



---

# **STRATEGIC ENVIRONMENTAL ASSESSMENT OF THE HYDROPOWER MASTER PLAN IN THE CONTEXT OF THE PDP VI**

## **Energy Supply and Demand – Baseline Assessment**

---

**Hanoi, October 2007**

**(Draft)**

The views expressed in this paper are those of the author and do not necessarily reflect the views and policies of the Asian Development Bank, or its Board of Governors or the governments they represent.

The Asian Development Bank does not guarantee the accuracy of the data included in this publication and accepts no responsibility for any consequences of their use.

Use of the term “country” does not imply any judgment by the author or the Asian Development Bank as to the legal or other status of any territorial entity.

## TABLE OF CONTENTS

<b>Table of Contents</b> .....	<b>ii</b>
<b>List of Tables</b> .....	<b>iii</b>
<b>List of Figures</b> .....	<b>iii</b>
<b>1. Overview of Energy sector</b> .....	<b>4</b>
1.1. Primary Energy Supply and Final Energy Consumption .....	4
1.2. Issues and Challenges.....	4
<b>2. Power Sector</b> .....	<b>5</b>
2.1. Supply and Demand.....	5
2.2. Development Strategy .....	8
<b>3. Coal Sector</b> .....	<b>9</b>
3.1. Overview .....	9
3.2. Demand and Supply.....	9
<b>4. Oil and Gas Sector</b> .....	<b>11</b>
4.1. Overview .....	11
4.2. Oil Sector.....	11
4.3. Gas Sector.....	12
<b>5. New and Renewable Energy</b> .....	<b>13</b>
5.1. Biomass .....	13
5.2. Wind .....	15
5.3. Solar.....	16
5.4. Geothermal .....	16
5.5. Small Hydro.....	17
5.6. Tidal.....	17
<b>6. Identification of Key Drivers in Hydropower Development</b> .....	<b>18</b>
<b>7. Annexes</b> .....	<b>19</b>

**LIST OF TABLES**

Table 1-1: Balance of primary energy supply and demand (KTOE).....5  
Table 2-1: Electricity consumption by sector .....7

**LIST OF FIGURES**

Figure 2-1: Trend in power capacity ..... 6  
Figure 2-2: Trend in power generation and consumption .....6  
Figure 2-3: Electricity consumption by sector.....7  
Figure 2-4: Electricity consumption by region.....8  
Figure 3-1: Coal production by mining method ..... 10  
Figure 3-2: Coal consumption ..... 11  
Figure 4-1: Crude oil production and export .....12  
Figure 4-2: Petroleum product import .....12  
Figure 4-3: Natural gas production trend.....13

## **1. OVERVIEW OF ENERGY SECTOR**

### **1.1. Primary Energy Supply and Final Energy Consumption**

Vietnam is endowed with many kinds of energy sources such as coal, oil, natural gas, hydropower etc... In order to meet growing energy demand of the economy, Vietnam energy sector has developed significantly during recent years in all aspects of exploration, exploitation, production, transmission, distribution, export / import. Energy sector in Vietnam currently is under management of Ministry of Industry and Trade (MOIT).

Vietnam currently has a interconnected power system from the North to the South via 500 kV lines. The power system includes several types of power plants such as coal fired, gas fired, CCGT, hydropower, oil fired power plants. Major electricity load centers are located in the North (Hanoi) and the South (Ho Chi Minh city). Coal resource is mainly located in the North of the country (more than 90% of total coal reserve). Coal is mainly used for power generation, industrial sector and export. Oil and gas resources have been explored mostly in the South. Almost domestic crude oil has been exported while petroleum products imported from outside because of very small refinery capacity is under operation at the moment. The first refinery is expected to start working in 2009. Natural gas has been exploited off-shore since 1995 (associated gas) and transported to mainland via gas pipeline. Downstream market for natural gas has been developing in the South. Looking at renewable energy potential and current use, the proportion of renewable energy use is very low. Most basic use of renewable energy in Vietnam is combustible biomass. An accuracy evaluation of potential for each energy source is currently needed.

Along with very high growth rate of energy demand, the energy sector is facing issues and challenges such as energy security, geographical distribution of resources and demand, reform process etc...

Domestic energy production in 2005 was 45.97 MTOE, in which coal production was 18.90, crude oil 18.86 MTOE, natural gas 1.84 MTOE and hydropower 1.39 MTOE. The average growth rate of energy for the period of 1990-2005 was 14.8%. GDP elasticity with respect to energy production was 2.0 with the economic growth for the same period was 7.55% per year.

Vietnam exports crude oil and coal while imports petroleum products. In 2005, net energy export is of 18.2 MTOE.

Total final energy consumption in 2005 was 21.80 MTOE and the annual growth rate for the period of 1990-2005 reached 11.6%. During the same period, growth rate of electricity consumption was 11.4%, oil and gas 11.4%, and coal 11.6%. Hence, GDP elasticity with respect to electricity, oil and gas, and coal are 1.9, 1.5 and 1.5 respectively.

In the energy consumption mix by sectors in 2005, the share of the industry sector was 44.0%, the transport sector 29.7%, the service sector 7.7%, the agricultural sector 2.4%, and the domestic sector 16.2%. In the energy consumption mix by energy sources in 2005, the share of petroleum product was 51.5%, coal 27.4%, electricity 17.5%, and natural gas 3.6%.

The intensity of energy consumption for commercial sector in Vietnam was 616kgOE/1,000 dollar (real dollar term in 1994). The average primary energy consumption per person in 2005 was 360kgOE/person, and the final energy consumption was 264kgOE/person. The average energy consumption of Vietnam is about 1/5 of the average levels of the world.

