenario	52	89,8	145,8	230,6	323,8	451
Base scenario	52	85,0	129,7	186,6	244,3	361,7
Low scenario	52	77,5	108,8	153,3	213,2	290,7

2. *Electric elasticity vs. GDP*

	2005-10	2011-15	2016-20	2021-25	2026-30
High scenario	1,55	1,159	0,905	0,91	0,91
Base scenario	1,58	1,22	1,037	1,01	0,97
Low scenario	1,57	1,18	1,044	1,01	1,01

3. *Energy elasticity vs. GDP*

	2005-10	2011-15	2016-20	2021-25	2026-30
High scenario	1,06	0,97	0,71	0,68	0,66
Base scenario	1,02	1,0	0,82	0,80	0,79
Low scenario	0,83	0,95	0,89	0,82	0,79

With the above outcomes, the average growth rates of electricity demand in the base scenario are as follows:

- 11.5-12% for the period 2005-2010
- 8.9-9.5% for 2011-2015
- 7.5% for 2016-2020
- 6.5-7% for 2010-2030

The electric elasticity per GDP ratio is about 1 by 2025 with the base scenario.

The energy elasticity per GDP ratio is about 1% by 2015 with the base scenario.

II. SOURCES DEVELOPMENT PLAN

2.1. Power development plan (PDP) model

2.1.1. Perspectives

- Balanced development of sources' capacity in the North, the Central and the South. Assurance of the reliability of power provision in each grid with connection to others to reduce unnecessary transmission. Share of reserved sources to reduce mutual reserves. Making full use of the raining seasons to bring about economic efficiency of hydropower plants. Avoidance of rapidly building sources in one region while slowly developing those in other regions.
- Continue to give priority to multi-functional hydropower plants: anti-flood, watering, electric generation…
- In each region, give priority to developing sources close to the loads to avoid distant transmission.
- Develop thermal power focusing on thermal power plants using coal to ensure the availability and fuel security.
- Make sources development plans, which take into account the risk of delay in implementation against the planning.
- Select the low cost plan, which meets the reliability criteria, then calculate the annual investment in sources for the planning period, then consider the feasibility of the investment in the context of the total investment.
- Draw a plan of sources taking into account the investment constraint and suggest a delay in implementation of some sources projects. The shortfall of power in this plan is limited due to some recommended energy saving measures.

2.1.2 Calculating models

Methodology: to solve the optimum problem to bring about balanced sources development in each region, taking into consideration of costs and effects of connecting wires to ensure safe and reliable power provision in each region and throughout the country.

Model: STRATEGIST is the main tool, using WASP-PDPAT II combination as both the supporting tool and checking tool for the solution of the optimum problem.

STRATEGIST (developed by New Energy Associates, LLC, USA) has the same approach as in WASP, namely to solve the optimum dynamic planning problem, target function is to minimize costs with given barriers. The advantage of STRATEGIST is the ability to emulate the power system, whereas including many connecting subsystems, to calculate effects of power exchange when efficiently operating sources, sharing reserved capacity as well as transmission losses from connecting subsystems.

The STRATEGIST program includes 3 important modules:

- The Load Forecast Adjustment (LFA) module describes load forecast according to the kinds and groups of customers, typical load graphs of those kinds and groups of customers, other coefficients… Besides, it is associated with other modules (GAF, FIR, CER) in calculating the elastic ratio of power need against electricity prices, in supporting demand side management and stimulation program. LFA presents the demand side in the optimum calculation.
- The Generation And Fuel (GAF) emulates in details economic, technical, financial targets and operating features of all hydro and thermal generators in the power system consisting of connecting subsystems; emulates fuels in use, their prices, hydrographic conditions of hydropower projects, enono-technically emulates connections in the power system. GAF presents the supply side in the optimum calculation.
- The PROVIEW (PRV) module is a dynamic programming. Like those in the WASP, PRV sets up and solves the optimum problem of long-term sources development based on the Belman optimum principle, which takes into consideration of the efficiency of the connections among the subsystems. The outcomes from PRV can serve as inputs of the PROMOD IV program.
- STRATEGIST can emulate 15 subsystems in connection and exchange of power. It has been used by over 50 energy corporations in the world.

The PDPAT II-WASP III complex combines PDPAT II and WASP III under the following principle:

Step 1: use WASP III to solve the optimum problem of sources of the power system for the planning period. The outcome of WASP III presents a contiguous outcome of the optimum problem of sources in the way to expand costs and minimize sources.

Step 2: use PDPAT II to elaborate the power system in various connecting subsystems to calculate annual costs according to some plans to change the location of sources, the exchanged capacity between the subsystems to find the best solution for combined sources.

The Wienna Automatic System Planning (WASP III) is made on the basis of dynamic programming. It weakness is that it does not take into consideration the connection between areas and regions.

The Power Development Planning Assistant Tool (PDPAT II) was developed by Tepco Corporation, Japan, is a calculation program that views the whole system including many connecting subsystems (10 at maximum). According to PDPAT, only receiving subsystem bears the cost of transmission, without posing any cost on other subsystems. It also emulates the optimum distribution of capacity among plants, which can be presented in daily, monthly or yearly graphs.

According to PDPAT II, the generating capacity of hydropower plants can be calculated so as to make a flat graph of distribution, so that to have an optimum operation of thermal power plants in the system.

PDPAT II can calculate an optimum fuel consumption of thermal and nuclear power plants. As a result, the optimum capacity of thermal plants can be calculated. The weakness of PDPAT II is that the planers must take try and true approach for calculating the optimum scenario for each and every year.

Therefore, the combination of PDPAT II and WASP III helps overcome the weak points of each model.

2.1.3. Considerations for calculation

Classification of hydropower plants

The econo-technical index is the ratio of B/C of each project against B/C of the most beneficial one (including benefits of power generation, watering and anti-flood). The index on efficiency (rural electrification, health care, education, infrastructure, local investment improvement,…) and socio-environment (water, ecosystem, land and forest, natural heritages, immigration…) is the ratio of the worst project against the given project.

Assessment of the availability of gas

The sum of sources (associate and natural gas) will jump from 5 billion m3 at present to 11.1 billion m3 in 2010, 14.6 billion m3 in 2015 and 14-15.6 billion m3 in 2020, in which about 63-68% of the reserves is in the Eastern floor, the rest is in the South Western floor.

Gas needed for other industries, including fertilizer production, steel mills, ceramic and cement plants… is projected to increase from 0.5 million m3 at present to 1.75 million m3 in 2010 and to 1.8-2 million m3 thereafter. Accordingly, the volume of gas for power generation will hardly exceed 14 billion m3 annually after 2010.

The availability of domestic coal and coal imports

The possible exploitation of domestic coal for the period 2006-1025 is expected to double over that from the Coal Master Plan in 2003.

Table2-1: Coal for power (10^3 tons)

Year	Base scenario	High scenario
2005	4160	
2006	4990	4990
2007	5340	5340
2008	6585	7535
2009	9255	13655
2010	16305	21935
2011	23385	23985
2012	27455	27785

Year	Base scenario	High scenario
2013	27785	27975
2014	27785	28545
2015	27380	29380
2016	27940	31180
2017	29100	33180
2018	29869	34380
2019	31088	37430
2020	32693	40430
2021	36073	42830
2022	38713	42830
2023	41660	42830
2024	41689	42830
2025	41790	42830

In the regional market, Indonesia and Australia are the two leading coal production and export and have become the prominent coal suppliers.

Nuclear power

Master Plan VI projects the use of nuclear power in 2017 for both base and high scenarios. The capacity of nuclear power plants will increase from 3x1,000MW in 2020 to 8x1,000MW in 2025.

Power importation from the regional countries

Besides 250MW Se Kaman 3 hydropower plant in the Southern Lao, the following plants are expected to be built in 2010 with total capacity of 1,600MW to export electricity to Vietnam: 488MW Se Kaman 1 plant, 485MW Se Kong 4 plant, 405MW Se Kong 5 plant, 240MW Nam Kong plant. It is expected that SE Kaman 1 and Se Kong 4 will be in operation in 2012-2013, followed by Se Kong 5 and Nam Kong.

