Part 2 Energy Outlook of Vietnam through 2025

Chapter 4 Procedure of Energy Outlook Formulation

In Part 2, we will conduct fundamental analysis for formulation of the National Energy Master Plan running various case studies using the Energy Database, the Energy Demand Forecasting Model and the Energy Supply Optimization Model that were constructed for the purpose of this study, examining different forecast results on energy outlook and their implications under various socio-economic development scenarios, effects of different energy policy options for securing energy supply, impacts on environment and so on.[10] In this chapter, first of all, we will explain on fundamental understanding and assumptions in conducting this study such as the world energy situation, crude oil price trend, issues facing Vietnam as well as some technical aspects such as composition of the analytical tools, major preconditions, setting of the fundamental scenario and directions of case studies.

4.1 International Circumstance and Issue of Concerns on Energy

Upon the turn of the century, the world energy demand has been accelerating its growing speed while clouds are beginning to spread over the world oil production increase. Reflecting the development, the world oil price has soared more than triple in the past seven years. The increasing energy consumption has also brought forward the issue of global warming as a matter of world concern. In Vietnam, where the per capita energy consumption is less than 1/10 of that of the developed countries, the energy demand is expected to grow fast along with its economic growth. Vietnam will shift from a net energy exporting to a net energy importing country sooner or later as the foregoing trend continues, to be more directly exposed to the rough movement of the world energy market. If we take a little bit longer look, we notice that Vietnam is facing various issues on energy that is essential for development of the country.

4.1.1 Increasing World Energy Demand

The world energy demand/supply outlook is filled with full of uncertainties. As the world economy is growing steadily led by the strong Asian development, many questions are raised whether we could continue this trend into the future or not consistently securing sufficient energy supply and protection of the environment. As the 2007 G-8 Summit at Heiligendam centered its dialogue on energy/environment issues, we are yet to find a clue to international collaboration, let alone the final answer. For example, IEA begins its World Energy Outlook 2006 with the following words:

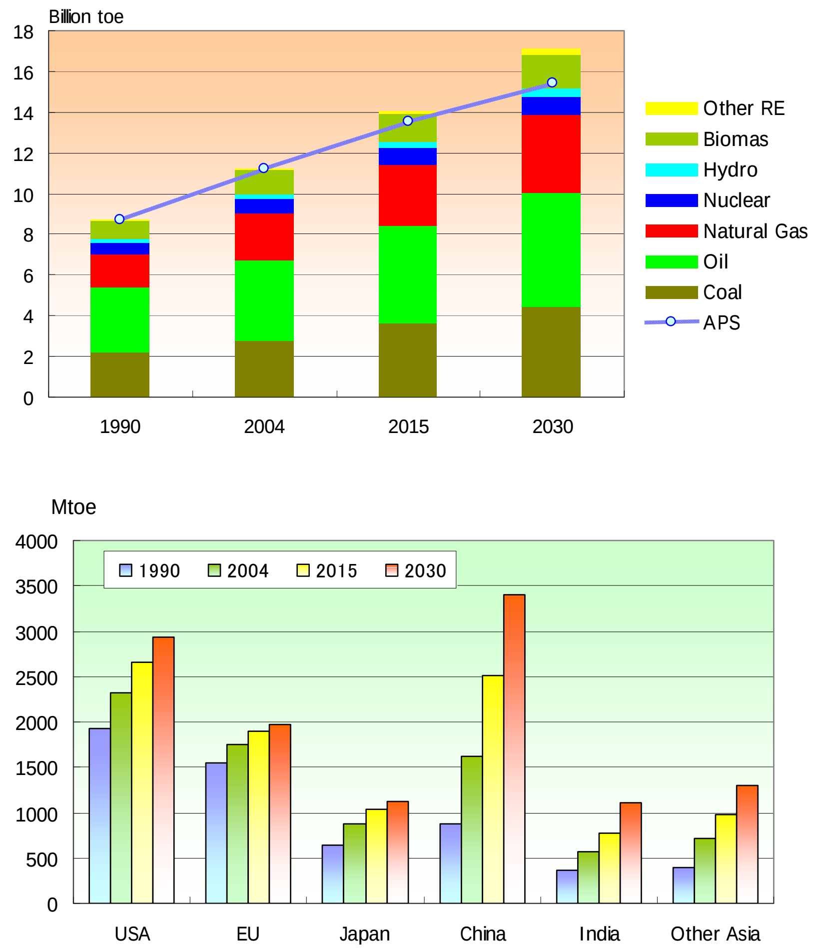
"The world is facing twin energy-related threats: that of not having adequate and secure supplies of energy at affordable prices and that of environmental harm caused by consuming too much of it".

"The need to curb the growth in fossil-energy demand, to increase geographic and fuel-supply diversity and to mitigate climate-destablishing emissions is more urgent than ever. … This year's Outlook … confirms that fossil-fuel demand and trade flows, and greenhouse-gas emissions would follow their current unsustainable paths through to 2030 in the absence of new government action. It

[10] *Please refer to Part 4 on the detail technical aspects of these analytical tools.*

also demonstrates, in an Alternative Policy Scenario, that a package of policies and measures that countries around the world are considering would, if implemented, significantly reduce the rate of increase in demand and emissions."

According to the IEA Outlook, the world energy consumption would grow in the reference case from 11.2 billion toe in 2004 to 14.1 billion toe, by 24%, in 2015 and 17.1 billion toe, by 53%, in 2030. However, applying measures such as promoting energy conservation, energy consumption could be reduced to 13.5 billion toe in 2015 and 15.4 billion toe in 2030.

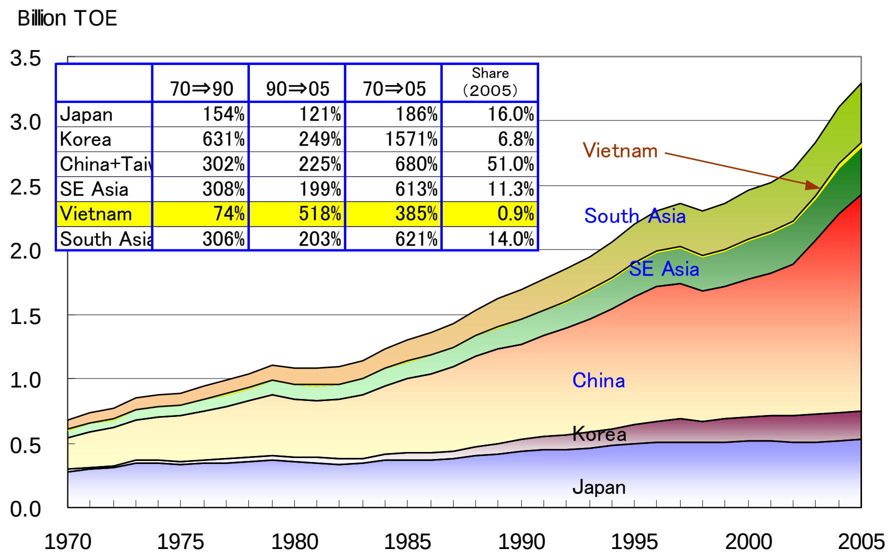


(Source) Compile from IEA Outlook

Figure 4.1-1 IEA World Energy Outlook 2006

On the other hand, looking into regional distribution in the Reference Case, while the demand increase in the developed countries remains limited, energy consumption of China, India and other developing Asia would double by 2030. Then, IEA concludes, "Without new policies of governments the Reference Case is not sustainable". How should the developing countries, who want to improve life of its nationals just up to a modest comfortable level, cope with such situation?

If we look to the recent world trend of energy that is the baseline of the IEA outlook, in the emerging countries such as China, India and Southeast Asian countries, who are leading the world economic growth, energy demand is increasing rapidly. During the five years from 2000 through 2005, the energy demand in Asia (excluding Japan and Korea) increased 25% while the world energy consumption increased 14%. Among them, China recorded 60% increase in the energy consumption during the same period. As increase of its domestic oil production nears the margin, China's oil import increased outrageously to 127 million tons in 2005, overtaking South Korea. Energy consumption of Vietnam has also increased at an annual average rate of over 11% since the 1990s, and its speed is accelerating recently. Despite the fact, the absolute quantity of the Vietnamese energy consumption shares only 0.9% among Asian countries. As energy is a big issue for Vietnam, it is apparent form Figure 4.1-2 that the matter should be considered along with the world stream.

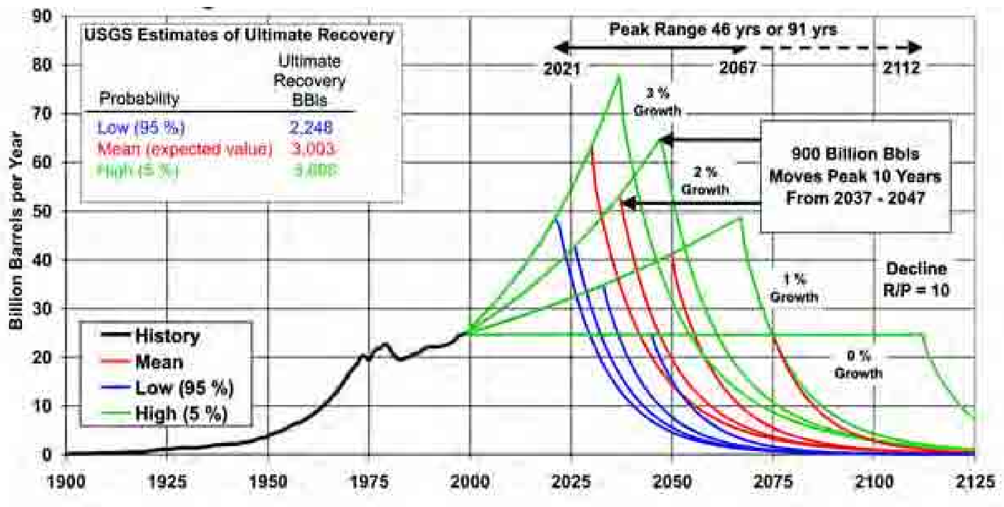


Source: Compiled from the BP Statistical Review of World Energy 2006

Figure 4.1-2 Asian Energy Consumption (excluding Middle East)

Upon the incident of September 11, 2001, a paradigm shift occurred in the world of energy and energy security became the top item of the world concern. Oil was re-recognized as a strategic commodity, and securing it became one of the top priority policy objectives of nations in the world. As the American stationing in Iraq is being prolonged without any clear prospect, the world oil price has increased to 6-fold of that of 1997 and triple of 2003.

At the same time, the oil peak theory suddenly got focused on. It is theoretically right that the world oil production will hit the peak at any rate since it is a fossil fuel with limited resource availability. However, the remaining years of the world recoverable oil reserves has stayed at around 40 years for quite some time, and the agenda did not come up to the top list of the argument. Despite many twists and turns, new oil discoveries have continued and the world oil production has increased during the past several decades. However, as the world oil production has now exceeded 80 million barrels per day indicating to 100 million barrels per day, overlapping with the prolonged Iraqi crisis, the oil peak theory has become to attract the world attention. Currently, recognition is being shared in the world that the world oil production would hit the peak within 20 to 30 years.[11] Under the circumstance, a view is becoming common recognition that energy price shall remain high in the future.



(Source) J.H. Wood, G.R. Long, D>F> Morehouse "Long-Term World Oil Supply Scenarios", UADOE/EIA

Figure 4.1-3 Oil Peak projected by US DOE

During the 1990s, we encountered another big change in the paradigm relating to energy and environment issues. The dialogue on the Green House Gas (GHG) has turned into actual international actions. Despite various talks exchanged on the possibility of global warming caused by emission of GHG, they had not produced any result leading to real actions. Then, at the third COP meeting held in Kyoto in 1997, an epoch making agreement was made that the developed countries listed on the Annex-I of the UNFCCC set forth an actual targets of reducing their GHG emissions for the first period of commitment (the five years from 2008 through 2012). Although there have been serious disputes on its equitability and feasibility, the perception would never be overturned that the responses against the global warming shall be the common objective of the human being. Now the focus is moving onto the point how we should establish the long-term response against the issues in the post-Kyoto era.

In January 2006, a new movement named as Asia-Pacific Partnership (APP) was organized including USA, who dropped out of the Kyoto Protocol regime, and China and India, who are not obliged GHG reduction under the Kyoto Protocol, and dialogue has started on sectoral approach on improving energy efficiency. In the fact that the Kyoto Protocol and the APP, when combined, cover almost of the world GHG emission, the global warming is now strongly recognized as the common issue for the human society.[12]

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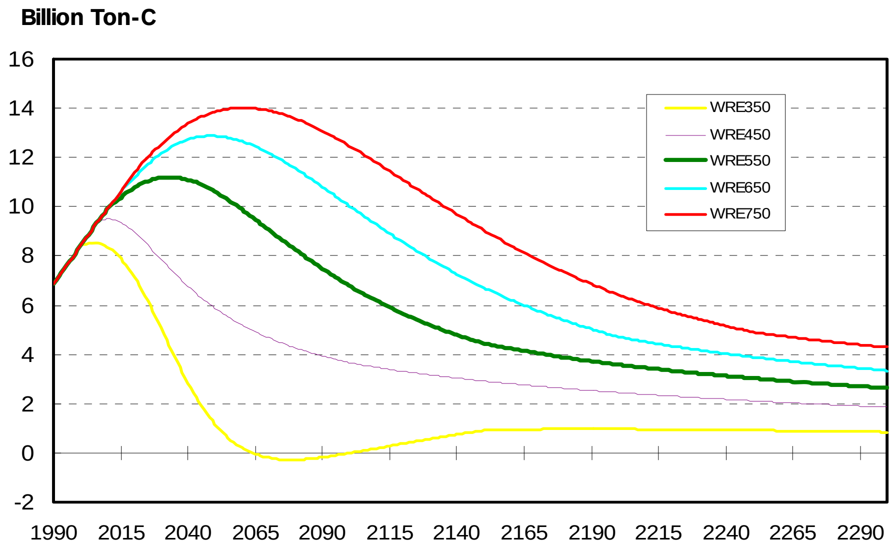
[11] The remaining years of the recoverable reserve are 65.1 years for natural gas and 155 years for coal, which are not immediate threatening. All these figures are for the end of 2005 and cited from the BP Statistical Review of World Energy 2006.

[12] Asia-Pacific Partners for Clean Development and Climate:

The first ministerial meeting was held in January 2006 in Sydney. Six countries of US, Australia, China, India, South Korea



(Source) Intergovernmental Panel on Climate Change

Figure 4.1-4 Scenarios for Stabilizing CO_2 Content in the Air

At the 2007 G-8 Summit held at Heiligendam, it was agreed that the member countries will consider seriously the decision made by EU, Canada and Japan to "reduce the emission of the green heating gas by 50% by 2050". To this end, the G-8 countries are going to organize a forum to explore for the possible structuring; the interim report will be made at the next Summit meeting in Japan and the final report will be made in 2009 in Italy.

Under the circumstance, Vietnam currently being still low in its economic development with less than 1/10 of energy consumption of developed countries shall need a big amount of energy for its construction of the economy and its per capita energy consumption would steadily increase along with economic development. The international trend is against the increase of energy consumption. While the UNFCCC stipulates common but differentiated responsibilities of the nations toward the global warming, it is a very important policy issue for Vietnam how to accept and digest such circumstance in the course of constructing the economy.

4.1.2 Axis of Energy Policies

Since commencement of Doi Moi (economic Reform) policy in 1986, the Vietnamese economy was

and Japan are the participants and there are eight task force groups on 1) cleaner fossil fuel, 2) renewable energies and scattered power source, 3) power generation and transmission, 4) steel, 5) aluminum,6) cement, 7) coal mining and 8) building and electric appliances. However, the activity range is limited to major industrial sectors and transportation sector is not included. Thus the activity does not cover the GHG emission fully.

As the Kyoto Protocol regime applies a top-down approach obligating emission reduction, the APP takes a bottom-up approach to improve energy efficiency in each sector under the concept of "a voluntary, non-legally binding framework". In addition, as the Kyoto Protocol aims at reduction of GHG by institutional measures such as Joint Implementation (JI), Clean Development Mechanism (CDM) and Emission Right Trade (ET), the APP focuses on technology such as promoting technology development and diffusion of the available technologies, to find out a clue to the solution of the global warming issue based upon regional cooperation. (Reference, IEEJ " Research on Fundamental Arrangement for Asia-Pacific Partnership") put on the track of extraordinary high economic growth and the domestic energy consumption also recorded a rapid increase. Despite the fact, Vietnam steadily developed its indigenous energy resources and realized energy self-sufficiency as a total balance. At present, however, its energy demand, in particular the electricity demand is not satisfied and therefore it is highly possible that the domestic energy demand may increase faster than past. On the other hand, the domestic energy production is anticipated to be approaching the plateau. As a result, Vietnam would change from an energy exporting to an energy importing country. This suggests that energy issues of Vietnam will change its nature from those confined within the country to those exposed to rough fluctuation of the international market.

Then, anticipating internationalization of energy structure, what elements should we keep in mind in formulating the energy policy? Energy is a global issue in the contemporary world and the major points considered in energy discussion may be summarized as follows.

1) Assurance of social development under good coordination among 3S, namely, Economy, Energy and Environment

2) Strengthening of 3S in energy, namely, Security, Sustainability and Stability

3) Rational energy use and energy conservation

4) Best mix of energy supply

Features of these factors are as follows.

1) Assurance of social development under good coordination among 3S

Energy is an essential material for the national economy, being used in every economic sector. Energy consumption grows along with economic development and we cannot expect sustained social development without stable energy supply. On the other hand, energy consumption accompanies emission of air polluting gases such as SOx, NOx and green house gases such as CO_2. Construction and operation of energy infrastructure such as refineries and power stations will also increase environmental burdens. In view of these, it is important to consider the energy plan, which shall materialize good balances among 3Es, namely, economic development, energy supply and environment.

2) Strengthening of 3S in energy

When we look into the matter of securing stable energy supply, we notice that the issues are composed of three factors, namely, energy security, energy sustainability and the stability of the energy market.

Issues to be considered in the aspect of energy security are those risks of supply restriction or disruption to be incurred by accidents, abnormal weather, attacks by terrorists, etc., and if the energy system of the country is equipped with a firm ability to cope with such incidents. Against such threatening to the energy supply chain, candidate counter measures may be those such as recovery of peace under international cooperation, reinforcement of emergency response system as well as diversification of energy type, geographical diversification of energy sources, strategic oil reserves, etc.

Sustainability of energy is an issue whether energy consumption and supply are assured for long term or not. In order to secure the necessary quantity, at first comes a question if sufficient consideration is made promoting exploration and development of domestic resources. Regarding the energy system of a country, it is an issue if the systems of energy supply, transport and consumption are constructed in the manner acceptable to the society in terms of economic viability and environment concern.

Answering to this difficult question, 1) on the consumption side, to construct as efficient and clean energy system as possible, 2) on the supply side, to promote introduction of non-fossil fuel such as nuclear and renewable energies, are expected to bring synergistic effects. Then, government initiative will play an important role in implementing technology transfer, technology development, public relations for promotion of energy conservation and rational energy use, and providing guidance via pricing, tax and subsidies.

As shown in figure 4.1-2, energy consumption of Vietnam is not very large among East Asian countries. Therefore, if it is provided with the power to follow other countries, it is not conceivable to incur any big problems in energy supply; even if its import dependency increases. It would be simply required to pump up the necessary quantity from the huge energy flow in the international market place. For this purpose, however, it is necessary for the country to prepare a firm and strong energy system, which is internationally competitive in terms of price and/or energy efficiency.

Stability of energy relates to transparency and price stability of the energy market. From the experience, it is necessary to provide an energy market foreseeable to some extent with fair transparency in order to assure smooth economic development. To this end, it is desirable that the market should be managed with transparency under an appropriately designed structure. At the same time, it is necessary to bring up business entities sufficiently competent in the harsh international market. It is also necessary for Vietnam, where per capita national income is still low among ASEAN countries, to consider development harmonized with social welfare policies such as protection of poor nationals and development of remote villages.

From the international viewpoint, Vietnam is one of the East Asian countries. In the field of stability in the energy market, they are facing twin problems, namely, the Asian Premium of the Middle East crude oil prices and the expanding light/heavy spread of crude oil prices. These problems are caused by factors as follows; 1) the Middle East dependence is extremely high in East Asia, 2) East Asia lacks a stable international market, and 3) investments in the downstream facilities are delayed worldwide. It is necessary to watch out these international trends as Vietnam is going to become a net energy importing country in a decade or so.

3) Rational energy use and energy conservation

Upon the turn of the century, energy demand increase in emerging countries such as China and India has been accelerating, which has brought the world energy balance tighter and is pushing up the energy price. Likewise in Vietnam, energy consumption is forecast to expand 7-folds in 20 years in the BAU case. Although it is not impossible to supply the projected quantity, it would become a heavy burden for the socio-economic development. While Vietnam has maintained a self-sufficient energy structure to date, the country does not have large resource reserves and shall turn into an energy importing country sooner or later. Therefore, it is a very important policy objective to implement rational energy use and construct a light-energy type country.

In examining the matter, we look to two aspects, namely, 1) efforts to enhance rational energy use and lower the unit energy consumption per sectoral GDP, and 2) efforts to lower the share of the heavy energy consuming industry and construct a light-energy economic structure. In addition, heavy energy consuming industries are under the effect of the economics of scale and generally construct easily identifiable large plants. Therefore, we will also check and examine the individual construction projects in these industries.

4) Best mix of energy supply

The objective of the National Energy Master Plan is to establish an optimized plan from the viewpoint of abovementioned 3E and 3S to realize the best mix of energy supply over the projected demand outlook considering every possibility of energy supply from inside and outside of the country. However, we cannot expect an automatically calculated logical solution on the stable and reliable long term energy supply. An optimized energy policy mix under certain assumptions would need to be adjusted flexibly should economic and energy circumstances change. In this context, as we are supposed to set out direction and priority of the energy policy mix to realize the energy best mix in the National Energy Master Plan, we are also required to pre-examine various measures how to steer our boat against changes in the economic and energy situation in and outside of Vietnam.

4.2 Economic Development and Energy Conservation

As the long term economic trend and energy conservation are the key elements to give great impacts on the energy trend of Vietnam, we would like to explain here the fundamental understanding on them in this study.

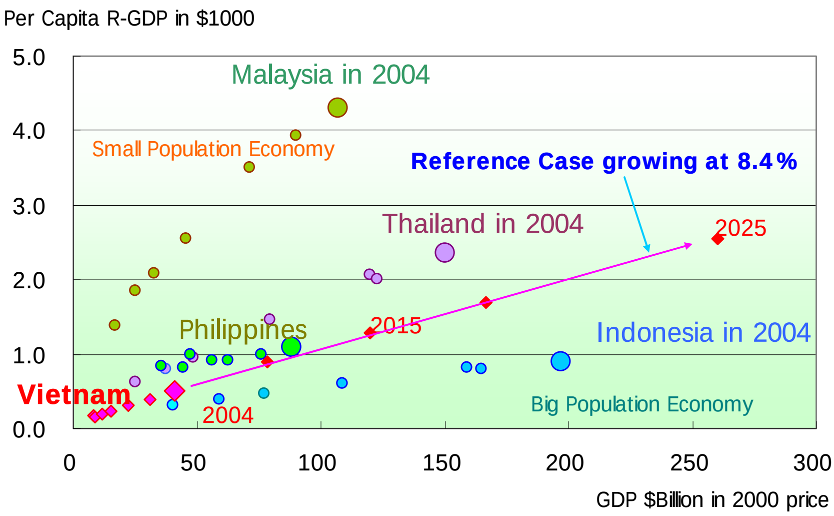
4.2.1 Economic Development Trend of Vietnam

Regarding the long-term economic outlook of Vietnam, the latest official plan is “The Five Year Socio-economic Development Plan 2006-2010”. Although there is no official outlook beyond the foregoing period, there is an outlook “Economic Development Forecast serving Study on Development for the period up to 2050” (hereinafter called as “EDF2050”), which was compiled by the energy economics analyzing group in March 2005. This outlook is used as the economic development scenario of the Sixth Power Development Plan (PDP6), and hence could be considered as semi-official one. It projects the long-term economic growth at around annual 8%, which may be deemed appropriate as a general view as follows.

As issues relating to energy and environment are anticipated to become serious in future, this is a creeping crisis, but not that catastrophe of the world economy is immediate. Rather, the global economy is in a healthy condition at this moment. Despite the current comfortable status, however, it is easily inferred that, as the size of the world economy expands enormously and it is led by emerging developing countries that need to construct the economic platform from the ground, competition will become fierce among them for securing feedstock and fundamental materials.

According to an economic theory, in the contemporary world where globalization progresses rapidly, the substantial economic difference between the developed and developing countries will continue to be the strong driver to sustain the world economic growth. Following the same theory, Vietnam will continue the steady growth as in the past during the 20 years of the projection period of this study. To materialize this, however, it is conditional that necessary energy and basic materials should be procured securely.

There is anticipation that the political situation in the world and region are uncertain, complicated and more difficult for developing countries, and that developing countries would be required difficult manoeuvring under the open economy policy of the WTO regime (EDF2050). However, once some fundamental conditions are prepared, it would be possible for developing countries to reduce the gap with developed countries. The contemporary world provides various measures for this, as ODAs and technology transfers have been applied widely in the past.

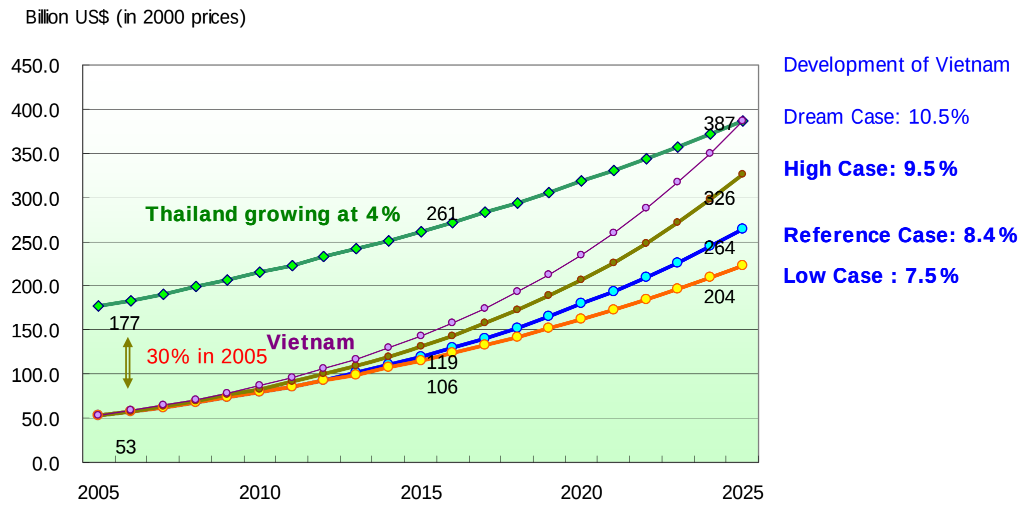


(Source) compiled from ADB "Key Indicators"

Figure 4.2-1 ASEAN and Economic Development of Vietnam

The recent rapid increase of FDI is an evident indicator to show that Vietnam has come out of the first stage of preparing for development and entered into the second stage for take-off. The cumulative amount of FDI in 2007 up to the end of September amounted to $9.7 billion; indicating $11.2 billion by the end of the year. Other forecast reveals an outlook that the 2008 FDI amount may grow to $14.5 billion, which is more than double of the amount scheduled in the current socio-economic development plan. Globalization and marketization of the economy have accelerated the inflow of FDI into Vietnam. Likewise, progress of tighter linkage and unitization with neighboring countries, Asian developed countries like Japan and US and European markets through accession to WTO would possibly accelerate economic growth of Vietnam. Transfer of industries from neighboring countries is already progressing substantially in labor-intensive industries as projected in EDF2050. However, the agriculture sector, which shared 20.9% of GDP and 56.9% of the labor force in 2005, will continue to supply labor forces to manufacturing industries and service industries for a log period.

From the above viewpoint, it may be appropriate to think that Vietnam will continue high economic growth exceeding annual 8% in future, and hence we will adopt the socio-economic development outlook of EDF2050 in this study for the Reference Case. As a result, per capita GDP of Vietnam, at present among the late coming group of four ASEAN countries, will increase from US$724 in 2006 to $2,550 in 2025, reaching the current level of Thailand.



(Source) compiled from ADB "Key Indicators"

Figure 4.2-2 Vietnam Catching-up Thailand

In 2004, per capita GDP were $501 for Vietnam and $2,355 for Thailand. The former was only 21.3% of the latter and their difference amounted to $1,854. If we assume that Thai economy would grow at annual 4% as in the past decade, per capita GDP of Vietnam will become 50% of that of Thailand at $5,200, while the difference in absolute amount will increase by 20%. From the viewpoint of comparative economic theory, this stipulates a rather conservative projection. In the *dream case* that Vietnam would catch-up Thailand in aggregate GDP, its growth rate shall be 10.5%. As the population of Vietnam is greater than Thailand, the per capita GDP of Vietnam still remains at 73% ($3,705) of that5 of Thailand. The above discussion may suggest that the high growth case for the study may be considered at half way between the dream case and the Reference Case.

However, capitals and industries would not keep flowing-in forever because of the wage difference. Most of the industries coming to Vietnam considering the comparative advantages are in principle export oriented in the sense that they aim at the international market as the place of their business but not limiting themselves to the domestic market.[13] Irrespective of high-tech or less high-tech in the nature of their products, they should be marketable in the international market both in quality and price. In this regard, the producers should be assured of smooth and rational economic activities in the country. Thus, in order for Vietnam catching-up the neighboring countries as shown in Figure 4.3-2, Vietnam is urged to prepare fundamental infrastructure essential for economic activities such as

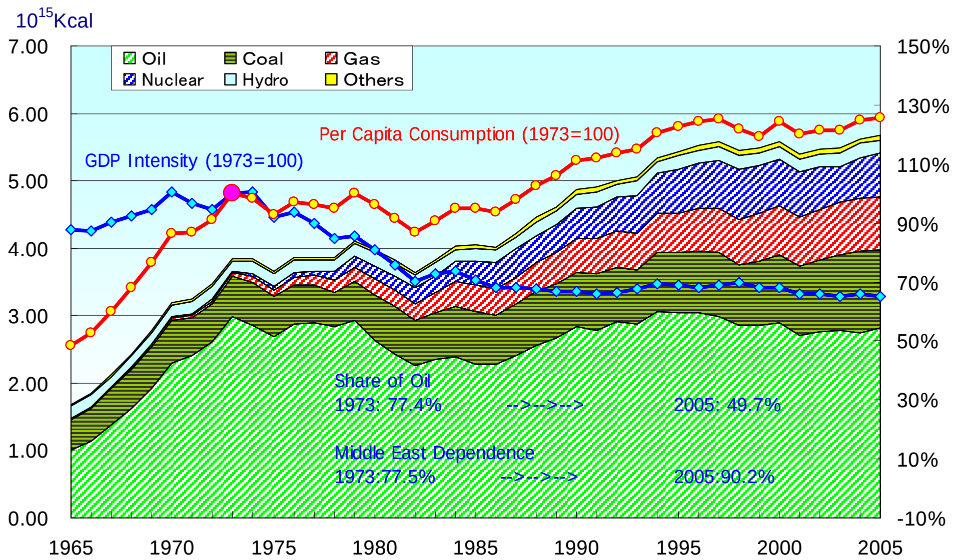
[13] *Here, we should not apply the classic definition of the export-oriented industry that they are simply the industries aiming at exporting products. It would be more appropriate to think that, in the contemporary world, an enterprise playing in the international market would locate a part of its business, from among the business value chain from feedstock to final product, in the country where it can enjoy the greatest benefit considering specific conditions at various countries. Therefore, it is essential to understand that, to support activities of such enterprises, it is necessary to prepare the fundamental elements of world class standard such as energy, transportation and communication.*

energy, transportation, communication, bushiness and life circumstance, etc., to bring up work forces that would produce goods and services marketable in the international place and upgrade the quality of the country's power.

4.2.2 Several Investigations on Energy conservation

While we could not avoid increase of energy consumption accompanying economic growth, it is very important to consider Energy Efficiency and Conservation (EEC) as a measure to mitigate issues of energy security and environment to be incurred. EEC is important in a sense that it is a measure to create "negative demand" and compares to discoveries of giant oil fields. In this regard, we would like to review the Japanese experience to tackle with the subject as a reference for this study.

Facing the oil crisis of 1973, various measures were implemented in Japan to strengthen its energy security. Energy conservation was one of the important policies together with energy supply diversification, and achieved a great result. By 2005, the energy intensity, ratio of energy consumption to GDP, has decreased by 65% compared with 1970, although per capita energy consumption increased by 26% during the same period.



(Source) IEEJ Handbook of Energy and Economic Statistics in Japan

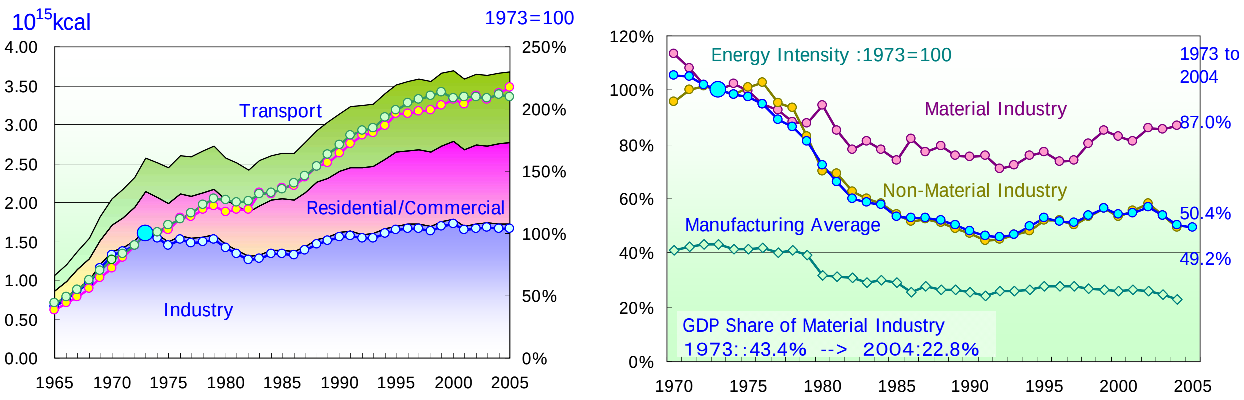
Figure 4.2-3 Energy consumption per GDP in Japan

If we look into the above progress more in detail, we notice the following remarkable tendencies as shown in Figure 4.2-4.

1) During the period from 1973 through 2005, energy consumption in the industrial and mining sector increased only 4%, while the energy consumption in residential/commercial and transportation sectors has more than doubled.

2) In the manufacturing sector, the energy consumption per sector GDP of the energy intensive material industries had decreased 13%, while it has decreased more than 50% in the non-material industries.

3) The energy intensity (energy consumption per GDP) of the whole manufacturing industry decreased 50%. In addition to the energy conservation in each sector, decrease of GDP share of the material industries from 43.4% in 1973 to 22.8% in 2004 also contributed to this substantially. If there were no change in industrial structure, the reduction of the energy intensity would have remained only at 21%. Shift of the industrial structure to a light energy type economy has brought a great effect.