### **1.2. Issues and Challenges**

The energy sector has been strongly developed and energy security has been improved much recently. However, development level is still low with many problems such as:

- General efficiency of the energy sector is still low.
- Effectiveness of production and business is not high.
- There is still loss compensation, cross subsidy in energy prices.
- Investment in energy development is still lower than requirement
- Delay in many energy projects

Total primary energy demand in 2010 is estimated to be TOE 63 million, in 2020 TOE 136 million and 2025 TOE 173 million. It is expected in 2014, Vietnam shifts from a net energy exporter to an importer due to limitation on primary energy supply. This calculation takes into account all types of indigenous energy sources as well as energy efficiency and conservation measures. Balance of primary energy supply and demand is shown in the following table.

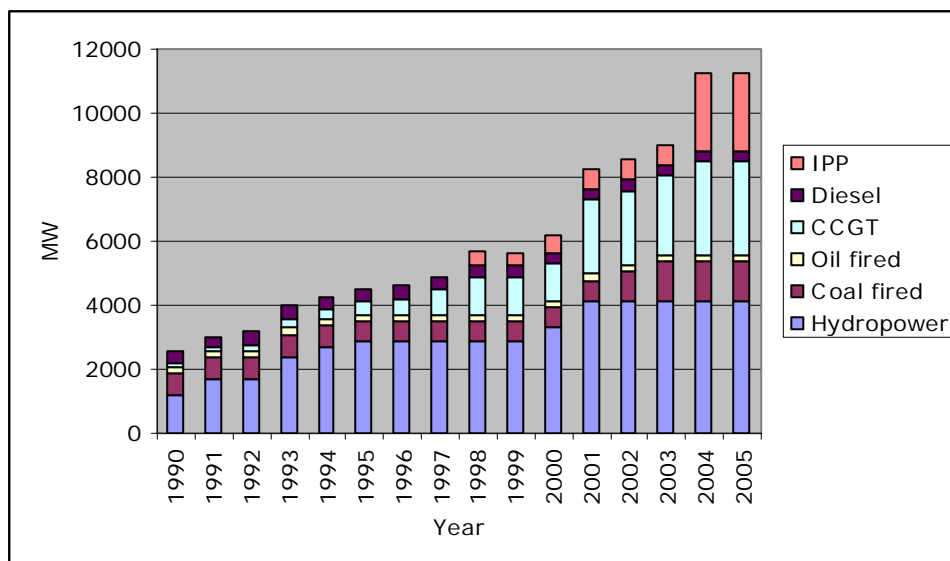
**Table 1-1: Balance of primary energy supply and demand (KTOE)**

Item	2005	2010	2015	2020	2025
<b>Primary energy demand</b>	<b>43832</b>	<b>63149</b>	<b>95058</b>	<b>135490</b>	<b>172773</b>
<b>Primary energy supply</b>	<b>61145</b>	<b>75276</b>	<b>87073</b>	<b>101679</b>	<b>105167</b>
Coal	18271	23957	27489	34189	36120
Crude oil	18120	20726	19688	19831	18955
Natural gas	6205	7885	11767	14712	16974
Hydropower	3762	7169	11390	13672	13481
Mini hydropower		404	568	898	1041
New and renewable	14788	15134	16170	18378	18596
<b>Balance</b>	<b>17313</b>	<b>12128</b>	<b>-7985</b>	<b>-33810</b>	<b>-67606</b>
<b>Import</b>	<b>11605</b>	<b>14641</b>	<b>22634</b>	<b>37328</b>	<b>68031</b>
<b>Export</b>	<b>-28917</b>	<b>-26769</b>	<b>-14649</b>	<b>-3517</b>	<b>-426</b>

## 2. POWER SECTOR

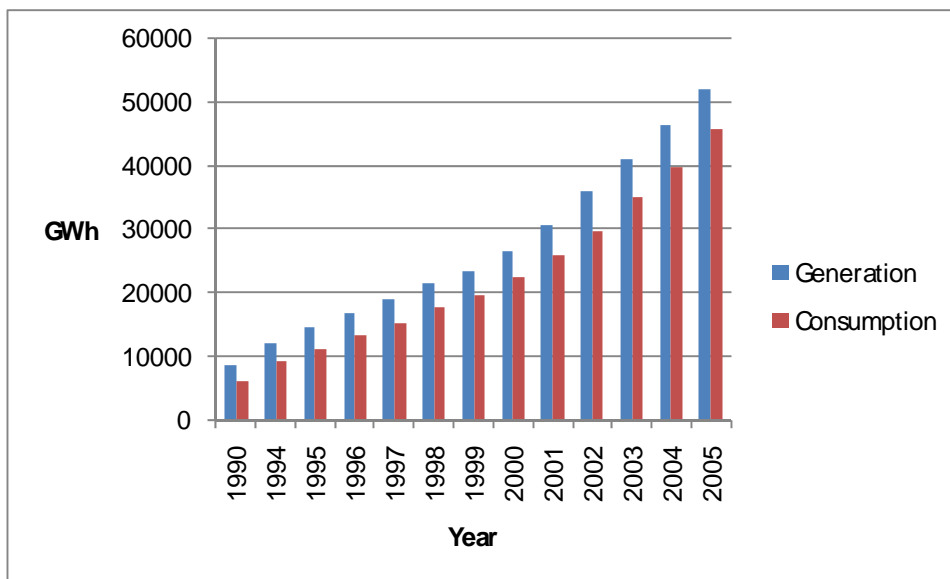
### 2.1. Supply and Demand

Vietnam power system has several types of power plants such as hydropower, coal-fired, oil-fired, gas-fired, CCGT etc... In the period of 2001-2005, total capacity of the whole system increased by 5,100 MW i.e. from 6,192 MW in 2000 up to 11,298 MW in 2005.



**Figure 2-1: Trend in power capacity**

Maximum generation capacity increased three-fold, from 2,796 MW in 1995 up to 9,255 MW in 2005, and average growth rate was 12.7% per year. Maximum generation capacity by regions is as: North: 3,886 MW; Central: 979 MW; and South: 4,539 MW. Power generation increased from 27,040 billion kWh in 2000 up to 53,462 billion kWh in 2005. Average growth rate is 14.6%. Regarding component of power generation, share of hydropower is gradually decreased from 54.8% in 2000 down to 30.8% in 2005.