It is expected to build a number of hydropower plants in North East of Campodia in 2015 to export electricity to Vietnam, including 375MW Lower Se San 3,222MW Lower Serepok, 207MW Lower SE San with total capacity of 800MW.

Vietnam is currently import electricity from Southern China with capacity of 200MW and will increase its import. In this regards, to 2015 Vietnam will import about 2,000MW from Southern China.

Elements used for calculation of sources development program

Besides the above hydro and thermal project related elements, the following economic elements and standards are to be used:

- Expected hours of blackout (LOLE in PDPAT or LOLH in STRATEGIST) are 24 hours/year on average, with the reliability rate of 99.7% in the North and the Central-South, which is equivalent to the rates in the developing countries in the region.
- The operation of plants is scheduled according to the expected hours of blackout.
- The hydrographic frequency rate is set at 90% to calculate the possible capacity to set aside marginal reserves for the drought with average water level rate of 50%, based on which econo-technical comparison of plans is made.
- The economic loss when having a 1kWh shortfall is 0.5USD/kWh, which is calculated on the basis of the economic value of products would have been produced, had there been no power blackout.
- The failure probability for gas thermal plants is 4-6%, coal thermal plants is 7-10% while that for hydro plants is 2%.
- Coal thermal plants should have capacity of 2x500MW or 2x600MW after 2010, and 2x1,000MW in 2018-2020.
- Gas thermal plants should have capacity of 3x110MW, 3x240MW or 3x250MW. The average efficiency in the normal climate in Vietnam is 48-49%.
- The exchange rates used in the calculation is that of 2005 (15,800 VND/USD)
- The depreciation rate is 10% with a linear depreciation method.

Power development plan

PDPs are compared on the basis of base loads, which take into account the following factors:

- Pre-feasibility reports on nuclear power plants, outcomes of the national hydropower master plan phase 1 and 2;
- Shortage of fuels, inflation of fuel prices;
- Transmission limit of the North-South 500kV wires;
- Costs and effects of pumped storage hydropower in covering load peaks and reserves;
- The Government policy on the rapid building of 12 thermal power plants for the period 2006-2010 and after 2010;
- Possible delay in operation of some approved sources in the system.

Master Plan VI roughly streamlines the sources on the basis of their economic use of fuels by calculating average costs of the proposed thermal plants.

The results show that the thermal plants in the North using domestic coal have the lowest average costs (3.5-3.8 UScents/kWh with the utility rates of 60-80%), followed by the coal fueled plants removed from the North to the South, then mixed gas fueled plants. Nuclear power will be competitive to thermal power using imported coal when the utility rate exceeds 75%.

2.1.4. Results

- Base load scenario (190 billion kWh in 2015) with 28,700MW overall capacity of newly built plants till 2015, in which that of hydro power is 9,400MW, gas fueled power 6,900MW, coal fueled power 9,870MW, imported power 1,900MW and other small scaled hydro power and renewable energy 1,200MW. To 2015 the total capacity of all power plants in Vietnam will reach 40,700MW, in which hydro power accounts for 33.2%, gas fueled power 30.6%, coal fueled power 28.2%, imports 4.9% and from other sources 4%, which meets the load demand of 31,495MW with the reserve rate of 29.1% in the raining season and 30.3% in the drought season.
- To 2020 the total capacity of all power plants in Vietnam will reach 60,300MW, in which hydro and pumped storage hydro power accounts for 28.25%, gas and oil fueled power 26.7%, coal fueled power 30.2%, nuclear power 3.3%, imports 8.5% and from other sources 2.8%.
- To 2025 the total capacity of all power plants in Vietnam will reach 85,100MW, in which hydro and pumped storage hydro power accounts for 25%, gas and oil fueled

power 19.8%, coal fueled power 41.8%, nuclear power 4.7%, imports 6%, renewable energy 2.7%, which meets the load demand of 68,400MW with the reserve rate of 23.5% in the raining seasons and 22.7% in the drought seasons.

2.2. Comments

On the basis of load forecast, the Master Plan selects the base sources, as follows:

Sources	Unit	2015		2020		2025	
Installed capacity	MW	40.700	100%	60.300	100%	85.100	100%
Hydro power	MW	13.500	33,2%	17.200	28,5%	21.300	29,2%
Gas fueled power	MW	12.500	30,6%	16.100	26,7%	16.900	19,8%
Coal fueled power	MW	11.500	28,2%	18.200	30,2%	35.600	41,8%
Imported power	MW	2.000	4,9%	5.100	8,5%	5.100	6%
Renewable power	MW	1270	4,0%	1.700	2,8%	2.300	2,7%
Nuclear power	MW	-	-	2000	3,3%	4.000	4,7%
Reserves		28,9/30,2				23,5/22,7	

2.2.1. Forecast on supply

a. Coal: the supply increases from the previous calculation, yet falling short of the coal potential. The coal production can provide 100 million ton.
b. Renewable energy: Vietnam has not paid adequate attention to these energy sources. Only primary data are available, which in general are incorrect and scientifically unreliable to assess adequate potential of these energy sources. Therefore, in the Master Plan, the forecast on this power is unreliable. It should be included in the national strategic goals for the 2006-2010 periods the task to rapidly survey and assess these energy resources to ensure energy security.

2.2.2. Sources development program

- It is necessary to calculate various plans with different scenarios. In principle, increasing investment in thermal, coal and gas energy, taking into account the generation of power from renewable resources, is a right approach.

- However, the tendency to fix the load coefficient at low value of 0.65 on average causes a raise in sources demand. The system reserve of above 30% after 2010 is high, thus forcing an increase in the system capacity, consequently raising prices of electricity and reducing the operation efficiency of the system. As a result, it requires huge investment from the state.
- The recommendation on using pumped storage hydropower plants is unreliable. It is still necessary to carefully study on the optimum use of hydro power in Vietnam, especially on selection of optimum capacity for big pumped storage hydropower plants with long-running reservoirs. According to our calculation, if the capacity of the Son La hydropower plant, which is currently under the technical design phase, increases by 800 MW, that of the Lai Chau plant increases to 1,400-1,500 MW, and capacity of other storage hydro plants also increases, the issue of peaks coverage in the electric system will be addressed significantly to 2025-2030. Pumped storage plants would be needed after 2030, when the power of atomic plants is big enough. Besides, with the expected structure of sources, in which hydro power will account for 19-20% total capacity and gas fueled power with combined turbines will account for 40% total capacity, it will be able to cover peaks in the system. Moreover, the Master Plan does not take into account reserved sources from households, which is about 880MW now, to cover peaks
- The introduction of atomic energy in Master Plan VI may be reconsidered because load forecasts have tended to be high, mobilization of other sources has not been considered adequately. Moreover, as stated in the Master Plan, there will be competition between atomic power and thermal power using imported coal when the consumption coefficient exceeds 75%.
- In terms of sources development scenarios, it is necessary to make comparative selection of scenarios between strengthening regional grids and building of local sources based on economic efficiency.
- To ensure balance of electric power and utility throughout the whole system in Vietnam and in each region, it is necessary to clarify criteria of regional classification and capability of exchange of power between regions, based on which the compatibility between sources growth rates and specially loaded grid development.

In short, the sources development program is oversize. Therefore, the problem of demand forecast and optimum calculation of sources development should be reconsidered based on appropriate exploitation of the country's natural resources and energy and feasible mobilization of capital, so to avoid the failure to implement or a slow implementation of the Master Plan. It should not be stressed that atomic energy will be available by 2020 with 17 million kW. The tendency to diversify ownership of electricity sources should be focused. It is important to identify hubs of electric sources in 3 regions of the country to minimize transmission loss, increase the safety and reliability of the grid.