(Source) Annual Report on National Accounts (Cabinet Office of Japan)
IEEJ Handbook of Energy & Economic Statistics in Japan

Figure 4.2-4 Evolution of Energy Intensity by Sector

Energy conservation may be implemented through improvement of the energy efficiency of energy using appliances and equipments, high efficiency operation and effective maintenance work. Among them contribution of efficiency improvement of appliances/equipments is most effective. Since these equipments may be used for 5 -15 years or longer, it takes substantial time for energy efficient ones to become widely used in the society. That is, effect of developing energy efficient appliances/equipments reveals cumulatively. For example, suppose that the energy efficiency of the latest model of an appliance is 10% higher then the average of the social stock and the social stock may be replaced in 10 years, energy efficiency will proceed 1% every year if there were no further improvement on the new models.

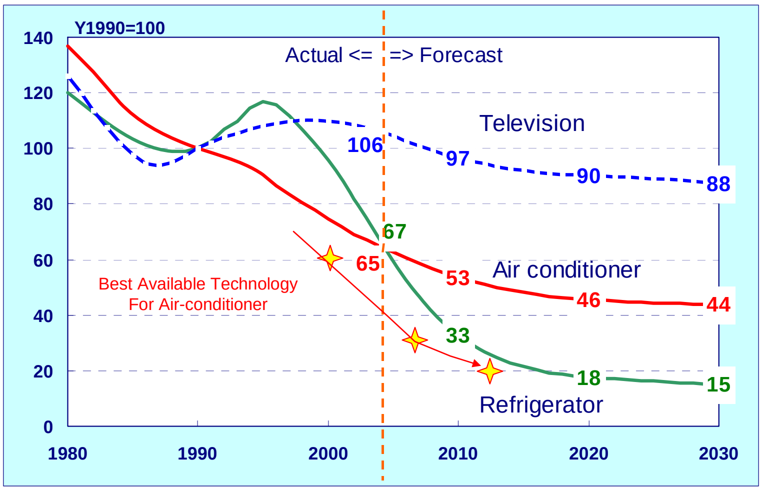
As shown in Table 4.2-1, Japan has pursued improvement of energy efficiencies of energy using appliances under the “Top Runner Program.” However, such top-running appliances would not necessarily represent the market. According to a survey by The Institute of Energy Economics, Japan, the average energy consumption rate of air-conditioners in Japan have been reduced to 2/3 during the period of 1990 through 2005, which compares to that of the latest model in 1998. Of the 2005 newest model, this is again reduced to 2/3. Here, we should note that such improvement has been achieved through extraordinary efforts of the engaged people. At present, there are 21 items listed under the top-runner program. The are committees on each item to examine the program consisting of more than 20 experts and working groups are attached to such committees to study feasibility of the target to be set for efficiency improvement from both technical and economic points.

As the result of the perverting effort of the industries toward such target, Japan has achieved the results as shown in Table 4.2-1.

Table 4.2-1 Improvement of Energy Efficiency under the Top-Runner Program

	Base Year	Target Year	Improvement	
			Target	Result
TV Sets	1997	2003	16.4%	25.7%
Video Cassette Recorders	1997	2003	58.7%	73.6%
Air Conditioners	1997	2004	66.1%	67.8%
Refrigerators	1998	2004	30.5%	55.2%
Freezers	1998	2004	22.9%	29.6%
Gasoline Passenger Cars	1995	2004	23.0%	22.0%

(Source) METI



(Source) IEEJ

Figure 4.2-5 Energy Efficiency of Home Appliances

From the above observation, an annual 1% energy conservation may be realized as a natural trend, though a nationwide promotion of EEC shall be required to enhance the energy conservation further. It is needless to say that efforts in every sector are required to promote such program, while the role of economic structure change is also large as discussed previously. In case of Vietnam, since the economy is going to expand 5 fold in the coming 20 years, 80% of the economy then prevailing will be newly constructed from now. In this context, rather than discussing on the past trend, we need to appropriately set out the position of the energy efficiency and conservation policy in constructing the *grand design* of the future economic society.

4.3 Crude Oil Price Scenario

4.3.1 Recent Crude Oil Pricing and Crude Oil Price Scenario in Demand Forecasting Model

4.3.1.1 Feature of Recent Crude Oil Pricing

Today, world crude oil prices are decided referring to crude oil spot prices at “Futures market” such as WTI spot price of NYMEX and Brent spot price of IPE, etc. The world crude oil price used to be decided by the international oil companies (Majors) before the oil crisis in 1973, and after then by the OPEC countries (the Organization of Petroleum Exporting Countries). At that time, Arabian Light crude oil (A/L) of Saudi Arabia, the representative crude oil of OPEC, was assumed as the "Marker Crude. Following the decision on the Marker Crude price at the OPEC Oil Ministers Meeting, other countries decided the prices of their crude oils taking into account of the differences of “API gravity[14]”, “Sulfur content”, etc. These price differences were called “Differentials”.

The OPEC crude oil pricing system collapsed in 1986 as the world oil demand-supply balance came to extremely loose, and then the OPEC’s leadership in pricing was lost. Then, “oil market” became to decide the world crude oil price reflecting the fundamental demand-supply balance. Today, “Spot price”, “Netback price”, “Futures market price” in the market are referred to as indices for crude oil pricing.

The present world oil market can be roughly divided into three. They are American market, Western market, and the Asia-Pacific Basin markets. There are typical futures market such as “New York Mercantile Exchange: NYMEX” in New York, “International Petroleum Exchange: IPE” (now its name is changed to IPC Future Exchanges) in London and “Tokyo Commodity Exchange for Industry” in Tokyo, etc. From all these markets, futures price changes are publicized around the clock. Today, oil has become so-called “Sensitive commodity” as speculative investors other than physical oil traders participate in the futures market and play money games for profit irrelevant to actual demand-supply situation. As a result, crude oil price is decided more by speculative actions than the market demand-supply trend. The current oil price is said to be $10–30/Bbl or more higher than the “Realities (the price decided by so-called Fundamentals).“

4.3.2 Energy demand forecast and crude oil price scenario

When energy demand and supply forecast is conducted, the crude oil price trend is usually set as one of the preconditions. For this purpose, a general procedure is not forecasting the future crude oil price but assuming some scenarios, setting out price scenarios such as “Reference case (Business as usual) “ and “High-price case”, considering the international oil situation. The same method is adopted in this study setting out scenarios such as the “Reference Scenario”, and corresponding “High-Price Scenario”, “Super-High-Price Scenario” and “Low price Scenario” as explained later.

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[14] An index to express gravity of petroleum, mainly crude oil, according to the method set out by the American Petroleum Institute (API). When the specific gravity is 1.0, the API gravity is 10 degrees. The larger the number, the lighter the crude oil having greater content of lighter products such as gasoline. For example, the standard API gravity for Arabian Light is 34° (SG=0.8550) and Arabian Heavy 28° (SG=0.8871).

4.3.2.1 Assumption of crude oil price by International Energy Agency

According to the assumption on the fossil fuel price of "IEA World Energy Outlook 2006", an average IEA crude oil import price in Base Case is assumed to rise to $55.00/barrel in 2030 from $50.62/barrel in 2005 in real term in 2005 dollar. In a nominal price, it rises from $50.62/barrel to $97.30 /barrel during the same period; the increasing rate of the deflator is 2.3% per year. In the IEA outlook, "Deferred Investment Case" is also assumed where the crude oil price in 2030 is assumed to be higher by $19/barrel in real term and $33/ barrel in nominal term than the "Base Case "; that is, $74/barrel in real term and $130.3/barrel in nominal term.[15]

Table 4.3-1 Forecast of prices of fossil fuels by IEA (International Energy Agency)

(unit: $/unit)

	unit	2000	2005	2010	2015	2030
Real term (year-2005prices)						
IEA Crude Oil Imports	barrel	31.38	50.62	51.50	47.80	55.00
(Deferred Investment Case)						(74.00)
Natural Gas						
Us imports	MBtu	4.34	6.55	6.67	6.06	6.92
European imports	MBtu	3.16	5.78	5.94	5.55	6.53
Japanese LNG imports	MBtu	5.30	6.07	6.62	6.04	6.89
OECD steam coal imports	tonne	37.51	62.45	55.00	55.80	60.00
Nominal terms						
IEA Crude Oil Imports	barrel	28	50.62	57.79	60.16	97.3
(Deferred Investment Case)						(130.30)
Natural Gas						
Us imports	MBtu	3.87	6.55	7.49	7.62	12.24
European imports	MBtu	2.82	5.78	6.66	6.98	11.55
Japanese LNG imports	MBtu	4.73	6.07	7.43	7.59	12.18
OECD steam coal imports	tonne	33.47	62.45	61.74	70.19	106.14

Note) Prices in the first two columns represent historical data. Gas prices are expressed on a gross calorie value basis. All prices are for bulk supplies exclusive of tax. Nominal prices assume inflation of 2.3% per year from 2006.

(Source) compiled from "World Energy Outlook 2006".

The above-mentioned price is lower than the WTI spot price by about five dollars/barrel, as the former is an average on various kinds of crude oils including heavier ones while the latter contains more light cuts for valuable products such as gasoline. The price difference between the world average and WTI may expand further because speculative movements in the market may affect WTI more. The basic pricing system in the Asian market applied to term contracts is to decide an individual oil price based on the spot prices of "Dubai + Oman" crude oils and adjusting the quality difference.

4.3.2.2 Future Crude Oil Price Scenarios

In this Study, we set out four scenarios on the future crude oil price trend, referring to studies run by

[15] *The IEA world Energy Outlook 2007 sets out an assumption that the average IEA crude oil import price in 2030 will rise to $62.00 for the Reference Case and $87.00 for the High Growth Case in 2006 dollars.*

IEA and other research institutes, such as the "Reference Scenario" and "High Price Scenario." The "Super-High-Price Scenario" is prepared to examine what situation would appear for Vietnam when the crude oil price rises extremely, and "Low Price Scenario" on the other extreme.

1) "Reference scenario"

The present world crude oil price fluctuates widely affected by, in addition to the traditional factors such as oil demand-supply situation (crude and refined products), weather and economic situation, speculative capital movement in the futures market. Taking account of the market circumstance, many organizations such as IEA and The Institute of Energy Economics, Japan adopt "Levelling-off" or "a marginal rise in real term" price scenario as the "Reference scenario." As the Reference Scenario for this study, it is assumed that the actual world import FOB price which was at $65/barrel as an average for the period from January to October, 2007 (the World export FOB price of USDOE database), will remains at the same level until 2025 in real term of 2005 value.

2)"High-price scenario"

The " High-price scenario" is the case where investment in oil development delays while oil demand continues to increase in Asian continues such as China and India and the USA toward tighter supply-demand situation, and hence the crude oil price rises considerably. It is assumed that the oil price rises even to the level of $75/barrel in 2010 and continues to be the same level up to 2025 in real term of 2005 value.

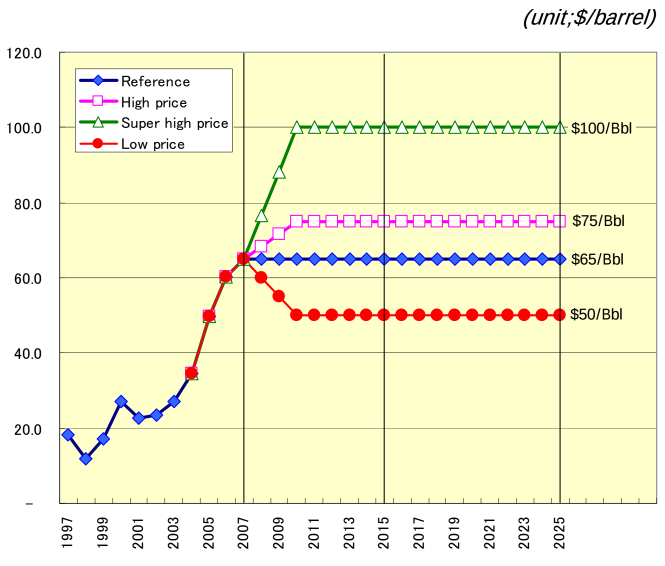


Figure 4.3-1 Actual world average import price (FOB) and forecast by scenario

IEA also considers that crude oil price would reach the level of $74/barrel in 2030 in real term of 2005, if the investment continues to delay. As IEA deemed this as an extreme case of "Deferred Investment", rapid increase of capital and material costs and shortage of technical experts on oil development have become remarkable recently compared to the time when the IEA Outlook was made in 2005, putting more pressure on the oil price. The recent soaring of crude oil price indicates that stronger pressures than before may be working in the market.

3) "Super-High-Price Scenario"

While a normal supply-demand situation in principle is assumed in the above-mentioned "High-price Scenario", it would be supposed that neither the demand-supply controlling effect nor the development promotion effect of price hike operate well, speculative capitals fan the flame of insecurity further, and the market reacts to this. In order to examine what situation would happen in Vietnam in such an extreme case, it is assumed that <u>the crude oil price rises to the level of $100/barrel in 2010 and remains at the same level up to 2025 in real term of 2005 value.</u>

USDOE also examines "High-price case" where crude oil price exceeds 100 dollars/barrel in 2030 in real term in its "Annual Energy Outlook: 2007." So, this is a case that should be examined sufficiently to consider the National Energy Master Plan.

4) "Low-Price Scenario"

Judging that the present crude oil price is raised by factors other than the demand and supply balance, it is possible to consider a scenario that crude oil price would fall back to the ordinary situation. In this scenario, <u>crude oil price may decrease gradually to $50/barrel by 2010 and then stabilize, or remain at the same level up to 2025 in real term of 2005 value.</u>

4.3.3 Estimation of export/import price of crude oil and petroleum products in Vietnam

4.3.3.1 Export price for Crude oil in Vietnam

Main indigenous crude oil of Vietnam is Bach Ho crude oil, and its properties are "light quality and low sulfur (API: 34.7 and Sulfur content: 0.08%)." Property of the Bach Ho crude oil is almost same to Sumatran Light (S/L=Minas) crude oil of Indonesia that is the representative grade of the Asian low-sulfur crude oils, and their prices are considered almost same in the international oil market, too. Therefore, in the following discussion, the S/L crude oil price (FOB) will be used as a substitute for the Vietnamese crude oil export price (FOB), as price data on S/L is easily available from the international statistics.

The following relationship is obtained applying regression analysis on the past trend of the world crude oil export price (FOB) and the S/L crude oil (FOB) based on the data of the United States DOE/EIA.

Sumatra Light =-0.4775 + 1.0877 × World Export Crude Oil Price

(T-value) (3.02) (228.30)

Analysis period: From the first week of 1997 to the fourth week in February of 2007

$R=0.995$ $R^2=0.990$

The estimated S/L crude oil price (= Vietnamese crude oil price) in future is shown in Figure4.3-2 applying the above-estimated equation. In 2010, they are $70 /barrel (five dollars higher than the world crude oil export price) in the Reference Scenario, $81/barrel (six dollars higher) in the High-Price Scenario, $108/barrel (eight dollars higher) in the Super-High-Price Scenario and $53/barrel in the Low Price Scenario. The expanding price difference reflects the situation that construction cost of desulfurization and cracking equipments, as the cause of the quality differentials, is on an upward trend and also the desulfurization/cracking cost increases according to rising crude oil price because these devices and manufacturing cost of hydrogen (both use crude oil and byproducts as own use) occupy substantial portion of the refining cost.

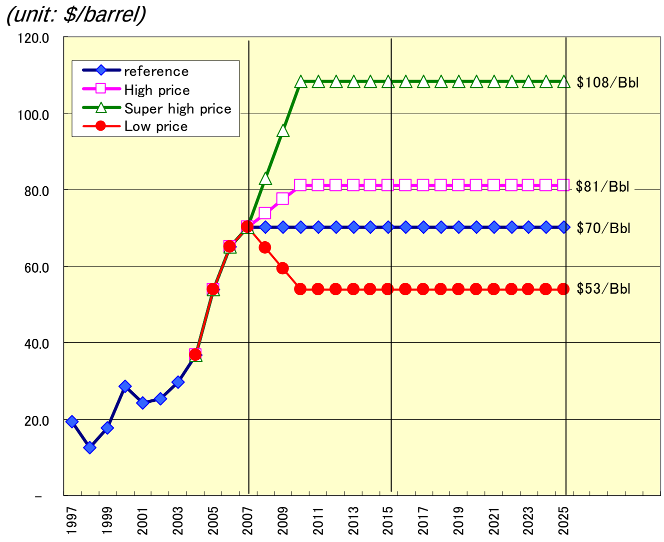


Figure 4.3-2 Actual average export price (FOB) of Vietnamese crude by Scenario

4.3.3.2 Import Price of Crude Oil in Vietnam

It may be reasonable to assume that crude oils imported for Vietnamese oil refineries in future will become the Middle East crude oils in view of supply availability. While there are various crude oils in the Middle East, Arabian light (A/L) of Saudi Arabia as the representative light grade and Arabian heavy (A/H) as the representative heavy grade are taken up in this analysis.

Although A/L yields more light products, it is heavier than S/L crude oil by 2 API degrees because residue of A/L is heavier than that of S/L. On the other hand, the desulfurization equipment is necessary to produce clean refined products because A/L has overwhelmingly high sulfur content, resulting in lower value. All in all after balancing lighter cut content and high sulfur content, S/L (Bach Ho) is valued higher than A/L.

Applying regression analyses on A/L (API: 33 and Sulfur content: 1.9%) and world average crude oil import price, future crude oil import prices corresponding to in each case are estimated as follows.

Arabian Light = 0.1799 + 0.9859 × World Export Price

(T value) (2.08) (379.86)

Analysis period: From the first week of 1997 to the fourth week in February of 2007

R=0.998 R2=0.996

The price level of A/L is almost same the world average crude oil import price as indicated in the above-mentioned expression. The estimated price for 2010 is $66/barrel (one dollar higher than the world crude oil export price) in the Reference Scenario, and $76/barrel (one dollar higher) in the High-Price Scenario, $100/barrel (almost same) in the Super-High-Price Scenario, and $51/Barrel (one dollar higher) in the Low Price Scenario.

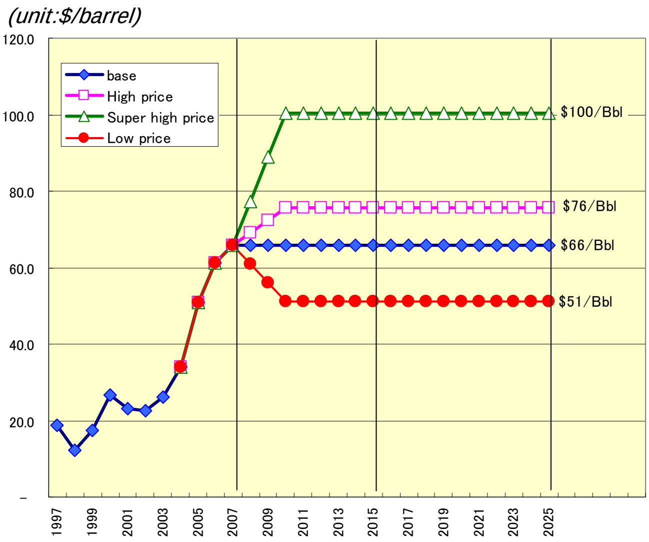


Figure 4.3-3 Arabian Light Crude Oil Export Price (FOB) by Scenario

On the other hand, suppose that demand for light quality crude increases worldwide making the supply balance tighter, there is a possibility of importing heavy quality Middle East crude oil. As the representative grade in such case, import of A/H (API: 28° and Sulfur content: 3.0%) is considered. The quality difference between A/L and A/H crude oil is at first the difference in the desulfurization and cracking cost, though both of them are high sulfur crude oils requiring desulfurization devices in refining gasoline and diesel oil. Because S/L (Bach Ho) crude oil is super-low sulfur, such desulfurization devices are not needed. In a word, major cause of the difference between Arabian and Southeast Asian crude oils is the desulfurization. However, the price difference shown in the market has considerably expanded in recent years substantially exceeding the cost difference, and reflecting deficiency of secondary refining equipments.

In the actual model, values obtained by regression analyses on each crude oil (FOB) and world crude oil price (FOB) are adopted. Incidentally, the result of the regression analysis on A/H and the world crude oil export price is as follows.

Arabian Heavy = 0.7086 + 0.8892 × World Export Price

(T value) (5.56) (232.99)

Analysis period: From the first week of 1997 to the fourth week in February of 2007

R=0.995 R^2=0.990

4.3.3.3 Domestic and international petroleum products Prices

We estimate the domestic energy prices based on each crude oil scenario. The domestic energy prices will follow the trend of the international energy prices and keep the linkage in future.

Vietnam is aiming to establish the platform for further economic development through economic structure reform into competitive market economy and improving efficiency of resources. It means transformation from the State regulatory pricing system to the market oriented pricing system.

Then, it is necessary to pay attention to pricing not only in the domestic market but also in the international market. Vietnam is going to shift from an energy exporting to an importing country at around 2015. As the National Energy Policy sets out energy pricing policy by each energy source, since the incremental energy demand needs to be supplied by import, it is necessary to move to a pricing system to follow the international market trend as soon as possible.

The current domestic energy prices remain at 1/2 or 1/3 of the international market prices. Such low energy prices would prevent efficient use and lead to wasteful use of energy. In order to promote reasonable development of domestic energy resources introducing necessary technology and fund into the energy sector, it is required to move to a pricing system following the international market. In this study, it is assumed that the domestic energy prices will reach the international market price levels in 2015.

1) Domestic petroleum prices[16]

Vietnam imports almost all of the petroleum products from the international petroleum products market. Therefore domestic petroleum prices may be deemed as already reached the international market price level and the spot prices at the Singapore market may be referred to as the indices. As prices of gasoline, kerosene, diesel and fuel oil at the Singapore market are available at USDOE/EIA, the domestic petroleum prices will be obtained adding freight, domestic costs like customs, etc.

(unit: cent/little)

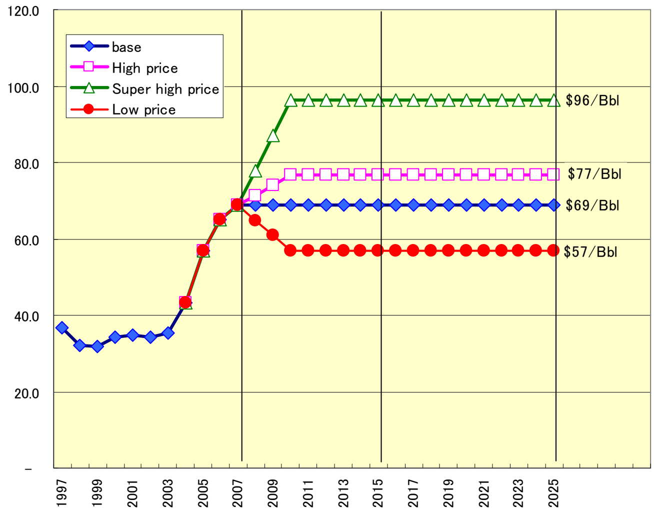


Figure 4.3-4 Retail gasoline price in each scenario

1) The Singapore spot market prices will change following each crude oil price scenario.
2) The domestic handling costs may be equal to the difference between the domestic retail prices and the Singapore market prices.
3) The above will be further adjusted by freights and the exchange rate to USD in the future.

All the above assumptions are applied to estimate prices of petroleum products such as gasoline,

[16] *Data for the price of petroleum products in Vietnam was acquired from IE (Institute of Energy). They are the retail prices, which include the import prices, customs and domestic costs like domestic transportation cost, etc.*

kerosene, diesel and fuel oil. Figure4.5-4 shows the estimated domestic gasoline prices as an example.

2) Coal and Natural Gas Price in Vietnam[17]

The coal and natural gas prices in the domestic market are set at levels considerably lower than those in the international market. In this study, it is assumed that they will be gradually revised to the international level by 2015 and then follow the each crude oil price scenario.

a) Coal Price;

The domestic coal prices diverse as they are set by grade. The present price for power sector is at \$20/ton and it is assumed in the PDP6 (The 6th Power Sector Development Plan) to be increased to \$29.7/ton in 2025. It is considerably low compared with \$60 – 70 /ton currently prevailing in the international coal market. It is apparent that the future coal import for power use should follow the international market price.

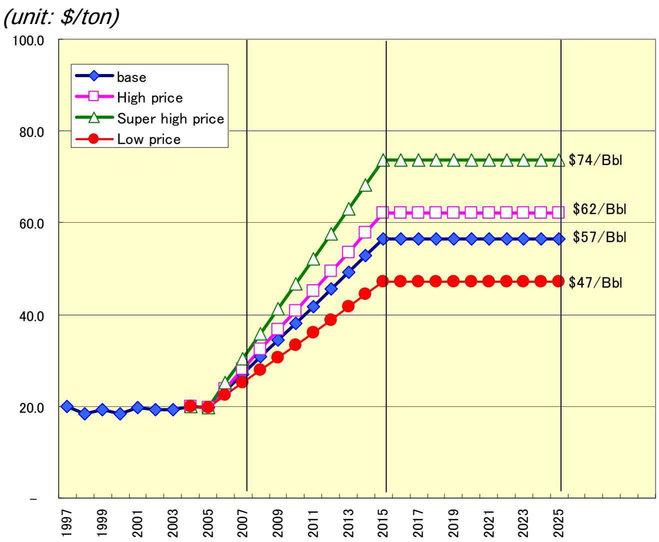


Figure 4.3-5 Domestic coal price to the power sector in each scenario

In this study, the is supposed that the Australian export price of steam coal (FOB) shall be the standard international market coal price and the Vietnamese coal price[18] will reach this level by 2015. The coal price to the cement industry is already deregulated in 2007 to be decided through price negotiation between VINACOMIN and the industry, while the price level is still far below the international market price.

b) Natural Gas price;

There are two prices on natural gas in Vietnam for associated gas and non-associated gas.

[17] *Data on the domestic prices of coal and natural gas were supplied by IE and VINACOMIN, while international data were collected by the Institute of Energy Economics, Japan.*

[18] *Prices are adjusted to their heat values assuming 6,322kcal/kg for the Australian coal and 5,500kcal/ton for the Vietnamese coal, while some with lower heat value of 4,500kcal/ton are also used for power generation. Coal prices for industrial use are also adjusted in the same manner, and different prices per ton are applied in heat value equivalent.*

Reflecting the history of natural gas development, it started with associated gas and recently non-associated gas production was added. Both of them are below the international level. They should be put at the same level in principle if no quality difference exists. In this context, it is assumed that the domestic natural gas prices will reach the international price by 2015 and then all of them will be priced in heat value equivalent.

As an index of the international natural gas price traded in Asia, the Japanese LNG import price is picked up with adjustment on freight difference.

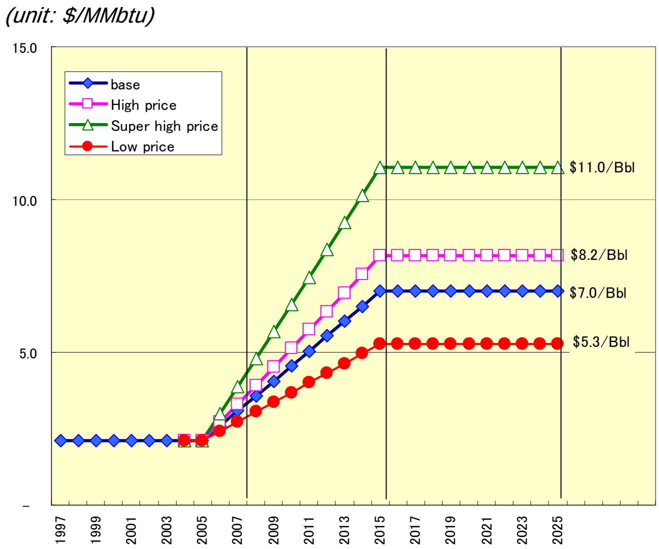


Figure 4.3-6 Domestic gas price in each scenario

4.4 Composition of the Long-term Energy Model

Analytical tools used in this study are composed of three blocks, namely, Energy Database, Demand Forecasting Model and Supply Optimization Model as shown in Figure 4.4-1. The energy database is a tool to compile the energy data of Vietnam consistently and is designed applying the IEA method as the standard. The database shall be operated independently from the analytical models; the data compiled and aggregated in the database are not directly linked to the models as a system, but to be used from time to time being copied to these models.

The long-term energy model is divided into two blocks, the Demand Forecasting Model and the Supply/Demand Optimization Model, in view of operational convenience, and adopts a one-way flow method "from demand forecasting to supply optimization." As the first priority is given to appropriately express the energy system of Vietnam in the models, simplification is tried to the maximum extent to avoid excess enlargement of them. For example, since it is no the main objective of this study to look into the socio-economic trend of the country in detail, it is designed to give the

socio-economic development scenario as a precondition to the model. Starting from suchpreconditions, the system is designed to analyze energy demand tendencies and policy options to realize energy supply optimization.[19]

[19] *In this study, the analytical model is designed referring to the experiences of IEEJ and method applied by various research institutes, and giving a priority on the operational convenience. The detail concept will be explained in Part 4.*

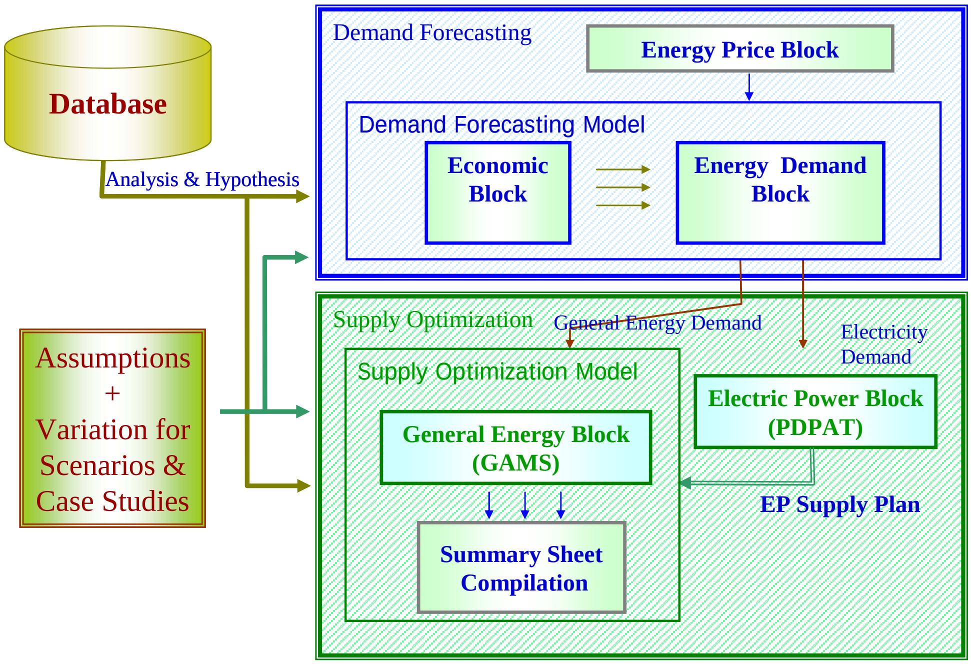


Figure 4.4-1 Composition of Long-term Energy Model

The demand forecasting model and the supply optimization model are further divided as follows. In the demand forecasting mode, an energy price sub-model is attached which at first calculates the domestic energy price movement in Vietnam referring to given assumptions on the world energy price trend. The outcome shall be used by copying the estimates into the demand forecasting model. The demand forecasting model is composed of the economic block and the energy demand block, while they are combined in the model and the energy demand estimation results will be obtained by giving major assumptions on economic and price elements. The results are output on an EXCEL summary sheet to be given to the supply model as inputs.

The supply block is composed of the electric power block and general energy block, and the optimization calculation shall be conducted in the following procedure.

1) Against the electricity demand estimated by the demand forecasting model, power generation quantity and fuel consumption shall be decided by type of power stations (coal, fuel oil, natural gas, nuclear, etc.) using the electric power supply/demand analysis model “PDPAT” developed by Tokyo Electric Power Company.

2) In the general energy block excluding the power sector, the optimized pattern of the energy supply shall be calculated using the Energy Supply/Demand Optimization Model (the “Supply Model”) developed for the purpose of this study.

3) Then, calculated estimates as above shall be aggregated to give the Total Primary Energy Supply. The aggregated result is output on an EXCEL summary sheet for easy comparison of cases. A brief summary table of the calculation results is also output.

As the work procedure, in case to change the price conditions, it is necessary to run four models in the order of 1) price model → 2) demand forecasting model → 3) PDPAT → 4) energy supply model.

In case assumptions on the demand forecasting were changed, three models after 2) shall be run. Likewise, in case of changing the conditions for the electric power sector, the last two models after 3) and in case of changing energy supply conditions, the last model under 4) shall be run. As the case study procedure is a little bit complicated like this, it is designed to improve the operational convenience by dividing the model into several blocks.

In the above system, the linear programming (LP) method is applied in the final supply optimization model. This is the method to logically assure the calculation of the "optimum solution as the whole system". However, the solution calculated by the model is decided by the assumptions and parameters given to the model. Whether the calculated solution indicates the true solution closely or not depends on how closely these assumptions and parameters are given to reflect the reality.

In the reality, however, it is impossible to give the model perfect assumptions and parameters. And, from operationality viewpoint, it is desirable to make the model as simple as possible. That is, we should think that these models are the tools to evaluate changes in future scenarios and/or effects of policy options, so as to project future plans for the desirable society by iteration of trial and error. As a consequence, it is not that the model will automatically give us a solution on the energy best mix but that the policy planner shall set out the policy objectives in pursuit of the energy best mix through examinations by the model. The model prepared for this study is not more than a tool to conduct such investigations.

4.5 Scenario Setting and Case Studies

Implementing the various analyses in this study, setting of assumptions for the Reference Case is the most important job to be carefully worked out since it represents the fundamental direction of the National Energy Master Plan. In this study, the BAU (Business as Usual) case was studied at first extending the current energy demand structure into the future. The future energy outlook is simulated there under the scenario that the Vietnamese economy would grow at a speed of annual 8.4% for the coming 20 years and the world energy price would remain at the current level through out the simulation period. The result is summarized as follows.

1) The final energy demand will increase at an annual growth rate of 8.6%, reaching 5.2 fold of that of 2005.
2) Due to resource constraints, the domestic energy production will peak out around 2015 unless large-scale discoveries were made.
3) As a result, the self-sufficiency ratio of energy supply will decrease rapidly. Vietnam would become a net energy import country by 2015 and the import dependence ratio would further deteriorate near to 50% by 2025.