**Figure 2-2: Trend in power generation and consumption**

Power sector in Vietnam is now facing dramatic increase in power demand. With an average annual growth of power demand for 10 years from 1996 to 2005 accounting for 15%, power demand in 2005 recorded 45,600 GWh that is 3.4 times larger than that of 1996 at 13,400 GWh. Peak demand has also more than tripled during this period, coming up to 10,500 MW from 3,200 MW.

Consumption share of industrial sector in the South is 50% of total electricity sale whereas in the North and Central is both less than 40%.

Monthly load curve of the whole country is characterized as follows:

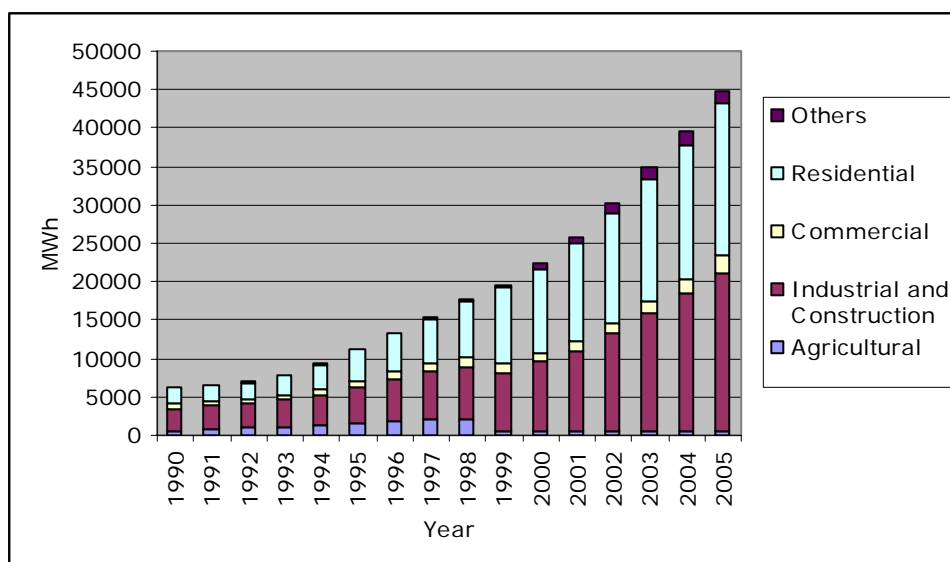
**STRATEGIC ENVIRONMENTAL ASSESSMENT OF THE HYDROPOWER MASTER PLAN IN THE CONTEXT OF THE PDP VI**

- Highest consumption of electricity occurs in summer from April to August in which the North and Central region is June and August respectively and the South in June.
- Lowest consumption of electricity occurs in January and February.
- The difference between highest and lowest consumption of electricity is 1.4-fold.
- In general, monthly load profile is slightly changed through the years.

System load factor has varied in the range of 0.61 to 0.66 and has increasing trend year by year in the period 1996-2005.

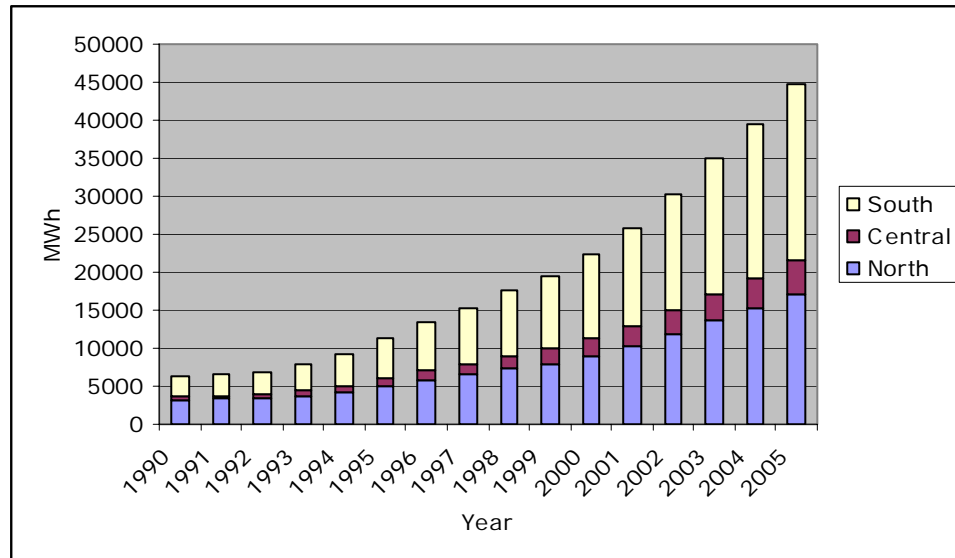
**Table 2-1: Electricity consumption by sector**

No.	Item	2000	2001	2002	2003	2004	2005
<b>I</b>	<b>Electricity Consumption (GWh)</b>						
1	Agriculture	428.3	465.2	505.6	561.8	550.6	574
2	Industry	9088.4	10503.2	12681.2	15290.2	17896.3	21302
3	Commercial & Hotel, Restaurant	1083.7	1251.3	1373.1	1513.3	1777.7	2162
4	Administration & Residential	10985.6	12651.1	14333.2	15953.3	17654.6	19831
5	Others	817.7	980.0	1341.7	1588.1	1817.4	1734
6	Total electricity sale	22404	25851	30235	34907	39697	45603
7	T&D loss (%)	14.0	14.0	13.4	12.7	12.1	12
<b>II</b>	<b>Share (%)</b>						
1	Agriculture	1.9	1.8	1.7	1.6	1.4	1.3
2	Industry	40.6	40.6	41.9	43.8	45.1	46.7
3	Commercial & Hotel, Restaurant	4.8	4.8	4.5	4.3	4.5	4.7
4	Administration & Residential	49.0	48.9	47.4	45.7	44.5	43.5
5	Others	3.6	3.8	4.4	4.5	4.6	3.8



**Figure 2-3: Electricity consumption by sector**

As can be seen in the above graph, residential and industrial sectors account for large shares in the total consumption. Agricultural share has reduced in recent years while commercial one is still of about 5% of the total.