III. HYDROPOWER DEVELOPMENT AND ITS RISKS

3.1. Hydropower development plan in Vietnam

According to the revised Master Plan V and Master Plan VI, the plan on building hydro plants with capacity above 50MW for the 2005-2020 periods is as follows:

Sources	Unit	2015	2020	2025
Master Plan	MW	40.700	30.300	85.100
Revised plan 1	MW	34.168	52.511	76.585
Revised plan 2	MW	35.653	54.794	79.915
Revised plan 3	MW	34.223	52.494	77.665

Whereas,
Revised plan 1: 10% reserves
Revised plan 2: 20% reserves
Revised plan 3: 20% reserves plus reserves from customers

It can be seen that the topography of the North with high mountains, of the Central with West-East slop and of the South with North-South slop creates 10 main river basins and a grid of small streams and creaks, which constitutes high potential in hydro power, especially small and medium scaled stations.

3.2. Assessment of the hydro power development plan

3.2.1. Hydropower in the system

To 2025, according to data from Master Plan VI, the number of hydropower stations exceeding 50 MW to be built and operate is enormous (10 projects to 2005, 48 projects to 2025 with total expected capacity of 21,300 MW). However to the demand of the electric system in Vietnam, the ratios of hydro power per power of other energy are obviously fading out over time (power fell from 44% in 2005 to 24.2% in 2025, electricity from 30.8% in 2005 to 14.1% in 2025). The reason for that decrease lies in the fact that demands keeps raising while economic reserves of hydro power is limited and falling. That reflects the weakening role of hydro power in the electric system over time against the state's plan to build more hydro plants of various sizes.

To meet the increasing demand of loads and electricity, the Government encourages domestic and foreign enterprises to build small and medium scaled hydro plants. Therefore, in Master Plan VI, hundreds of hydro plants with capacity from 1 MW to hundreds of MW are to be built by domestic and foreign companies. Master Plan VI points out that the potential of small sized hydro plants under 30MW in Vietnam is estimated of 2,300MW, which could generate 8 billion kWh of electric power.

3.2.2. Challenges to hydro power development in Vietnam

The development of large hydro plants in a vacuum of systematic and comprehensive research and assessment of the hydropower development master plan may cause a number of disadvantages and negative impacts, as follows:

a. Risks from weather and natural conditions

The construction of a line of hydro plants, especially the big ones concentrated in the North, would cause risks from weather. Whenever droughts occur, especially in the dry season, hydro plants will not operate at adequate capacity. According to the National Regulation Center of Vietnam, between 2001 and 2005, a shortfall of hundreds of MW and millions of kWh occurred every year during peak hours in the dry season due to the lack of water inflows to hydro plants. The system had to dismiss a significant load of 200-300 MW.

To overcome this, in the chosen plan on sources development in Master Plan VI, along with hydro power, coal fueled plants in the North, gas fueled plants in the South will also be built to balance demand-supply in each region and interregional transmission will also be set up to cover the shortfall in each region.

Since hydro power is the major source in the system, the plan sets reserves for the drought seasons to secure the whole system, namely: to 2010, the reserve rates are 29.1% and 33.5% for raining seasons and drought seasons, respectively; to 2015 are 28.9% and 30.2%; to 2025 are 23.5% and 22.7%, respectively.

b. Risk from equipment supply and engineering and capital

According to the electric sources development plan for 2003-2010, 29 hydro projects would be built with capacity above 50MW and tens of projects under 50MW. That has not taken into account the risk from engineering and supplying hydro equipment. Due to the restrain capability of the mechanical sector in Vietnam, most of hydro equipment is imported (from EU, India, Russia and mainly from China). In practice, the delay of 6 months to 1 year in construction of hydro power stations and provision of electricity to grids against the plan is mainly due to a delay in supply of equipment. In addition, the financial risk is also a considerable one. Capital arrangement capacity is also another factor which leads to the delay because large dams require vast investment.

c. Impacts on natural and social environments

Irrigation-Hydro projects have been able to regulate water flows for human being's use. In practice, as a result from the planning and construction hydro projects, the environment has been effected, thus doing harm to the water resources, as follows:

- Flowing water from one basin to others is common in small sized hydro projects to combine flows of water from various basins. That leads to exhaustion of water resources, and harms to the environment.
- Impacts on the biodiversity and ecosystems, effects of water flows at downstream on erosion and sedimentation and changes of sub-climate in flooded areas cause negative consequences to the environment of the project areas and the areas around the projects, which consist of hidden and unpredictable challenges to the monitoring and control of the projects.
- Downstream of rivers where hydro plants are built will dry up after the construction finishes. Many projects cause drought at river downstream in a wide area, thus posing impacts on agricultural cultivation and households' use in the areas.

- The construction of reservoirs of various sizes is associated with resettlement. The resettling people are faced with difficult living standards. Flood land and houses cause big challenges to hydro development, which should be addressed with concrete policies.
- Chapter 13 of Master Plan VI is on "Environment and Environmental Protection in Energy Development", yet impacts of large hydropower haven't been categorized and evaluated fully. It is necessary to build a monitoring and evaluation and data system from the project feasibility study, construction and operation.

d. Other related issues

Development of small scaled hydropower is an appropriate policy to bring into full play of renewable energy and meet the demand of the power system, especially in the distant areas. To realize this policy it is necessary to address the following related issues:

- Electricity pricing is important to appraise the feasibility of the project. The Government encourages small hydropower investors to negotiate the prices. However due to the current rigid framework and the application of pricing cap, many small hydropower projects have been unable to implement.
- Since small hydro plants are usually located in the remote areas, the transmission is a challenge to their overall investment, thus affecting the feasibility of the projects. As transmission master plans in provinces have not been completed, there lacks support from the government to the development of small hydro power.
- According to water flow forecasts, the water resources become exhausted. The resources have been used for various purposes, such as watering, running water, making hydropower... Therefore, it is necessary to coordinate among water users on the basis of energy efficiency and economic targets, and to introduce a comprehensive model of water utility.

3.2.3. Calculation outcomes

Table 3-1: Plan on construction and operation of hydropower plants with capacity exceeding 50MW in 2003-2010

No	Project	Capacity (MW)	Time to finish and put in operation
1	Sê San 3	260	2005-2006
2	Tuyên Quang	342	2006-2007
3	Đại Ninh	300	2007-2008
4	A Vương I	210	2007
5	Thác Mơ	75	2008
6	Quảng Trị	70	2007
7	Đăk Rinh	100	2007
8	PleiKrong	100	2008
9	Bản Lả	300	2008
10	Đồng Nai 3+4	510	2009-2010
11	Sông Tranh 2	162	2009
12	Sông Côn 2	57	2009
13	Buôn Kuốp	280	2008-2009
14	Sông Ba Hạ	220	2010-2011
15	Thượng Kon Tum	220	2010-2011
16	Bản Chát	200	2010
17	An Khê + Ka Năk	173	2009
18	Sơn La	2400	2009-2010
19	Buôn Tua Sha	85	2009
20	Srêpôc-3	180	2009-2010
21	Sê San 4	330	2011
22	Cần Đơn	72	2003
23	Sê San 3A	108	2006
24	Spok Phu Miêng	54	2006
25	Đakr Tih	72	2007
26	Thác Muối	53	2007
27	Na Le	90	2007
28	Cốc San - Chu Linh	70	2007
29	EakRông Hnăng	65	2008

Table 3-2: Plan on construction and operation of hydropower plants with capacity exceeding 50MW after 2010

No	Project	Capacity (MW)	Time to finish and put in operation
1	Huội Quảng	560	After 2010
2	Lai Châu	1200	
3	Dăk My -4	210	
4	Nậm Chiến	175	
5	Hua Na	195	
6	Sông Bung -4	200	
7	Bản Uôn	250	
8	Đồng Nai 2	80	
9	Đồng Nai 5	100	
10	Sông Bung 2	126	
11	Bắc Mê	280	
12	Đăk My I	210	
13	Đức Xuyên	100	

Source: Decision 40/2003/QĐ-TTg on sources development plan to 2010 and beyond

3.3. Analysis of the impacts of hydropower on the environments

3.3.1. Positive impacts

- Effectively combined use of water resources help prevent floods, improve irrigation, reduce consumption of other fossil fuels and bring down carbon emission, which benefit the natural environment. Besides, associated reservoirs create beautiful landscape views.
- The construction of hydro plants creates jobs for people.