In terms of the relation of the per capita energy consumption and per capita GDP, the Vietnamese energy consumption trend is substantially higher than those of ASEAN counties. It would not be possible for Vietnam to continue the current trend unchecked as projected in the BAU Case, as Vietnam changes from an energy exporting to an importing country while the world energy balance is tightening. In order to avoid the situation that energy issue would become the constraint for the sustainable economic growth, it is required to mitigate the stress arising from the above trends as

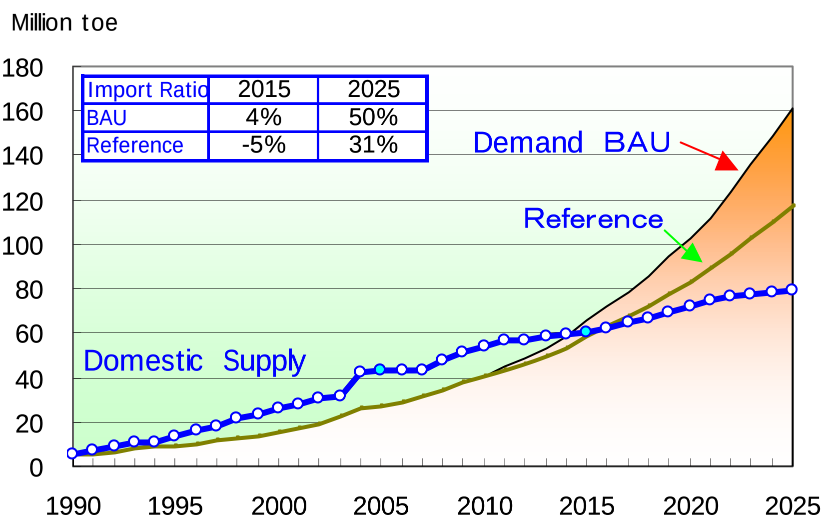


Figure 4.5-1 BAU Case versus Reference Case

much as possible. In this context, the Reference Case for this study is set out that, with enhanced energy conservation, energy consumption would be decreased by 10% in 2015 and by 25-30% in 2025 from those forecasted for the BAU Case.

As shown in Figure 4.5-2, various cases were run in this study starting from the Reference Case. Factors examined in these case studies may be classified into those relating to (1) change of energy demand and (2) change of supply condition as follows.

1) Factors relating to change of energy demand

・Economic growth scenario

・Energy price scenario

・Modernization and urbanization scenarios affecting non-commercial energy use.

・Energy conservation scenario

・Motorization scenario

2) Factors relating to change of supply condition

・Possibility of coal import

・Natural gas utilization: Construction of gas fired power plants and city gas supply system

・Introduction of nuclear power plants and its schedule

・Construction plans of oil refineries and their timing

・Introduction schedule of renewable energies

Starting with the Reference Case, explanations will be given in Chapter 5 on the cases relating to changes of the energy demand, and cases relating to changes of supply conditions are explained in Chapter 6.

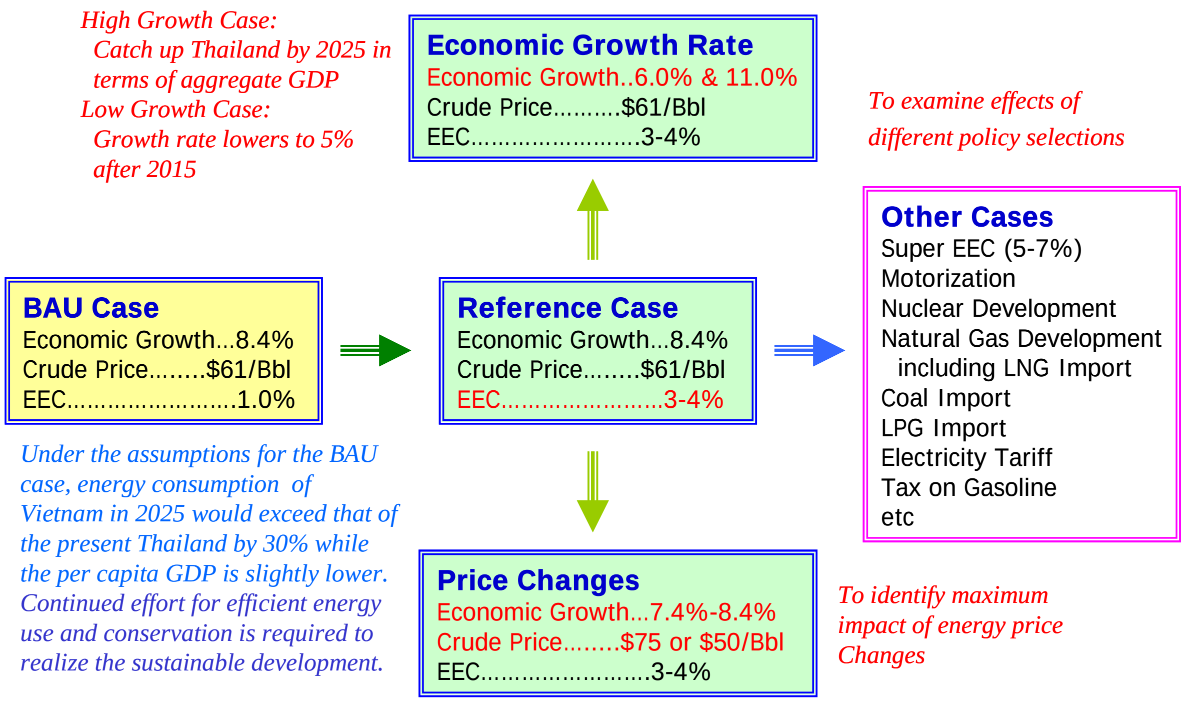


Figure 4.5-2 Case Setting

Chapter 5 Energy Demand Forecast

In this chapter, outcome of the demand analysis using the Demand Forecasting Model will be presented. Case setting and estimation results will be explained on the cases relating to changes of the energy demand, that is, on the Reference Case, "High economic growth case" (Low economic growth case as an additional study), "High energy price case" (Low energy price case as an additional study) and "Super EEC case", respectively.

5.1 Reference Case as the Standard Scenario

5.1.1 Economic growth scenario

With regard to the middle-long term economic outlook of Vietnam, we follow in this study the projections made in the present Socio-Economic Development Plan and EDF2050 and assume that annual 8.5% economic growth will continue through 2020 and this will slightly slow down to 8.0% afterwards. As discussed in the previous chapter, main background of this projection may be summarized as below.

1) The economic gap with the leading ASEAN countries and China continues to be the driving force for high economic growth of Vietnam. The economic gap (the gap of per capita GDPs) between Vietnam and other countries would not disappear easily even though high economic growth exceeding 8% continues.

2) The agricultural and fishery labor force shares 57% of the total labor force (44 million), being substantially higher than Thailand (43%) and Indonesia (44%). Strong pressures will continue to exist supplying labor forces from the primary sector to the secondary and tertiary sectors.

3) Under the circumstance, should the social infrastructure be developed smoothly, FDI inflow and fixed capital formation could be expected to continue the current high speed for a considerably long period.

Table 5.1-1 Economic growth outlook in the middle and long term

This project		2006-2020	2020-2025
	Reference case	8.5	8.0
EDF2050		2011-2020	2021-2030
	High growth case	8.5	8.0
	Predicted case	7.2	7.0

(Note) Please refer to Chapter 12 on estimation of the individual economic variables

The Five-Year Socio-Economic Development Plan 2006- 2010 set forth as its main targets to maintain high economic growth, to resolve education, medical and poverty problems, to improve and protect environment, etc., with numerical targets as follows;

a) Average GDP growth rate for 2006～2010 at annual 7.5～8.0% (targeting more than 8.0%)

b) Economic structure with Agriculture:15～16%, Industry & Construction:43～44% and Service:

40～41%

c) Average growth rate of export at annual 16%

d) Share of the total investment over GDP to be maintained at more than 40%.

e) Foreign Direct Investment (FDI) as a total amount for 2006-2010 to be US$35～40 billion.

However, the current trend for 2006-2007 indicates a possibility of higher economic growth exceeding the above targets backed by increases in export and FDI inflow. Under a conservative estimation, it could be predicted that an average economic growth rate of 8.5% would be achieved adequately for the period of 2006-2010. In the long tem outlook by EDF2050, the average economic growth rate for 2011-2030 is set at a very high level of 7.0-8.5% as shown in Table 5.2-1. However, reviewing the 20-year history of economic growth before the Asian currency crisis of 1997, the average growth rates of the leading ASEAN countries were 11.9% for Malaysia and 7.9% for Thailand. In particular, considering the fact that the per capita GDP of Thailand in the middle of 1970s was at the same level as the current figure of Vietnam, and that the latter still remains at one fourth of that of Thailand, it would be said safely that the economic scenarios of the EDF2050 is not excessive.

5.1.2 Other important assumptions

With regard to the main factors having strong impacts on the energy demand, assumptions for the Reference Case are made as follows;

5.1.2.1 Population Growth

The growth rate of the population in Vietnam was 1.4% in the past 5 years. According to EDF2050, it is estimated that the population growth rate is 1.1% up to 2020. After 2020, the growth rate may slow down to 0.8% through to 2025.

Table 5.1-2 Population growth rate

	Unit	2010/2005	2015/2010	2020/2015	2025/2020
G.R. of Population	%	1.1	1.1	1.1	0.8

(Source) EDF2050

5.1.2.2 Exchange Rate

According to Purchasing Per Parity Theory (PPP theory) of the floating exchange rate system, the exchange rate between two countries (in this study, the US and Vietnam) is basically determined by the difference between the inflation rates of them. However, the reliable exchange rate could not be forecasted easily, even though applying the PPP theory, since it is subject to various changes in the interest rates, economic fundamentals, foreign trade balances and so on. In this study, the future exchange rates projected in the EDF2050 is adopted which stipulates that VND would depreciate at an annual rate of 2% through 2020 and then level off as follows.

Table 5.1-3 Exchange Rate Outlook: VND vs. US$

	2005	2010	2015	2020	2025
VND/US$	15,916	16,856	17,947	19,609	21,168

(Source) EDF2050

5.1.2.3 Energy Prices

With regard to the world crude oil price, it is assumed that the current price level prevailing for the first nine months of 2007 would remain same in real term up to 2025, as discussed in Chapter 4 and after referring to the studies of IEEJ and IEA, and that prices of other energies may follow the same trend. It should be noted, however, that, should the world crude oil price remain at the same level, the domestic energy prices in Vietnam will be subject to depreciation of VND against US$ (or by the difference of inflation rates in the calculation of the model).

1) Petroleum product prices

At present, the petroleum product price system in Vietnam is being reviewed. In the past one or two years, petroleum product prices in Vietnam have increased about 30% except for the fuel oil for the power sector. In future, as prices continue to increase, the pricing system may evolve so that domestic prices should be decided through market mechanism referring to international prices. From the cost composition viewpoint, petroleum product prices consist of crude oil price, refining cost, transportation cost and sales cost with adjustment by tax and subsidy. As the number of automobile is forecast to increase fast and a significant amount of investment is required for road construction, it may be necessary for Vietnam to consider policy selections relating to the energy and environmental taxation with due study on the precedence in other countries.

2) Coal price

The coal price is being adjusted to the international price level except those for the power sector, and the latter will also be increased in due course. At the same time, it is estimated that the future coal production cost will increase as the production system will shift from the open pit system to the underground mining. And thus, after some adjusting period, the domestic coal price will become linked to the international price. Thus, it is assumed in this study that the domestic coal price shall reach the level of the international coal price by 2015.

3) Natural gas price

While the natural gas prices are being determined by the individual contract for each project, it is estimated that it will move closer to the international natural gas price (the CIF price of LNG traded in Asia). Thus, it is assumed that the natural gas in Vietnam will reach the international level by 2015. As the international natural gas prices are linked to the crude oil price, the natural gas price after 2015 is assumed to be levelling off as same as crude oil.

4) Electricity tariff

The current electricity tariff system applies the sectoral electricity tariffs and higher tariffs for bigger consumers, together with preferential policy for rural residents. These may be reviewed by 2015-2020 in principle to become a cost based tariff system. As the details of the new system are not apparent at this moment, it is assumed that the electric tariff would be, starting from the current system, decided with 50:50 impacts of two elements, which are future crude oil price and improvement of the labor productivity, i.e., wage, in Vietnam. When the new system becomes more apparent in future, the applied electricity tariff system should be revised, accordingly. The above assumptions are summarized in Table 5.1-4 below.

Table 5.1-4 Petroleum product prices in Reference case

Products	Unit	2005	2010	2015	2020	2025
IEA world export price	US$/bbl	50	65	65	65	65
Crude oil export price of Vietnam	US$/bbl	54	70	70	70	70
Coal FOB	$/ton	20	38	57	57	57
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5
Natural Gas (Domestic price)	$/MMBTU	3.3	5.1	7.0	7.0	7.0
Gasoline retail price	Dong/liter	8,933	11,885	13,010	13,820	14,257
Kerosene retail price	Dong/liter	6,300	11,266	12,348	13,126	13,547
Diesel retail price	Dong/liter	6,500	10,897	11,943	12,696	13,102
Fuel oil price in Vietnam	Dong/liter	4,633	6,761	7,410	7,877	8,129
LPG price in Vietnam	Dong/kg	13,800	20,484	22,451	23,866	24,630
Electricity for Agriculture use	Dn/KWh	660	1,012	1,118	1,236	1,365
Electricity for Residential use	Dn/KWh	695	1,065	1,177	1,301	1,437
Electricity for Industry use	Dn/KWh	829	1,271	1,405	1,553	1,716
Electricity for Commercial use	Dn/KWh	1,359	2,083	2,302	2,544	2,811

5.1.2.4 Economic structure and energy conservation

In the middle-long term energy demand forecast, progress of energy conservation will have a significant cumulative effect. According to the experiences in Japan, the energy conservation issue could be considered in two separate aspects as below.

1) The industry structure reflecting the ratio of the energy intensive industries (mainly materials industries) and the non-energy intensive industries

2) Promotion of energy conservation in each sector

1) Industry structure

It is considered that, in the economic development of Vietnam, existence of economic differences with neighboring countries and the big agricultural population will be the main driver and the export oriented assembly industries will lead the economy. Meanwhile, except for the abundant reserves of bauxite, Vietnam is not in a position to develop big material sub-sectors, although materials are necessary to some extent for economic development.

In general, economics of scale works well in the materials industry and the plants are big in size. Therefore, in addition to the econometric model analysis, it is appropriate to consider the new construction plans in the four major energy intensive sub-sectors such as Iron/Steel and Non-ferrous metal, Paper & Pulp, Oil and Chemical products and Cement & Ceramics. In this study, considering that the government of Vietnam aims at construction of a less energy intensive economy, it is assumed that the growth rate of energy intensive industry should be a half of that of the whole manufacturing industry. In Vietnam, however, as the energy intensive industry shares 63% of the GDP of the total manufacturing industry, it shares only 47% in energy consumption over the whole manufacturing industry, and it shares merely 22% in the energy consumption over the whole economy. Therefore, it is considered that promotion of sectoral energy conservation may have greater impact in Vietnam than the changes of the position of the energy intensive industries in its economic structure. Sectoral development trends are projected as shown in Figure 5.1-1 referring to the projection in EDF2050 and above discussions.

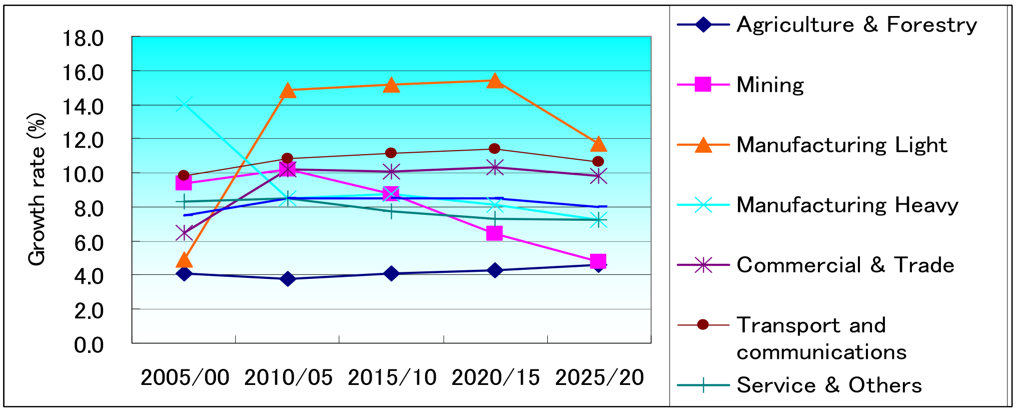


Figure 5.1-1 Five-year average GDP Growth Rate by Sector

The agricultural sector will continue steady growth through promotion of commercial products, while the mining sector may be affected by slowdown of oil and gas production. Light manufacturing industries typically represented by assembly industries such as home appliances, car manufacturing and electric machines/appliances will grow rapidly with burgeoning investments from Japan and other neighboring countries. In contrast, production of the heavy and chemical industries may be limited for the domestic market, and hence they may grow slower than the GDP growth rate. While commercial and transport sectors generally grow in proportion to GDP, as these sectors in Vietnam are in substantially low levels compared with ASEAN countries, they are expected to grow faster in future. Development trends of each sector diverse depending upon the starting position and national economic policy. As discussed above, the future economic growth of Vietnam will be driven by assembly industries and commercial and transportation sectors.

2) Sectoral energy conservation

It is assumed for the BAU Case that energy conservation may progress at a speed of the current trend, and for the Reference Case that the main industries will make substantial efforts on energy conservation strongly backed by the Government. However, looking at the current status of preparation of the energy conservation laws and implementation system, its achievement timing stipulated in the national strategy would be substantially delayed.

Considering the time lag for the effect of energy conservation efforts to materialize, the study period is divided into three steps as shown below.

Step 1: Preparation and Trial

Start a trial program by 2009, with priorities on organizing the EEC implementing system and offices with legal platform, construction of database system and promotion of public relations.

Step 2: Partial implementation

Set forth the governmental guidelines and policies on EEC and apply them partially to the energy users selected from each sector by 2010-2015

Step 3: Full scale implementation

Apply the EEC policy and legislation to all the designated energy consumers by 2016-2025.

With the above-mentioned efforts, energy conservation is supposed to realize as shown in Table 5.1.5. Details of the energy conservation activities will be discussed in Chapter 9 and 10.

Table 5.1-5 Energy conservation rates

(Unit: %)

Sectors	Cases	2010-2015		2016-2020		2021-2025	
		Power	Fossil	Power	Fossil	Power	Fossil
Agriculture	BAU	1.0	1.0	1.0	1.0	1.0	1.0
	Promotion	1.0	1.0	1.0	1.0	1.0	1.0
Industry (Light)	BAU	1.0	1.0	1.0	1.0	1.0	1.0
	Promotion	3.0	3.0	3.0	3.0	3.0	3.0
Industry(Heavy)	BAU	2.0	2.0	2.0	2.0	2.0	2.0
	Promotion	3.0	3.0	3.0	3.0	3.0	3.0
Transportation	BAU	1.0	1.0	1.0	1.0	1.0	1.0
	Promotion	1.0	1.0	1.0	1.0	1.0	1.0
Comercial &Service	BAU	1.0	1.0	1.0	1.0	1.0	1.0
	Promotion	3.0	3.0	3.0	3.0	3.0	3.0
Residential	BAU	1.0	1.0	1.0	1.0	1.0	1.0
	Promotion	3.0	3.0	3.0	3.0	3.0	3.0

5.1.2.5 Increase of Automobiles

In Vietnam, motorbikes are used widely as popular transportation vehicle with 19 million units registered in 2005. Motorbikes are owned one for one household already, though its sale is running at a high level. On the other hand, the number of four-wheel-vehicles is only 577,000, among which only 195,000 units of passenger car was recorded in 2005. In its background, there are several factors such as low income, high import tax, regulation on used car import, poor road conditions and so on. However, as income level improves and the number of business successors increases, there is a possibility that the passenger car ownership would rapidly increase as we have seen in other Asian countries. Then, as a passenger car uses over 1,500 litter gasoline per year while a motorbike only 150 litter, it is possible that the gasoline and diesel consumption start to increase rapidly from certain timing. Triggers may be reduction of import tax, deregulation of the used car import and growth of automobile assembly sectors.

The growth rate of motorbike will gradually saturate in future, and instead, passenger car may start rapid increase around 2010. However, as the number of the passenger car may most likely be at around 3 million in 2025, it could be predicted that the growth of gasoline demand would remain moderate within the projection period of this study. Then, should the plateau level of motorbike be higher, the gasoline demand would be greater. However, as the increase of motorbike from 30 million to 35 million units would push up the gasoline demand in 2025 by about 300,000 kl (+4.4%); the 20 year average growth rate would be increased from 4.7% to 4.9%. This would not have a very serious impact. On the other hand, viewing that the number of truck is also forecast to increase, we should watch out the possibility of gasoline type smaller trucks may increase to some extent.

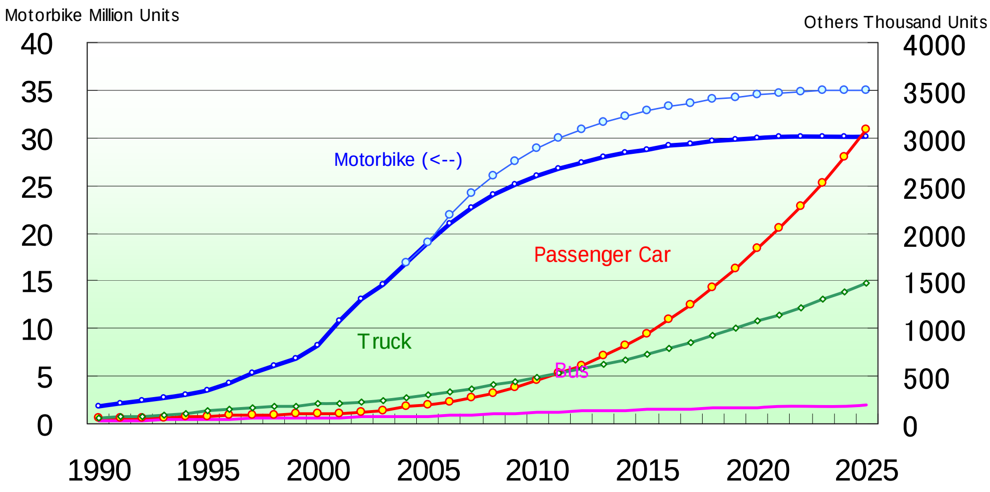


Figure 5.1-2 Prevails of Motorbikes, Cars, Buses and Trucks

Motorization is a world common trend. Although increase of gasoline demand is not very large in this projection, there is a possibility that an explosive increase of motor vehicles may start in Vietnam sometime in future. In considering this, it is required to draw up a *grand design* of the future transportation system as soon as possible. Construction of transportation system takes a long lead-time. If development of the public transportation system is delayed, the transportation would be excessively depending on a mono-mode system as seen in ASEAN countries and China, leading to drastic increase of oil demand. Meanwhile, huge capital funds will be required to construct the transportation system. As foreign and commercial investments have certain limitation in the field of infrastructure construction, it is necessary to establish a system in the discussion for the grand design to self-generate the capital fund required for the construction of the transportation system.

In this analysis, prevalence speeds of motor vehicles, namely motorbike, passenger car, bus and truck, are estimated based on hearings in the motor industry and the past experiences in ASEAN countries. The gasoline, jet fuel, diesel and fuel oil consumed in other mode of transportations, namely by ships, aircrafts and trains, are also forecasted in the model.

5.1.2.6 New and Renewable Energies and Power import

Use of new and renewable energies is generally classified into power generation and oil-alternative fuel. For the power generating use, there are hydro, wind, solar, biomass and nuclear, and for the oil-alternative use bio-ethanol and bio-diesel. The future trends of these energies are entered into the model as assumptions on the new and renewable energy supply plan as shown in Table 5.1-6.

Table 5.1-6 Plan of New and Renewable energies in GWh

	2005	2006	2010	2015	2020	2025
Hydro	16,634	18,261	34,604	52,351	62,912	63,691
Power Import	66	931	4,858	7,997	24,815	24,830
Renewables	741	275	2,157	4,675	6,637	8,181
Nuclear					10,268	24,566
Total	17,441	19,467	41,619	65,023	104,633	121,269

5.2 Other scenarios relating to change of energy demand

In addition to the Reference Case, as the elements to incur certain changes of energy demand, scenarios relating to changes in (1) economic growth and (2) energy price are examined.

5.2.1 Changes in Economic Growth Rates

It is important to recognize in advance the effect to what extent the energy demand would be up-lifted and what sort of issues would be anticipated if a higher economic growth were materialized compared with the Reference Case. As discussed in Chapter 4, suppose that in a dream case Vietnam would catch up Thailand by 2025 in terms of aggregate GDP (with an average growth rate of 10.5%), the middle point between the dream case and the BAU Case may be the upper ceiling to examine the High Growth Case. In this case, the average growth rate would be 9.5%.

Table 5.2-1 Economic Growth Rates for Case Study

Years	High Case	Reference Case	Low Case
2005	8.4	8.4	8.4
2006	8.5	8.5	8.5
2007	8.5	8.5	8.5
2008	9.5	8.5	8.5
2009	9.5	8.5	8.5
05-10	8.9	8.5	8.5
10-15	9.5	8.5	7.8
15-20	9.5	8.5	7.0
20-25	9.5	8.0	6.5
05-25	9.4	8.4	7.4

Since the major objective of the national energy policy is to secure stable energy supply and to construct the energy infrastructure for rational delivery and use, it would be sufficient if adequate preparation were made for such a high demand growth case. In the low economic growth case where the economic growth is lower than the Reference case, slower energy policy could be allowed. The simulation result of the Low Economic Growth Case is expected to be similar to that of the High Energy Price Case. In this analysis, the economic growth rate for the Low Economic Growth Case is assumed at 7.5% on average for the entire period, while economic growth rate would be declining from 8.5% for 2005-2010 to 6.5% for 2015-2025.

5.2.2 Changes in Energy Price

When energy price rises, the energy demand will be depressed. As there are many views and opinions on the future trend of energy prices in the world, we assume for the High Energy Price Case in this study that the crude oil price in 2005 real term would reach US$75/bbl by 2025. This scenario compares to the IEA scenario of stagnant investment in the upstream of the oil industry stipulated in its World Energy outlook 2006. Because such substantial hike of energy price would depress the world economic growth to a considerable extent, we assume that the economic growth rate would be lower by 1% compared with the Reference Case.

Prices of petroleum products and natural gas will also increase linked with crude oil price. However, since coal reserves are abundant all over the world and its supply would be expanded as the demand grows, coal price is assumed to increase at a half speed of the crude oil price. The retail prices of typical energy sources for the Reference Case and the High Price Case are shown in Figure 5.2.1.

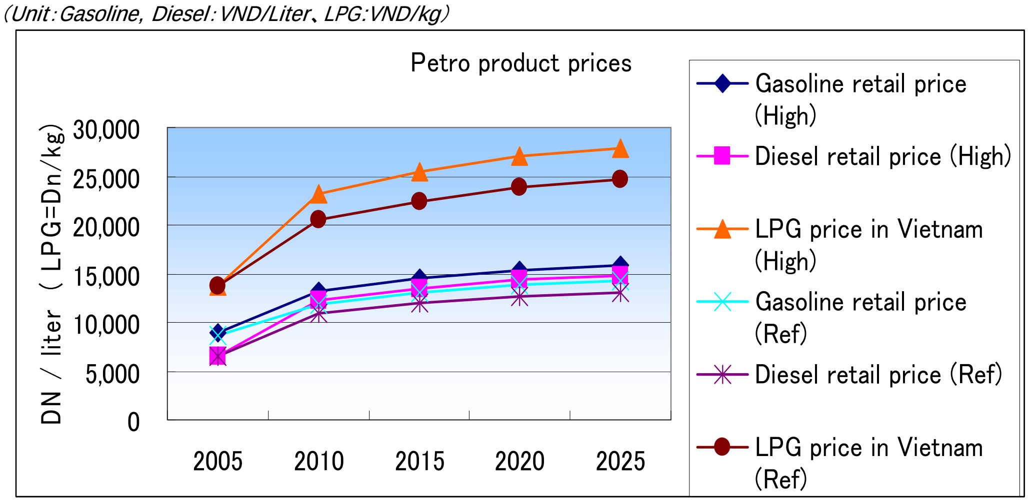


Figure 5.2-1 Energy prices in Reference Case and High Energy Price Case

In contrast to the above case, impacts of the lower energy prices are also examined. In this case, the world crude oil price is supposed to decrease moderately down to US$50/Bbl by 2010 and after then level off. In this case, energy demand would increase compared with the Reference Case as structural changes of economy would be stagnant and energy conservation mind would be dull. According to the Japanese experience, energy intensity to GDP increased during the period of low oil price.

5.3 Energy demand in the Reference Case

5.3.1 Final energy demand in the Reference Case

In Vietnam, it is considered that modernization of energy will progress in Manufacturing, Commercial and Services, and Residential sectors. In the sectors, use of non-commercial energies will decrease, and the demand of substituting energies such as LPG and electricity will increase rapidly. In the transportation sector, diesel gas oil demand for automobile will increase greatly. However, as the prevalence of motorbike nears to its plateau while four-wheeled passenger car is slow to increase, growth of gasoline demand would be moderate. On the other hand, reflecting increase of freight transport by motor vehicles, the diesel gas oil demand is expected to grow fast.

In this study, energy conservation rate is set at annual 1%for the BAU Case, which may be generally expected as discussed in Chapter 4, and at 3% for the Reference Case where EEC efforts should be strengthened.

In the BAU Case, the current high energy elasticity to GDP (1.6 in 2005) is expected to lower to 1.2 by 2025, a moderate level observed in neighboring countries. However the per capita electricity consumption is still extremely high compared to neighboring ASEAN countries. The past and current energy supply system in Vietnam excessively depends on electricity, and it is forecasted that the system would not change much. Though the current power shortage is serious, it is necessary to examine carefully whether the high energy elasticity and electricity dependence would continue to the future or not.

In the Reference Case, it is assumed that a half of the current energy conservation target of the Government policy would be achieved. This would create 9% energy conservation for 2015 and 23% for 2025, and the energy elasticity in the scenario would become 0.9 in 2025 near to the value generally seen in other countries.

Table 5.3-1 Energy Demand Outlook in Reference Case

		2005	2010	2015	2020	2025	25/05
Power demand (TWh)	Reference Case	46	86	132	203	293	9.8
	BAU Case	46	87	148	252	400	11.6
	Gap%	0%	-2%	-11%	-19%	-27%	
	Elasticity	2.0	1.6	1.1	1.1	0.9	
Final energy demand (MTOE)	Reference Case	23	33	47	67	91	7.2
	BAU Case	23	34	51	80	118	8.6
	Gap%	0%	-2%	-9%	-16%	-23%	
	Elasticity	1.6	1.0	0.8	0.9	0.9	

(Note) Final Energy Demand does not include energy consumption in Transformation sectors and Power stations.

While the economic assumptions in the Base case of PDP6 are same to that of the Reference Case, power demand forecasts are substantially different as shown in Figure 5.3.1. As discussed in Chapter 2, the power demand forecasted in PDP6 is substantially excessive compared to neighboring countries. This may have been caused because hydropower ratio is high in Vietnam and people depend on the cheap hydropower supply excessively while supply of other modern energies such as petroleum products and city gas were poor. If this situation continues, Vietnam would be keeping substantially higher dependence on it compared to other countries. However, since cheap hydropower resources are limited, increase of electricity tariff would become unavoidable sooner or later leading to dissolution of the over dependence on electricity and the per capita electricity consumption would become similar to the level of neighboring counties (2,000-3,000kWh per person in 2005). At the same time, natural gas use at residential and industry sectors would progress in due course.

(Unit: TWh)

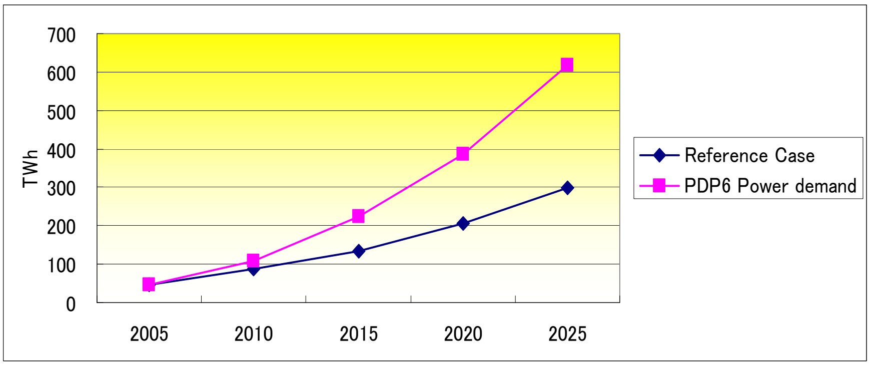


Figure 5.3-1 Comparison of Power Demand between Reference Case and PDP6

5.3.2 Energy Demand Trend by Sector

The energy conservation rate in 2025 as a comparison of the sectoral final demand of the BAU Case and the Reference Case, Light industry is the top sector realizing almost 30% energy conservation as shown in the table below, followed by in the order of Commercial sector, Residential sector, Heavy industry sector, Transportation sector and lastly Agriculture sector. As the whole country, it is 23% for 2025, which is in the range of 20-30% targeted by this project.

In the electricity demand, energy conservation rates for Reference Case compared to the BAU case are set at 11% for 2015 and 27% for 2025. The reduction ratio in the electricity sector in 2025 is larger than the 23% assumed for the final energy demand. The Commercial sector is the top energy conserving sector at 28% in 2005, followed by in the order of Light industry sector 28%, Residential sector 285, Heavy industry sector 15%, Transportation sector 15% and Agriculture sector 0%. This means that when a half of the Government target is achieved on energy conservation, its effect on the electricity demand would be 27% demand reduction in 2025.

Table 5.3-2 Energy conservation rate to Final energy consumption（BAU vs. Reference）

		2010	2015	2020	2025
(1)Agriculture	%	0	0	0	0
(2)Industry (Light)	%	-3	-14	-22	-30
(3)Industry (Heavy)	%	-1	-6	-10	-14
(4)Transportation	%	-1	-4	-8	-12
(5)Commercials & Service	%	-2	-12	-20	-28
(6)Residentials	%	-2	-12	-20	-28
Total	%	-2	-9	-16	-23

Table 5.3-3 Energy conservation for power by sector（BAU vs. Reference）

		2010	2015	2020	2025
(1)Agriculture	%	0	0	0	0
(2)Industry (Light)	%	-2	-12	-20	-28
(3)Industry (Heavy)	%	-1	-6	-11	-15
(4)Transportation	%	-1	-6	-10	-15
(5)Commercials & Service	%	-2	-12	-20	-28
(6)Residentials	%	-2	-12	-20	-28
Total	%	-2	-11	-19	-27

5.3.3 Energy demand in Agriculture sector

The final energy demand in the Agriculture sector increases from 570 ktoe in 2005 to 833 ktoe in 2015 and 1,163 ktoe in 2025, and the annual average growth rate of the final energy demand in the Agriculture sector will be 3.6% per year from 2005 to 2025. The average growth rates by energy are Coal: 0.9%, Oil products: 3.0%, Gas: 0% and Electricity: 8.0%. The growth rate of the electricity demand is significantly high in this sector. Incidentally, electrification rate of the agricultural sector will gradually grow from 8% in 2005 to 12% in 2010, 15% in 2015, 17% in 2020 and 20% in 2025.