**Figure 2-4: Electricity consumption by region**

Electricity load centers are located in the North and the South. Electricity demand in the South accounts for more than 50% of the total consumption while that in the North and in the Central 40% and 10% respectively. Electricity consumption in Hochiminh city, the largest city in Vietnam, makes up about 50% of the South's consumption.

## **2.2. Development Strategy**

In order to meet the rapidly growing demand, the power industry has struggled to expand and improve the power system through power resource development, enhancement of high voltage transmission lines connecting the country's three regions (North, Central and South), reduction of transmission and distribution losses (T&D losses), importing electricity from neighboring countries and DSM efforts etc... In summary, development strategy for power sector in Vietnam is as follows:

- Promotion of conventional power resource development typified by hydro and thermal energy,
- Power import from neighboring countries,
- Development of renewable energy,
- Nuclear power development,
- Control of power demand through energy efficiency improvement and DSM (Demand Side Management),
- Financial resource mobilization: attraction of ODA, equitization process, IPP development,
- Tariff revision: reflecting long-run marginal cost of supply, removal of cross subsidy etc...,
- Institutional reform of power sector, and
- Rural electrification

### **3. COAL SECTOR**

#### **3.1. Overview**

The coal business of Vietnam was not unified until VINACOAL was established on October 10, 1994. Based on Prime Minister Decision No.345/2005 QD-TTg, VINACOAL and Vietnam Minerals Corporation had merged to form VINACOMIN on December 26, 2005. VINACOMIN becomes to cover a broad range of activities from the mining to processes and sales of coal and mineral resources (bauxite, iron ore, copper, lead, zinc, and other mineral). VINACOMIN is mainly organizing geological exploration, production, processing, domestic sale, and import and export on coal related business, and has presently been changed into the diversified management that has business conditions like mineral and metallurgy, electricity, construction materials, real estate investment, construction machinery, and service industry, etc.

As a coal player excluding VINACOMIN, the Thai Nguyen Iron and Steel Corporation (TISCO) that is a subsidiary of the Vietnam Steel Corporation (VINASTEEL) organizes two collieries (Phan Me and Lang Cam) in Thai Nguyen province, and they produce coal and consume at own facilities. PT. Vietmindo Energitama of 100% capital investment from Indonesian owns Vietmindo colliery in the Quang Ninh province, and is producing and exporting coal. In addition to these, there are eight collieries in whole country where are located in Ninh Binh province, Hoa Binh province, Son La province, Yen Bai province, Thai Nguyen province, and Da Nang city. These collieries are doing coal business.

The following are issues that coal sector are facing:

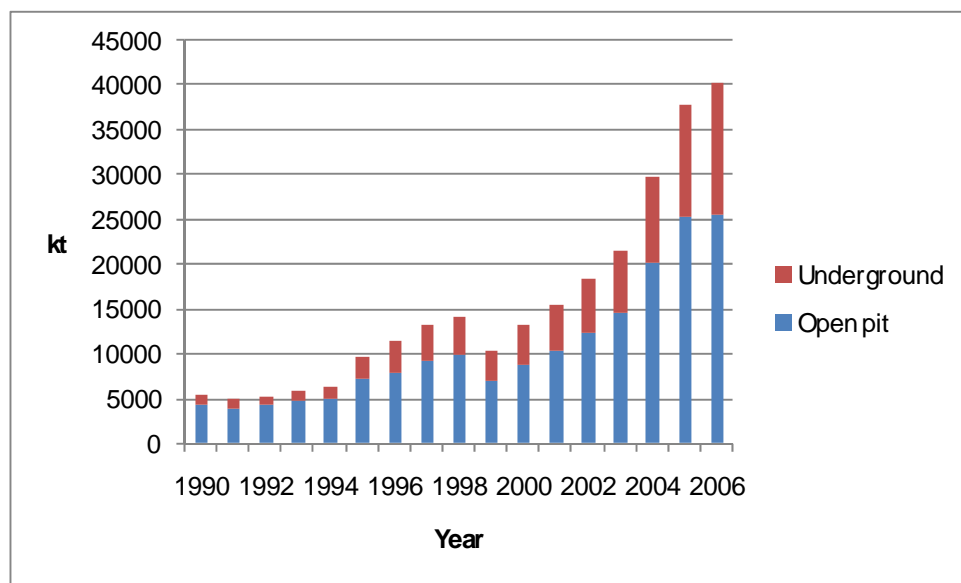
- **Mineable Reserves:** The mineable coal reserves with 3.39 billion tons excluding peat are including sub-bituminous coal 530 million tons of the Red River Delta region that is seemed difficult to mine economically.
- **Development of Red River Delta:** mining cost is seemed to high considerably, and there is little possibility of coal supply from Red River Delta coalfield from the economical aspect.
- **Mining Cost:** The mining cost of coal is rising in the past several years, and will be seemed to rise further when underground mining method will become a main force in the future.
- **Mine Safety Technology:** It is certain that the amount of the coal resource that is mineable by opencast method decreases greatly, and underground mining will become a main method in Quang Ninh coalfield that is main coal production region. As for the underground, the mining condition and the working environment are worse than the opencast, and the accident incidence is also seemed to increase.

#### **3.2. Demand and Supply**

As of the end of 2006, coal reserves excluding peat in Vietnam is 5,833 million tons as the geological reserves. By coal type, 71.2% of the geological reserves are anthracite, and are depositing in Quang Ninh Province located at the northeast of Vietnam where is a major coal producing site. As for the rest, sub-bituminous coal deposit 1,580 million tons (27.1%) at Khoai Chau region of Red River Delta, and fat coal deposit 96 million tons (1.7%). The coal reserve-production ratio (R/P) is calculated on the assumption that the geological reserves by production volume in 2006 become approximately 145 years.