3.3.2. Negative impacts

- The disintegrable, adjustable, overlapping master plans pose impacts on forests and basins, making changes in river streams and flowing speeds, thus creating sedimentation, and erosion. Reservoirs create floods, which change the ecosystems and destroy their diversity. That may cause changes in the climate of the sunken areas. Besides, there might be the possibility that creating big reservoirs may also lead to earthquakes.

- Big reservoirs cause massive resettlement, which changes living conditions and the cultural environment of ethnic groups in the region.
- In many hydropower projects, such as Hoa Binh, Thac Ba, the related environmental and social issues have not been completely addressed decades after the construction of the plants. The negative impacts on the environments always remain hidden, making it difficult to evaluate and control.

3.3.3. Addressing the impacts

To minimize negative impacts on the environments, Master Plan VI proposes a number of general solutions for planning hydro power and providing econo-technical measures for residents to be resettled, as follows:

- Accomplishment of the master plan of national hydro power in the power system.
- In every project, impacts on the environments must be considered and appraised.
- Provision of long-term soft loans without collateral to the resettled households in the beginning to stabilize their living condition and promote the household economy.
- Funding for rural infrastructure (roads, irrigation, electricity, running water...) from domestic and foreign sources.

The analysis of environment impacts in Master Plan VI lacks supporting statistics to quantitatively calculate costs and effects caused by the construction of hydro plants. Besides, Master Plan VI takes no consideration of the hidden threats to the environments due to the massive, unplanned, uncoordinated administration of master planning of hydropower in provinces.

3.4. Conclusions

To maintain an annual socio-economic growth rate of 8%, it is imperative to ensure energy security, including load coverage. The state policy in this regard is to make full use of all sources of energy and cooperate with neighboring countries to ensure adequate provision of power according to the Master Plans.

Vietnam has a great potential of hydro power. Hydropower is a source of renewable energy. Therefore, it has been encouraged to develop. However, large dams can cause negative environmental and social impacts. From 1996-2000, 30 hydropower stations with capacity above 50MW and hundreds of small and medium scaled stations with capacity under 50MW were built. In the future, 42 large hydropower plants with capacity above 500MW will be built. If this is not carefully planned and done, it will be difficult to control the negative impacts. However due to restraint potential, according to Master Plan VI, the role of hydropower will fall gradually. Thermal power has become the leading source of energy in the system in Vietnam.

Master Plan VI proposes some recommendations to minimize the negative impacts of hydropower on the environment, but there should be more detailed procedures and methods to minimize these impacts in the most effective and least costly way.

IV. RENEWABLE ENERGY

4.1. Sources of renewable energy in Vietnam

Being an agricultural country, having monsoon tropical climate, 3,200km long coast receiving winds from the ocean, and a vast sea area, Vietnam has diverse natural energy resources, including almost all available resources in the world, as follows:

- Wind energy
- Solar energy
- Small and micro hydropower
- Geothermal energy
- Biomass
- Biogas
- Oceanic energy sources, such as tides, streams, waves

The research and development on making use of these above sources has been paid attention for many decades in Vietnam. Although the outcomes of that research and development throughout the country remain limited, which falls short of building a reliable scientific basis to exploit these sources, the outcomes has initially proved the need, role and efficiency of the renewable energy and the feasibility and possibility of developing these sources, especially in the remote areas that have no access to the national grid.

4.1.1 Wind energy

(i) Potential

To assess the potential of wind energy in Vietnam, hydrographic and meteorological agencies have collected and processed statistics of wind for many years to evaluate wind mechanism and potential of this energy throughout the country.

According to the observation and calculation, the strongest wind blow in Vietnam is found in the Eastern islands with annual average speeds measured in distant islands as follows: 7.6m/s in Bach Long Vi, 6.3m/s in Spratley , 6.8m/s in Phu Quy, 4.9m/s in Hon Dau, 4.4m/s in Co To. In some mountainous areas with special topography, annual average wind speed reaches

4m/s. Inland wind speed is found insignificant. Accordingly, the potential of wind energy increases from the inland to the Eastern islands.

However, these findings are limited since statistics can only be gathered at 10m height at the meteorology stations, where it is not suitable for gather appropriate wind statistics. Besides, equipment for gathering the data is obsolete and on the basis of interval measuring mechanism. Therefore, the calculation outputs do not reflect accurately the potential of wind energy in Vietnam. Yet, they could provide an overview of wind mechanism and potential of wind energy at low latitude throughout the country and in the islands.

Recently, some research institutes and companies measures wind blow at the coastal line and islands in the North and the Central at 30-60m latitude in proper locations with continuous measuring mechanism and modern equipment. The results are found optimistic, which presents a prospective of effective exploitation of wind energy in some coastal areas in Vietnam.

According to the assessment of wind energy in the Southeast region by the World Bank, Vietnam has the biggest potential of 100,000MW. Vietnam has good-excellent wind mechanism at 65m latitude with annual average wind speed of 8-9m/s, which is suitable for building high-capacity wind power plants. 9% of the total area of Vietnam can exploited wind energy.

As a result of the research and development in Vietnam and the assessment of the World Bank, it would be optimistic of the potential of wind energy in Vietnam, which allows not only to set up small and medium scaled wind mills in the remote areas, but also to build vast wind power plants to supplement to the power system in Vietnam. To make it happen, it is necessary to carry our basic research and evaluation of this energy and application of modern technologies, especially in the highest potential areas.

(ii) Application of wind energy

The application of this energy has long been carried out in Vietnam with early purposes to pump water, generate power in the remote areas having no access to the national grid. Many national projects and foreign supported projects on research and development, especially production of small capacity wind power equipment as well as introduction of foreign technologies to Vietnam have been implemented. However the results remain limited with low quality, small scale and lack of sustainability.

Recently an 800kW diesel fueled-wind mixed station was built in Bach Long Vi Island. That is the first station of this kind in Vietnam using modern technology. The success of this station proves the possibility of developing high-capacity wind power stations in Vietnam.

4.1.2. Solar energy

(i) Potential

Vietnam has a vast potential of solar energy, especially in the Central and the South, where sunshine remains almost throughout the year.

Solar energy is proved to be the biggest and stable renewable energy in Vietnam for present and long-term use. However, this energy source scatters unevenly throughout the country due to the topography. Besides, the radiation intensity of solar energy remains insignificant in Vietnam and changes randomly. Therefore, the potential of solar energy varies across regions, as shown in Table 4-1

Table 4-1 Data on radiation intensity in Vietnam

Region	Hours of sunshine/year	Radiation kcal/cm^2/year	Application possibility
The Northeast	1500-1700	100-125	Low
The Northwest	1750-1900	125-150	Medium
Northern Central	1700-2000	140-160	Good
Central Highlands, Southern Central	2000-2600	150-175	Very good
The South	2200-2500	130-150	Very good
Average	1700-2500	100-175	Good

In the Northeast, including the provinces of Cao Bang, Bac Kan, Lang Son, Tuyen Quang, Thai Nguyen, Vinh Phuc, Bac Giang, Bac Ninh, Quang Ninh, sunshine appears most in May-

October with total average radiation intensity of 3,600Wh/m2/day. In some mountainous areas the total average radiation intensity can not exceed 3,600Wh/m2/day due to frog and cloud.

In the Northwest, including the provinces of Lai Chau, Son La, Lao Cai, Ha Giang, Yen Bai, Phu Tho, Hoa Binh, due to its topography, it is divided into 2 sub regions, as follows:

- The under 1,500m height region: sunshine appears most in March-May with total average radiation intensity exceeding 3,500Wh/m2/day, reaching 5,831Wh/m2/day in some places.
- The above 1,500m height: sunshine appears most in August-May with the average radiation intensity exceeding 3,600Wh/m2/day.