(unit: kTOE)

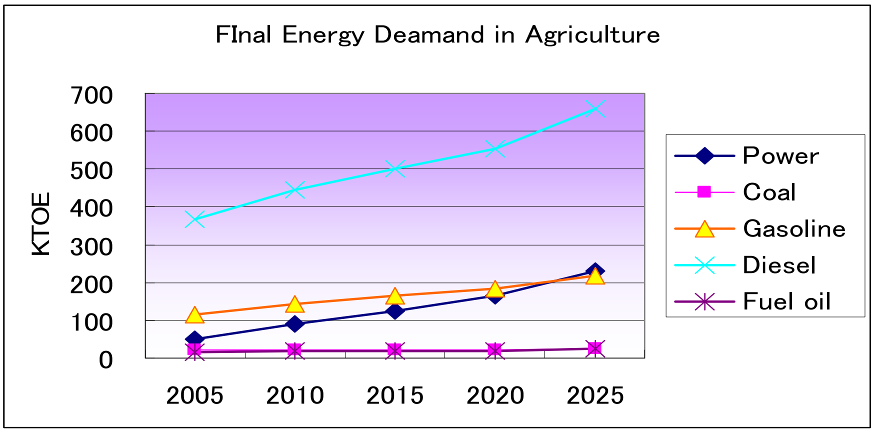


Figure 5.3-2 Final Energy Demand in Agriculture sector

5.3.4 Energy Demand in Light Industry Sector

The Light industry sector is the main industry that shall lead the future Vietnamese economy, and thus its energy demand will show the highest growth among sectors. The final energy demand of the sector is forecast to increase from 8,800ktoe in 2005 (including electricity demand and non-commercial energy) to 17,600ktoe in 2015 and 39,800ktoe in 2025. The demand elasticity to the sector GDP is estimated at a relatively low level of 0.52 for the period from 2005 to 2025 with the average growth rate at 7.9%. It is desirable to conduct an in-depth study on the demand tendency and energy conservation potential in this industry. Meanwhile the growth rates of the final energy demand by energy are generally high such as Coal: 5.8%, Oil products: 8.6%, Gas: 10.3% and Electricity: 10.3%. As the natural gas demand is forecast to grow at 10.3%, this is estimated extending the current demand structure. However, there is a possibility that natural gas demand may increase faster, once gas infrastructure such as trunk pipelines and delivery network were developed, replacing with the demand for coal and petroleum products.

In the Light industry sector, a special attention should be paid to LPG, a kind of petroleum products, which has recorded an abrupt growth of 38% per year in the last 5 years. The high growth rate of LPG has started since 1999 in accordance with the growth of the light industry; LPG is used in production lines and welfare facilities for the workers at these factories. LPG is an environmentally.

Since the domestic supply of LPG is limited in Vietnam, most of the LPG must be imported in future. However, the international LPG market is quite unstable and its price is vulnerable. Therefore, it is better to consider that the LPG supply would be limited at a certain level, and that a best mix with other substituting energy sources such as coal and oil products should be studied seriously. The electricity ratio of the sector, which shows the share of electricity over the total energy consumption of the sector, will increase from 17% in 2005 to 24% in 2010, 25% in 2015 and 26% for 2020 and 2025.

(Unit :kTOE)

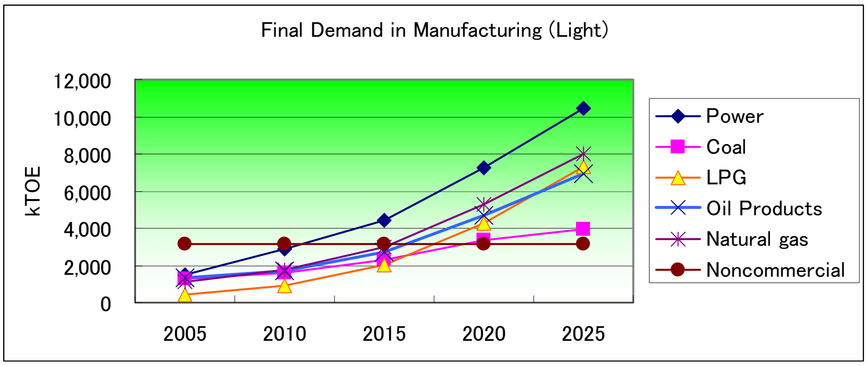


Figure 5.3-3 Final Energy Demand in Light Industry Sector

5.3.5 Energy Demand in Heavy Industry Sector

The final energy demand in the heavy industry sector is forecast to increase from 4,900 ktoe (including electricity demand) in 2005 to 9,000 ktoe in 2015 and 13,300 ktoe. The growth of the heavy industry sector may remain relatively moderate in Vietnam as the government aims at construction of a less energy intensive economic structure.

The average growth rate of the final energy demand in the sector will be 5.1% per year from 2005 to 2025.Growth rates by energy are Coal: 4.9%, Oil products: 5.1%, Gas: 4.8%, electricity: 7.1%.

(Unit:kTOE)

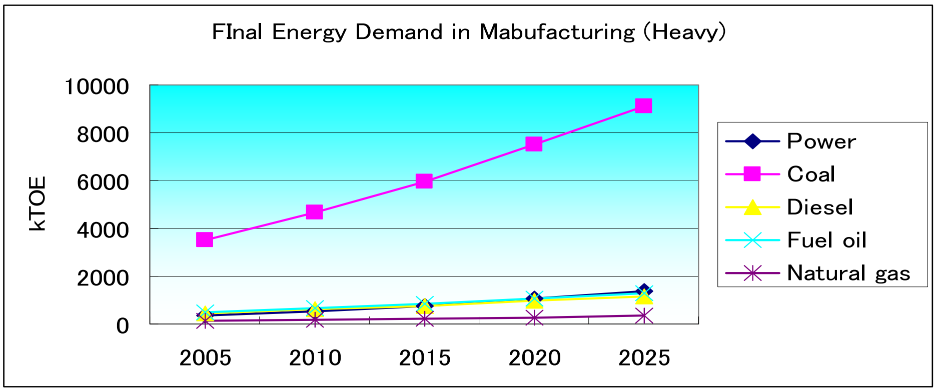


Figure 5.3-4 Final Energy Demand in Heavy Industry Sector

The growth rate of electricity is comparatively high in this sector. Likewise the light industry sector, natural gas has a possibility to grow faster pending development of infrastructure; then, demand for coal and petroleum products will decrease instead. The electricity ratio of the sector, which shows the share of electricity over the total energy consumption of the sector, will increase from 7% in 2005 to 8% in 2010, 9% in 2015, 10% for 2020 and 11% for 2025.

5.3.6 Energy Demand in Transportation Sector

Today, motorbike is prevailing as the most popular passenger transportation means among the Vietnamese citizens, while truck, railway and ships are the major mass freight transportation system. However, as the railway is on the narrow gauge with single truck system, we could not expect much on this sector. As we have seen in other South East Asian countries, it is needless to say that motorization is inevitable in Vietnam as well, and the number of motor vehicle will start to increase fast from certain time.

Table 5.3.4 shows the forecast of motor vehicles in Vietnam. The motorbike prevalence is at the world top level slightly behind Thailand, and will be gradually peaking out in the near future. It was one for four persons (total 20 million units) in 2006, and the plateau may be something like one for three persons (total 30 million units plus in 2025). Instead, passenger car may begin fast increase around 2010, and reach 3 million units, or 23 fold of the current number, in 2025. However the growth of gasoline demand will remain moderate as the number of motorbike will be peaking out. The number of buses in Vietnam may also peak out at around 0.2 million units in 2025 when compared to experiences in neighboring countries.

Table 5.3-4 Trends of Transportation vehicles（Registered number）

		2005	2015	2025	15/05	25/15	25/35
Motorbike	Mil. Units	19.1	26.6	31.0	3.4%	1.5%	2.5%
Pas. Car	Thousand	195	950	3084	17.2%	12.5%	14.8%
Bus	Thousand	79	147	193	6.5%	2.8%	4.6%
Truck	Thousand	304	733	1469	9.2%	7.2%	8.2%
Total Car	Thousand	577	1830	4746	12.2%	10.0%	11.1%

As the ratio of freight transportation between railway and truck is 51:49 at present, the share of truck will increase up to 65% in 2025, and the number of truck to 1.5 million units or 7.5 times of the current level in 2025. With the above-mentioned growth of transportation vehicles, the final energy demand in the transportation sector is forecast to increase from 3,900ktoe (including electricity demand) in 2005 to 12,900ktoe in 2015 and 13,900ktoe in 2025.

As a result, the average growth rate of the transportation fuels from 2005 to 2025 will be 5.9% per year. By energy source, they are gasoline: 4.8%, diesel gas oil: 6.7%, jet-fuel: 6.5% and fuel oil: 4.7%. The growth rate of diesel oil is the highest among them, while that of gasoline is rather moderate as increase of passenger car and peaking out of motorbike are offsetting. However, we need to watch carefully any indication that passenger car ownership may increase abruptly after 2025. On the other hand, diesel gas oil demand is forecast to increase steadily as the main energy to support the economic development, while electricity demand may increase reflecting construction of subways in future.

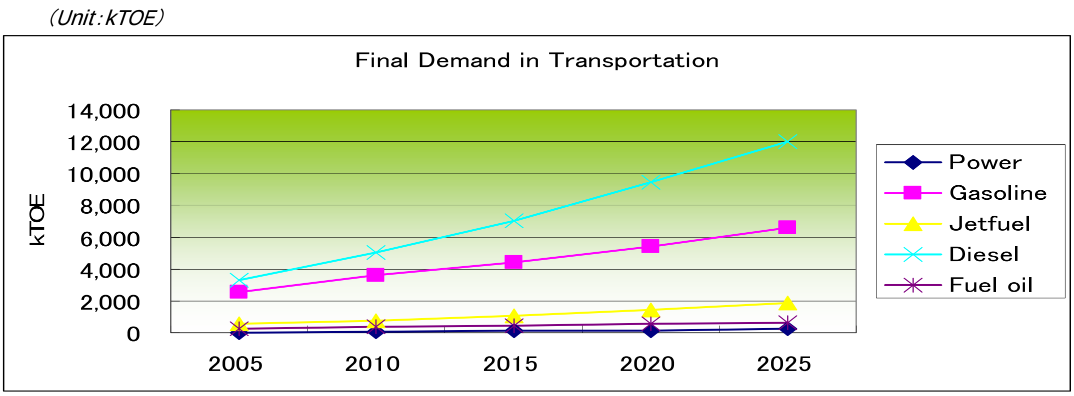


Figure 5.3-5 Final Energy Demand in Transportation Sector

5.3.7 Energy Demand in Commercial Sector

Final energy demand in the Commercial sector is forecast to increase from 1,300 ktoe (including electricity demand) in 2005 to 2,400 ktoe in 2015 and 3,900 ktoe in 2025. The average growth rate of the final energy demand will be 5.5% per year from 2005 to 2025. The growth rates of the final demand by energy source are coal: 1.92%, LPG: 5.7%, oil products (kerosene, gas oil and fuel oil): 3.57% and electricity: 11.3%. The growth rate of electricity demand is the highest. Specific feature of the Commercial sector for the last 5 years is the high growth of LPG increasing at 16% per annum,

(Unit:kTOE)

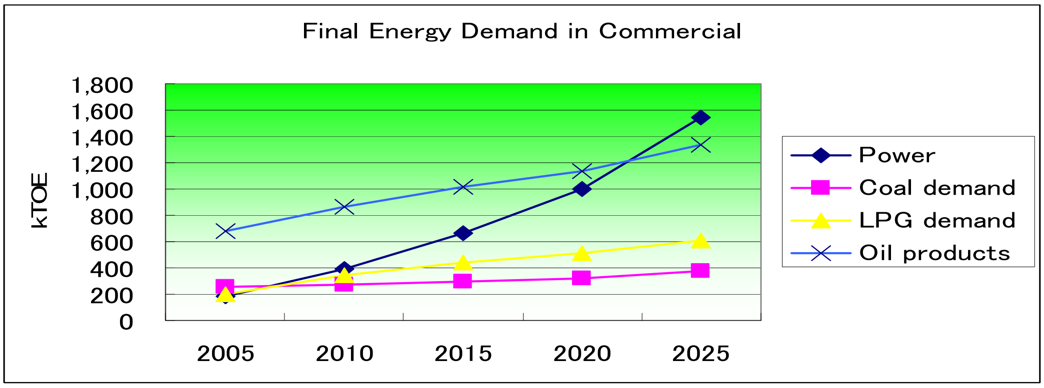


Figure 5.3-6 Final Energy Demand in Commercial Sector

followed by electricity demand at 12%.

On the other hand, consumption of fuel oil and kerosene has decreased in the same term, being replaced with LPG. Likewise the light industry sector, demand for LPG which is clean and easy to use will increase greatly, it is necessary to investigate what kind of energy should be selected and how they should be supplied to such sector. The electricity ratio of the sector, which shows the share of electricity over the total energy consumption of the sector, will gradually increase from 15% in 2005 to 21% in 2010, 27% in 2015, 34% for 2020 and 40% for 2025.

5.3.8 Energy Demand in Residential Sector

The final energy demand in the Residential sector is forecast to increase from 14,900 ktoe to 18,400 ktoe and 23,700 ktoe in 2025. The average growth rate of the final energy demand in the sector will be 2.3% per year from 2005 to 2025. Growth rates of the final demand by energy source are coal: minus 2.3%, LPG: 10.4%, oil products (kerosene, gas oil and fuel oil): 3.8%, electricity: 9.8% and non commercial energy: minus 1.3%.

(Unit:kTOE)

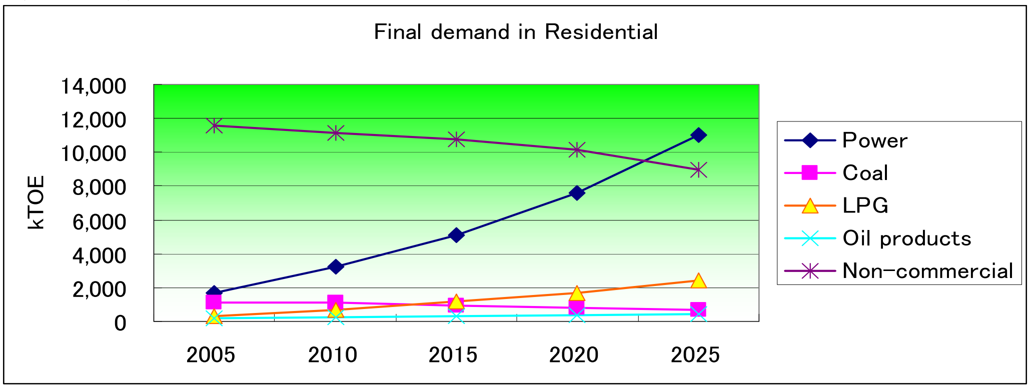


Figure 5.3-7 Final Energy Demand in Residential Sector

The significant issue in the Residential sector is that the growth of electricity and oil products, especially LPG, is very high. Supported by strong GDP growth, demands for electricity (mainly for refrigerator and air conditioner) and LPG (mainly for cocking) are increasing rapidly reflecting increase of municipal workers and improvement of their life styles in recent years. On the other hand, non-commercial energies like woods and charcoal are decreasing as the rural population declines and kitchen style in municipal residences are changed. However as already discussed for the light industry sector, domestic supply of LPG is limited and international market may be tight. Thus, development of any other substituting energy such as city gas should be investigated as soon as possible. The electricity ratio of the sector excluding non-commercial energy will gradually increase from 54% in 2005 to 60% in 2010, 67% in 2015, 72% for 2020 and 75% for 2025.

5.3.9 Petroleum Product Demand

Petroleum products demand outlook for the Reference Scenario is as shown in Table 5.3-5. Quantities slated under "LPG Substitute" indicate the potential demand for LPG which need to be substituted by other energy, such as kerosene or city gas, because LPG supply would not be able to increase in pace with demand growth.

Table 5.3-5 Petroleum Products Demand Outlook

Products	2005	2010	2015	2020	2025	2005	2015	2025	15/05	25/15
LPG	963	1,971	3,641	4,342	4,418	8.3	16.1	10.1	14.2	2.0
LPG Substituted	0	0	0	2,133	5,937	0.0	0.0	13.6		
Gasoline	2,687	3,697	4,516	5,491	6,657	23.2	19.9	15.2	5.3	4.0
Kerosene	332	342	373	423	511	2.9	1.6	1.2	1.2	3.2
Jetfuel	534	736	1,031	1,415	1,872	4.6	4.5	4.3	6.8	6.2
Diesel	5,162	7,456	10,294	14,089	18,301	44.5	45.4	41.8	7.1	5.9
for General	5,149	7,456	10,294	14,089	18,301	44.4	45.4	41.8	7.2	5.9
for Power	13	0	0	0	0	0.1	0.0	0.0		
Fuel oil	2,214	2,096	2,807	4,329	6,090	19.1	12.4	13.9	2.4	8.1
for General	1,616	2,020	2,742	3,939	5,295	13.9	12.1	12.1	5.4	6.8
for Power	598	76	65	390	795	5.2	0.3	1.8	-19.9	28.5
Total Oil demand	11,598	16,298	22,662	32,223	43,786	100.0	100.0	100.0	6.9	6.8

5.3.9.1 LPG

LPG is consumed in the manufacturing, commercial and household sectors. As introduction of natural gas is not transparent at present, extraordinary demand increase is expected for LPG compared to other petroleum products. As the national average demand increase is expected at annual 12.6%, major demand sectors will be Light manufacturing: 15.3%, Household: 10.4% and Commercial sector: 5.7%. The potential demand of LPG is estimated to increase from the actual record of 1,000 ktoe in 2005 to 10,000 ktoe in 2025, indicating that serious supply problem would be incurred.

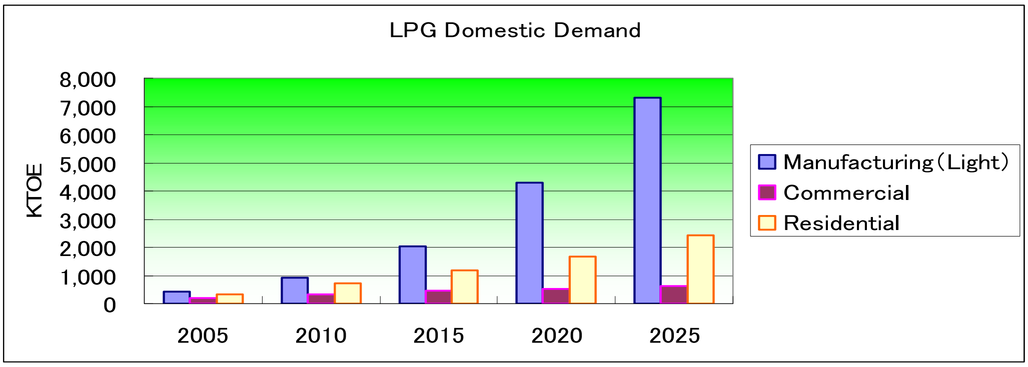


Figure 5.3-8 LPG Demand

5.3.9.2 Gasoline

Gasoline is mainly consumed by motorbikes and other motor vehicles, while certain quantity is also used for driving small boats in Vietnam. According to the current classification, gasoline for small boats is classified for the agriculture and fishery sector, and gasoline for motorbike and motor vehicles for the transportation sector. However, the consumption in the transportation sector is overwhelmingly big. Thus, the overall growth rate of annual 4.6% is very close to the demand growth for motorbike and passenger car at 4.7%. Gasoline demand is projected to grow from 2,700 ktoe in 2005 to 6,700 ktoe in 2025 by 2.5 times, and 97% of which will be for motorbike and cars.

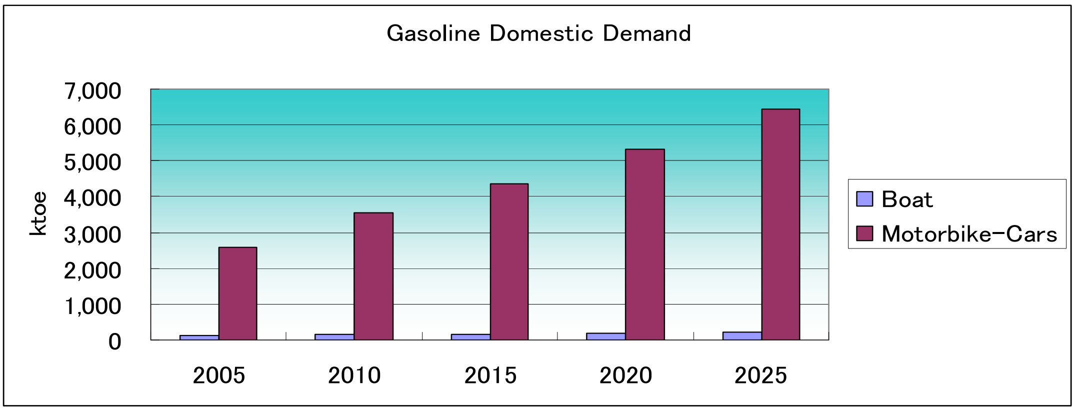


Figure 5.3-9 Gasoline Demand

5.3.9.3 Kerosene

Kerosene including jet fuel is used by aviation industry, light manufacturing sector as well as commercial and residential sectors. Among them jet fuel demand shows 6.5% growth reflecting internationalization and vigorous domestic economic activities. Kerosene may be extensively consumed in the manufacturing sector as well, showing 6.8% annual growth during the projection period. On the other hand consumption in the commercial and residential sectors may be replaced by electricity and LPG, and consumption growth in these sectors may remain modest at 1.6% and 2.3%, respectively. The total kerosene consumption is estimated to increase from 900 ktoe in 2005 to 2,400 ktoe in 2025 by 2.8 times.

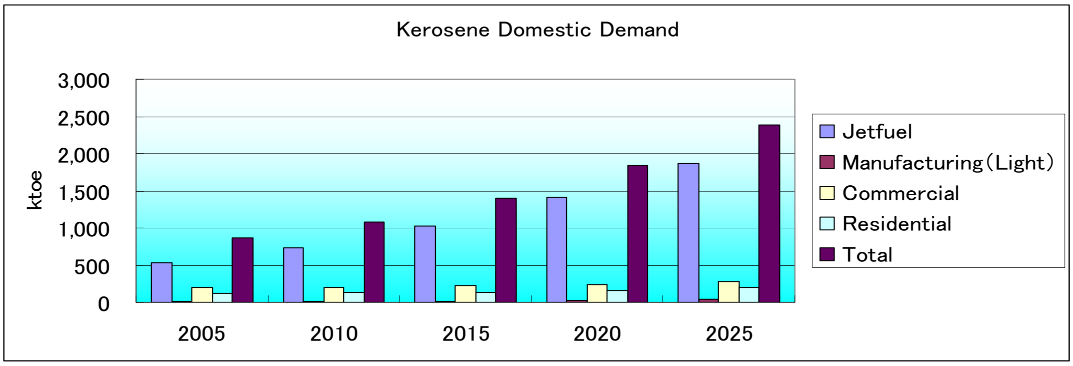


Figure 5.3-10 Kerosene Demand

5.3.9.4 Diesel Gas Oil

As diesel gas oil is widely used in transportation, manufacturing, agriculture, commercial and residential sectors, the consumption in the transportation sector shares big amount. Since most of the consumption in the manufacturing sector may be used for transportation of own cargos, diesel gas oil may be deemed as mostly for transportation use. Although gas oil used to be burnt for power generation, consumption in this sector is decreasing and may be limited for use at independent diesel generators in future.

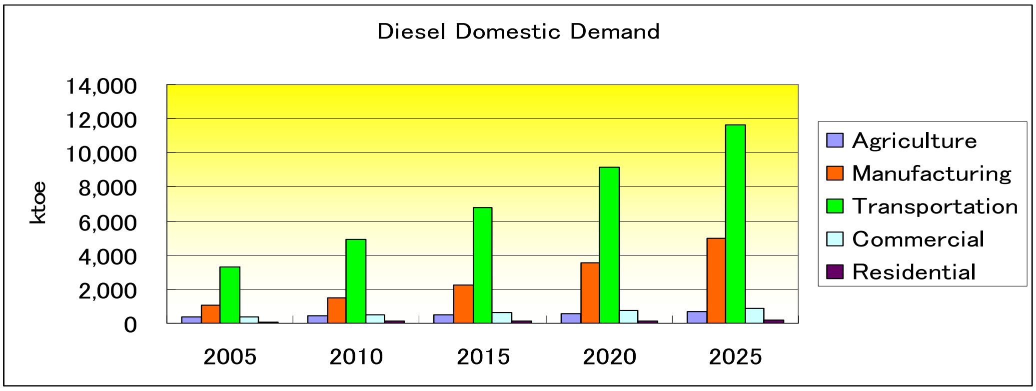


Figure 5.3-11 Diesel Gas Oil Demand

Demand in manufacturing and transportation sectors will be large and their demands are estimated to increase at annual 8.0% and 6.5%, respectively during 2005 through 2025. Consumption in residential and commercial sectors will be also active to grow at 5.9% and 4.3%, respectively. The total diesel gas oil demand will increase from 5,100 ktoe in 2005 to 18,000 ktoe in 2025 by 3.6 times.

5.3.9.5 Fuel Oil

Fuel oil is widely used in manufacturing, electric power, transportation, commercial and residential sectors. In particular, demand in manufacturing and power sectors are large sharing 54% and 28%, respectively, followed by transportation sector at 12%. These three are the major demand sectors, while the aggregate share of agriculture, commercial and residential sectors is small at 7%. The same tendency continues through 2025, and the demand composition then will be manufacturing 65%, electric power 22% and transportation 9%. Average growth rates for 2005 –2025 will be manufacturing 6.7%, transportation 4.7% and electric power 4.3%; fuel oil consumption is estimated to grow accompanying high growth of the manufacturing sector. The total fuel oil consumption is estimated to increase from 2,200 ktoe in 2005 to 6,700 ktoe in 2025 by 3.0 fold.

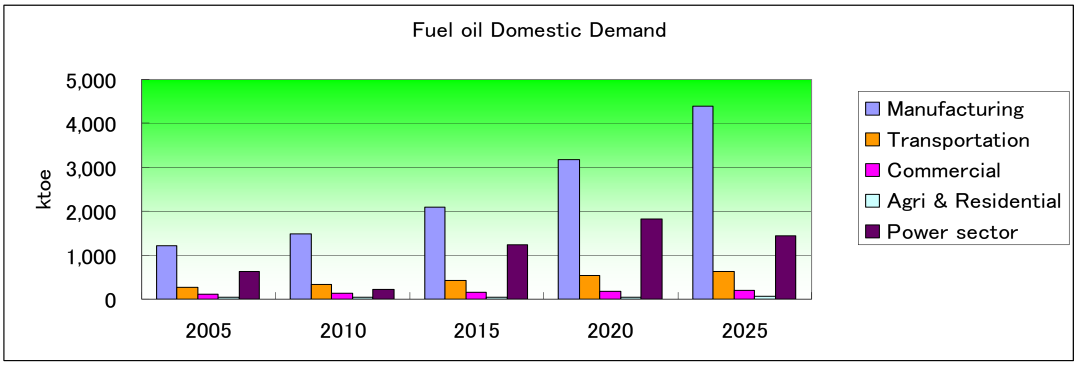


Figure 5.3-12 Fuel Oil Demand

5.4 Energy Demand under Other Scenarios

5.4.1 Changes of Economic Growth Rate

5.4.1.1 High Growth Case

The High Economic Growth Case assumes an economic growth rate higher than that for the Reference case; 9.5% vs. 8.4% for the entire period of 2008-2025. The differences in the final energy demand between two cases are 9% for 2015 and 34% for 2025. The final energy demand for the High Growth Case is substantially active in all sectors such as Industry, Commercial and Residential as the GDP growth rate is assumed at a considerably higher level. As the GDP elasticity of the High Growth Case is calculated to slow down from 1.7 for 2000-2005 to 1.0 for 2020-2025. However, it is questionable if such high elasticity would continue when very high economic growth is achieved for a very long period such as 20 years; there is a possibility that energy conservation may evolve faster than estimated. Anyway, should any symptom of such high economic growth were found, counter policies must be advanced promptly.

The electricity demand is forecast to grow in the High Growth Case 9% higher for 2015 and 33% for 2025 compared with the Reference Case. And the GDP elasticity of power demand decreases from 2.0 for 2005-2005 to 1.1 for 2020-2025. However, as the GDP grows 6 times from 2005 to 2025 at annual 9.4%, the power demand grows 8 fold of the current demand. Though this forecast seems considerably high, the forecast made in PDP6 is still higher than this. As a highest possible case is calculated here as is meant by the extremely high economic growth rate while its probability may be low, the outcome may indicate some criteria in considering energy supply policies.

Table 5.4-1 Energy Demand in High Economic Growth and Reference Cases

		2005	2010	2015	2020	2025	25/05
Power demand (TWh)	High Growth Case	46	89	145	237	389	11.3
	Reference Case	46	86	132	203	293	9.8
	Gap(%)	0%	3%	9%	16%	33%	
	Elasticity	2.0	1.6	1.1	1.1	1.1	
Final energy demand (MTOE)	High Growth Case	23	34	51	78	121	8.8
	Reference Case	23	33	47	67	91	7.2
	Gap(%)	0%	3%	9%	17%	34%	
	Elasticity	1.7	1.0	0.9	0.9	1.0	

5.4.1.2 Low Growth Case

As a reference, the Low Economic Growth Case is set as shown below. The final energy demand in the Low Growth Case is 17% lower than the Reference case for 2015 and 41% for 2025. Power demand is 19% lower for 2015 and 44% lower for 2025. In contrast to the high growth case, the conceivable lowest case is calculated here. As its probability may be low, it may be thought as criteria for the floor value. In such a case, it is important to refrain from excessive investment and try to establish an efficient energy system.

Table 5.4-2 Low Economic Growth Case and Reference Cases

		2005	2010	2015	2020	2025	25/05
Power demand (TWh)	Low Growth	46	86	126	176	233	8.5
	Reference	46	86	132	203	293	9.8
	Gap(%)	0%	-4%	-19%	-35%	-44%	
	Elasticity	2.0	1.6	0.9	0.8	0.9	
Final energy demand (MTOE)	Low Growth	23	33	44	57	71	5.9
	Reference	23	33	47	67	91	7.2
	Gap(%)	0%	-3%	-17%	-33%	-41%	
	Elasticity	1.7	1.0	0.6	0.6	0.7	

5.4.2 Energy Price Changes

5.4.2.1. High Energy Price case

In the High Energy Price Case, we examine a scenario that energy prices increase, economic activity is depressed by the high energy prices, and economic growth rate fall 0.5% lower from the Reference Case.

Generally speaking, the energy demand is calculated with changes in energy intensity multiplied by economic activity. Increase of energy prices usually gives a bigger impact on the economic activity rather than the energy intensity. In the High Energy Price Case, GDP growth rates goes down from 8.5% to 8.0% for 2010-2020 and from 8.0% to 7.5% for 2010-2020. As a result, the final energy demand decreases with 6% for 2015 and 12% for 2025 compared to the Reference Case. This is caused by lowered energy intensity and 0.5% slow down of the economic growth. If economic growth rate does not change, the final energy demand decreases only 1.5% for 2015 and 1.5% for

2025. That is, even under the high energy prices, the impact on the demand elasticity is small.

Table 5.4-3 High Energy price Case and Reference case

		2005	2010	2015	2020	2025	25/05
Power demand (TWh)	High Price Case	46	83	124	186	261	9.1
	Reference Case	46	86	132	203	293	9.8
	Gap(%)	0%	-3%	-6%	-9%	-11%	
	Elasticity	2.0	1.6	1.1	1.0	0.9	
Final energy demand (MTOE)	High Price Case	23	32	44	61	80	6.5
	Reference Case	23	33	47	67	91	7.2
	Gap(%)	0%	-4%	-6%	-9%	-12%	
	Elasticity	1.7	0.9	0.8	0.8	0.8	

(Note) Final energy demand does not include energies consumed in Transformation sector and power sector

However, under high energy prices, it is possible that energy conservation may be promoted at a higher speed; the afore-mentioned 6% reduction for 2015 and 12% for 2025 would be a minimum reduction amount. The similar trend is seen in the power demand, with decline of 9% for 2015 and 17% for 2025 compared to the Reference Case, while, should economic growth be same with the Reference Case, the power demand reduction is 0.9% for 2015 and 0.9% for 2025.

5.4.2.2 Low Price Case

On the Low Energy Price Case, the same story as the High Energy Price Case may be applicable; improvement of the energy intensity may be delayed. It is a story that, due to low energy prices, motivation for energy conservation is weaker and energy conservation would not make progress. On the other hand, it is possible that higher economic growth may be realized in the Low Price Case; although we apply the same growth rate here. Table 5.4.4 and Table 5.4.5 summarize the energy prices and energy conservation factors for the Low Price Case vs. the Reference case.

The results of the demand forecast for the Low Price Case is as follows; the final energy demand will be greater in the Low Price Case by 7% in 2015 and 16% in 2025 compared with the Reference Case. This is because energy conservation is deemed not to progress due to low prices. If energy conservation would make same progress with the Reference Case, there would be no big difference in the final energy demand between the two cases. This means that, should the energy conservation promotion progress at the same speed, the assumed crude oil price difference of $61/Bbl for the Reference Case and $50/ Bbl for the Low Price Case would not bring any apparent differences in the final demand.

Table 5.4-4 Energy prices in Low price case and Reference case

Low Prices		2005	2010	2015	2020	2025
IEA world export price	US$/bbl	49.9	50.0	50.0	50.0	50.0
Crude oil export price of Vietnam	US$/bbl	51.5	53.9	53.9	53.9	53.9
Coal FOB (For Power)	$/ton	19.7	28.8	37.9	37.9	37.9
Asian LNG CIF	$/MMBTU	6.4	6.4	6.4	6.4	6.4
NG price (Non Associated)	$/MMBTU	3.3	4.6	5.9	5.9	5.9
Reference Prices		2005	2010	2015	2020	2025
IEA world export price	US$/bbl	49.9	65.0	65.0	65.0	65.0
Crude oil export price of Vietnam	US$/bbl	54.0	70.2	70.2	70.2	70.2
Coal FOB (For Power)	$/ton	19.7	38.1	56.5	56.5	56.5
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5
NG price (Non Associated)	$/MMBTU	3.3	5.1	7.0	7.0	7.0

Table 5.4-5 Energy conservation factors

Sectors	Cases	2010−2015		2016−2020		2021−2025	
		Power	Fossil	Power	Fossil	Power	Fossil
Agriculture	Reference	1.0	1.0	1.0	1.0	1.0	1.0
	Low price	1.0	1.0	1.0	1.0	1.0	1.0
Industry (Light)	Reference	3.0	3.0	3.0	3.0	3.0	3.0
	Low price	2.0	2.0	2.0	2.0	2.0	2.0
Industry(Heavy)	Reference	2.0	2.0	2.0	2.0	2.0	2.0
	Low price	2.0	2.0	2.0	2.0	2.0	2.0
Transportation	Reference	1.0	1.0	1.0	1.0	1.0	1.0
	Low price	1.0	1.0	1.0	1.0	1.0	1.0
Comercial &Servic	Reference	3.0	3.0	3.0	3.0	3.0	3.0
	Low price	2.0	2.0	2.0	2.0	2.0	2.0
Residential	Reference	3.0	3.0	3.0	3.0	3.0	3.0
	Low price	2.0	2.0	2.0	2.0	2.0	2.0

Table 5.4-6 Low Energy Price Case & Reference Case

		2005	2010	2015	2020	2025	25/05
Power demand (TWh)	Low price	46	87	140	227	345	10.6
	Reference	46	86	132	203	293	9.8
	Gap(%)	0%	1%	6%	12%	18%	
	Elasticity	2.0	1.6	1.2	1.2	1.1	
Final energy demand (MTOE)	Low price	23	34	50	75	105	8.0
	Reference	23	33	47	67	91	7.2
	Gap(%)	0%	3%	7%	12%	16%	
	Elasticity	1.7	1.0	0.9	1.0	0.9	

Conversely, should energy conservation willingness become weaker due to lower energy price, there is a possibility that the final energy demand might increase by 16% in 2025 compared with the Reference Case. In addition, when the energy prices are low, economy may enjoy higher growth with lower constrains leading to much higher energy demand. Likewise the power demand, the power demand will be 6% higher in 2015 and 18% in 2025 in the Low Price Case.