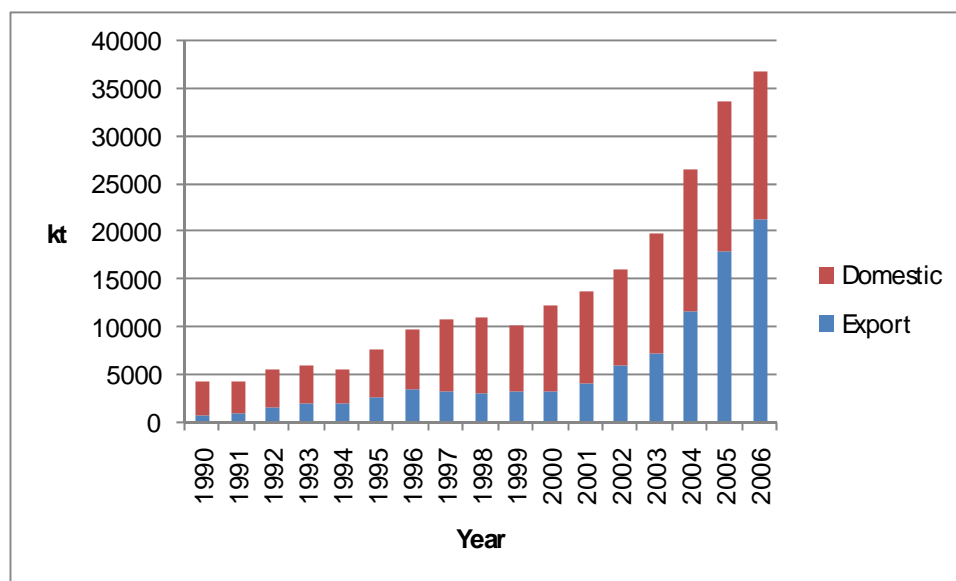
On the other hand, the mineable reserves are 3,390 million tons, and being about 58% quantities of the geological reserves, of which anthracite is 2,830 million tons (83.5%), sub-bituminous is 525 million tons (15.5%), and fat coal is 36 million tons (1.1%) by coal type. This means that a share of anthracite increases. The R/P ratio of mineable reserves becomes approximately 85 years.

The raw coal supply is also increased by 35.00 million tons from 9.64 million tons in 1995 to 44.67 million tons in 2006, and annual average growth rate at this period was 15.0%. At the same period, an increasing of national corporations is 31.31 million tons (average increase rate 14.3.3% a year), whereas that of other suppliers is 4.0 million tons (27.9%). As the result, the supply ratio by national corporations including the Vietnam National Coal Corporation (hereinafter referenced to as VINACOAL) and the Vietnam National Coal and Mineral Industries Group (hereinafter referred to as VINACOMIN) is still high in 2006 with 91.3%. On the other hand, coal import is estimated 500 thousand tons a year which are mainly coking coal for the iron industry and steam coal for other industry (IPP).



**Figure 3-1: Coal production by mining method**

Coal consumption in Vietnam is increasing 38 million tons from 7.82 million tons in 1995 to 45.84 million tons in 2006, and average annual growth rate of 17.4% in this period. An increase in domestic coal consumption in the same period was 11.06 million tons (average annual growth rate 11.2%), whereas coal export increased hugely compare with domestic demand as 26.96 million tons (23.9%). As the result, the percentage distribution of domestic to export was reversed from 64:36 to 35:65.



**Figure 3-2: Coal consumption**

Electricity, construction material and cement industries is account for majority of domestic coal demand. In future, coal demand for electricity forecast dramatically increase, then coal demand for cement and construction material will increase.

Coal export increased substantially after 2002, because export for china was increased rapidly. Present major destinations for coal export are China and Japan, but Vietnam exports low grade coal for coal-fired power in China and high grade one for iron & steel and general industry in Japan.

## **4. OIL AND GAS SECTOR**

### **4.1. Overview**

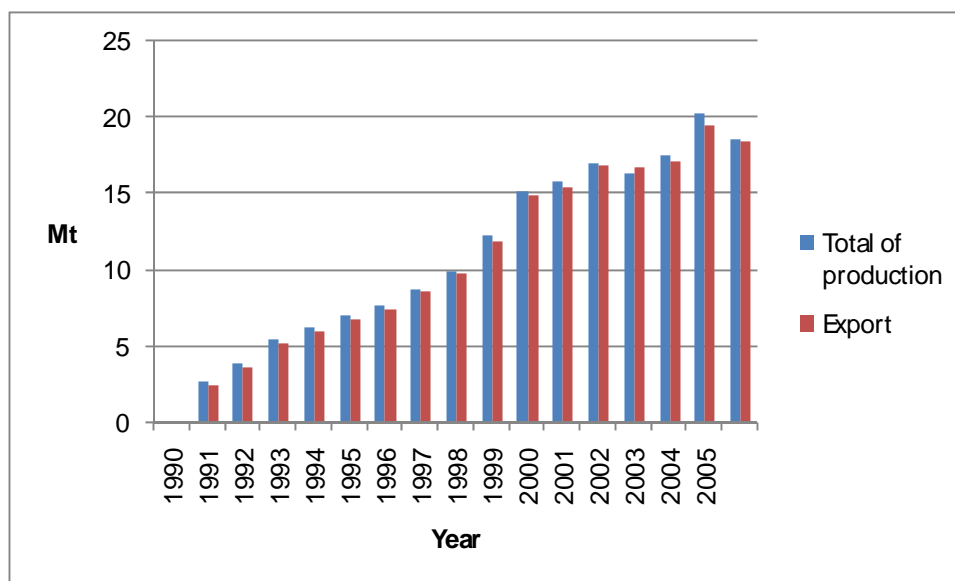
Major oil and gas fields under production or development in Vietnam situate mostly off-shore region to South-East from Ho Chi Minh city, and to South-West in the Gulf of Thailand/near border of Malaysia. While the current development is centered off-shore region in the South, other regions are expected in future development such as the Gulf of Tonkin in the North or off-shore Central part of Vietnam in the South-China Sea, although outstanding issue of the border exists.