In the Northern Central, including the provinces from Thanh Hoa to Hue, sunshine appears most in April-October with an increase of radiation intensity when going South, in which the total average intensity exceeds 42,300Wh/m2/day.

In the Red River delta, including the provinces of Hanoi, Hai Phong, Ha Tay, Hai Duong, Hung Yen, Ha Nam, Nam Dinh, Thai Binh, Ninh Binh, sunshine appears most in May-October with the average radiation intensity from 3,900-4,100Wh/m2/day, which ranks medium throughout the country.

In the Central Highlands, including the provinces of Gia Lai, Kontum, Dac Lak, Dang Nong, Lam Dong, sunshine appears most in July-September with total average radiation intensity exceeding 4,500Wh/m2/day,

In the Southern Central, including the provinces of Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, sunshine appears most in March-October with total average radiation intensity exceeding 4,500Wh/m2/day, in some months reaching 6,500Wh/m2/day.

In the Southeast, including the provinces of HCMC, Binh Phuoc, Ninh Thuan, Tay Ninh, Binh Duong, Dong Nai, Binh Thuan, Ba Ria-Vung tau, sunshine appears almost throughout the year with total average radiation intensity exceeding 4,500Wh/m2/day, which is the most appropriate areas for applying solar equipment.

In the Mekong delta, including the provinces of Long An, Dong Thap, An Giang, Tien Giang, Vinh Long, Ben Tre, Kien Giang, Can Thom Hau Giang, Tra Vinh, Soc Trang, Bac Lieu, Ca mau, sunshine appears almost throughout the year with total average radiation intensity exceeding 4,500Wh/m2/day, which is the most appropriate areas for applying solar equipment.

From the statistics, it appears that Vietnam has a high stability of radiation intensity, especially in the South, thus having a high potential of solar energy, which can be used to provide heat and electricity to the remote areas, help dry agricultural products. In the next 15-20 years with the increasingly competitive prices and the improvement and diversification of solar technologies, solar energy will become a vast source of renewable energy, a main and strategic solution of sources not only for power provision to the remote areas but also supplement to the state system, thus ensuring energy security and environment protection.

(ii) Application of solar energy

Solar energy is used to provide electricity and heat. In terms of power, about 6,000 small solar power stations with total capacity of 750kW have been installed in the mountains and islands, half of which is used for telecommunication, 30% is used for public power for the community centers, schools, clinics... and the rest is for household use.

To 2004, the total capacity of PVs in Vietnam is 800kW and classified in 3 groups: (i) installation in the special facilities, accounting for 50%, (ii) installation in the public offices, hospitals, condensed residence, recharging stations, accounting for 30%, and (iii) installation in households, accounting for 20%.

There has been early use of PVs in the South. Many 500-1,000Wp stations have been installed to charge batteries for household use, 250-500 Wp stations for hospitals, clinics, community centers, 22.5-50 Wp stations for household use.

In the Central, there are 2 projects with biggest capacity in Vietnam:

- PV-hydro mixed power with capacity of 125 kW, of which PV capacity alone is 100kW. The project was put in operation in Gia Lai province since 1999 under the sponsorship of NEDO.

- PV-wind mixed power with capacity of 9kW, of which PV capacity alone is 7kW. The project was put in operation in Kon Tum province since 2000 under sponsorship of Tohuku electric corporation, Japan, and EVN.
- About 165 household-leveled PVs were also installed in Gia Lai, Quang Nam, Binh Dinh, Quang Ngai, Khanh Hoa with capacity of 40-50 Wp/house. About 25 200-800Wp PVs were installed for community use.

In the North, the application of PVs is later than in the South, however the introduction of PVs for households in mountains, islands and borders was faster. To 2002, 450 40-75Wp PV stations have been installed for household use, 94 165-300Wp PV stations for border guards and islands, 42 165-525Wp PV stations for clinics and schools.

In Quang Ninh, there are 2 PV projects funded by the State, as follows:

- 3 billion VND project with capacity of 20kWp, implemented by the Institute of Energy and the Center of Renewable Energy at Hanoi Polytechnic University since 2001.
- 15kWp PV station set up by the Institute of Energy in Coto island in 2001.

VP Solar corporation, Australia, helped with a 150Wp PV project for public lighting and a 400Wp station for storage of vaccines in Cao Bang province.

Another PV pilot project funded by Norwegian Government was introduced in Lang Son province in 2002 with total capacity of 3,000Wp for electricity and radio stations of the communes.

Besides, about a 95,000Wp capacity has been used for telecommunication and marine navigation. Some 805kWp project is to be implemented in the mountainous areas.

In terms of heating, there has been research and development of low-cost long-run water-heating devices used in households, restaurants, hotels. Although these devices are suitable for commercial purposes, they have not been widely introduced and used in Vietnam due partly to the under-awareness of the people.

4.1.3. Geothermal energy

According to geological assessment, there are 300 natural hot springs with surface temperatures of 30-40oC mainly found in the Northwest and Northern and Southern Central.

In practice, Vietnam has found 269 hot spring sites, of which 30 sites are identified to be used for geothermal power with large scale to produce 340MW power.

Geothermal energy can be used for heating and generating power. However, due to shortage of budget, only surface research was conducted without drilling for samples, thus falling short of properly assess of the geothermal potential in Vietnam.

In Vietnam, geothermal is only used for therapy not for generating power. Forecasts show a theoretical capacity of 472MW, of which 200Mw will be in use in 2020 mainly in the Central.

In terms of exploitation scales, the natural, econo-technical conditions in Vietnam do not allow to build big hubs like those in developed countries. Learning the experiences of France, China, the Philippines, Thailand..., the installation of pilot power stations with small capacity is not require big investment while serves best lives and production of small residency, especially in remote areas, which is appropriate to Vietnam.

According to the research, the future stations in Vietnam are as follows:

No	Name of the stations	Capacity (MW)	Location
1	Mộ Đức	3x6,2	Quảng Ngãi
2	Hội Vân	3x5,1	Bình Định
3	Lệ Thuỷ	3x7,1	Quảng Bình
4	Tu Bông	3x5,1	Khánh Hoà
5	Nghĩa Thắng	3x5,1	Quảng Ngãi
6	Đảnh Thạnh	3x3,8	Khánh Hoà
	Total	97,2	