5.4.3 Other Case studies for reference

(1) Supper Energy Conservation Case

While in the Reference Case energy conservation factors are aimed to be in the range of 20-30% for the period of 2010-2025, we have examined a Supper Energy Conservation (Supper EEC) Case as an additional scenario. The expected conservation factors are 40-50% as stipulated in the Government EEC plan; sectoral values are shown in Table 5.4.7. As also illustrated in figure 5.4-1, the final energy demand in the Supper EEC Case is 6.4% lower in 2015 and 15% lower in 2025 compared with the Reference case.

As the Government plan of energy conservation is close to this Supper EEC case, it is necessary to implement extraordinary promoting policy and introduction of most advanced technologies in order to achieve it.

Table 5.4-7 Energy conservation factor by sector（Supper EEC Case）

Sectors	2010-2015		2016-2020		2021-2025	
	Power	Fossil	Power	Fossil	Power	Fossil
Agriculture	1.0	1.0	1.0	1.0	1.0	1.0
Industry (Light)	4.0	4.0	4.0	4.0	4.0	4.0
Industry(Heavy)	4.0	4.0	4.0	4.0	4.0	4.0
Transportation	1.0	2.0	1.0	2.0	1.0	2.0
Comercial &Service	4.0	4.0	4.0	4.0	4.0	4.0
Residential	4.0	4.0	4.0	4.0	4.0	4.0

(2) Super High Price Case

A result of the simulation for the Super high Price Case is shown below assuming the crude oil price to reach $100/Bbl by 2010 and remain at the same level.

In this case, the higher oil price is supposed to give greater impact on the economy and the economic growth rate would slow down by 1% compared to the Reference Case, to be at annual 7.5% for the period of 2005-2020 (8.5% for Reference Case) and 7.0% for 2020-2025 (8.0% for Reference Case). As a result, energy consumption may decrease in the Super High Price Case compared to the Reference Case by 14% for 2015 and 24% for 2025. This is largely caused by the 1% decline in the economic growth rate, indicating that, if higher oil price persists to make economy stagnant than projected in the Reference Case, there is a possibility that the final energy demand would fall back to3/4 of the Reference Case. The same story applies to the power sector; electricity demand decreases in the Super High Price Case by 12% for 2015 and 22% for 2025; 299 TWh in 2025 for the Reference Case declines to 230 TWh.

(Unit MTOE)

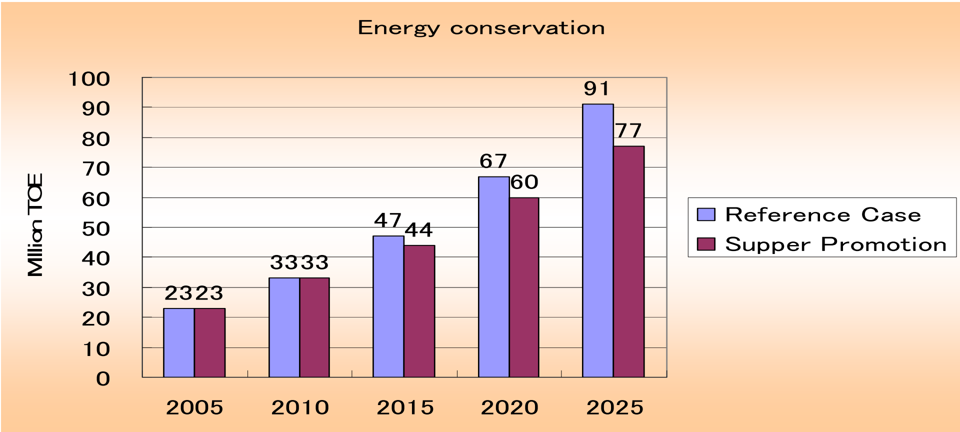


Figure 5.4-1 Comparison between Supper EEC and Reference Case

Table 5.4-8 Price Assumptions for Super High Price Case vs. Reference Case

Super High Case		2005	2010	2015	2020	2025
IEA world export price	US$/bbl	49.9	100.0	100.0	100.0	100.0
Crude oil export price of Vietnam	US$/bbl	54.0	108.3	108.3	108.3	108.3
Coal FOB (For Power)	$/ton	19.7	46.7	73.8	73.8	73.8
Asian LNG CIF	$/MMBTU	6.4	11.5	11.5	11.5	11.5
NG price (Non Associated)	$/MMBTU	3.3	7.1	11.0	11.0	11.0
Reference Prices		2005	2010	2015	2020	2025
IEA world export price	US$/bbl	49.9	65.0	65.0	65.0	65.0
Crude oil export price of Vietnam	US$/bbl	54.0	70.2	70.2	70.2	70.2
Coal FOB (For Power)	$/ton	19.7	38.1	56.5	56.5	56.5
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5
NG price (Non Associated)	$/MMBTU	3.3	5.1	7.0	7.0	7.0

5.4.4 Demand Comparison in Cases

The following figures summarizes the final demand forecast (Figure 5.4-3) and electricity demand (Figure 5.4-4) that have been reviewed in the foregoing sections. In the figure 5.4-3, the final energy demand in the order of their growth rates are as follows;

① High Economic Growth Case

② Low Energy Price Case (EEC is Slow)

③ Reference Case=Low Price Case (same EEC with the Reference Case) =High Price Case (same GDP with the Reference Case)

④ High Price Case (GDP growth is reduced by 1%) = Supper EEC Case

⑤ Low economic growth case

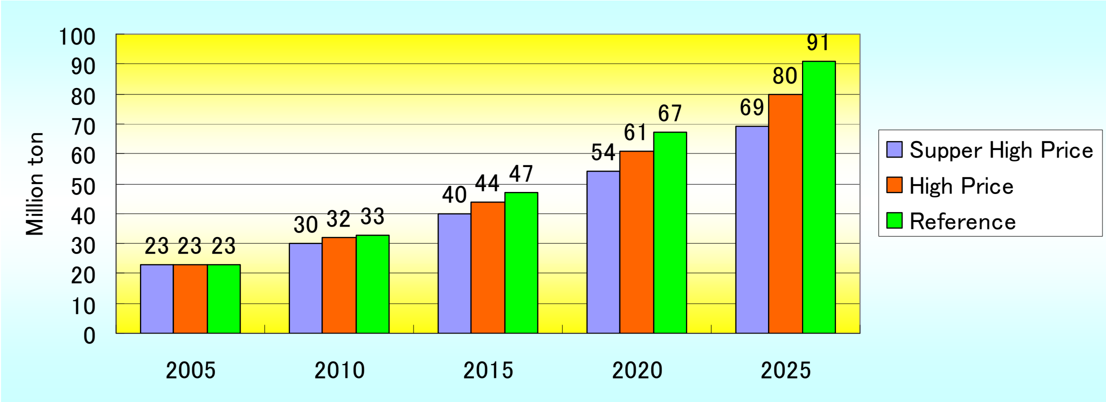


Figure 5.4-2 Super High Price Case vs. Reference Case

(Unit:kTOE)

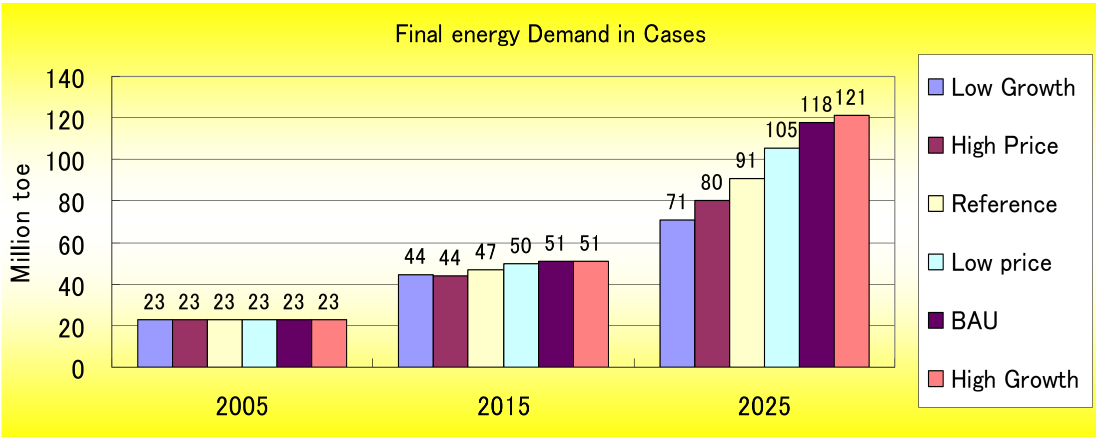


Figure 5.4-3 Final Energy demand in the Cases

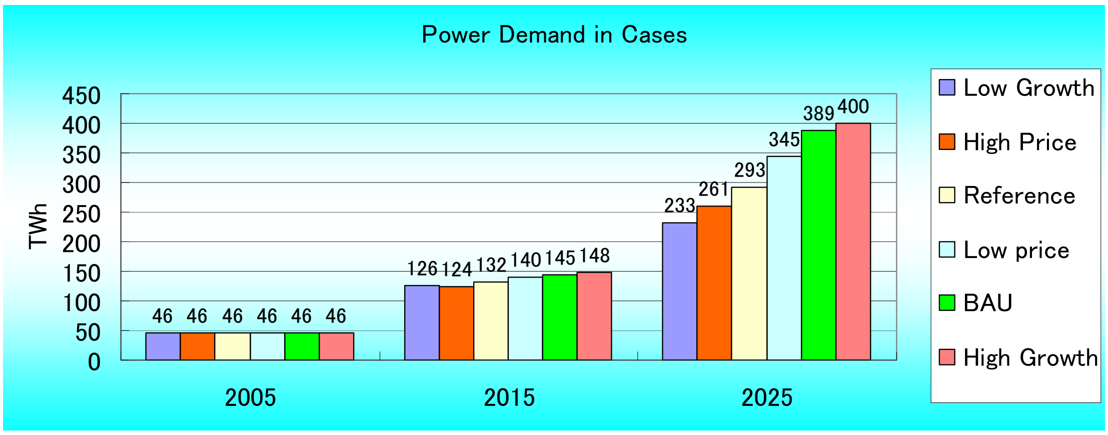


Figure 5.4-4 Power Demand in the Cases

5.5 Summary of Implications

(1) Energy demand increase in the manufacturing and the household sectors

The final energy demand is forecast to increase at annual 8.1% in manufacturing sector and 7.2% in residential sector, uplifting the nation's average demand increase of annual 7.2%. In the Reference Case, energy conservation is scheduled to progress 2% per year faster than the BAU Case. Suppose this target were achieved, demand increase in manufacturing and residential sectors would still be steep as above. In view of the domestic and world energy supply tightening in future, the government is required to seriously consider promotion of energy conservation.

(2) Rapid increase of LPG demand

Potential demand for LPG is forecast to increase substantially in manufacturing, commercial and residential sectors. However, since domestic as well as international LPG supply is not abundant, it is inevitable to face supply shortage if the demand continues to increase as projected in the Reference Case, at annual 12% for 2005-2025. In many countries, natural gas is supplied in place of or in addition to LPG as fuel for manufacturing, commercial and residential sectors. However, construction of natural gas pipeline requires lead long time and huge investment. In Vietnam, it is necessary to study soonest possible on its future design toward creation of multi-mode gas delivery system suitable for the geography.

(3) Increase of motor vehicles and gasoline and diesel oil demand

Motorbike is widely used in Vietnam as important transport measure of citizens. Although car ownership is curbed under the national policy, those new type cars like INOVA of Toyota (7 seater) with tax benefit are showing explosive sale. As passenger cars of 1,500 –2,000 cc class consume ten-fold more gasoline compared with motorbike, it is inevitable that demand for gasoline and diesel gas oil will increase rapidly as car ownership increases.

Once motor vehicle upsurge begins, serious traffic congestions may occur in big cities like Hanoi and HCMC due to narrow and complicated road system. It is well known from experiences of Japan and other countries that traffic congestion also gives serious impact on the health of citizens along the roads. In addition to securing stable supply of motor fuel, construction of rational transport system and improvement of gasoline and diesel gas oil qualities are among the important issues to be tackled with.

Chapter 6 Energy Supply Analysis

Energy demand outlooks under various scenarios were examined in the previous chapter. In this chapter, using energy supply models, we analyze changes in energy supply pattern corresponding to such different demand forecasts and resulting issues. In addition to the cases relating to changes in demand forecast (BAU case, Reference case, High Growth case, Low Growth case, High Price case, Low Price case) examined in the previous chapter, cases relating to changes in supply conditions are also analyzed in this chapter as follows.

1) Difference in start up timing and size of nuclear stations
2) Increased natural gas supply
3) Advance of the second and third refineries
4) Increased supply of new and renewable energies
5) Regulation on CO_2 emission

6.1 Assumptions on Energy Supply Conditions

At first, we will explain the assumptions on the supply of various energies applied in the analysis of this chapter. They are applied commonly to all the cases except for those discussed in Section 6.5 to examine effects of changes in energy supply conditions.

6.1.1 Assumptions for Electric Power Sector

Power resource composition of each case is based on the annual development plan made by IE following Power Development Master Plan. Basic conditions of power development by fuel type are summarized later and Figure 6.1-1 presents a relationship between generation cost and plant load factor by fuel type based on the data derived from PDP6. As shown in the figure, it is clear that pumped storage power (PSPP) as peak power, gas thermal as middle power and coal & nuclear as base power are suitable power resources. Due to the constraints of fuel supply in north and south region in Vietnam, hydropower and domestic coal are the major fuel sources in north and domestic gas conveyed by pipeline, nuclear and import coal are the major sources in south region.

Hydropower: All the hydro potential will be developed by 2019.

Nuclear: First unit starts its operation in 2020. Total capacity at 2025 becomes 4,000MW.

Oil / diesel thermal: Existing power plants will be shutdown after completing its lifetime.

Coal thermal: In the north region, thermal power fueled by domestic coal as well as hydropower is the base power supply source. In the south region, domestic gas thermal development is given priority but import coal thermal will be developed to cover the deficit depending on the power demand.

Gas thermal: Power plants are developed in the south region bringing in gas from gas fields in south offshore.

Renewable energy: Small-scale hydropowers with a capacity of less than 30MW and wind powers are included.

Power import: Power import from China, Lao PDR and Cambodia is included.

PSPP: First unit operation is planned in 2019.

In cases to examine demand variation, capacities of hydro, nuclear, oil, diesel and renewable energies, power import and pumped storage power shall be decided following the basic development plan made by Vietnam. Coal and gas thermal development is adjusted through expediting or delaying their projects based on the size of power demand of individual 6 cases. In the cases where power supply conditions are changed, conditions of infrastructure development are modified while total power demand is same as Reference Case. Detail preconditions for these cases of supply condition change are explained later.

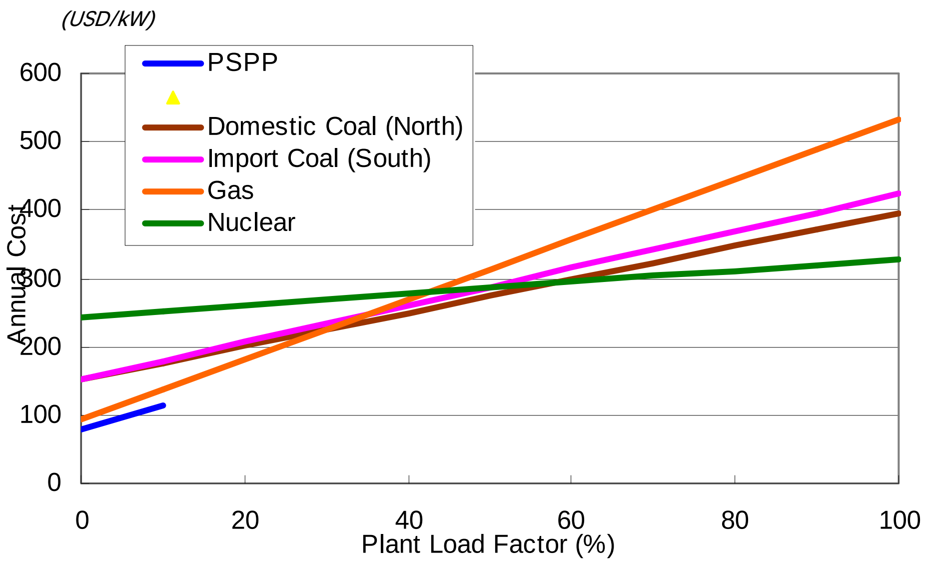


Figure 6.1-1 Annual generation cost by plant load factor

Cases on supply condition change: Nuclear delayed or promoted

Here, three cases are studied, namely, 1) nuclear delayed case alternated by coal, 2) nuclear delayed case alternated by LNG and 3) nuclear promotion case. In the first two cases it is assumed that construction of nuclear power plants delays and EVN shall seek for alternative power resources. As an alternative power, coal is most likely to be the best source since it is cheaper than other fossil fuels. Therefore, the delayed nuclear substituted by import coal is chosen as one case. Substitution by LNG developing LNG receiving terminals could be the other option considering benefits in terms of national security and risk allocation in fuel procurement. LNG demand and supply is tight at present, but it could be procured in the long run by 2020.

In the third case or nuclear promotion case, it is assumed that the first unit starts operation in 2020 as scheduled, and others will start in turn with double capacity of the Reference Case or in total 8,000MW at 2005. As a result, it is expected that the southern region power demand will be mainly covered by gas and nuclear, supported by small amount of import coal thermals.

6.1.2 Assumptions for Coal Sector

1) Production

Domestic coal production capacity is set at 67.5 million tons at maximum in 2025 based on the outlook of coal production projected in "Sustainable Development Strategy of Coal Industry" published by VINACOMIN in May 2007.

Coal is classified into three grades as high, medium and low by heat value, and their heat values are set at 7,500 kcal/kg for the high grade, 5,500 kcal/kg for the medium grade and 4,000 kcal/kg for the low grade. Raw coal is separated to clean coal and waste by processing at coal preparation, and raw coal production at 100% will be distributed to 25% for the high grade, 45% for the medium grade, 20% for the low grade, and 10% as the waste. This means that the clean coal production is assumed at 90% of the raw coal production. This ratio is set in reference to the preparation flow at the Cua Ong coal preparation plant that is the biggest in Vietnam.

2) Import

There are two types of import coal such as thermal coal for the electricity in the central and southern regions and coking coal for the steel making in the northern region. Import quantity is calculated as the difference between domestic production and demand, while coal-fired power plants in the central and southern regions will purchase import coal only, and its heat value is set at 6,500 kcal/kg.

3) Export

With regard to coal export, actual figures are listed for 2005 and 2006, and estimated one for 2007 with an assumption of minimum 18 million tons. After 2008, the whole quantity of the PCI coal of high value for steel making is assumed to be exported, while other grade coal would be exported only if surplus occurs in domestic coal supply. The minimum quantity of coal export is set at 7% of the clean coal production, which is the ratio of the high grade PCI coal over the total production.

4) Domestic Consumption

Domestic consumption is classified broadly into two categories, electricity sector and the other sector, and the electricity sector uses coal with priority to other sectors. Electricity sector is also classified into two categories, power plants using domestic anthracite and those using imported steaming coal. Coal consumption is calculated based on the power generation quantity estimated by PDPAT II. The domestic anthracite coal-fired power plants are assumed to consume only anthracite regardless the coal grade. However, the average heat value of the coal consumption by the power sector is set at 5,500 kcal/kg, and it is assumed that this will be achieved by blending of high and low quality coals as appropriate. Coal consumption at power plants for import coal is also assumed to be only import coal of heat value at 6,700 kcal/kg. On the other hand, the other sector is assumed to consume the rest of domestic coal after electricity sector use them first, and then import coal if domestic coal supply is insufficient.

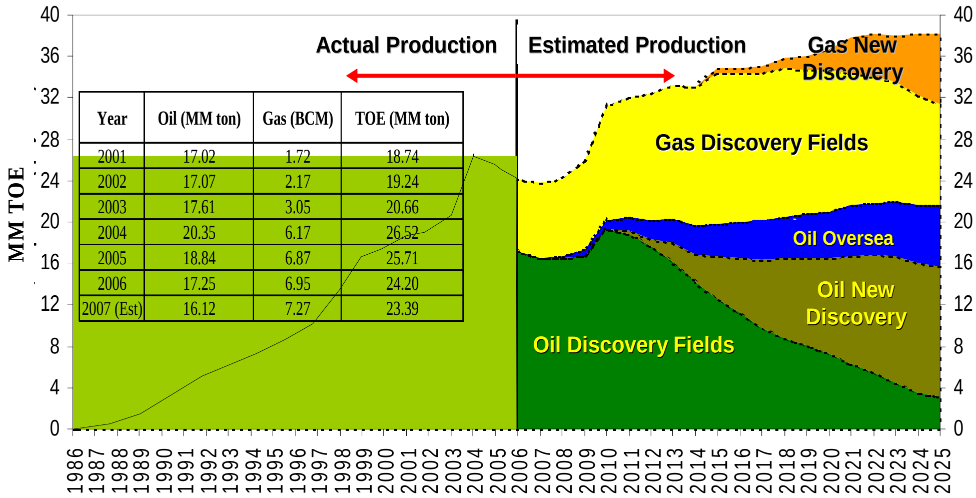
Cases of Supply Condition Change：Productivity Growth Case

Although it is non-commercial at present, the Red River coalfield may start production after 2015 as it becomes profitable for mining due to soaring coal price exceeding production cost substantially. Introducing advanced production and safety technologies to the Quang Ninh coalfield, productivity will be improved drastically so that the national coal production capacity may reach 100 million tons by 2025.

Export may increase in this case, while there would not be any change in the result as the domestic demand is adequately supplied with domestic coal in the Reference Case. Thus, there would not be any meaningful outcome for the Reference Case. Therefore, this case is run only for the High Growth Case where anticipated greater amount of coal import may change.

6.1.3 Assumptions for Oil and Gas Sector

Vietnamese oil and gas production forecast are quoted from the information presented at the IEA workshop entitled as "Oil Security and National Emergency Preparedness" held in Bangkok, September 2007. As shown in Figure 6.1-2, the forecasted figure is indicated as a sum of the existing and expected reserves. Oil production is anticipated to decrease gradually till around 2010, then, 300 thousand BD level will be maintained up to 2025, i.e., 320 thousand BD from 2015 to 2020, 300 thousand BD for 2025, which would require substantial efforts. Looking at natural gas, yet-to-be-developed fields will turn to be materialized so that the production will increase to 15 billion cubic meters per year in 2015, and 16 billion cubic meters in 2025, from the current level of 7 billion cubic meters. However, it should be noted that there is a possibility of great production jump once large discovery is made in deep-water or elsewhere since the reservoir size of the existing gas fields in Vietnam is rather small, 1-2 Tcf, compared with those in other South-East Asian countries.



Year	Oil (MM ton)	Gas (BCM)	TOE (MM ton)
2001	17.02	1.72	18.74
2002	17.07	2.17	19.24
2003	17.61	3.05	20.66
2004	20.35	6.17	26.52
2005	18.84	6.87	25.71
2006	17.25	6.95	24.20
2007 (Est)	16.12	7.27	23.39

(Sourse) Tran Huu Truong Son, Ministry of Industry and Trade, Vietnam,
"VIETNAM OIL SECURITY POLICIES", Oil Security and National Emergency Preparedness,
IEA, Bangkok: 17-18 September 2007

Figure 6.1-2 Crude oil and gas Production Past and Forecast (1)

As for the supply demand balance of crude oil, the export amount is calculated as the difference between the above-mentioned domestic production and the feedstock processed at the domestic refinery (-ies). When domestic production is in excess, the rest will be exported and in short the balance will be imported.

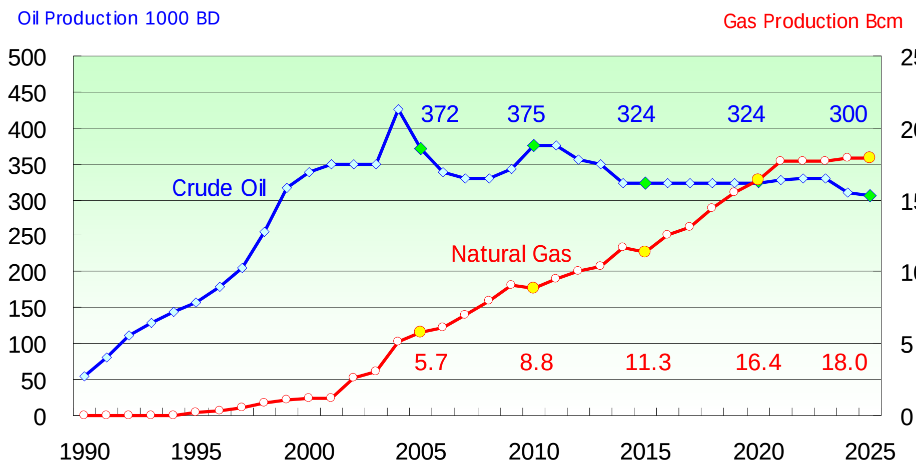


Figure 6.1-3 Production of crude oil and gas

As for the downstream activity, the first refinery now under construction in Dung Quat will come into operation in 2009. At first, the feedstock is scheduled 100% with domestic crude oil, though 15% of it will be shifted from 2020 to imported high-sulfur crude that is the maximum acceptable design limit. The second refinery scheduled on stream in 2015 is planned to receive imported crude oil for 50% of the feedstock from starting.

The strategic oil stockpiling will start from 2010 storing imported crude oil. National Energy Policy (Strategy) stipulates construction of strategic oil stockpiling system with capacity equal to 30 days of average oil consumption in 2010, 60 days of oil consumption in 2020 and 90 days in the year after 2020 as target. Assumptions of strategic oil stockpiling in this section are as follows.

- Strategic reserve oil equal to 30 days of the average consumption will be stored in 2010.
- From 2011 to 2019, only the quantity in short of the target will be filled in the storage as oil consumption will gradually increase year by year.
- In 2020, additional 30 days of will be filled in the storage to meet the requirement of 60 days.
- According to the National Energy Policy (Strategy), the target of strategic oil stockpiling after 2020 is 90 days. However, we assume this target to be moved to 2025. Before 2025, only the quantity in short of the target of 60 days will filled in the storage same as the previous period.

In the following analysis, the above-mentioned stockpiling is incorporated into the supply/demand balance table of crude oil, while it is excluded in the balance table of the Total Primary Energy. That is, the total energy import shall be calculated as the sum of the amount required from the supply and demand balance table plus the incremental amount of stockpiling.

Condensate associated with domestic gas production is handled as gasoline equivalent for the sake of the modelling simplification. In the analysis of gasoline supply demand balance, the sum of the imported and produced gasoline plus condensate is regarded as domestic supply, and the excess quantity will be exported as light naphtha.

Cases of Supply Condition Change

1) Doubled natural gas supply

With accelerated domestic natural gas development and production as well as start of LNG import, natural gas supply amount may become double of the one envisaged for the Reference Case in 2025. Fuel conversion will take place at both existing and planned coal-based power plants in to gas-based ones. Further, fuel conversion may occur in the existing demand and potential demand may also be materialized in industrial and residential sectors, substituting coal, oil, and non-commercial energies. In this case, one LNG receiving terminal (3 million ton/year receiving capacity) will be built in the Southern province in 2020, followed by another terminal of the same capacity in Northern Province in 2023.

2) Acceleration of No.2 and No.3 Refinery Construction

The construction of the No.2 and No.3 Refineries may be advanced to start in 2013 and 2016, respectively. The refining capacity, production yield, and feedstock crude type of No.3 refinery are assumed as same as No.2 Refinery.

6.1.4 Assumptions for New and Renewable Energy Sector

In the renewable energy supply plan, Bio-Fuel is considered in addition to Electricity as referred to in 6.1.1. I n "Development of Bio-Fuels in the Period up to 2015, Outlook to 2025 (Draft)", the target is set that gasoline and diesel demand shall be 100% replaced by gasohol E5 and bio-diesel B5 by 2025.

However, it is not easy to achieve the target considering the current biomass production volume in Vietnam and international bio-fuel production volume. Therefore, bio-fuel supply condition is assumed for the Reference Case as follows.

-Bio-Ethanol: since current production volume of the material crops (e.g. sugarcane, cassava) is relatively large, 30% of gasoline demand may be replaced by gasohol E5 by 2025

-Bio-Diesel: since current production volume of the material crops (e.g. oil palm, coconut, jatropha) is virtually nil at present in Vietnam, 10% of diesel demand may be replaced by bio-diesel B5 by 2025

Cases of Supply Condition Change: Bio-Fuel Increase Case

Bio-Fuel Increase Case is set as stipulated in "Development of Bio-Fuels in the Period up to 2015, Outlook to 2025 (Draft)" that gasoline and diesel demand may be 100% replaced by gasohol E5 and bio-diesel B5 by 2025.

6.2 Energy Supply / Demand Balance of Reference Case

The optimized energy supply/demand balance for the Reference Case, as set forth as the standard case of this study, obtained through the simulation using the above mentioned models is as follows.

6.2.1 Crude oil supply / demand balance

The crude oil supply balance is composed of production, import, export, consumption at oil refineries and the quantity being set aside for oil stockpiling, although it is included in Figure 6.2-1. The estimated result is shown in Figure 6.2-1, where the horizontal scale gives years from 2005 through 2025. The crude oil production is given as an external variable, and then the S&D Model decides the consumption at oil refineries, necessary import, export and oil stockpiling. The annual amount of oil stockpiling is calculated as a product of the annual consumption of petroleum products and the specified stockpiling days, the basic rule of which was explained in 6.1.3.

(Unit: Million ton)

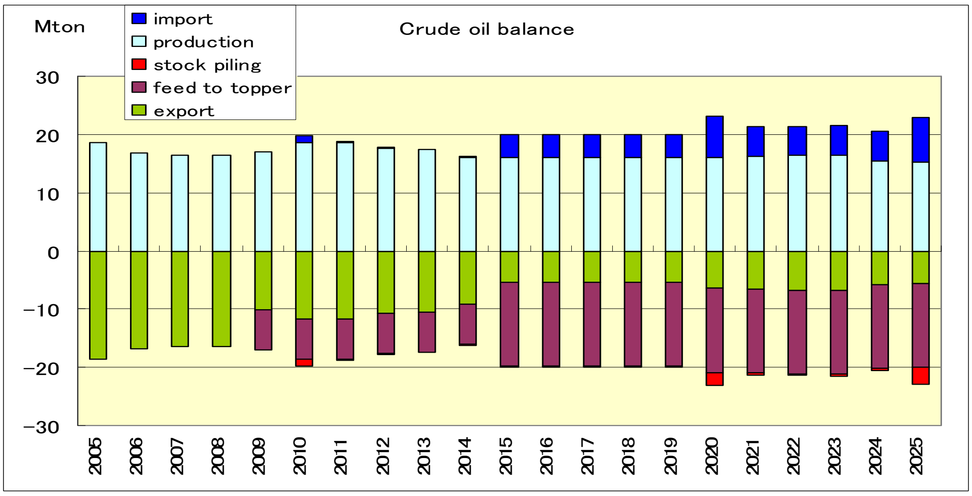


Figure 6.2-1 Crude oil supply and demand balance

In the graph, the upper bar the above abscissa axis shows input as production and import and the lower bar shows output as export, consumption at oil refinery and stockpiling. The total length of the upper bar is equal to that of the lower bar and they are balanced. As no oil refinery is operating for the first four years from 2005, all the crude oil production goes to export. The first oil refinery starts operation in 2009 and runs at full load through 2025. The crude oil production remains at the same level, so the crude oil export in 2009 decreases by the amount of refinery processing.

National oil stockpiling starts from 2010 as shown in Figure 6.2-2. The second refinery starts in

(Unit: Million ton)

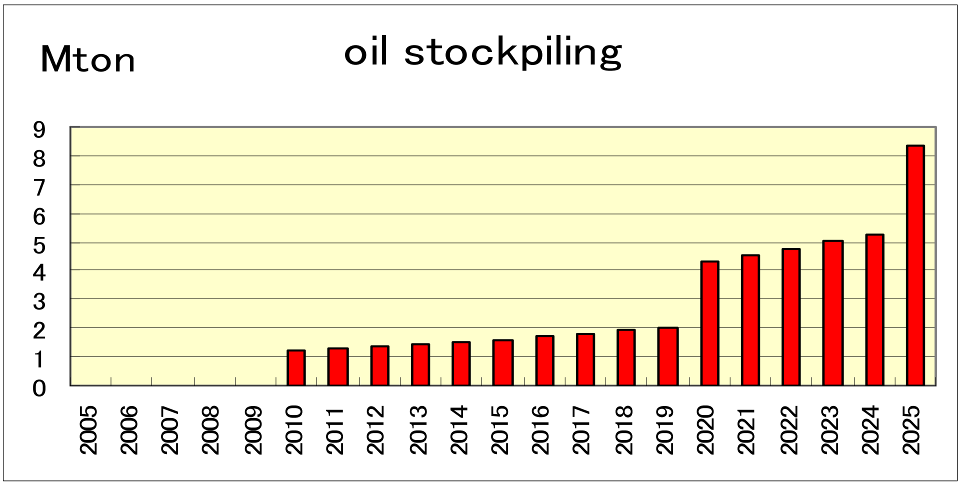


Figure 6.2-2 Transition of oil stockpiling

2015 and operates at full lord from the beginning. A half of the feedstock for the second refinery will be imported crude oil, thus crude oil import starts from 2015 excluding those for oil stockpiling. At the first refinery, 15% of the feedstock will be switched to import crude oil from 2020, increasing the total import quantity.