### **4.2. Oil Sector**

Although oil portion is the majority rather than gas for Cuu Long, gas portion is larger in others such as Nam Con Son, Malay Tho Chu, Song Hong (Red River), vice versa. Looking at the trend of the reserve since 80's, the increase after 90's is significant, especially gas. However the growth seems to decline in 2000's.

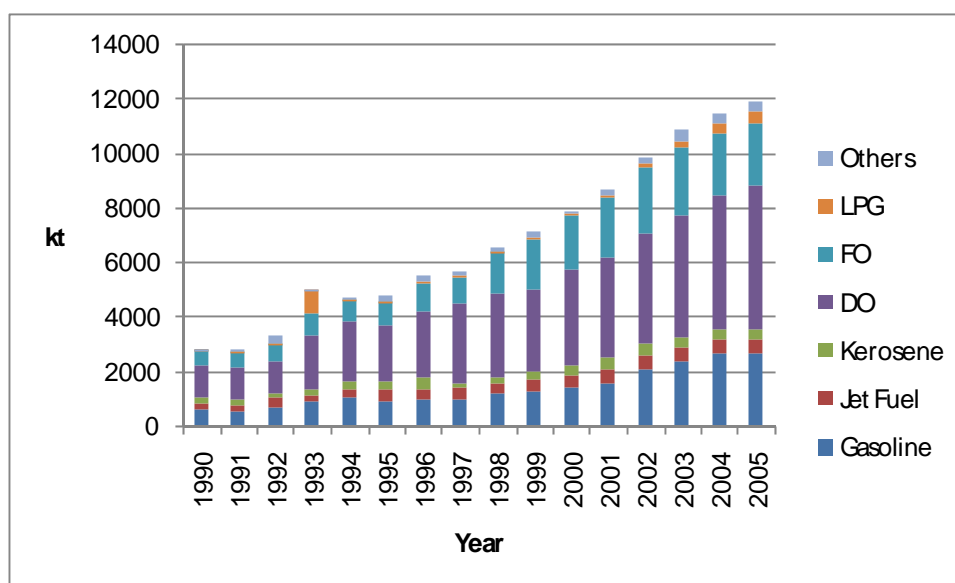
As overall, ratio between accumulated production and potential reserve is 15-20, however, one between exploited reserves and potential reserve remains only 5-7 level. Hence, further activities are expected in the exploration and development field.

Looking at the trend of oil production in Vietnam, the main oil field of Bach Ho seemed to pass the peak and to start declining in its production. Although such newly developed fields of Rong, Dai Hung, Rang Dong, Ruby, Su Tu Den have started production, both figures of total production and export amount reached the peak in 2004, and tend to decrease in 2005 – 6



**Figure 4-1: Crude oil production and export**

While Vietnam produces crude oil, no refinery exists in the country. So that, it relies its oil product supply upon import. Diesel oil and gasoline occupies more than 50% and almost 30% respectively in the total imported oil products, which results remarkable transport fuel share that both diesel oil and gasoline reaches 80% in total.



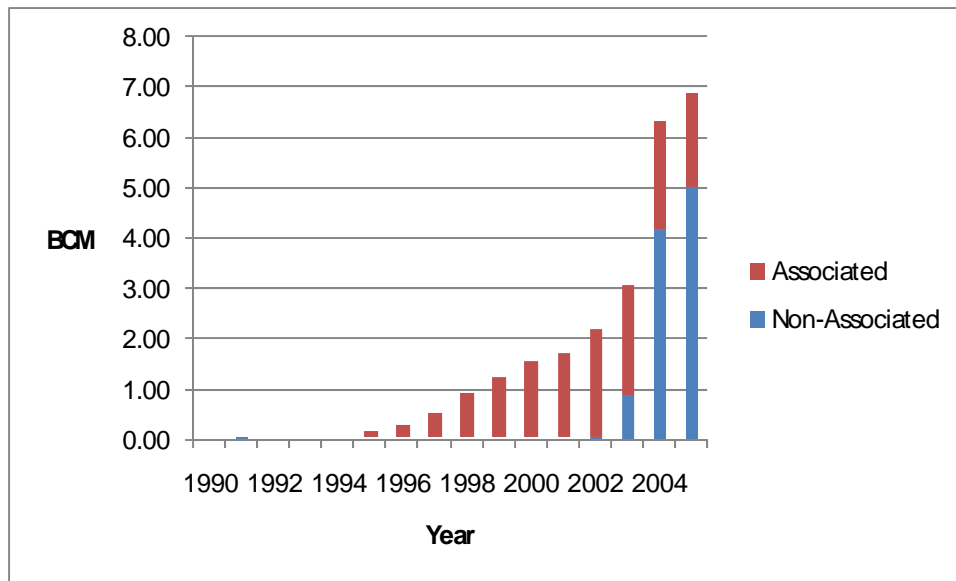
**Figure 4-2: Petroleum product import**

Looking at the trend, Jet Fuel in transport sector and Kerosene in commercial /residential sectors are regarded as to remain in almost the same level, however, we can observe a stable growth in overall in industrial sector, diesel and gasoline in transport sector. LPG consumption in industrial, commercial, and residential sectors is simply growing year by year, as well as its import and production.

### 4.3. Gas Sector

Natural gas production in Vietnam became substantial in 1990. At the beginning, associated gas is majority in the production, however, after production started from such gas fields as Nam Con Son or Lan Tay in 2000, non-associated gas production increased. It is characteristic that more than 80% of gas is used for power generation. As for gas consumption in Industrial

sub-sectors, almost half is used for chemical sub-sector, which mostly used for fertilizer (ammonia/urea) production.



**Figure 4-3: Natural gas production trend**

## 5. NEW AND RENEWABLE ENERGY

The most basic use of Renewable Energy in Vietnam is Biomass for heat. Fuelwood, agricultural residue and animal waste are used as heat source of households. Small Hydro and Bagasse is used for power generation, however their generation in 2005 was 265.57GWh, which is approx. 0.5% of total generation (51769.68GWh) in Vietnam .