Potential geothermal areas in Vietnam

No	Place	Geochemical ratios						pH	M (g/l)	Temperature (^{o}C)	
		Na/K	Na/Ca	Cl/Ca	Cl/B	Cl/Li	Cl/Rb			Suffice	underneath
Northwest, North											
1	Na Hai (Sam Mứn, Điện Biên)	14,23	5,67	0,34	5,11	9,68	372,67	7,3	0,41	78,0	192,0
2	Pom Lót (Sam Mứn, Điện Biên)	23,85	1,13	0,17	6,13	16,06	2372,91	6,8	0,51	74,0	150,4
3	Nà Ban (Than Uyên, Lai Châu)	2,60	0,01	0,00	57,74	11,12	855,83	7,8	1,67	36,7	199,1
4	Mường Lói 2 (Điện Biên)	25,80	0,63	0,04	7,33	12,12	1779,69	6,8	0,41	36,5	140,0
5	Bản Sáng (Tuần Giáo, Điện Biên)	2,25	0,06	0,02	43,24	57,85	715,17	7,3	0,58	50,5	225,6
6	Nậm Păm (Mường La, Sơn La)	8,75	0,30	0,04	583,74	11,79	485,79	7,5	0,74	55,5	192,2
7	Pác Ma (Mường Tè, Lai Châu)	19,11	5,27	0,49	8,60	33,02	1337,60	7,1	0,37	62,5	169,1
8	Quỳnh Châu (Hưng Hà, Thái Bình)	9,65	0,92	0,45	274,93	570,36	-	8,1	0,24	37,2	187,8
Northen Central											
1	Bang (Lệ Thủy - Quảng Bình)	13,45	65,50	3,53	17,17	35,46	71,52	8,3	0,53	100,0	214,0
2	Sơn Kim (Hương Sơn Hà Tĩnh)	14,86	25,06	2,77	6,68	39,35	155,79	7,9	0,23	78,0	189,0
3	Huyện Cổ (ĐăKrông- Quảng Trị)	9,97	7,54	3,65	60,77	150,52	377,69	7,9	0,51	70,2	189,0
4	Dương Hoà (Hương Thủy - Huế)	11,71	12,11	12,91	414,05	275,19	1005,87	7,7	0,85	68,0	189,0
5	Kim Đa (Tương Dương-Nghệ An)	20,04	13,87	1,20	52,69	30,64	172,82	7,6	1,06	73,5	162,9
Southern Central											
1	Thạch Trụ (Mộ Đức, Quảng Ngãi)	24,54	6,21	8,39	3125,10	208,25	3002,59	7,5	4,91	80,0	163,0
2	Hội Vân (Phù Cát, Bình Định)	30,09	39,68	1,03	539,30	147,04	1674,48	7,0	0,53	85,0	147,0
3	Bình Châu (Bà Rịa, Vũng Tàu)	46,10	6,46	7,12	2839,70	328,63	9411,70	7,7	3,64	83,0	154,0
4	Tu Bông (Vạn Ninh, Khánh Hoà)	42,66	32,21	31,51	5466,00	577,35	430,57	8,4	0,68	77,0	143,0
5	Nghĩa Thắng (T Nghĩa, Quảng Ngãi)	32,49	40,46	31,30	346,27	175,40	3330,65	7,0	0,62	78,0	146,0
6	Thạch Bích (Trà Bồng, Quảng Ngãi)	34,76	27,34	18,21	3494,70	266,19	3866,12	7,8	0,45	65,0	145,0

4.1.4. Other renewable sources (biomass, biogas...)

Bioenergy accounts for 15% primary energy in the world and 38% in developing countries. In those countries, burning directly biomass for heating, drying in rural households, and providing heat for local industries is common. This kind of use presents a low efficiency of energy transformation. In practice, a more efficient use of biomass can provide 3-4 times as much energy as in the traditional ways of using.

Biomass consists of rice husks, sugar cane bagasse, wooden wastes and others. The potential is calculated on the basis of each biomass in Vietnam, as follows:

a. Potential of rice husks:

Based on the analysis of waste/product of various rice samples:

- Dried straw-dried rice ratio: 1:1
- Dried husk-dried rice ratio: 1:5
- Dried straw used for fuel accounts for 30% of the total
- Dried husks used for fuel accounts for 50% of the total

Given the rice production in 2002 in Vietnam was 32.5 million tons, the amount of straw and husks would be 32.5 million tons and 6.5 million tons, respectively. Based on the rice productivity, the potential of rice husks sources is calculated at Table 4-2.

Table 4-2. Potential of rice husks for power across regions

Region	Theoretical potential (Million tons)	Exploitation ratio (%)	Practical potential (million tons)
Whole country	6,504	23	1,5
Red river delta	1,289	-	-
Northeast	0,445	0	0
Northwest	0,086	0	0
Northern Central	0,586	0	0
Coastal southern Central	0,341	-	-

Central Highlands	0,123	0	0
Southeast	0,330	-	-
Mekong delta	3,54	46	1,5

b. Potential of sugarcane bagasse

Besides rice production, Vietnam also produces vast amount of sugarcane. The leftover after harvest and sugar production creates a big source of fuel, which can meet the demand for energy of sugar factories and residents in the sugarcane planting areas. According to research and surveys, 1 ton of sugarcanes could make 300kg bagasse with 50% humidity and release a heat of 7.8Mj/kg. This is a local fuel source used for thermal purpose to generate power for local use.

According to statistics in 2002, the potential of sugarcane bagasse is shown as follows:

Table 4-3: Potential of sugarcane bagasse across regions

Region	Theoretical potential (Million tons)	Exploitation ratio (%)	Practical potential (million tons)
Whole country	4,5	63	2,80
Red river delta	0,038	0	0,00
Northeast	0,170	35	0,006
Northwest	0,147	41	0,006
Northern Central	0,764	96	0,734
Coastal southern Central	0,667	75	0,503
Central Highlands	0,035	75	0,265
Southeast	0,761	78	0,594
Mekong delta	1,555	77	0,95

c. Potential of wooden wastes and other biomass:

Wastes from wood processing include wooden powder, wood residues..., accounting for 60-70% of the wooden material. In 2002, given the finished wood was 800,000m3, wooden wastes was estimated 800,000 tons. Besides agriculture residues, such as coffee bean, peanut skins, corn tree and curb can also be used for fuel. The potential of these fuels is shown as follows:

Table 4-4: Potential of wooden wastes and coffee bean skin

Biomass	Theoretical potential (Million tons)	Exploitation ratio (%)	Practical potential (million tons)
Coffee bean skin	0,075	-	-
Wooden waste	0,8	10	0,08

Table 4-5: Potential of biomass

Biomass	Theoretical potential (Million tons)	Exploitation ratio (%)	Practical potential (million tons)
Rice husks	6,504	23	1,5
straw	32,500	-	-
Bagasse	4,500	63	2,80
Sugarcane leaves	2,000	80	1,60
Coffee bean skin	0,075	-	-
Wooden waste	0,8	10	0,08

According to the assessment of the Ministry of Industries, the potential biomass in Vietnam is 43-46 million TOE/year, of which 60% is from wood, 40% from farm residues.

Power generation and co-generation from biomass sources is estimated by EVN at 250-400MW.

Due to high cost and scattering sources of inputs, bio-energy technologies have not developed in Vietnam, which falls short of its potential.

Small hydropower mainly developed in the Northern mountains and the Central accounts for 10% of the total hydropower in Vietnam, which is currently exploited effectively, helping supplement the national power system, especially in the remote areas.

Biogas is mainly used for cooking, lighting and generating power. Main inputs to produce biogas include animal originated agents and plant residues. Energy from biogas is not only a useful fuel, but also constitutes a solution for the environment in rural areas.

Vietnam remains an agricultural country with 80% residents living in the rural. Husbandry is developing in rural areas. Many big concentrated farms have been set up, which creates abundant sources of materials for bio-energy. The potential of biogas is projected high. Tens of thousands biogas cells have been built in the rural in Vietnam. It is necessary to learn from the previous experiences, find appropriate, sustainable and highly efficient technologies.

Besides the above energy resources, Vietnam can make use of marital energy resources such as wave, tide, stream energy... However, a lack of basic research and survey prevents it from assessment of the full potential of these energy resources.

4.2. Comments

In the Master Plan, the renewable energy issues was mentioned and considered, however the role of these sources in the next 15-20 years is projected insignificant in all development scenarios.

In the base scenario, to 2015 total capacity of renewable sources is projected at 1,270MW (4%) with electricity production of 3.3 TWh (1.7%); to 2020, it is 1,700MW (2.8%) and 5.1 TWh 91.7%); to 2025, it is 2,300MW (2.7%). These are low targets compared with those in other countries and even in the ASEAN countries.

The consideration and calculation of renewable energy in Chapter VII of the Master Plan have some drawbacks:

- It should come to an agreement of terms used in the Master Plan. For example, instead of using "new energy, renewable energy, new and renewable energy, small hydro and renewable energy", it should use only one term "renewable energy" to present small hydro power (under 10MW capacity), wind energy, geothermal, biomass, biogas, marital energy.
- There is no elaboration of each type of renewable energy nor specification of database used for calculation and selection of a combined source of renewable energy. It should

also identify targets and coefficients regarding capacity and power of various renewable sources in the Master Plan.