6.2.2 Petroleum products supply/demand balance

While there is no full scale oil refinery before 2009, small qu nd the export position continues for 2015 through 2025 as shown in Figure 6.2-3.antity of gasoline is produced at a condensate splitter using the condensate produced at gas processing plant. The first oil refinery starts operation in 2009. The gasoline production exceeds the demand for the first 3 years, and the surplus will be exported. The domestic gasoline supply falls short of demand and gasoline import occurs again for the next three years from 2012. The second refinery staring up in 2015, the gasoline production exceeds the domestic demand again a

(Unit: Million ton)

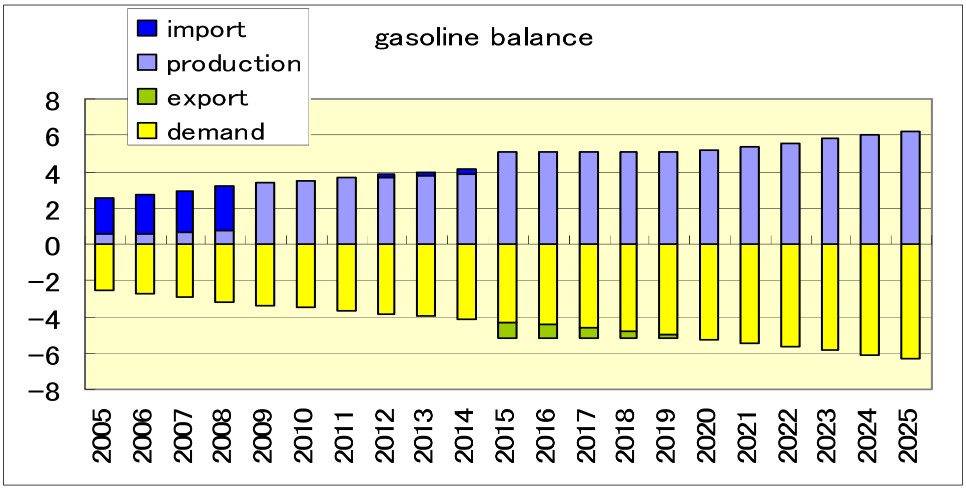


Figure 6.2-3 gasoline supply and demand balance

Fuel oil demand may be classified into two types; consumption at power plants and by general users excluding the power sector. The consumption of fuel oil at power plants is estimated by the power sector model PDPAT II . Figure 6.2-5 shows that not much quantity of fuel oil is consumed at power plants for the period from 2009 to 2019. But there appears a symptom afterwards that fuel oil consumption increases reflecting expanding shortage of power source development; this requires careful consideration. Fuel oil consumption by general users increases at annual 6% for the entire projection period. The fuel oil being produced at maximum capacity in domestic refineries, the incremental demand needs to be balanced by import.

Since LPG is consumed only by the general block users, the length of the bar in Figure 6.2-6 shows the total demand. Domestic production of LPG comes from oil refineries and natural gas processing facilities, and any shortage is being supplied via import.

(Unit: Million ton)

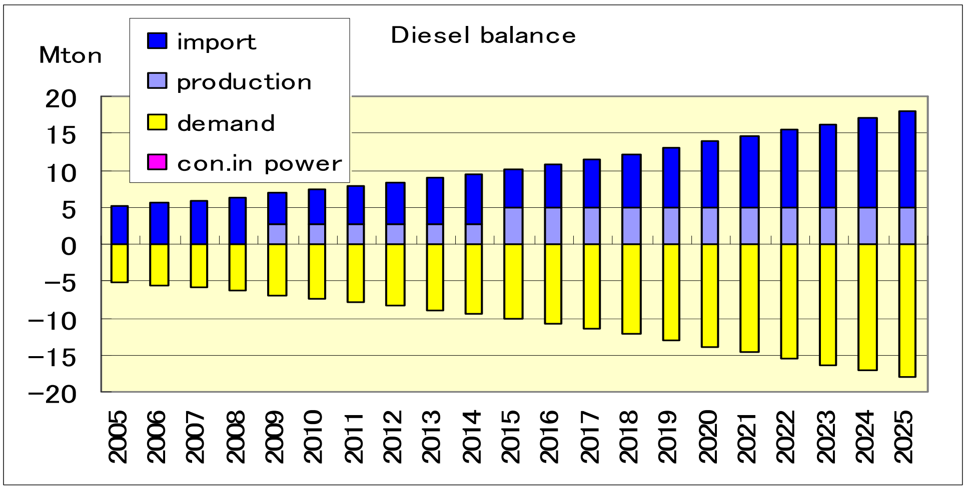


Figure 6.2-4 diesel oil supply and demand balance

(Unit: Million ton)

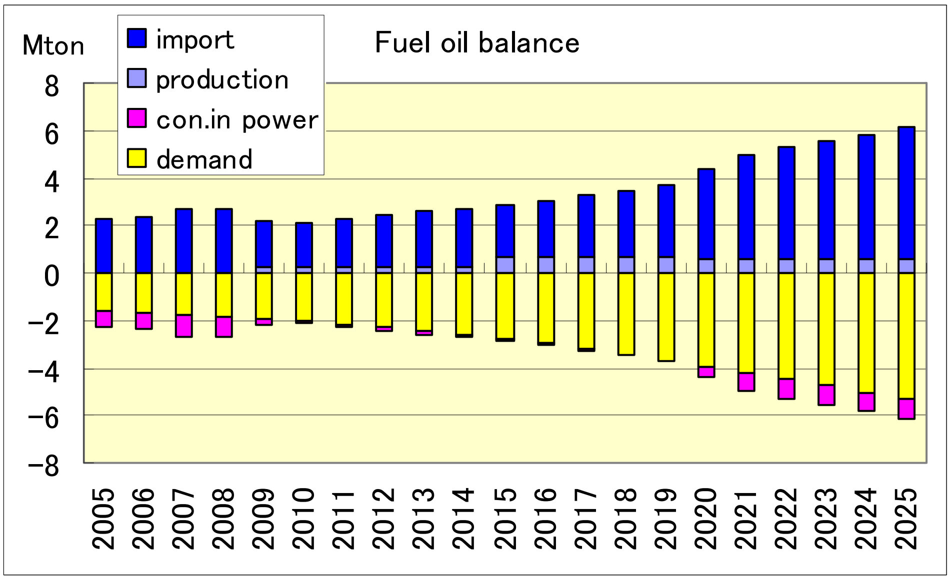


Figure 6.2-5 fuel oil supply and demand balance

However, we should note that LPG supply in the international market is not very affluent. In this model, therefore, it is assumed that the maximum production from the domestic refineries will be 1.1 million ton per year and the maximum import quantity will be two million tons per year in addition to the production at gas processing plants. LPG demand in Vietnam will be increasing fast every year as shown in Figure 6.2-6 and the domestic production and import assumed as above would become unable to satisfy the demand sooner or later. To give a temporary solution in the model, we assume that the gap may be filled with some LPG substitute fuel. Import kerosene is tentatively considered as the LPG substitute fuel here, though it is necessary to consider it seriously how to satisfy the potential demand of L PG which will be mainly required by many users in industry, commercial and residential sectors. If we could prepare natural gas delivery system, it is most desirable to substitute the supply with city gas in view of the needs on the demand side.

(Unit: Million ton)

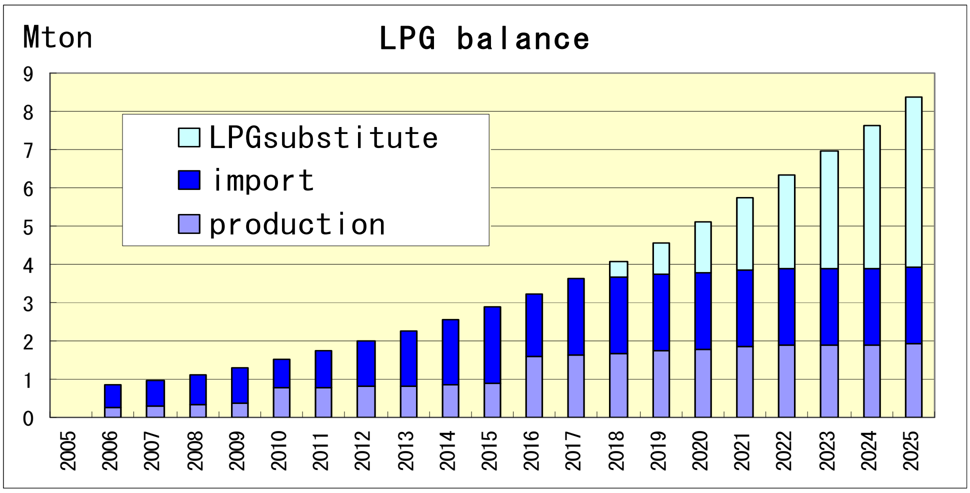


Figure 6.2-6 LPG supply and demand balance

6.2.3 Coal supply/demand balance

Raw coal produced in the country is classified into three grades after coal preparation or size control, that is, high, medium, low quality coals. In this model, domestic coal is classified into three grades as explained, while import coal mainly used at power stations are classified into one grade of 6,500 kcal/kg. Figure 6.2-7 shows the coal supply/demand balance.

As domestic coal production steadily grows to 67.5 Mt by 2025, it satisfies adequately the aggregate demand for power plants and general users and has enough capacity to direct high quality coal such as coal for PCI as well as low quality coal in surplus into export. As import coal supply is meant only for import coal-fired power plants, import volume will increase gradually after 2015 but would not exceed 14 million tons even in 2025.

(Unit: Million ton)

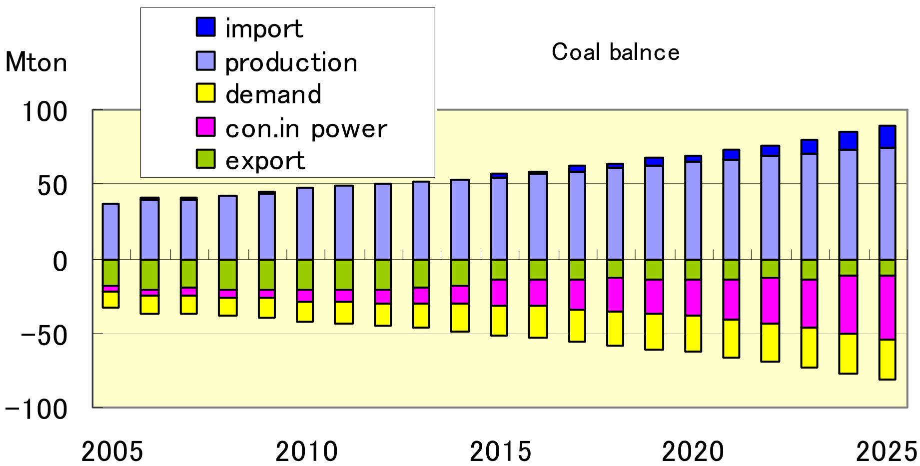


Figure 6.2-7 Coal Balance

6.2.4 Natural gas supply/demand balance

Natural gas supply/demand balance is shown in Figure 6.2-8. The domestic production of natural gas is estimated based on the current proved reserve, which is not very big compared with those in neighboring countries. On the other hand, natural gas demand by power plants and general users is forecast to grow steadily. As a result, natural gas import will be required at around 2021. Thus, it is necessary to start considering the measures to accommodate such increasing demand well in advance. In case the aforementioned LPG shortage would be supplemented by natural gas supply, start up timing of natural gas import need to be advanced substantially. The consumption quantity at power plants is estimated by PDPAT II .

(Unit: Million ton)

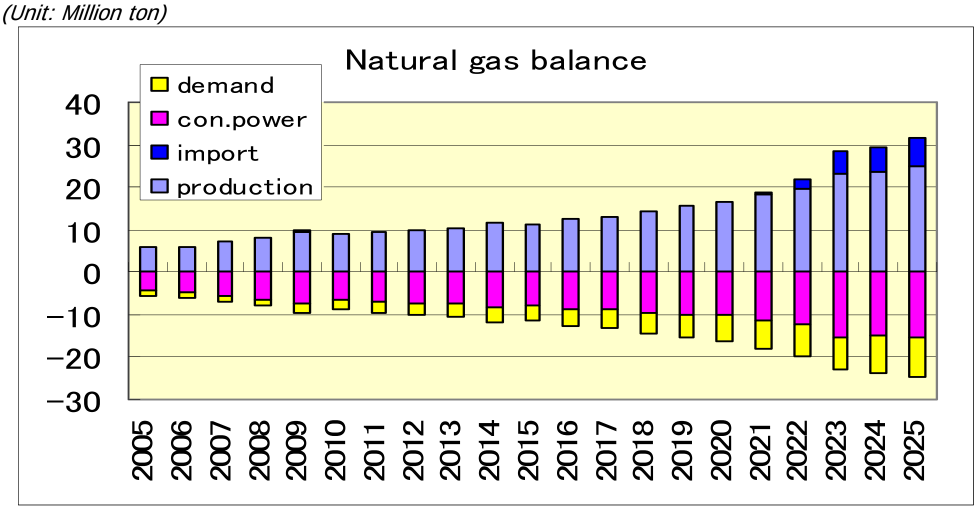


Figure 6.2-8 Natural gas balance

6.2.5 Electricity supply/demand balance

All the output data on the fuel consumption for power generation are estimated by PDPAT. Power generation by fuel is shown in Figure 6.2-9.

The freedom on selection of power sources among nuclear, hydro and renewable energy power plants is relatively small because of various constraints on availability of resources and construction sites. As a result, coal (domestic and import) and natural gas, which have relatively greater flexibility, share high portions over the total power generation and always exceeds 50% in aggregate. Nuclear power plants are scheduled to start from 2020. The estimated power supply in 2025 is, in the descending order, natural gas, domestic coal, hydro, import coal, import electricity, nuclear, renewable energy and fuel oil.

The share of nuclear power is small in the total power supply and fuel oil consumption is estimated to be much smaller. However it is necessary to take note of the following possibilities.

1) Should development of other power sources be delayed, the deficit may be supplemented by oil even if it is expensive
2) Bitumen might be used for power generation at oil refineries.

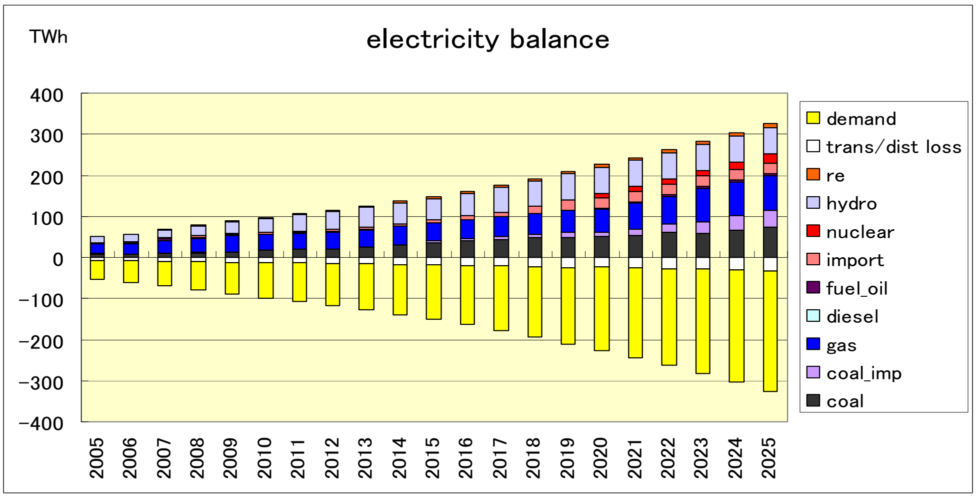


Figure 6.2-9 electricity balance

6.2.6 CO_2 emission

The CO_2 emission will increase along with increase of energy consumption as shown in Figure 6.2-10.

This amount of CO_2 emission is almost equal to the figure calculated by a relevant organization in Vietnam. Most of the future incremental energy demand needs to be supplied by fossil fuel such as coal, oil and natural gas. As concern on the global warming is rising worldwide, it may be necessary for Vietnam to step up the discussion on the agreement made at the East Asian Summit meeting to observe the "common but differentiated responsibilities."

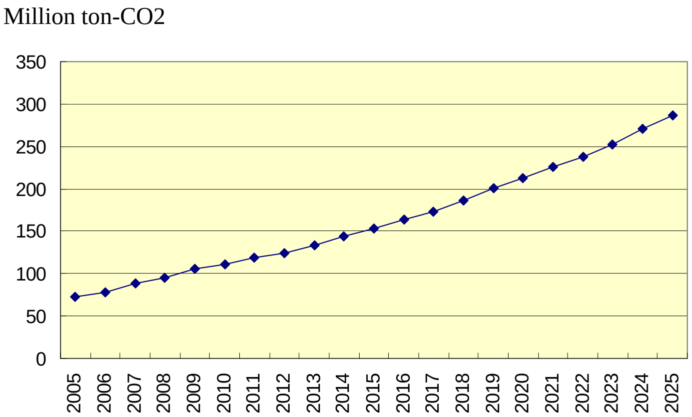


Figure 6.2-10 CO_2 emission

6.3 Energy Supply Patterns in Main Cases

In this section, we will examine the six main cases, namely, BAU, Reference, High Growth, Low Growth, High Price and Low Price cases, to look into what differences would be seen in the energy supply pattern and what issues would be implicated from them. We will refer to the detail analyses on each sector including additional case studies in the following section.

6.3.1 Energy Import and Import Ratio

The most remarkable difference among the six cases appears in the energy import quantity and the energy import ratio. This is because the future energy demand fluctuates subject to outlook on economic growth and energy price, while the domestic production has certain limit and the same energy supply scenario is applied to the six cases. Energy import quantities and import ratios for the six cases are as shown in Figure 6.3-1, Figure 6.3-2

Million ton

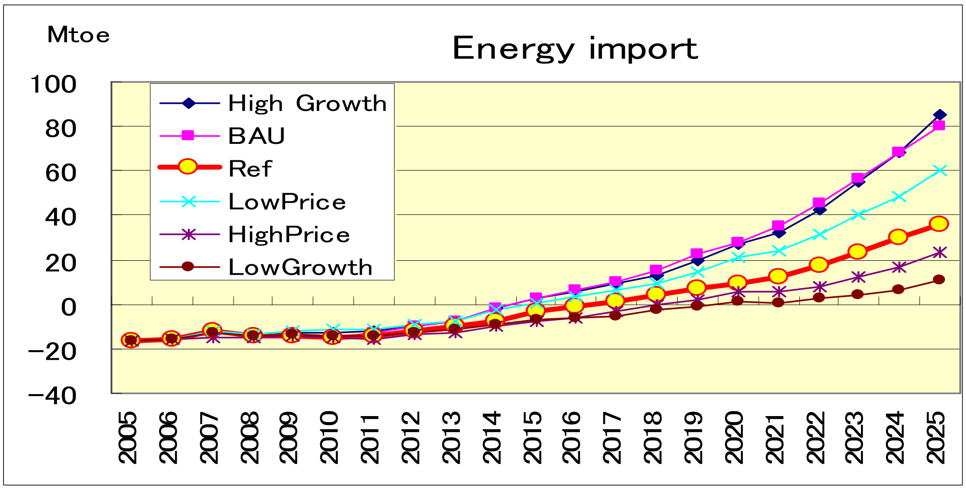


Figure 6.3-1 energy import

%

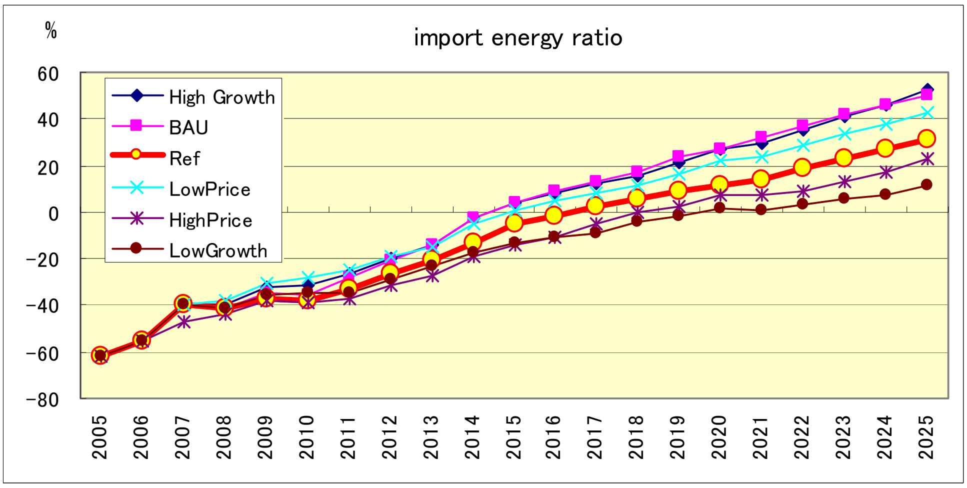


Figure 6.3-2 energy import ratio

In the Reference Case, Vietnam will become a net energy importing country in 2017 save for oil stockpiling. This will occur earliest in 2015 for the High Growth Case, BAU case, Low Price case and latest in 2020 for the Low Growth Case. Anyway, Vietnam will shift from an energy exporting to an energy importing country sooner or later, and it is the most important issue in the energy sector to consider how to cope with such new position.

6.3.2 Petroleum products supply/demand balance

The first refinery in Vietnam will start at Dung Quat in 2009, which will supply about 70% of the domestic demand for petroleum products while the rest still needs to be imported continuously. As the demand for petroleum products continues to grow, oil refineries keep operating at full lord from the beginning in all of the six cases, and the petroleum products are produced at their maximum capacity, while any demand exceeding the domestic production is imported. However, the gasoline balance is a little bit different. After start up of the second refinery, the domestic gasoline production exceeds the demand and the surplus will be exported after 2015, except for the High Growth case in which gasoline import becomes necessary after 2020. With startup of the second refinery, byproducts such as asphalt will be also produced. Therefore the detail supply/demand balance in the refining sector should be analyzed by a more detailed model which could facilitate in-depth examination of production balances.

(Unit: Million ton)

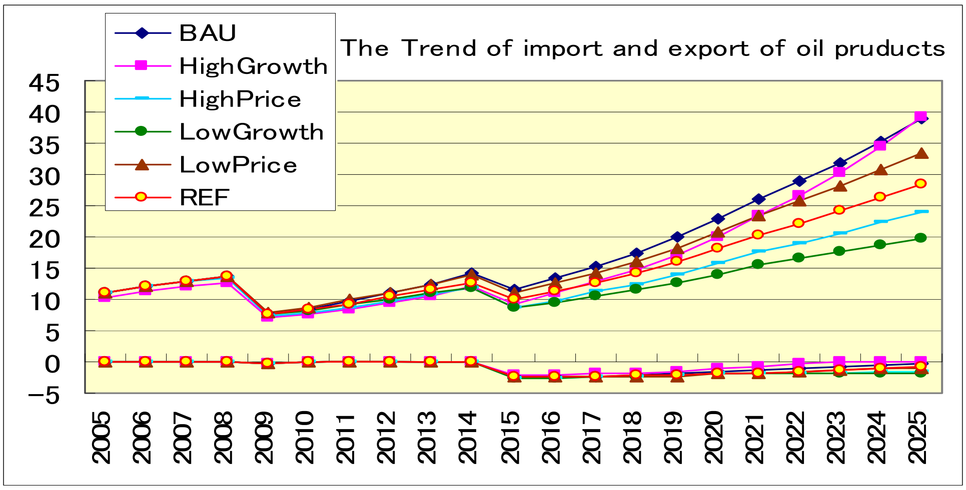


Figure 6.3-3 The trend of import and export of oil products

6.3.3 Coal supply/demand balance

Figure 6.3-4 shows progress of the domestic coal production. Domestic coal production capacity and also production itself will increase stably by 2025. The coal production hits the maximum ceiling if average coal export price is higher than domestic coal sales price. In an opposite case of price relationship, domestic coal production is assumed to satisfy the domestic demand plus export of the high grade PCI coal for steel making that share 7% of the raw coal production. From the coal price setting on the study, the coal production remains at the maximum capacity from 2007 till 2025 regardless of the case.

Nevertheless, coal import for large scale coal-fired power stations starts between 2015 and 2018 in the southern region. The coal import rapidly increases from around 2021 in the BAU Case, the High Growth Case and the Low Price Case as shown in figure 6.3-5. The coal import in the Reference Case is 14 million tons in 2025, more or less one third of the BAU Case, which shows that power demand control by energy saving appears in full effect.

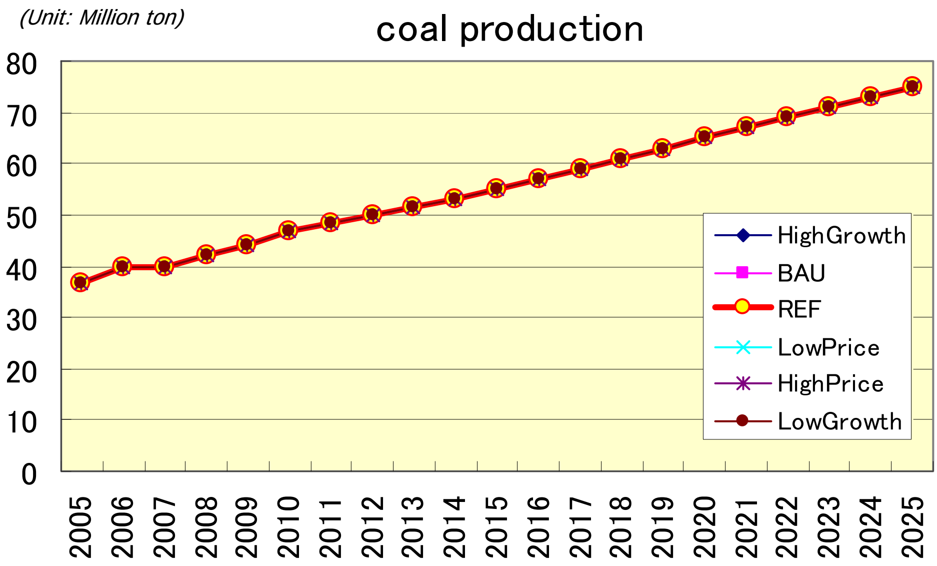


Figure 6.3-4 Coal production

Meanwhile, importing coal from overseas requires building infrastructure such as coal receiving terminals that require long lead time. To fix such plan, it is necessary to discuss more in detail about coal supply and demand outlook to select appropriate measures to proceed with.

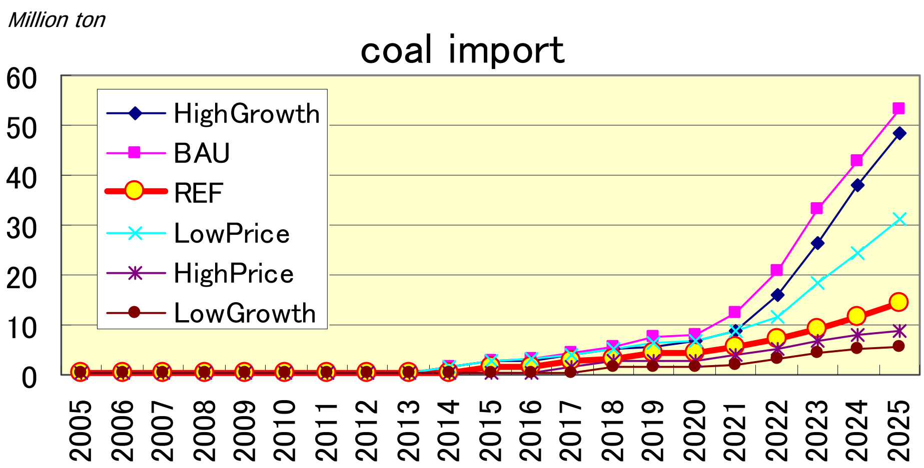


Figure 6.3-5 Coal import

6.3.4 Natural gas supply/demand

Changes in the natural gas production pattern are different compared to other energies. In the High Growth, the BAU, the Low Price and the Reference cases, natural gas production reaches the maximum capacity in 2021, while in other cases such as the High Price and the Low Growth cases, where the energy demand is dull, natural gas production would not reach the full operation.

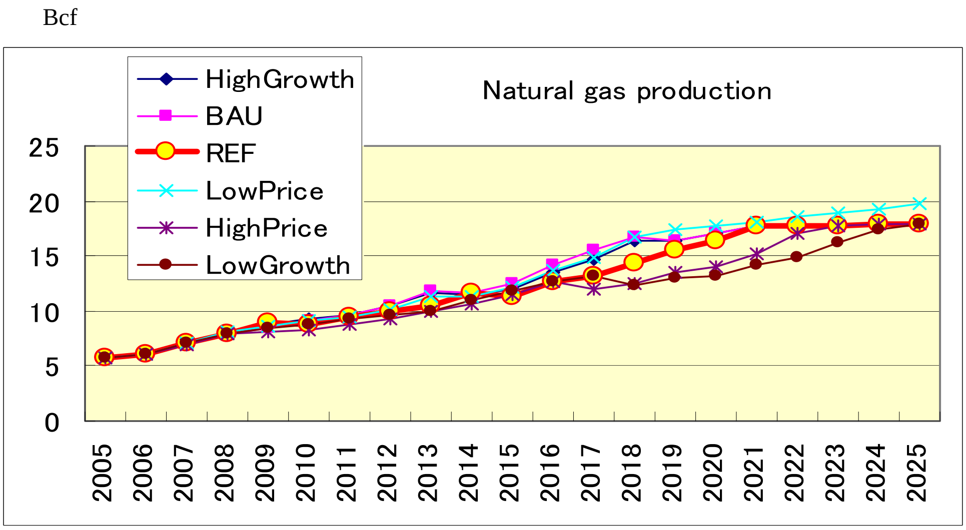


Figure 6.3-6 Natural gas production

As the natural gas supply fluctuates substantially among cases, this reflects the difference in the gas consumption at power plants. Once a gas fired power plant is constructed, it generally continues operation irrespective of changes in surrounding conditions such as energy price, and gas field would be operated following such demand pattern. Figure 6.3-5 illustrates the progress of natural gas consumption at power plants.

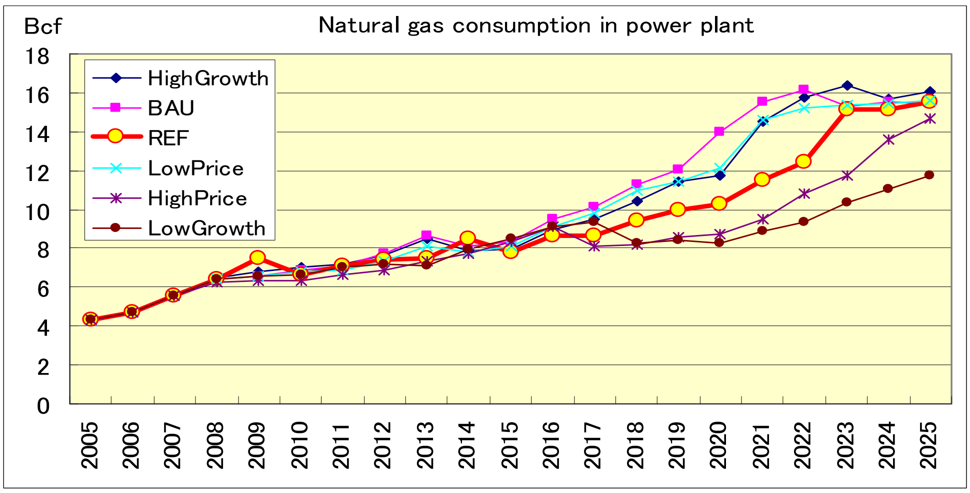


Figure 6.3-7 Natural gas for power plant

As the natural gas demand at power plants is supposed to provide the anchor demand in developing the domestic natural gas market, we need to further look into the construction timing of natural gas fired power plants. Such study should be conducted from one step higher position than the pursuit of the optimum fuel mix for power supply with a view to establish *the grand design of the national natural gas supply system*.

In the high demand cases, the domestic natural gas production reaches the ceiling in early years and natural gas import will supplement it; from 2018 in the BAU Case and from 2021 in the Reference

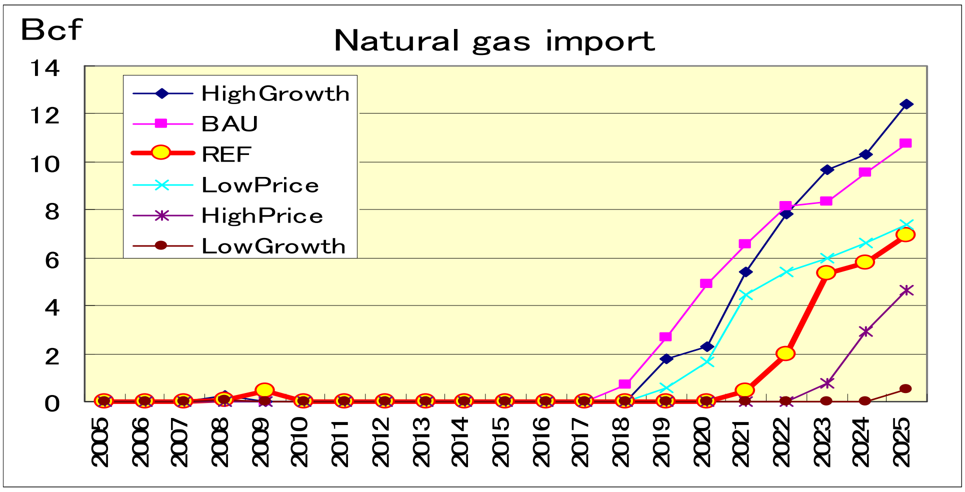


Figure 6.3-8 Natural gas import

Case. However, in the Low Growth Case, gas import occurs only in 2025.

In case city gas system were developed in urban areas such as Hanoi and Ho Chi Min, replacing the demand for LPG now expanding fast nationwide, then the plateau timing would be substantially advanced for the domestic natural gas production and, domestic production cannot satisfy the demand with the currently proved reserves. If an energy policy to widely utilize natural gas were adopted for the future energy supply, it is necessary to advance the establishment of the grand design as mentioned above considering the substantial lead time required for preparing the gas import and delivery system.

6.3.5 CO_2 emission

Figure 6.2-8 shows the comparison of CO_2 emission in six cases. The CO_2 emission in the High Growth Case and BAU case in 2025 is 1.5 times greater than that of the Reference Case and 2 times greater than that of the Low Growth case.

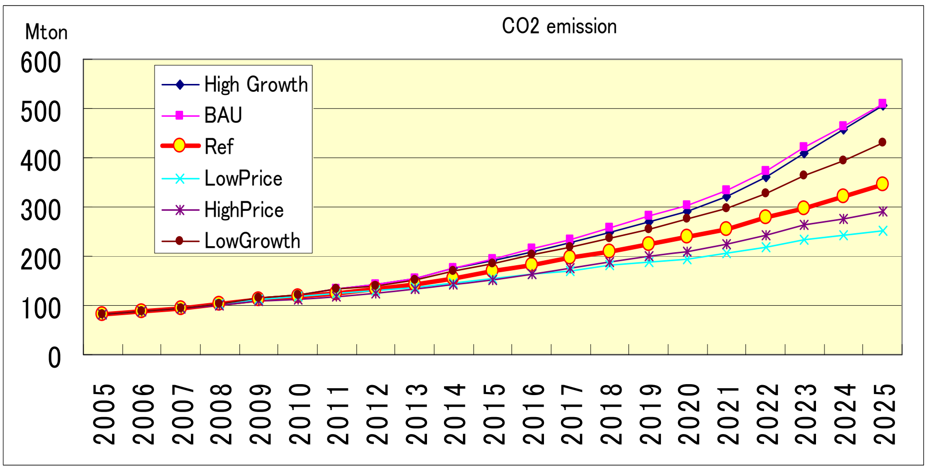


Figure 6.3-9 CO_2 emission

6.4 Energy Supply Patterns subject to Changes in Demand

6.4.1 Effect of EEC Promotion

In this study, it is assumed that energy efficiency and conservation (EEC) will progress at annual 1% in the BAU Case and 3-4% in the Reference Case. This effect of EEC is reflected greatly in the primary energy supply pattern. In 2025 when the effect of EEC appears at maximum, the total energy demand in the Reference Case will be smaller than that in the BAU Case by more than 20%.