Looking at the renewable energy potential and current use, a proportion of renewable energy use is low compared to the potential, although an accuracy evaluating each energy resource is not high.

### 5.1. Biomass

#### Potential

According to the VIAEPT (Vietnam Institute of Agricultural Engineering and Postharvest Technology) under MARD (Ministry of Agriculture and Rural Development), it is estimated that total amount of biomass resources in Vietnam is about 30 million ton/year. Assuming that one third of biomass resources are used for power generation, its potential is about 500MW.

#### Current Use

##### - Heat

Biomass is the one of the most basic energy in the remote and mountainous area, and fuelwood, agricultural residue and animal waste are used as heat source of households. Vietnam is agricultural country, and there are huge amount of biomass resources such as bagasse, rice husk and, rice straws, but, most of biomass resources are used as heat source, and, exceptionally, in central and south areas, they are used for power generation (about 50MW).

##### - Power Generation (Bagasse)

Most of sugar mills installed cogeneration system using bagasse, which generates heat and electricity necessary for sugar production.

3 sugar mills, Son La Sugar Mill (Son La Province), La Nga Sugar Mill (Dong Nai Province), Sucrerie de Bourbon Tay Ninh Sugar Mill (Tay Ninh Province), provide surplus electricity to the power grid.

Sucrerie de Bourbon Tay Ninh Sugar Mill has installed the largest cogeneration system in Vietnam. Its capacity is 24MW (12MW x 2) and 9-10MW is used for the sugar mill and the rest is sold to the power grid (EVN). The current electricity sales price is 4.15 US-cent/kWh, which is valid for 3years, and after it is expired, the sugar mill and EVN will negotiate about price and validity period.

Sucrerie de Bourbon Tay Ninh Sugar Mill once had the expansion plan of sugar production and cogeneration system, however it was stopped because it was difficult to procure necessary amount of sugarcane.

#### - Power Generation (Rice Husk)

According to EC-ASEAN COGEN Programme, there are about 130 rice mills in Vietnam, and each capacity is 15-600t/shift. Vietnam is one of the largest rice export country in the world, but capacity of common rice mill is still small.

In the past, rice husk generated from rice mills were treated as follows; 1) to provide local people as fuel, 2) to sell as feed for cultured fish, 3) to sell rice husk dealer (middleman).

However, nowadays, demand for rice husk are decreasing because rice husk users, such as brickyard and households, are switching its fuel from rice husk to coal. Accordingly, some rice mills must pay money to rice husk dealer for collection of rice husk, therefore, treatment of rice husk is going to be problem for rice mills.

Some rice mills have installed small cogeneration system using rice husk, but electricity is used only in rice mills, and not provided to the power grid.

In Long An province, cogeneration system (50kW) was installed in the rice mill with the aid of the Government of Australia (AUSAID), however it is operated only 1 week a year because the capacity is too small and it requires 3 workers for operation, then its profitability is too low.

If large amount of rice husk can be collected from rice mills with low cost, rice husk cogeneration can be feasible. However, because each rice mill's capacity is small and they are scattered, collection of large amount of rice husk is very difficult and it is the barrier to rice husk cogeneration.

#### - Bio-fuel

At present, in Vietnam, bio-fuel (bio-ethanol, bio-diesel) is not in commercial production.

(Future Prospects)

#### - Power Generation

The potential of biomass power generation is estimated to be 250 – 400MW, and surplus electricity (about 30%) can be provided to the power grid. However, there are no development plans of biomass power generation (bagasse, rice husk, etc.), and it is thought to be necessary to overcome the following barriers for the promotion.

Regarding bagasse, stable procurement of sugarcane is the highest barrier. Sugar mills purchase sugarcane from farmers based on long-term purchase agreement. However, in case that there are more profitable crops than sugarcane, many farmers tend to reduce sugarcane

production and increase profitable crops production, breaching the contract. The purchase price of sugarcane tends to be less than other crops, thus the incentive to sugarcane production is low, and sugarcane production volume is unstable. In addition, the sugar is in competition with the imported one from Thailand and Cambodia, then the price of sugar is unstable and it adversely affects the sugarcane purchase price.

Regarding rice husk, effective collection of rice husk from small and scattered rice mills is the highest barrier. The current situation that the treatment of rice husk is going to be cost is following wind. However, the feasibility of rice husk collection through rice husk dealer is unknown, because they are not organized and there is no statistic data. Therefore, the feasibility study is necessary.

#### - Bio-fuel

In May 2007, “Development of Bio-Fuels in the Period up to 2015, Outlook to 2020” was produced and is under approval process by prime minister.

There are some bio-fuel development plans, such as bio-ethanol production in sugarcane mill and bio-diesel production using Basa (fish oil) and used cooking oil; however, there are no bio-fuel plants in Vietnam at present. Table 2.5-10 is the summary of studies on bio-fuel in Vietnam.

## **5.2. Wind**

### **Potential**

Various studies evaluated the wind power potential in Vietnam. Because there is no comprehensive wind measurement data covering whole country, there is large difference between the evaluated potentials.

According to the 6th Power Development Master Plan (Draft), wind power potential of areas which wind speed is over 3m/s is evaluated as 600MW.

In the World Bank: Wind Energy Resource Atlas of Southeast Asia, 2001, average wind speed in South-East Asia is estimated by simulation analysis. Based on the flow of upper atmosphere, using ground level altitude, land coverage pattern, degree of vegetation activity, geographic features and roughness of ground, wind speed at 65m from the ground is simulated. It doesn't use the wind measurement data near the ground, which has a large margin of error. According to the result, it is estimated that in central coastal area, average wind speed is over 9m/s according to seasons.

In the EC-ASEAN Energy Facility Programme, based on the above simulation, it is estimated that the wind power potential in Vietnam is 22,400MW. It is quite high compared to other estimations. It assumes that 20% of potential area evaluated as “Relatively High”, “High” and “Very High” are developed.