- Although the renewable energy is given priority for development in the Master Plan, in each plan there is no clear reflection of that priority.
- Data for assessment of renewable energy are simple, inaccurate and insufficient. Consequently, using these data to select a source development plan has no reliably scientific basis.
- The renewable sources in Vietnam listed in the Master Plan are insufficient. Even for the mentioned sources, the presentation is primitive and insufficient, which lacks analysis of their role, econo-technical features, prices, roadmaps for development in the time to come...
- In the world trend of utility industry, besides the traditional centralized solution, the new tendency of “decentralization” of utility close to loads is currently paid adequate attention. In the next 15-20 years, this trend will present an efficient, feasible and proper solution for sources of renewable energy. This should be considered in the planning of the national power.
- It should be stress that renewable energy has a strategic role in the next 15-20 years as both off-grid supply to remote areas, islands and supplement to the grid.

In conclusion, in the master plan, the use of renewable energy in Vietnam has not been put in a fair place to its potential and necessary, taking into account the big picture of national system and energy security. It is imperative that the Master Plan reconsider viewpoints and policies and measures to appreciate and develop these invaluable sources of energy.

In the short-run, it should be widely recognized that renewable energy is a clean, potential and strategic energy and should be given priority to develop.

For the 2006-2010 period, it is important to carry out basic research and surveillance the potential of renewable energy in a systematic manner to provide a basis for strategic planning of this energy in the coming periods.

V. CONCLUSIONS AND RECOMMENDATIONS:

5.1. General Conclusions

It is possible to say that Vietnam has made progresses in the national power planning. Recent Master Plans have enabled Vietnam Electricity to enter quick development basically meeting the power demands for socio-economic development. However, it is necessary to have more comprehensive research for these Master Plans. The methodologies and results of Master Plan VI have shown substantial changes, though some parts lack reliability and persuasiveness.

Article 8 of the Law on Electric Power of Vietnam states that national and local power development plan (PDP) is to be made and approved to serve as the basis of electric investment and adjusted according to the national socio-economic development plan and strategies. The PDP should be made for 10 years with vision for the next 10 years.

Article 9 of the Law on Electric Power of Vietnam states that the Ministry of Industry organizes the construction, including the contents, procedures, guidance, monitoring, verification and examination of the PDP, and submits to the Prime Minister.

The Institute of Energy under EVN is appointed by Ministry of Industry in building the PDP; the Ministry of Industry forms an appraisal committee to receive opinions from relevant ministries and offices and submits the PDP to the government for approval. The procedure follows Article 8 and Article 9 of the Law on Electric Power of Vietnam issued in 2005, yet there remain some shortcomings.

The power system is an essential element in the national energy system with close relations to energy branches and the social, economic development and the environment. As a result, the PDP built for 10 years with the vision for the next 10 years is only optimum with the appropriate socio-economic development plan. The PDP is built by only one institute under EVN lacking cooperation among other institutes under various energy sub- branches and social, economic institutes. This leads to the lack of data and experts to make the PDP more objective.

The limitation is clearly shown in the PDP outcomes as follows:

a. Limitations related to the implementation of Vietnam power development strategy from 2004 – 2010 approved by the Prime Minister's Decision 176/2004/QĐ-TTg dated Oct 5, 2004:

The strategy states clearly: "Acceleration of research and development of alternative energy to meet the power demand, especially in remote and island areas". In the PDP VI, this is not well reflected. Research by domestic and international evaluated the potential for these alternative energy resources (wind, solar, biomass, tidal, biogas, biofuel, biodiesel) is large. However, the data on these sources are rough inadequate and inaccurate. As a result, the data of these sources in the PDP needs to be reconsidered. Close attention and research should be paid to the exploitation of these resources from 1006 to 2010, and this task should be a strategic task because in the future, these alternative energy resources shall have a significant role in power development.

In addition, the power development strategy states: "Forming of a competitive power market and diversification of power investment and business, encouragement of the participation of various economic sectors and disencouragement of enterprises' monopoly." This content is reflected in the PDP in terms of power policy without detailed recommendations on the formation and development of a competitive power market and diversification of investment and especially the influence of these trends on power planning outcomes. Besides, other recommendations of energy sub-branches have not been paid close attention to in the PDP such as: power generation from low quality coal under 4.850 Kcal/kg by the Coal and Mineral sector, pricing structure (floor and ceiling prices) applied to small hydro power and alternative energy investors.

b. Limitations on sources calculation:

Due to the lack of energy data, electricity demand orientations have been projected based on slow long-term socio-economic development plan. As a result, the only method used is the energy elasticity based on GDP scenarios. The plan presents a local accumulative calculation approach not bases on data from other industrial sectors such as coal, gas and oil, etc. In addition, as far as renewable energy is concerned, only tentative statistics are available, but in general are incorrect, and unreliable to have a comprehensive assessment of these sources' potential. It is necessary to reconsider the forecast of possible uses of such sources as geothermal, wind power, solar energy, biomass, biogas, oceanic power and other renewable energy (biofuel, biodiesel...) and DSM in the Master Plan.

c. Limitations on input data for optimum power development:

Input data in source calculation in the PDP is limited. From the data in the PDP, we can see that coal, gas and hydraulic resources are not enough for development, and renewable energy resources data are not available or very limited, which leads to difficult options in power development. Over calculation in power demands, power reserve and limited data availability has made the PDP put into use all energy resources that have feasible data for power generation. The power shortage is made up of imported power and future nuclear power development. It is possible to say that the PDP outcomes are rough in energy balance between power sources and power demands without breakthrough research in finding alternative energy as well as recommendations on optimum use between energy and power. There need to have more data from research on whether to boost coal production in the country or import coal from abroad and especially alternative energy and DSM solutions.

d. Limitations on capital mobilization:

The system reserve of above 30% after 2010 is high, thus forcing an increase in sources demand and the system capacity, consequently raising prices of electricity and reducing the operation efficiency of the system. As a result, it requires huge investment from the state.

Too high reserve margin is one of the main reasons that lead to the total investment in twenty years estimated at 80 billion USD, or 4 billion USD per year on average. This investment is too high, which pose a burden on the national economy. As demand tends to be high, sources must expand, especially in the absence of a clear and reliable reasoning of fund mobilization capability in Master Plan VI. That has been a weakness of all master plans developed so far, and a main reason for delays in implementation of the approved plans.

In the PDP, the optimum feasible solutions are not shown clearly. The PDP only shows the need for investment capital without showing where this capital will come from. As a result, the implementation is often behind schedule due to lack of investment.

e. Limitation of human resources:

The PDP is built by only one institute under EVN, thus lacking the experts from other institutes under various energy sub- branches and social, economic institutes. The PDP construction needs the participation of these experts to make it more transparent and objective. The appraisal includes representatives from relevant agencies such as Ministry of Industry, Ministry of Natural Environment and Resources, Ministry of Finance, Ministry of Agriculture and Rural Development, Ministry of Science and Technology, which follows the law, yet shows lack in cross examination among branches so the representatives' opinions are often too general or more qualitative than quantitative. Opinions from energy sub-branches such as the Coal and Mineral Cooperation are often overlooked.

5.2. Recommendations

5.2.1. Legal Framework

At present, Vietnam only has the Strategy on Power Development until 2010 according to the Prime Minister's Decision Number 176/2004/QĐ-TTg dated Oct 5, 2004. Long-term strategy until 2003 and further needs to be developed:

- National Policy on Energy, whose draft version has been available for a long time, should be completed and approved. The law and regulation on national energy including pricing policy renewable energy, DSM and IPP, SPP should be approved and implemented. Pricing policy should also be approved. This can serve as legal framework for power investors.
- The long-term Strategy on National Economic Development should be completed. For the past years, power, coal and oil and gas development plans have been based on the sector's orientation or data from other sectors without having official data from Ministry of Planning and Investment or the National Institute of Economics.
- The law on DSM has not yet been available. After years of DSM research and implementation, until the year 2003 the government issued DSM decree number

102/2003/ND-CP with guidance from the Ministry of Industry including labeling of power saving applicants together the pricing guidance from the Ministry of Finance. In 2006, the government has approved the National Strategy on DSM for the period of 2006-2015. These activities have helped in DSM, yet DSM law should be built and approved soon.

5.2.2. Organization capacity building:

Related Ministries, energy research institutes, corporations and other NGO should be equipped with energy planning capacity building, including critic capacity.