Table6.4-1 shows which supply item would be greatly affected when the total energy demand is decreased by EEC as a comparison of the BAU Case and the Reference Case. The top items 1, 2, 3 and 5 are all regarding the domestic and import coal used for power plant. The progress of EEC leads to decrease of electricity demand, then generation by domestic and import coal, and fuel consumption. As a result, decrease of coal import occurs. Thus, the greatest effect of EEC would appear in the coal fired power plants. In addition, the coal demand of the general block users will also decrease by 20.3%. Looking at the outcome conversely, if the progress of EEC is not sufficient as expected, it is necessary to take actions for coal import earlier.

Table 6.4-1 Effect of EEC on Individual Supply Items (at 2025)

order	energy	term	unit	reference	BAU	diffrence	ratio vs BAU %
1	coal	import	kton	14,226	53,026	-38,800	-73.2
2	power	import coal fuel	GWh	41,461	125,696	-84,235	-67.0
3	coal	for power	kton	43,716	85,785	-42,069	-49.0
4	LPG	LPGsubstitute	kton	5,259	9,099	-3,841	-42.2
5	natural gas	import	MMm3	6,911	10,781	-3,869	-35.9
6	naptha	to gasoline	kton	1,260	1,944	-684	-35.2
7	CO2	emission	Mton	345	508	-163	-32.1
25	crude oil	import	kton	7,805	8,537	-732	-8.6
26	natural gas	for power	MMm3	15,512	15,472	40	0.3
27	power	natural gas	GWh	85,186	84,889	298	0.4
28	coal	export	kton	13,203	5,250	7,953	151.5
29	naptha	export	kton	844	160	684	427.3

Following these items, the demand of LPG would decrease by 29.4% leading to decrease of LPG substitute's import by 42.2%. In case of natural gas, demand decreases by 29.5% leading to decrease of import by 35.9%. Among others, decreases in demand for petroleum products would lead to reduction of import of kerosene, diesel and fuel oil as well as the quantity set aside for the crude oil stockpiling.

6.4.2 Effects of Economic Growth Rate Change

Next, let us examine cases in which the economic growth rate will be higher or lower than that of the Reference case while the same EEC rate is assumed. For 2025 when the maximum effect of the difference in economic growth will be observed, items with 50% or more difference between the High Growth Case and the Reference Case are shown in Table 6.4-2.

Table 6.4-2 Effect of Growth Rate Changes (at 2025)

order	energy	term	unit	High Growth	reference	difference	increase ratio (vs reference%)
1	coal	import	kton	48,300	14,226	34,074	239.5
2	power	imoprt coal fuel	GWh	109,213	41,461	67,752	163.4
3	natural gas	import	MMm3	12,385	6,911	5,474	79.2
4	naptha	to gasoline	kton	2,104	1,260	844	67.0
5	coal	for power	kton	80,412	43,716	36,697	83.9
6	LPG	LPGsubstitute	kton	9,302	5,259	4,044	76.9
9	CO2	emission	Mton	507	345	162	46.9
31	coal	export	kton	5,250	13,203	-7,953	-60.2
32	naptha	export	kton	0	844	-844	-100.0

The order of the high ranking items in Table 6.4-2 is very similar to that of Table 6.4-1. The increase of electricity demand creates fuel consumption increase at coal power plants, increase of coal import, and then increase of coal consumption. After this in the higher ranking comes the increase of import of natural gas and LPG substitute. A big difference between Table6.4-2 and Table 6.4-1 is that the expansion rate becomes extremely greater. It means that changes in the economic growth rate by 3% would substantially undermine the effect of EEC promotion at annual 2-3%.

In the Low Growth Case, the energy supply decreases compared to the Reference Case. The largest effect of the reduced economic growth appears in natural gas import quantity, which shows a similar rate of coal import. In this case, the effect of the economic growth rate reduction is slightly stronger than that of the EEC rate deterioration.

Table 6.4-3 The comparison between Low Growth and reference

order	energy	term	unit	Low Groth	reference	difference	ration (vs reference%)
1	natural gas	import	MMm3	480	6,911	-6,432	-93.1
2	naptha	to gasoline	kton	420	1,260	-840	-66.7
3	power	imort coal fuel	GWh	16,270	41,461	-25,191	-60.8
4	coal	import	kton	5,686	14,226	-8,540	-60.0
5	LPG	LPGsubstitute	kton	2,947	5,259	-2,311	-43.9
6	coal	for power	kton	27,239	43,716	-16,477	-37.7
7	diesel	import	kton	8,598	12,958	-4,360	-33.6
9	CO2	emission	Mton	252	345	-94	-27.1
30	naptha	export	kton	1,684	844	840	99.5
31	coal	export	kton	26,724	13,203	13,521	102.4

6.4.3 Effect of Energy Price Trend

Next, we will examine the cases in which the energy price is higher or lower than that of the Reference Case while the same EEC rate is assumed.

In the High Price Case, as energy price increases, energy demand decreases and thus the energy supply will be affected. The greatest effect appears in Naphtha being treated as part of gasoline, which decreases by 44%. This occurs as gasoline demand is suppressed because of high price, and naphtha otherwise to be blended into gasoline goes for export. The Table 6.4-4 shows that the increase ratio of naphtha export is biggest. Furthermore the decrease of power generation by import coal leads to coal import reduction. The natural gas demand decreases 16% in the power sector and 26% at general users. The decrease of domestic coal for power source leads to increase of coal export.

Table 6.4-4 The comparison between High Price and reference

order	energy	term	unit	High price	reference	difference	ratio vs reference)
1	naptha	to gasoline	kton	701	1,260	-559	-44.4
2	poer	import coal fue	GWh	25,838	41,461	-15,623	-37.7
3	coal	import coal fue	kton	8,920	14,226	-5,306	-37.3
4	natural gas	import coal fue	MMm3	4,663	6,911	-2,248	-32.5
5	coal	for poweer	kton	31,892	43,716	-11,824	-27.0
6	LPG	LPG substitute	kton	3,974	5,259	-1,284	-24.4
7	power	coal fuel	GWh	56,884	73,138	-16,254	-22.2
30	naptha	export	kton	1,403	844	559	66.2
31	coal	export	kton	23,133	13,203	9,931	75.2

Table 6.4-5 Comparison between Super High Price and reference

order	energy	term	unit	Super High Price	reference	difference	ratio vs reference %
1	natural gas	import	MMm3	0	6,911	-6,911	-100.0
2	naptha	to gasoline	kton	210	1,260	-1,050	-83.4
3	power	import coal fu	GWh	15,696	41,461	-25,765	-62.1
4	coal	import	kton	5,485	14,226	-8,741	-61.4
5	LPG	LPG substitute	kton	2,699	5,259	-2,560	-48.7
6	coal	for power	kton	26,240	43,716	-17,476	-40.0
7	diesel oil	import	kton	8,702	12,958	-4,256	-32.8
8	natoral gas	demand	MMm3	6,419	9,274	-2,855	-30.8
36	coal	export	kton	28,763	13,203	15,561	117.9
37	naptha	export	kton	1,879	844	1,035	122.7

Table 6.4-6 Comparison between Low Price and reference

order	energy	term	unit	Low Price	reference	difference	raio vs reference %
1	coal	import	kton	31,241	14,226	17,015	119.6
2	power	import coal	GWh	82,178	41,461	40,716	98.2
3	coal	for power	kton	63,790	43,716	20,074	45.9
4	LPG	LPG substit	kton	7,301	5,259	2,043	38.8
5	CO2	emission	Mton	429	345	84	24.3
35	coal	emssion	kton	5,250	13,203	-7,953	-60.2

In the case of the Super High Price, trends are almost same to those observed in the High Price Case; the top six items are same though their order and magnitude are different. Export of coal and naphtha increase similarly with the High Price Case.

As the energy demand change from the Reference Case is small in the Low Price Case, there would be least changes in the energy supply pattern between them. Compared to changes of economic growth rate, price change, regardless of increase or decrease, would give limited effect on energy consumption, and hence supply/demand balance.

6.5 Energy Supply Patterns for Various Case Studies

In this section, results of case studies on various energy supply conditions will be examined, such as effects of changes in nuclear power plant operation timing and capacity, natural gas supply increase, acceleration of No.2 and No.3 refinery operation, increase of renewable energy supply and so on.

6.5.1 Start-up Timing and Size of Nuclear Power Stations

In the case delay in start-up of nuclear power should be supplemented by fossil fuels by free selection, coal with cheap generation cost is selected overwhelmingly. Import coal as well as CO_2 emission increase greatly. Conversely, in the case the capacity of nuclear power should be doubled, import coal and CO_2 emission decreases substantially.

6.5.5.1. Nuclear delay supplemented by coal

As the nuclear power is assumed to start operation in 2020 in the Reference case, it is assumed in this case that it would delay and coal would be used as the as main substituting fuel in place of nuclear. Figure 6.5-1 shows the comparison of these two cases.

Since nuclear power plants are planned in the southern provinces of Vietnam, coal thermal power development fuelled by import coal will most likely be accelerated once nuclear development delays. Temporary decrease of power generation by gas and domestic coal appears in 2022 of Figure 6.5-1 caused by bulk increase of coal thermal capacity and generation using import coal.

As a matter of reality, if nuclear power development delays, it is difficult to supplement the deficit only by existing power plants as the single unit capacity of nuclear power is quite large. Therefore, it is important to simultaneously schedule development of substituting power resources such as coal to cope with possible delay in nuclear power development.

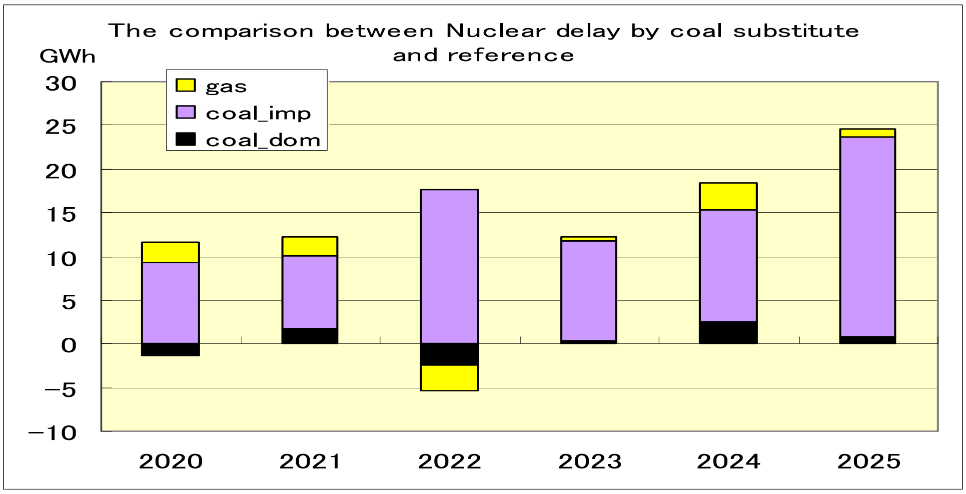


Figure 6.5-1 Nuclear delay supplemented by coal

6.5.1.2 Nuclear delay supplemented by natural gas

Figure 6.5-2 shows the change of fossil fuel consumption when delay in nuclear development would be supplemented by natural gas. This case presumes that increase of production and/or import of gas would be possible and such activities are supported by national policy to promote the use of natural gas as a comparatively clean energy among fossil fuels. In the calculation, one LNG terminal with power plant is scheduled. As mentioned above, review of the overall development plan shall be made as soon as delay of nuclear power development is anticipated, considering the long lead-time required for construction of power plant to substitute.

In Figure 6.5-2, the lower part under x-axis shows the decrease of generation by power sources such as domestic coal and import coal caused by bulk increase of gas thermal power.

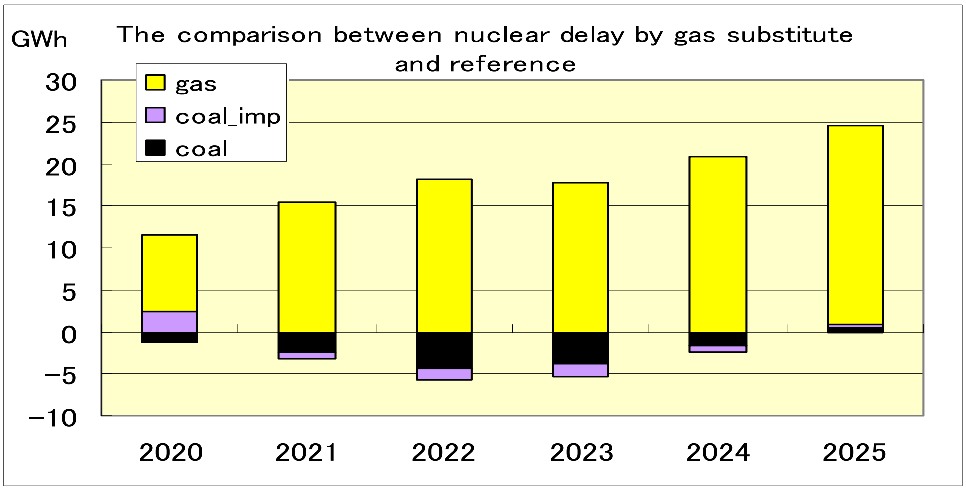


Figure 6.5-2 Nuclear delay supplemented by natural gas

6.5.1.3 Increase of Nuclear power capacity

Figure 6.5-3 shows the impact of increased nuclear capacity to 8,000 MW in 2025 or double of the capacity scheduled in the Reference Case. Right blue bar indicates increase of electricity generation by nuclear and left bar shows the alternated electricity generation by fuel type due to the increase of nuclear power generation. In 2021 and 2022, total electricity generation by fossil fuels decreases regardless of fuel type. After 2023, consumption of imported coal will dramatically decrease as construction of imported coal thermal could be postponed substantially thanks to increase of nuclear power capacity.

(unit : GWh)

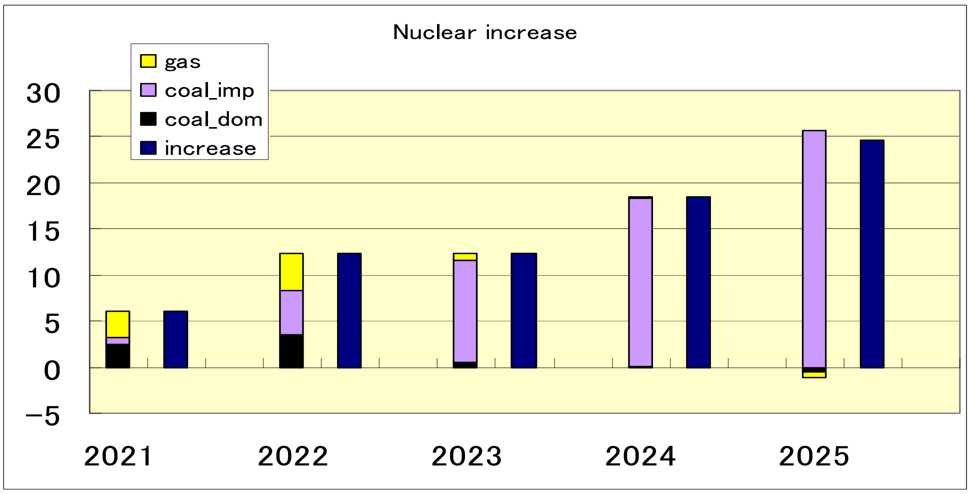


Figure 6.5-3 Increase of Nuclear Capacity

6.5.2 Changes in Natural Gas Production

The drastic increase of natural gas production is not expected in the Reference Case, although gradual increase is scheduled after 2015 as explained in 6.1.3. However, accelerating domestic development and production as well as starting LNG import, it is assumed that natural gas supply amount would increase to double of the Reference Case in 2025. Then, coal-based power plants will be converted into gas-based ones, resulting in coal demand decrease. Consequently, CO_2 emission keeps decreasing after 2015, and will be decreased by 30 million tons in 2025.

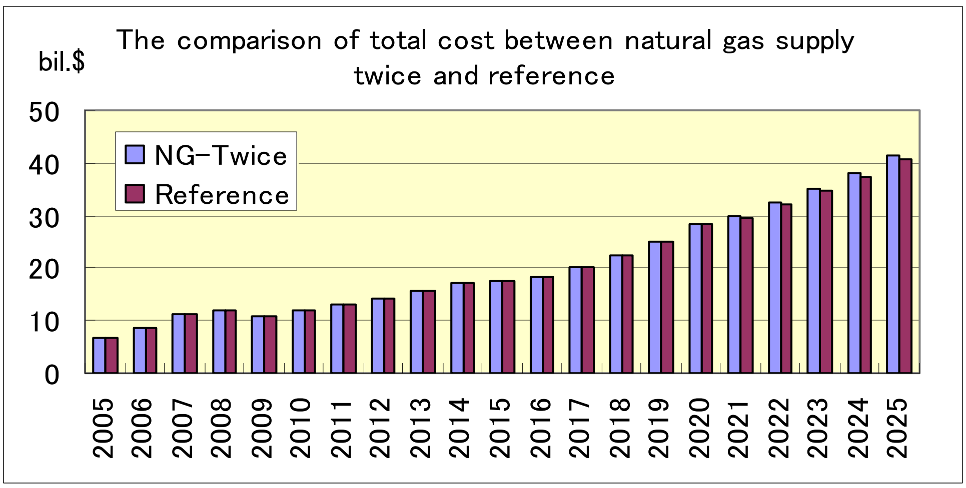


Figure 6.5-4 Cost Comparison with Reference Case in Natural Gas Supply Increase

Considering the history of natural gas market creation and development, once natural gas is introduced into power generation as anchor demand justifying trunk pipeline, potential demand along the route could be developed in industrial and residential sectors. Fuel conversion to natural gas occurs at existing factories and buildings and also initiating potential demand increase. This being the case, natural gas demand could be further accelerated than calculated for this case.

6.5.3 Advanced Start-up of No.2 and No.3 Refineries

To accommodate increasing oil product demand especially transport fuel, start-up of No.2 and No.3 refineries would be advanced to 2013 and 2016, respectively.

Focusing on the supply/demand balance of gasoline, it becomes not necessary to import upon start-up of No.1 refinery, and excess amount will become available for export when No.2 refinery starts and the excess amount further increases as No.3 refinery comes on stream. Although gasoline demand keeps increasing, export position will be maintained until 2025 as shown in Figure 6.5-5. Therefore, the construction and/or expansion timing should be examined carefully after completion of No.2 refinery or following one. Then, scale-merit should be fully evaluated considering possibility of taking in the substantial demand in surrounding region such as China and ASEAN countries. Since the calculation result indicates that the export position of oil products continues after 2015, further expansion case has not been taken up. If required, expansion of the then existing refineries should be considered first from economic viewpoint, rather than construction of new No.4 and 5 refineries.

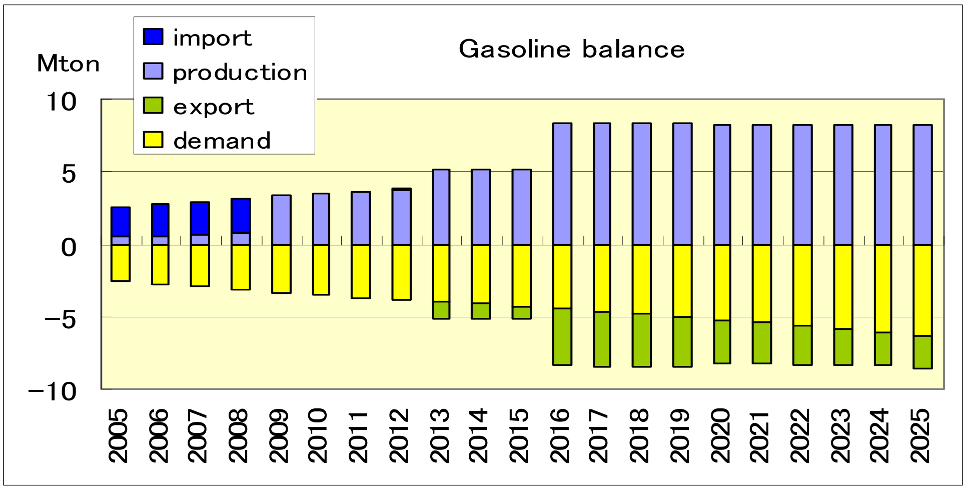


Figure 6.5-5 Gasoline balance in No.2 and No.3 Refinery Accelerated Construction

6.5.4 Bio-Fuel Increase Case

Considering that Bio-Fuel is currently NOT produced in commercial basis in Vietnam, substantial effort is necessary to achieve the Bi-Fuel production target set out in “Development of Bio-Fuels in the Period up to 2015, Outlook to 2025 (Draft)”.

Especially for Bio-Diesel, it is necessary to produce new material crops such as oil palm and jatropha, which are currently NOT produced in Vietnam[20]. Therefore, it is necessary to develop the both technology and social system that make such production expansion contribute to economic development of rural villages.

However, when the Bio-Fuel installation target is achieved, demand for fossil fuels and dependence of oil import could be reduced drastically (see below). Also, based on the discussion at the East Asia Summit that development of bio-fuel should be promoted on a large scale under international cooperation between ASEAN and advanced countries, contribution of Vietnam is expected in this field.

When the mixing rate of bio-fuels into gasoline and diesel oil is increased, demand of gasoline and diesel oil will change and their demand/supply will be balanced by decrease of production/import and increase of export. Figure 6.5-6 and Figure 6.5-7 show such changes against the Reference Case. In case of gasoline, decrease of production occurs in 2010, 2020-2025, decrease of import occurs in

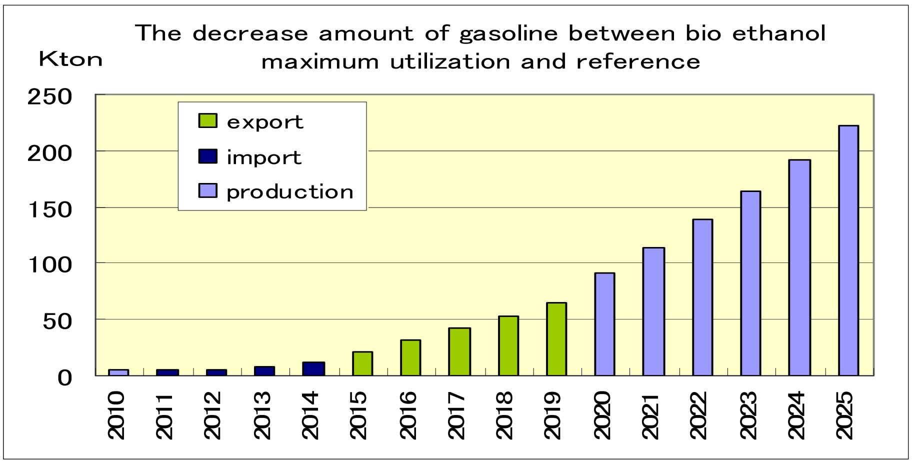


Figure 6.5-6 Decrease of gasoline against Reference Case

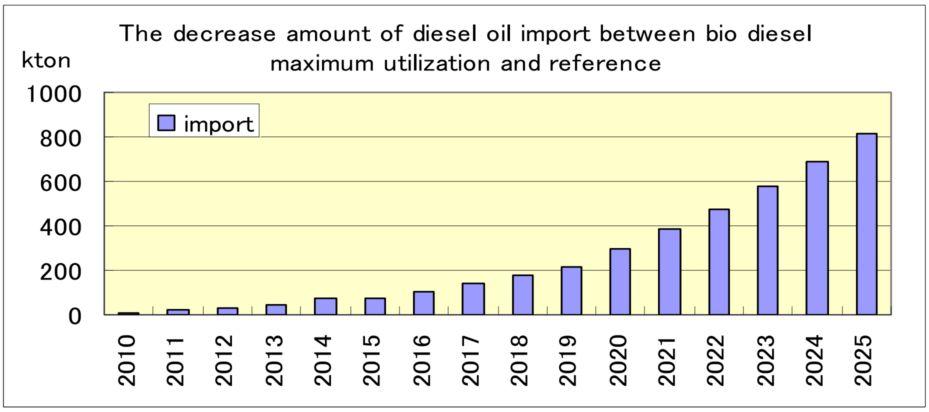


Figure 6.5-7 Decrease of diesel oil against Reference Case

2011-2014 and increase of export occurs in 2015-2019. In case of diesel oil, even though bio-diesel supply is increased, it is still in short supply and necessary to import, therefore only

[20] Assuming that productivity of jatropha oil is 2 ton/ha, bio-diesel conversion ratio is 95% and density of bio-diesel is 0.84kg/liter, about 450,000ha is necessary to supply about 1million kilo liter of bio-diesel in 2025

decrease of import, equivalent to increase of bio-diesel, occurs.

6.5.5 Constraints on CO_2 and SOx Emission

All case studies explained above do not assume any regulation on CO_2 emission. Fuel consumption at power plants is estimated by PDPATⅡand is given as input for the optimization model. As there is only a little flexibility in the fuel selection in the supply optimization model, examining CO_2 emission regulation for these cases would not be meaningful. If CO_2 emission regulation should be examined, it is necessary to liberate the foregoing system so that the optimization model should decide the overall fuel consumption including power plant too. It should be noted, however, that as the optimization model uses annual aggregate quantity of power generation and fuel consumption only, there is no guarantee on supply assurance for peak demand.

Then, a new case study with CO_2 emission regulation as desk plan may be run under assumptions that generation and fuel consumption will be decided not by PDPATⅡ but by the optimization model. Under this assumption that power composition is free for the supply model, an optimal solution of the case study with CO_2 emission regulation could probably be obtained. We conducted this temporary trial giving the condition that the maximum CO_2 emission should be 90% of the Reference Case. However, feasible solution was not obtained. In order to attain any meaningful solution, we need to examine various elements further such as power generation capacity, load factor and so on.

6.6 Challenges in the Long-Term Energy Supply

In previous section, the features and differences of energy supply case are clarified on various cases mainly focusing on the Reference Case. Now let us try to identify issues and challenges in the long-term energy supply based on the foregoing supply analysis. Harmonization of 3E (Economic development, Energy supply and Environment) and reinforcement of 3S (Security, Sustainability and Stability) have become common objectives of energy policy in the world now. As the linkage with the world economy becomes stronger, Vietnam could not be free from these policy challenges common in the world. Straightforward, promotion of energy conservation and establishment of stable energy supply system are indispensable in order to materialize the sustainable economic development. And, to this end, assurance of transparency and effectiveness of the market is required.

a) Challenge 1：Efficient use of energy and promotion of energy conservation：

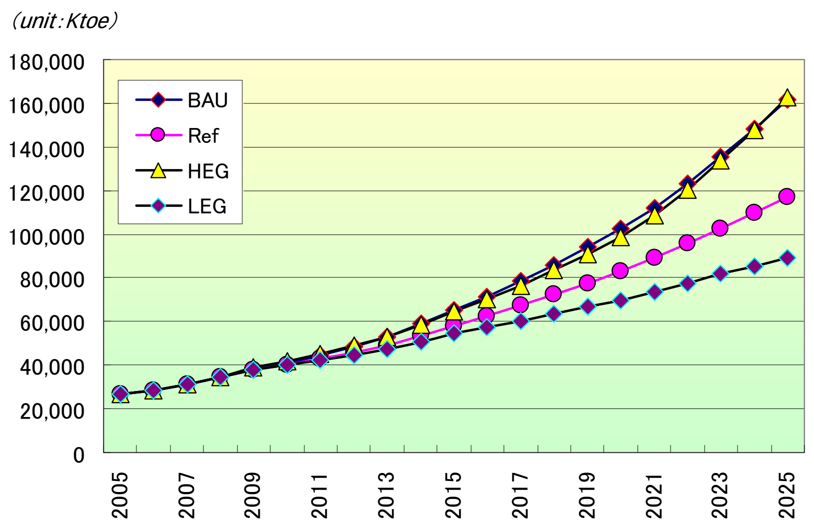
At first, let us summarize the case setting and energy demand trend again.

In the BAU case, the economy will grow at annual 8.4% through to 2025. Without specific energy conservation policy, primary energy supply increases six-fold from 26.95 Mtoe in 2005 to 161.38 Mtoe in 2025. Vietnam will change from a net energy exporting country to a net energy importing country and dependence on the importing energy will be about 50%. In the Reference Case, therefore, energy conservation effort will be strengthened by 2-3% more than the BAU case and curb the increase of energy consumption in order to reduce the dependence on importing energy. As a result, the primary energy supply reduces by 27% to 117.06 Mtoe and dependence on importing energy can reduce down to 30%.

A case in which economic growth rate increases by 1% to 9.5% is examined as the Vietnamese economy is growing quite actively at present. The primary energy supply in this High Economic Growth Case is almost at the same level as the BAU case. Then, dependence on import energy exceeds 50% to highlight the energy security as a serious issue. In terms of primary energy supply, the effect of one point percent change of economic growth rate almost counterbalances to 2-3% improvement of energy conservation.

On the contrary, a case in which the economic growth rate decreases by 1% to 7.4% due to reasons such as deterioration of the world economy and/or the recurrence of monetary crisis in Asia is examined. In this Low Economic Growth Case, the primary energy supply is calculated to be 89.17 Mtoe in 2025. The 1% point decrease of economic growth rate has effected to 24% decrease from the Reference Case in the primary energy supply. Dependence of importing energy is greatly improved to 11%.

From these estimation results, it is feared that the energy supply required to meet the High Growth Case would be extremely huge and cause big issues of energy security, although it is a desirable selection of high economic growth to serve improvement of people's life. The importing energy dependency is an important factor to judge threatening to the energy security under the situation world long-term energy supply going toward tight. In this sense, slowdown of the economic growth rate to that of the Low Growth Case would be a desirable one, while an economic growth rate of annual 7.4% is still high among many other countries. The Reference Case is positioned just on the middle of two cases, which is compatible to the high economic growth rate and the reducing dependence of the importing energy.



(note)BAU: Business As Usual Case、Ref:reference Case、HEG:High Economic Growth Case、LEG:Low Economic Growth Case

Figure 6.6-1 Comparison of estimated results of energy demand by case

The first challenge comes from this analysis. The energy conservation effort substantially more than that in natural trend is required in order to achieve the policy objectives of 3E and 3S; the conservation targets set out in the Reference Case should be realized by whatever means.

b) Challenge 2 : Establishment of Reliable and Efficient Energy Supply System
(For example: Development of Gas Resources and Gas Consumption)

Tracing the changes of the primary energy supply mix by case, share of oil goes down and share of coal goes up as the economic growth rate becomes higher. The natural gas roughly maintains the same share. The share of hydropower decreases little by little with the constraint of resources, although it increases occasionally during the projection period. The nuclear and renewable energy are highly important but share of these energies is still very small in 2025 over the primary energy supply. These trends reflect the constraints on energy resources as the precondition for supply, such as relatively rich coal resources, some constraints on oil resources and possibility of gas development, and constraints on the demand side may also be reflected at the same time.

The reason why coal supply changes most greatly among cases is because electric power demand reacts to the change of total demand first and greatest, and coal-fired thermal power will be influenced in turn. Coal can easily respond to demand changes with greater capability of increase in both domestic production and import at relatively reasonable price. On the other hand, domestic oil supply is rather rigid reflecting resource constraints. Incremental supply may have to dependent on new discoveries and otherwise oil import, although increase of oil demand in the transport sector, the core sector of oil demand, is rather moderate (Figure6.6-2). Natural gas demand is forecast to increase mainly based on the demand growth in the power sector as there is still a room for development although resource constraint exists.

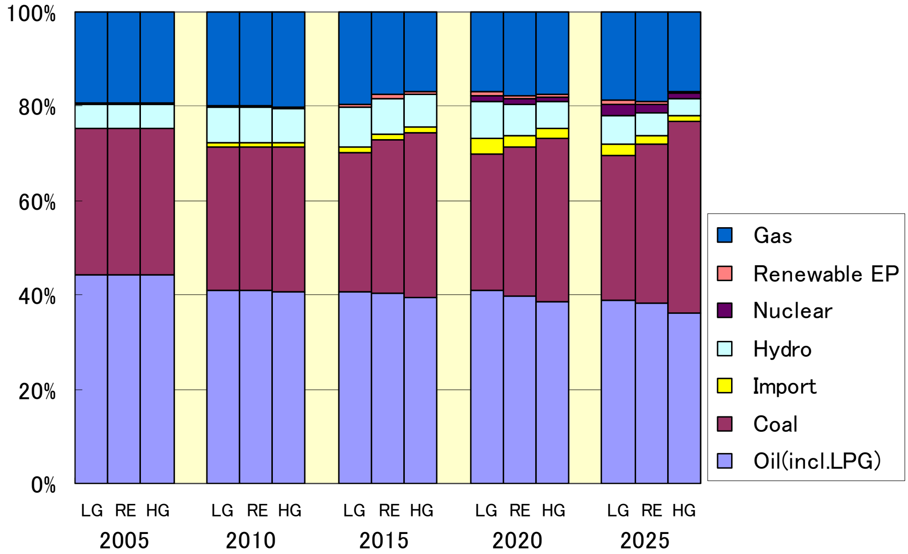


Figure 6.6-2 Changes of primary energy supply mix by case

From the global warming point of view, on the other hand, Vietnam has no obligation on the CO_2 emission agreed in the Kyoto Protocol (COP3). However, Vietnam will be required some effort in future to control CO_2 emission on the basis of "common but differentiated responsibility". As for the estimation of CO_2 emission in four cases as referred to before, CO_2 emission will increase by 6-times from 87mtCO_2e (million ton of CO_2 equivalent) in 2005 to about 500mtCO_2e in 2025 in the BAU and the High Growth Cases, in which largest energy demand is forecast. On the contrary, in the Low Growth Case, the CO_2 emission decreases to 3-times of the current level, or a half of these cases or 250mtCO_2e in 2025. In the Reference Case, it decreases by 4.2-times or to 345mtCO_2e which is in the middle of these cases. Considering the global warming issues, Vietnam may be cordially requested to lower the CO_2 emission to the level of the Reference Case.

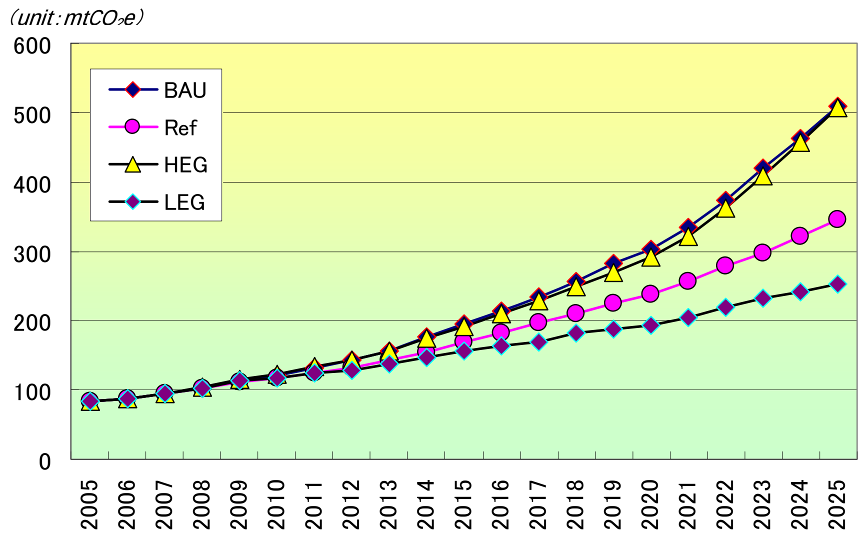


Figure 6.6-3 Comparison of CO_2 Emission by case

The second challenge induced from the estimation result is construction of reliable and efficient energy supply system and realizing of the desired supply mix. In our case study, coal plays the role of a swing producer. Taking issues like air pollution, domestic health and global warming into consideration, it is very important to consider in the future scope of energy structure development of natural gas resources, market and supply system, in particular demand in non-power sector such as industrial and residential, in order to avoid excessive dependence on the coal supply.