### **Current Use**

The total installed capacity is about 1MW, but there is no grid-connected wind power plant in Vietnam. The Bac Long Vi Island wind power project (800kW, Spanish-made, commencement of operation: 2004), which is the largest in Vietnam, has been stopped for the problem of operation. The project is funded by the Government of Vietnam, and the Vietnamese local NGO (Youth Association) is responsible for development, operation and maintenance. However, because appropriate technology transfer had not been implemented and the supply contract of maintenance parts was terminated, it can not be operated.

### **Future Prospect**

According to the 6th Power Development Master Plan (Draft), total installed capacity will be about 170MW.

In the past, the following are indicated as the issued and subjects for the evaluation of wind power potential.

- There is no comprehensive wind measurement data covering whole country
- The common wind data is measured at about 10m from the ground, so it is affected by the roughness of the ground, and has a large margin of error

However, IE has stated the detail wind potential survey, and in April, 2007, has already finished the survey in Ninh Tuan Province and confirmed 100MW potential. IE plans to implement the survey in possible provinces accordingly, and early grasp of the wind power potential in Vietnam is expected.

### **5.3. Solar**

#### **Potential**

Vietnam is relatively rich in the solar energy potential with 4.5kWh/m<sup>2</sup>/day of annual average sunshine nationwide. Especially solar potential of central and central-southern provinces, which amount of solar radiation is stable throughout the year, is high. For example, Nha Trang city (Khanh Hoa Province), located in the central coastal area, shows 5.15kWh/m<sup>2</sup>/day of annual average sunshine hours, it is higher than that of Japan (3.4-4.4kWh/m<sup>2</sup>/day). According to the ESMAP, Renewable Energy Action Plan, 2002, it is estimated that the solar potential for household in unelectrified area is 2MW.

#### **Current Use**

Looking at the current status of solar power installation in Vietnam, total installed capacity is 1,152kWp at December, 2004.

#### **Future Prospect**

There are 2 main barriers to install solar power. First one is high initial investment cost. In general, PV (Photo Voltaic) panels are imported, and cost of PV panel is about 8.0-8.5US\$/Wp and transportation cost (5-7%) is added.

Second one is capacity of PV panel. Average capacity of PV panel is small (22.5Wp), and it is often overloaded and damaged in case that the power demand is high.

Therefore, the dissemination of solar power would be possible if the barriers are overcome by the following measures.

- Reduction of initial investment cost by domestically production of PV panel and financial support by the government
- Technology development for increase of PV panel capacity

### **5.4. Geothermal**

#### **Potential**

According to the 6th Power Development Master Plan (Draft), 29 potential geothermal sites were identified, and it is thought that 12 sites can be suitable for geothermal power plant (about 180MW). Also, it is evaluated that whole geothermal potential in Vietnam is 340MW.

### **Current Use**

There are no geothermal power plants in Vietnam at present.

### **Future Prospects**

MINERAL & ORMAT company (U.S.A.) carried out the feasibility studies of Bang, Nghia Thang, Mo Duc, Hoi Van, Tu Bong and Danh Thanh sites for development of 112.7 MW geothermal power, however, because the profitability was not attractive, the projects was stopped.

There is no specific geothermal development plan at present.

## **5.5. Small Hydro**

### **Potential**

According to the 6th Power Development Master Plan (Draft), small hydro power potential (equal or less than 30MW) is estimated to be over 2,300MW and 8,000-9,000GWh. However, some potential sites which are located far from load center, and their economic feasibility are expected to be low, therefore, the coordination with local economic development plans is necessary.

According to the ESMAP, Renewable Energy Action Plan, 2002, small hydropower (under 10MW) potential is estimated to be 800-1,400MW, and 110-115MW has been developed.

### **Current Use**

There are 49 grid-connected small hydropower plants (total capacity: 64MW, unit capacity: 100kW-10MW, 1 plant is stopped). And there are about 300 off-grid small hydropower plants (total capacity: 70MW, unit capacity: 5-200kW) in north and central provinces, but their reliability is low and more than half of them have been stopped. Also, about 150,000 of small hydro power system (0.1-1kW) for households has been sold .

### **Future Prospect**

The approach to small hydropower development in Vietnam is as follows.

- Grid-Connected: Small Hydropower Development based on 6th Power Development Master Plan (Draft)
- Off-Grid: Upgrade/Renewal of exiting hydropower plant and Development of hybrid system (ex. Solar and Small Hydro)

## **5.6. Tidal**

### **Potential**

According to the survey by IE, 18 potential tidal sites were identified considering the conditions of gulf, lagoon, pond and tide. It is evaluated that the tidal potential of Vietnam is not high, and there are some sites suitable for small scale tidal power plant.

Also, it is recommended that some potential sites (Cam Ranh Lagoon, Cuu Long River Delta and Co To Island, etc.) should be surveyed in detail.

### **Current Use**

There are no tidal power plants in Vietnam at present.

### **Future Prospects**

As described above, regarding some potential sites, detailed potential survey is recommended. Barriers of tidal power development are recognized as follows:

- Because potential sites are often located far from large load center, cost of transmission line increases electricity tariff.
- It is difficult to construct standalone tidal power plant because it is unstable power generation depending on the tidal condition.
- Environmental negative impact caused by tidal power plant has not been grasped.

## **6. IDENTIFICATION OF KEY DRIVERS IN HYDROPOWER DEVELOPMENT**

In order to meet rapidly growing energy demand of the economy, the energy sector in Vietnam has developed strongly in recent years. Along the very high economic development target in next several decades, energy supply should keep growing at very high rate. It is expected that, Vietnam becomes energy net importer in 2014 when domestic supply capability would reach to the plateau. Hydropower is given priority to develop in future as mentioned in the National Energy Strategy. The following key drivers for hydropower development should be taken in to account:

- High growing electricity demand
- Enhancement of energy security by reduction of import dependency
- Improvement of rural electrification
- Reduction of green house emissions and other pollutions

**7. ANNEXES**