- The Strategy Institute under the Ministry of Planning and Investment should be equipped with capacity building to build long-term socio-economic development plan which includes the orientation for industrial sectors and energy sector.
- The Strategy Institute under the Ministry of Industry should be equipped with capacity building to organize long-term strategic PDP.
- The Committee on National Energy should be formed to conduct macro regulation on energy sub-sectors. This has been long recommended yet not implemented. This should be an objective organization with strategic vision to boost sustainable energy development.

5.2.3. Methodology:

It is necessary to make full use of available models for demand forecasts and energy planning, including such forecast models as MEDEES, MEAD, DDAS…, such planning models as WAPIII, EFOM-EVN, MARKAL, ETB, PDPAT2, STRATEGIST…, together with capacity building for consulting agencies. It is also needed to study comprehensively, making revisions to adapt to Vietnam's condition of economy, geography, environment, information shortage…

5.2.4. Finalization and revision of database:

Up-to-date and accurate data input is vital in power research but the recent available electric data is scattered and sometimes out-of-date and incorrect. Data should be collected, with appraisal, from various sources: statistics agencies, ministries and research institutes. Data should be objective and managed in a scientific and systematic way. Data related to environmental index in large power plants and new technology used in these plants should be monitored and is ready for uses in the PDPs.

5.2.5. Finalization of planning procedures:

The Ministry of Industry should take a lead in planning. The Ministry's Institute of Strategy should act as a focal point in organizing and coordinating other relevant agencies in building the master plan. Appraisal of the master plan should also be paid more attention.

Capable consultants in the PDP should be chosen from various institutes, not from one institute to combine their knowledge and insights as well as to exclude the possibility of data manipulation and monopoly.

The planning procedure should take into consideration the followings:

- The appraisal board should include experts and specialists from relevant agencies such as Ministry of Industry, Ministry of Natural Environment and Resources, Ministry of Finance, Ministry of Agriculture and Rural Development, Ministry of Science and Technology, and also from other NGOs such as VUSTA, and IPP, SPP, BOT representatives
- The appraisal time should not be too short. 2 months is appropriate.
- PDPs should be known to the public so investors can contribute idea and raise funds.

5.2.6. Techniques in planning:

The power system is an essential element in the national energy system with close relations to energy branches and the social, economic development and the environment. Hard power planning at present is not suitable for the socio-economic development of the country. To be able to make hard power planning, it is vital to have detailed socio-economic development plans available. In Vietnam, only the 5-year socio-economic development plan is up-to-date; other longer plans are not usually reliable and take long time. As a result, there should be a combination between the hard and soft power plans. The hard power plan should be built by independent power sectors to meet the index used in the 5-year socio-economic development plan. However, energy plants usually take long time and require huge investment, there should have soft power plan or orientation plan, which envisions the power development for the next ten years. This soft plan can be done in combination with the bottom-up strategy (from energy sub-branches) and top-down strategy (from the national socio-economic development plan.

In mapping the development plan, it is necessary to proceed thorough and integrated studies on requirements and possibility of the national socio-economic development from various scenarios from the worst one to the best one for 15-20 years, in every 5-year periods. Based on the outcomes of the studies, energy demands and load demands would be projected.

The 5-year hard plan should be built from the index in the socio-economic development plan and the orientation of the 10-year soft plan. This plan is the combination of other 5-year hard plan built by energy sub sectors such as EVN, Petro Vietnam and the Coal and Mineral Corporation. The office building this plan is responsible for updating data and reflecting changes in the socio-economic development and changes in the comprehensive energy planning.

The 10-year soft plan or the program for optimum calculation of mass energy system development, in appropriate with the socialist-oriented market economy and the energy, fuel potential of the country should be designed, to draw suitable plans for optimum development of the country's energy system and bring about a harmonious development among energy sub-divisions and power grids.

The master plan for comprehensive development of the national energy system, or so-called soft plan, must be set up by a national energy research institution (National Commission on Energy) headed by the Prime Minister and participated by other relevant ministries and agencies.

5.2.7. Research on master planning of national energy system development:

- Research on interdisciplinary energy: energy sub-divisions have close relations and can be substituted among each others. The main content of research is to study methodology and calculation programs, to identify a reasonable growth rate for each sub-division in the whole system, including coal, oil, hydro power, atomic power, renewable energy. The research outcomes have been used for making suitable strategy and policy on appropriate and integrated development of the mass energy system and its sub-divisions to ensure the goal of national energy security.

- Research on the linkage between energy development and socio-economic development and environment issues: to set up a methodology for study external relations between energy development and socio-economic development and environment issues in the international integration and the regional energy exchange. The research outcomes would create a scientific basis for the state macro regulation on sustainable development of energy, socio-economic and environment development. Studies on social and environmental impacts from exploitation and use of energy to propose solution, including CDM project. Studies on methodology and program on calculating reasonable prices of energy (electricity, coal, oil…) in the context of the socialist-oriented market economy and the regional integration.
- Research on technologies for exploitation and use of new and renewable energy in Vietnam: it is necessary to survey, evaluate the potential of the renewable energy in Vietnam to build an accurate database on wind power, solar energy, geothermal power, biomass, biogas, biofuel, oceanic energy… for studies and planning of effective exploitation and use of the new and renewable energy at industrial scales, as well as for application of new and advanced technologies in new and renewable energy areas.
- Research and development of effective and energy saving technologies (DSM): effective use and saving of energy in life and production is one of the important tasks of scientific research on energy, which unfortunately has not been paid adequate attention, thus being limited in the outcome, while it is common in every economic sector and in the society that energy is use with squandering, low efficiency, big loss.
- The research outcomes would create a scientific and practical basis for planning suitable development of energy system and making policies on the state macro regulation on energy to ensure the national energy security.

5.2.8. Planning for electricity development:

- Electricity development planning should be conducted in line with the 5-year fixed plans and orientation for the following 10 years.
- In forecasting electric demands in the plan, a number of models can be used, which must include the bottom-up model of forecasts. The 5-year plan on electric sources development should be built concretely on the basis of technical, capital elements,

timing of hooking up to electric grids, operation modes, environment and resettlement related aspects… In short, it is to ensure the timing of implementation.

- Planning for the following 10 years is based on the orientation of comprehensive development of the national energy system (top-down) and the branch's features (bottom-up).
- Calculation of demands should be conducted thoroughly with various models, in which it is necessary to focus on effective use of energy, solution to reduce the power intensity. Electricity development should be taken with the top-down approach and elasticity between GDP and energy.
- In terms of sources development balance, it is necessary to carefully study and competitively select between solving the fuel transportation problem (transport of coal from the North to the South, or import of coal) and transmission of electricity with 500 kV, two-switch wires. The policy on developing vast sources (grand hydro plants, electric generation complexes, atomic plants…) should be made with consultation with relevant ministries and agencies and the public to ensure the transparency of planning and gather supports for the implementation.
- Since the electricity branch is interested only in planning electricity development, no attention has been paid to addressing the thermal load demands. Consequently, the combination of electric and thermal sources development in condensed industrial zones, oil refinery plants, sugar factories, trade centers and apartment buildings… is neglected. Therefore, in the planning, it is necessary to pay adequate attention to the promotion of good policies on developing these sources.
- In consideration of sources development, the electricity branch should consider increasing investment to make more feasible planning. For the short fall of sources, it is necessary to open to investment from other social and economic sectors. In realizing the policy on diversification of electric sources and encouraging investors from outside the electricity sector to develop sources, it is important to clarify and make policies on transparent ceiling and floor prices of electricity generated from such projects as BOT, BOO, IPP, and transmission costs.
- In terms of new and renewable energy, it is necessary to make preferential policies and recommendations to the state on the development and use of the new and renewable energy.
- It is necessary to build an economic and financial analysis model in the master plan upon the features of the soft planning. Since the soft planning is the orientation, it is

imperative that economic and financial calculation and analysis of sources be conducted carefully and accurately based on inputs of available and reliable capability and targets for fund raising.

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