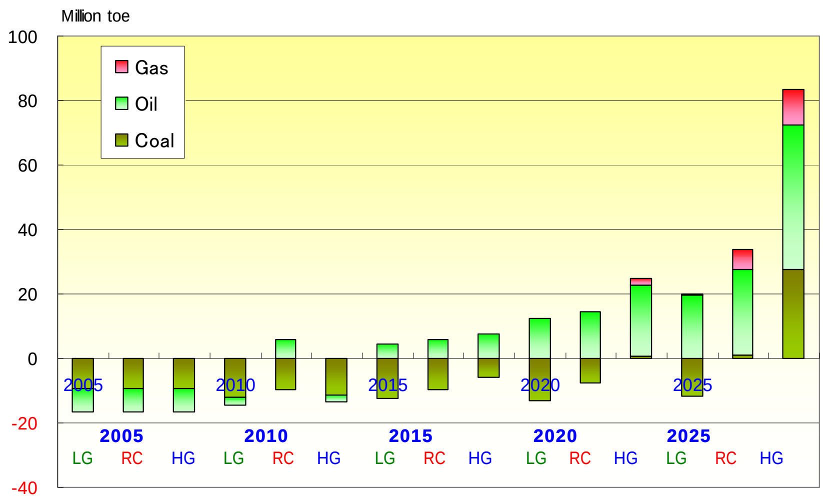


Figure 6.6-4 Net Energy Import

c) *Challenge 3： Stable Supply of Importing Energy and Strengthening of Energy Security*

It is inevitable that Vietnam changes into a net energy importing country around 2015 pending demand trend. As petroleum products have been imported totally up to now, crude oil, natural gas and coal will also be exposed directly to the rough fluctuations in the international energy market. Thus, stable supply of import energy and reinforcement of energy security are the third challenge. As economics of scale works strongly in energy sector, world-class importing system should be constructed in the oil and coal sectors. In addition, as the dependence on the global market increases, it is necessary to promote energy supply enterprises, which can able to overcome the rough waves in the international market, as well as reinforcement of national emergency response ability such as state oil stockpiling.

d） Challenge 4： Energy Sector Reform and Modernization of Energy Market

It is desirable that policy objectives such as energy conservation and reinforcement of the energy supply system should be realized through market mechanism based on economic principles. This is the forth challenge. In the modern society where size of economy has become tremendously huge and international linkage become extremely closer, use of market mechanism is the strongest method to materialize various economic objectives. However, market failures have been experienced in many countries in the 1990s. To proceed with marketization, we need to develop an appropriate market design, as will be discussed more in detail in Part 3.

In order to find solutions to various issues and challenges inferred from the foregoing analyses on the long term energy demand forecast and supply outlook, it is necessary to identify the fundamental direction of the energy policy, formulate realistic roadmaps and action plans on energy conservation, energy supply and marketization, and implement them. We will discuss how to proceed with these tasks in Part 3.

Chapter 7 Strategic Environmental Assessment (SEA) - (Environmental and Social Considerations (ESC) -

7.1 Backgrounds for application of SEA

Human activities based on goodwill, whether they are policy formulation, preparation of a plan, or a development project, aim at bringing benefits in society and environment. However, most people may have known the possibility that those activities might be accompanied by negative side-effects. Human activities without due attention might set on environmental pollution with increased emission and discharge of pollutants. Activities with a large scale of physical transformation might also cause unnecessarily extensive loss of nature and peoples' means of livelihood.

When plans and projects with physical transformation and by-products of pollutants are prepared and implemented, it is nowadays a global common sense that they must be accompanied with the activities for 'environmental and social considerations (ESC)' to enable themselves to proceed effectively, avoiding or alleviating such negative impacts.

It is the EIA system that is the most known ESC activity internationally. The energy sector that the study is concerned with can not be indifferent to such problems as air pollution by the combustion of fossil fuel, and the issues of resettlement and water pollution associated with power, coal and oil developments.

Therefore, EIA would come into mind as ESC for the energy sector plan. The study of the national energy master plan, however, faces two difficulties to apply EIA to itself. First, the scope of the study is so extensive as to cover the whole country and the extensive energy sector entirely including electric power, coal, oil and gas developments. Secondly, the study is about a master plan, especially at the stage in the vicinity of national policy formulation. Though the EIA system has produced many effective tools for analysis and evaluation since the 1970s, those have been targeting individual specific projects and not quite fitting to a broad ranged planning activity and considerations in the very upstream of development plans.

Since the mid-1990s when it came to face the weak areas of EIA and various environmental degradations at the macro level, the new method of SEA has become the subject of study with quick steps. Especially these years, there are increased numbers of countries and international organizations that employ it in a legal system or as a standard measure. The conduct of SEA is required by legislation in the countries of Holland, Denmark and Finland in north Europe and France, and Spain. In addition, the EU has set the guidelines for SEA and the World Bank is reflecting the concept of SEA in its umbrella policy.

Vietnam became actually a front runner among developing countries in requiring SEA by legislation when she enforced it with the revised law on environmental protection in July 2006.

With such backgrounds, the concerned study is required to apply the method of SEA as a means of ESC.

7.2 Methodology

7.2.1 Purpose of the SEA

Purpose of conducting SEA in this study is, conceptually, to enhance sustainable development of society through comprehensive consideration of economy (efficiency and security), society (equality and fairness) and environment protection in an integral manner. As a practical method, it is to provide technical support for conduct of SEA required by domestic law of Vietnam for formulation of National Energy Master Plan by indicating evaluation method. The JICA guideline for social and environment consideration also requests such study based on viewpoint of SEA in formulation of master plans.

7.2.2 Level of SEA Application

Fr evaluation of environment impact, there are two methods, i.e., EIA and SEA. While EIA is applied to evaluate individual projects, SEA is applied to evaluation for administrative decision making such as policymaking, basic plan and/or consolidation of multiple projects positioned in the upstream of individual projects. The SEA to be conducted in this study shall be applied to the basic plan of energy sector. As the sector includes downstream sectors such as oil, natural gas, coal, electric power and renewable energies, evaluation is also made on these sectors.

7.2.3 Method of Evaluation

1) Scoping

As scoping at the stage of sector basic plan, we prepared a checklist for each sub-sector. That is, based on the energy flowchart of Vietnam and standard items listed in existing EIA guidelines of the sectors concerned, we extracted items that could potentially cause social and environmental impacts and assembled them into categorized groups of indicators for evaluation of impacts. We also conducted surveys on Vietnam with respect to the current state of social and environmental conditions, the fundamental distribution of resources and the legal structures for environmental and social considerations, which should provide basis for making judgments on energy-sector activities that would give burden on environment and society.

2) Formulation of Alternative Scenario

Six basic cases were run by the energy supply/demand team relating to differences in energy demand forecast and supply conditions. Difference in demand outlook is caused by different assumptions on economic growth rate, crude oil price and energy conservation rate, and each case produces different supply structure and environment burden. In addition, starting from the Reference Case, we examined a case restricting the CO_2 emission to a half in consideration of the global climate change issue. However, we appreciate further discussion in Vietnam regarding desirable future scope of the nation.

3) Evaluation of Alternative Scenario

Alternative scenarios are evaluated on the sub-sectors of the energy supply enumerating extent of impact on indicators scheduled on the checklist. Such indicators consist of six major indicators (global warming indicator: G, air and environment indicator: A, water environment indicator: W, forest and ecology indicator: F, social fairness indicator: S, and transformation of land and life indicator: T) and lower indicator groups under each major indicator. Impact of alternative scenarios is compared to each indicator, and, giving two types of weight, extent of impact and seriousness of indicator is differentiated.

The two types of weights are expressed firstly by the weight differentiating the seriousness of an indicator relating to time, space, irreversibility and probability of occurrence (V), and difficulty of mitigation (technical, economical and socio-political difficulties) (M), and these two weights are multiplied to unadjusted scores of each indicator. Calculating for each scenario the impacts enumerated on each indicator, indicator of magnitude of Total Environmental and Social Impacts (ESI) are obtained for total eighteen cases (3 sub-sectors times 6 alternative scenarios). With construction of this indicator, comparative analysis of expected impact on different cases has become possible.

7.2.4 Dialogue with Stakeholders

Various research and discussion were repeated on the items below during each stage of scoping, indicator selection, checklist compilation, alternative scenario formation and evaluation. It was aimed to assure confirmation of opinions of and sharing information with stakeholders in Vietnam as the main body of planning.

Fundamental survey (information collection and analysis)

Compilation of draft by the Study team

Discussion /confirmation with the counterpart teams on energy sectors

Explanation to and exchange with energy related experts (major implementing bodies of sub-sectors, administrative offices on energy and environment, other experts and local stakeholders relating to major projects) at workshops

7.2.5 Mitigation and Environment Management

At the last part of the Study, we will extract, on the Reference Case as the base of the proposal, major indicators that would give greater burden on society and environment, and consider and propose on each indicator measures of abatement and mitigation of negative influence on society and environment.

7.3 Site Description (for the Target Area of the Plan)

7.3.1 Climate and Geography of the Site (the entire Vietnam)

Vietnam has 300 thousand km^2 of national territory. It is mountainous in the northwest and in the central highlands facing the South China Sea, with peaks reaching up to 8000ft (2450m). In the north around Hanoi and in the south around Ho Chi Minh City, there are extensive low-lying regions in the Red River delta and the Mekong delta respectively.

Vietnam has a tropical monsoon type of climate; from May to September the south monsoon sets in, and the country is dominated by south to south-easterly winds. From October to April, the north monsoon is dominant with northerly to north-easterly winds affecting the country. There is a transition period between each monsoon season when winds are light and variable. The country has a single rainy season during the south monsoon of May through September. Rainfall is infrequent and light during the remainder of the year. Rainfall is abundant, with annual rainfall exceeding 1000mm almost everywhere. Annual rainfall is even higher in the hills, especially those facing the sea, in the range of 2000-2500mm. For coastal areas and the parts of the central highlands facing northeast, the season of maximum rainfall is during the south monsoon, from September to January. These regions receive torrential rain from typhoons which move in from the South China Sea at this time of the year. The weather at this time is cloudy with frequent drizzle. During the north monsoon, northern Vietnam has cloudy days with occasional light rain, while southern Vietnam tends to be dry and sunny. Temperatures are high all year round for southern and central Vietnam; but northern Vietnam has a definite cooler season as the north monsoon occasionally adverts cold air in from China. Frost and some snow may occur on the highest mountains in the north for a few days a year. In the southern Vietnam, the lowlands are sheltered from outbreaks of colder northerly air and the dry season is warm to hot with much sunshine.

Table 7.3-1 Average rainfall and temperature in Hanoi and Ho Chi Minh

Hanoi					
Month	Rainfall	Temperature			
	Monthly Average	Daily Average		Lowest Recorded	Highest Recorded
		min.	max.		
Jan	19	12	20	6	33
Feb	27	13	21	7	35
Mar	39	18	24	11	37
Apr	80	21	29	10	38
May	198	22	32	15	42
Jun	240	25	33	20	39
Jul	322	26	32	23	40
Aug	345	25	32	21	39
Sep	250	24	31	18	37
Oct	99	23	28	14	37
Nov	44	19	25	8	36
Dec	21	16	21	7	37

Ho Chi Minh					
Month	Rainfall	Temperature			
	Monthly Average	Daily Average		Lowest Recorded	Highest Recorded
		min.	max.		
Jan	14	21	32	13	37
Feb	4	22	33	15	38
Mar	12	23	34	19	39
Apr	42	24	34	20	40
May	220	25	33	21	39
Jun	331	24	32	22	38
Jul	313	25	31	20	35
Aug	267	24	32	19	34
Sep	334	23	31	21	35
Oct	268	23	31	20	34
Nov	115	22	30	18	35
Dec	56	22	31	15	36

Source: 2002 The Embassy of the Socialist Republic of Vietnam in the United Kingdom.
< http://www.vietnamembassy.org.uk/climate.html>

7.3.2 Environmental and social conditions

The country's natural ecosystems, the Vietnam Environmental Monitor (VEM) 2005 describes, support nearly 10 percent of the global mammal and bird species. This biodiversity makes a major contribution to many development sectors such as forestry, fisheries, agriculture, health, industry, and tourism. Forest cover is increasing and the government has set a target of 43 percent forest cover in the country by 2010. Yet, natural forests are increasingly fragmented and degraded. Over two-thirds of Vietnam's natural forests are considered poor or regenerating.

Forest cover, including both natural forest and plantations, is 37 percent of the total land area of the country. About 18 percent of that total is plantations. Only 7 percent of remaining forest is "primary" forest, and nearly 70 percent is poor quality secondary forest. There are 39 documented wetland types, including mangroves and other inter-tidal forests, brackish lagoons, sea-grass beds, and coral reefs, all of which have high species richness and productivity. The marine environment covers 20 distinctive ecosystem types; many are regionally unique in their oceanographic properties. These support more than 11,000 species. About 1,100 square kilometers of coral reefs are widely distributed from the north to the south, with the largest area and highest biodiversity found in the center and south of the country. Vietnam's coral reefs support nearly 400 species of reef-building corals, which compares with the most diverse systems worldwide.

With another famous source for endangered species, Vietnam's threatened species can be summarized on Table 7.3-2, 7.3-3 and 7.3-4, while the tables include information on full species ONLY (i.e. not subspecies, varieties or geographically isolated subpopulations or stocks).

Table 7.3-2 Number of threatened species in each major group of organisms (Critically Endangered, Endangered and Vulnerable categories only)

Mammals	Birds	Reptiles	Amphibians	Fishes	Molluscs	Other Invertebrates	Plants	Total
45	42	27	18	30	0	0	148	310

Source: Summary Statistics, 2006 IUCN Red List of Threatened Species.

Table 7.3-3 Number of extinct, threatened and other species of animals

EX	EW	Subtotal	CR	EN	VU	Subtotal	LR/cd	NT	DD	LC	Total
0	0	0	27	47	88	162	4	113	89	995	1,363

Source: Summary Statistics, 2006 IUCN Red List of Threatened Species.

Note: IUCN Red List Categories: EX - Extinct, EW - Extinct in the Wild, CR - Critically Endangered, EN - Endangered, VU - Vulnerable, LR/cd - Lower Risk/conservation dependent, NT - Near Threatened (includes LR/nt - Lower Risk/near threatened), DD - Data Deficient, LC - Least Concern (includes LR/lc - Lower Risk, least concern).

Table 7.3-4 Number of extinct, threatened and other species of plants

EX	EW	Subtotal	CR	EN	VU	Subtotal	LR/cd	NT	DD	LC	Total
0	0	0	25	38	85	148	1	32	15	65	261

Source: Summary Statistics, 2006 IUCN Red List of Threatened Species.

Ecological systems and the biodiversity contained within them provide much of the basic needs of the rural poor—from foodstuffs to fuel wood, medicines, and potable water. In addition, they provide insurance against natural disasters, to which the poor are particularly vulnerable. Some 25 million Vietnamese depend on forest systems and an estimated 8 million depend on fisheries as their primary source of household income. An additional 12 million get part of their income or subsistence from fisheries. Over 85 percent of protected areas in Vietnam are located in areas of high poverty.

7.3.3 Protected Area

As of 2004, the national system of protected areas included 126 approved special-use forests (SUFs), comprising 28 national parks, 59 conservation areas, and 39 landscape-protected areas, with a total area of 2,541,675 ha, according to VEM 2005, pp37 (Appendix 6.1, Table 7.3-5).

International protected area categories in Viet Nam include two Ramsar sites, four Man and Biosphere Reserve sites and five World Heritage sites (e.g. Ha Long Bay). The first Marine

Protected Area (MPA) of 10,500 hectares was established in 2001 in Hon Mun, Nha Trang Bay; it is managed in collaboration with the World Conservation Union (IUCN) to serve as a model for collaborative MPA management in Viet Nam.

Table 7.3-5 Protected Areas in Viet Nam

National Designations	International Categories
Special-use forests 126	Wetlands of International Importance (Ramsar) 2
National Parks 28	World Heritage Convention 5
Conservation Areas 59	UNESCO-MAB Biosphere Reserve 4
Nature Reserve 48	ASEAN Heritage 4
Species and Habitat Conservation Areas 11	
Landscape Protected Areas 39	
Marine Protected Areas (proposed) 15	

Source: (Right Column) BirdLife International, 2005, Sourcebook of existing and proposed protected areas in Vietnam.
(Left Column) World Database on Protected Areas 2006, IUCN Vietnam-URL April 2007
http://www.iucn.org/places/vietnam/

7.3.4 Demographic information

In 2007, Vietnam has the population of 85 million, next to Indonesia among ASEAN countries. Around three quarters of inhabitants in Vietnam live in rural areas and depend on agriculture for their livelihoods. Vietnam is a densely populated country, 257 person/km^2 on average, with a population growth rate of about 1.3 percent in 2007. Rural population density is highest in the irrigated lowlands, especially the deltas of the Red and Mekong Rivers (1,238 and 432 person/km^2). In the densely populated regions, land resources are scarce and little natural area remains. There are few protected areas in the irrigated lowlands. In recent years, large numbers of people have moved from the densely populated north of Vietnam to settle in areas rich in natural resources, especially the central highland provinces of Kon Tum, Gia Lai and Dak Lak. (Source: ICEM, 2003. pp13. Data updated from the original)

Regionally, the poverty rate became just under 50 % in mountainous area and below 30 % in hilly areas of the North East, the Central Highlands and the Central Coast while other areas such as the Red River Delta, the South Central Coast, the South East and the Mekong Delta, had the poverty rate below the country's average rate of 16.0 % in 2006.

Table 7.3-6 Regional Poverty Rate of Vietnam (1998 and 2006) (Unit: %)

	Whole country	Red River Delta	North East	North West	North Centarl Coast	South Central Coast	Cental Highlands	South East	Mekon River Delta
1998	37.4	29.3	62.0	73.4	48.1	34.5	52.4	12.2	36.9
2006	16.0	8.8	25.0	49.0	29.1	12.6	28.6	5.8	10.3

(Note) General poverty rates have been estimated by monthly average expenditure per capita according to the poverty lines by GSO and WB with different standards as follows: 1998: 149 thousand dongs; 2002: 160 thousand dongs; 2004: 173 thousand dongs; 2006: 213 thousand dongs.
(Source) General Statistics Office, Vietnam Homepage

According to the "Vietnam Poverty Update Report 2006" investigated by the Vietnamese Academy of Social Sciences, it is reported that ethnic minorities are participating less and benefiting inadequately from growth process and these facts has become a major concern in Vietnam. Referring to the data of VHLSS04 (the Vietnam Household Living Standards Surveys of 2004) which was carried out by the General Statistics Office, the authors clarified that ethnic minorities only accounts for 12.6% of the total population but occupies 39.3% of the poor population of Vietnam. And poverty reduction process for ethnic minorities is far behind than the Kinh-Hoa; a majority of Vietnam. As a result, the absolute difference in poverty rate between the Kinh-Hoa and ethnic minorities has been increasing more and more. In 2004, poverty rate for ethnic minorities was 61%, which is approximately 4.5 times of the poverty rate for the Kinh-Hoa.

In Vietnam, there is a strong correlation between protected area locations and poverty (see Figure 7.3-3). Poverty in and around Vietnam's protected areas is a factor of the remote, mountainous and isolated areas with limited access to markets and minimal arable land. Many of Vietnam's protected areas are in ethnic minority areas. Therefore, ethnic minority communities are often dependent upon natural resources in protected areas for their well being. (Source: ICEM, 2003. pp28)

7.3.5 Economic trend and policy

Economically Vietnam slightly exceeded 500 US dollar in GDP per capita as late as 2004, having been in a tale running group among ASEAN countries. However, with the Doi-Moi policy since 1986, Vietnam economy grew steeply and recorded annual 8.5% growth in 2005. At the 10th national conference of Vietnamese Communist Party held in April 2006, they announced the national goals as follows.

Vietnam will achieve 8% of economic growth annually and exceed 1000 US dollars of GDP per capita by 2010.

Vietnam will walk out of a backward country.

Vietnam will become a modern industrialized country by 2020.

7.3.6 Environmental target of Vietnam

Five major objectives from 2005 to 2010 are in the following, according to the national strategy for environmental protection until 2010. Here, priorities are placed on water quality management and waste management.

100% new manufacturers, which are built up from 2005-2010, enforce using clean technology or pollution mitigation and waste treatment equipment to meet environmental standard.

50% businesses and manufacturers would be certificated to meet the environmental standards or 14001 ISO Quality standards.

30% of households and 70% of businesses would classify waste at source, 80% public areas are equipped with wastebaskets to collect waste.

40% urban areas, 70% industrial and export processing zones must have wastewater treatment system that meets the environmental standards. 90% domestic, industrial and service solid waste will be collected. 60% harmful waste and 100% hospital waste will be treated.

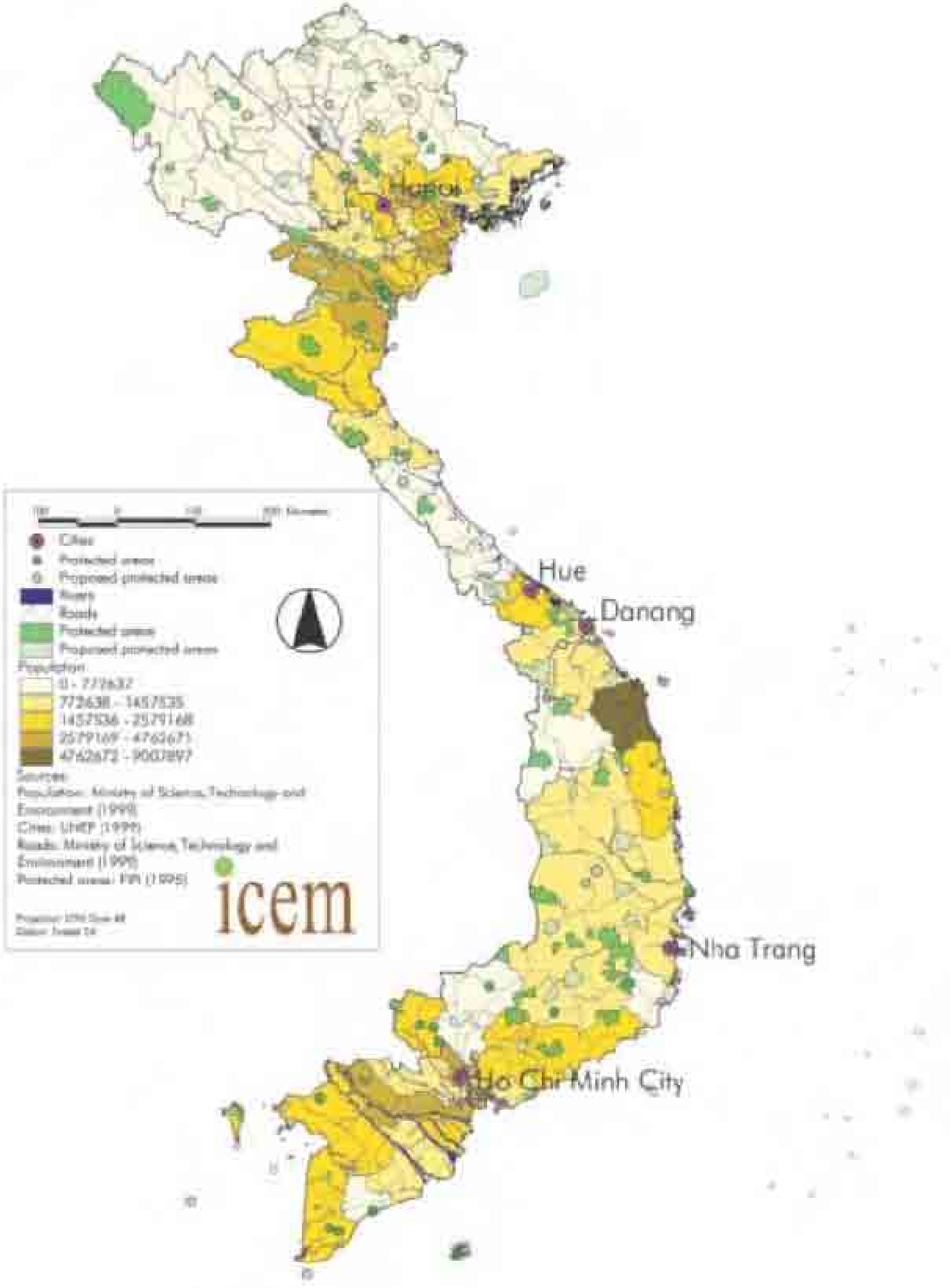


Figure 7.3-1 Map of Population and Protected Areas in Vietnam

Source: Vietnam National Report on Protected Areas and Development, Review of Protected Areas and Development in the Lower Mekong River Region, 14pp. ICEM, 2003.

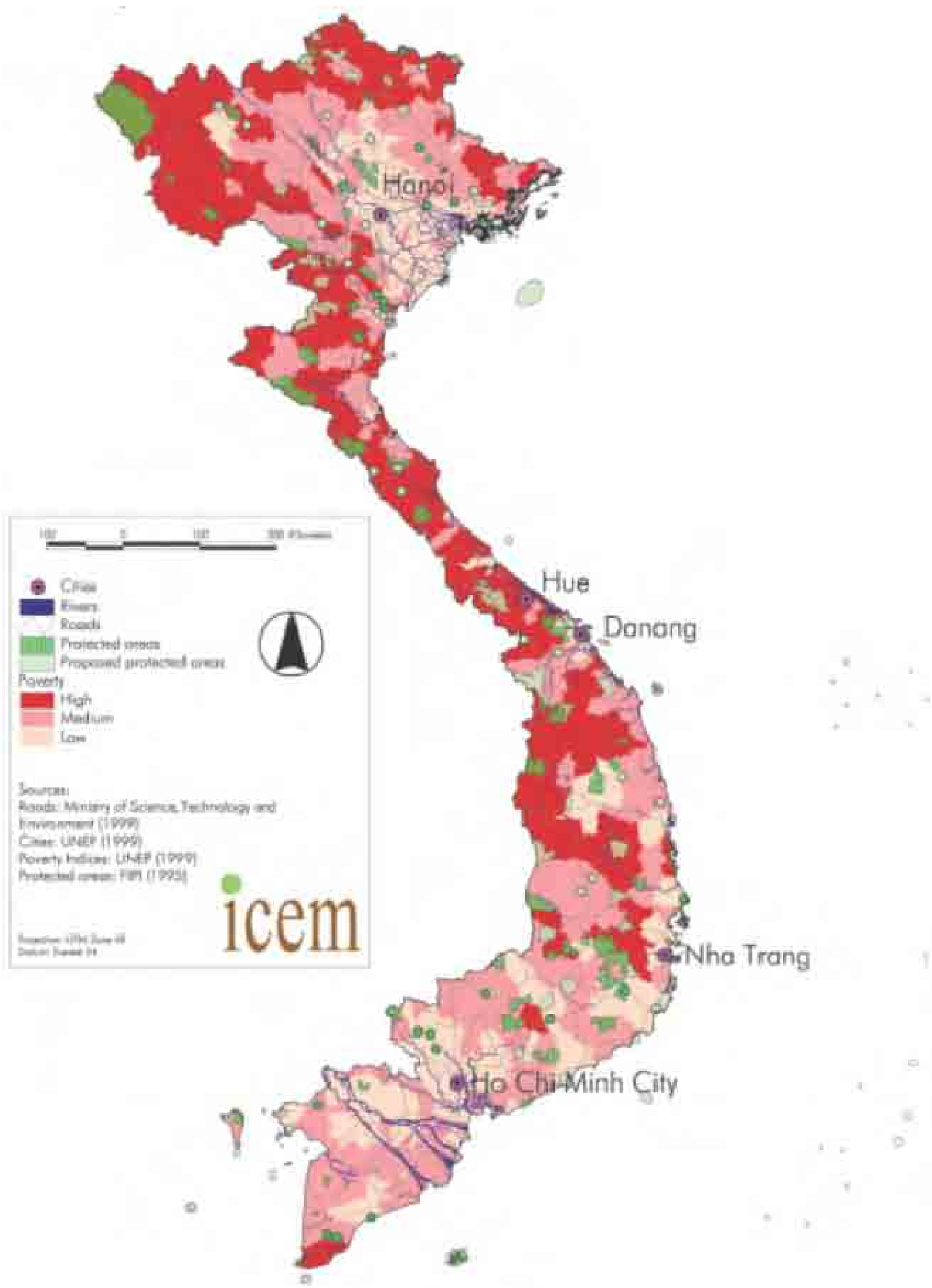


Figure 7.3-2 Map of Poverty and Protected Areas in Vietnam

Source: Vietnam National Report on Protected Areas and Development, Review of Protected Areas and Development in the Lower Mekong River Region, 29pp. ICEM, 2003.

7.4 Legal Framework of ESC

7.4.1 Legislation in relation with ESC (EIA and SEA) and their relation to the Project

The legal framework of ESC (EIA and SEA) in Vietnam consists of the following legislation.

Basic Law

- Law on Environmental Protection, dated 29 November 2005 (enforced on 1 July 2006)

Regulations for Implementation of Law

- DECREE on Detailed Regulations and Guidelines for Implementation of Some Articles of Law on Environmental Protection (No: 80/2006/NĐ-CP), GOVERNMENT, 09 August 2006
- DECREE on regulating environmental protection in designing, appraisal of development strategies, planning, plans, programs and project (No: 140/2006/NĐ-CP), GOVERNMENT, 22 November 2006

Guidelines for Implementation of Law

- CIRCULAR on guideline for strategic environmental assessment, environmental impact assessment and environmental protection (No. 08/2006/TT-BTNMT), MONRE, 08 September 2006
- CIRCULAR on guideline for implementation of Decree No 140/2006/NĐ-CP dated 22/11/2008. (No. 06/2006/TT-BKH), MPI, 27 August 2007

'The law on Environmental Protection' is first introduced in 1994 and revised in 2006. The law is the basic law that stipulates on the environmental impact assessment and protection issues in Vietnam. The old version prescribed EIA and the responsibilities of Environmental Protection in the country, and the revised one added the provisions on strategic environmental assessment (SEA).

To actualize and implement the requirements on SEA designated by 'The law on Environmental Protection', Decree No. 140/2006/ND-CP stipulated the list of the development activities that must make SEA report as follows.

Table 7.4-1 List of Development Activities that must make SEA reports

(Stipulated in Decree No. 140/2006/ND-CP)

No.	Type of Development Activities
1	National economic and social development stratergies. These are commonly prospects in the range of 10 years and more
2	Development strategies of a sector or a field on the national scale.
3	Economic and social development stratergies for economic - social regions and special territory areas.
4	Economic and social development master plannings
5	**Sector or field development master plannings**
6	Other develoment plans as stipulated in item 4, provision 1 of the decree

Decree No. 80/2006/ ND-CP prescribes on 'information disclosure' in Article 23. In Annex 1, it also spells out the list of projects that must make EIA reports which includes the sub-sectors of energy, such as coal, oil and gas, and electric power facilities.

Table 7.4-2 Annex 1: List of projects that must make EIA reports

(Attached with Decree No. 80/2006/NĐ-CP)

No	Projects	Scale
1	Projects of national importance	All
2	Projects that use partly or wholly land area, or have bad influence on natural conservation areas, national parks, historical and cultural vestiges, famous landscapes that are ranked or not yet but gazetted by people's committees of provinces and cities directly under the central government as protected areas.	All
3	Projects that are potentially risky for bad impacts directly on water sources of river basins, coastal seas, or areas with protected ecology	All
4	**Atomic power station** projects	All
5	**Thermonuclear power station** projects	All
6	**Nuclear reactors** projects	All
7	Projects of construction of production, business, and service establishments that use **radioactive or generate radioactive wastes**	All
.	....	–
23	Projects of **oil, gas exploitation**	All
24	Projects of **oil refinery** (except LPG extracting, lubricant production projects)	All
25	Projects of building **oil, gas pipelines**	All
26	Projects of **gasoline, oil stock**	Capacity from 1000 m^3 or more
27	Projects of **petrochemical products** (surface activated substances, methanol)	All
29	Projects of building **oil, gas storage**	All
30	**Thermo-electric stations** projects	Capacity from 500 MW or more
31	**Hydro-electric stations** projects	Lake with capacity from 1,000,000 m^3 of water or more
32	Projects of **high voltage electricity lines**	Length from 50 km or more

7.4.2 Procedure of SEA in relation with the Project

The Article 14 of Law on Environmental Protection orders that; strategies, planning, development plan of industrial sectors and fields on the national scale are subject to the elaboration of SEA reporting. According to the Article and hearings at MOIT and MONRE, the government organization in charge of the preparation of national energy master plan is obliged to prepare a SEA report concomitantly in preparing the MP.

The Article 17 (7a) of the Law also indicates that; The Ministry of Natural Resources and Environment (MONRE) shall organize councils for appraisal of the strategic environmental assessment reports of projects subject to approval by the National Assembly, the Government or the Prime Minister. So, the MONRE is to appraise the SEA report for the Project (since it requires the approval by the prime minister) [21].

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[21] In hearings, held in December 2006 and May 2007, at the Environmental Unit, Science and Technology Department of MOIT, which is the environmental management unit of MOIT, and the Reviewing, Appraisal and Environmental Impact Assessment Department of MONRE, which holds jurisdiction over SEA and EIA in Vietnam, officials of the both organs agreed on the same view that the national master plan formulation of the energy sector should require the approval of the prime minister.

CIRCULAR No. 08/2006/TT-BTNMT, MONRE express in its section II that; agencies assigned to formulate projects (hereinafter called project owners) have to elaborate SEA reports and set up a SEA working group, including experts on environment, scientists with qualifications relevant to the field of projects to execute SEA and elaborate SEA reports of strategies (master plans and plans).

According to this provision, the Energy and Petroleum Department (EPD) of MOIT and the Institute of Energy (IE) bear the responsibility in preparing the concerned SEA report and set up a SEA working group. Then, the EPD of MOIT is to send application documents for technical appraisal of SEA reports to MONRE (Decree No. 80/2006/ ND-CP, GOVERNMENT, Article 9 and CIRCULAR No. 08/2006/TT-BTNMT, MONRE, Section II., 2.1).

The application documents for the technical appraisal consist of the following ones. (Decree No. 80/2006/ND-CP, GOVERNMENT, Article 9, Clause 1; and CIRCULAR No.08/2006/TT-BTNMT, MONRE, Section II, 2.2).

a) Application Letter for technical appraisal by the project owners

b) SEA reports

c) Draft strategies, planning, and plans

According to the Circular above and the hearings at MONRE, SEA report should be submitted to MONRE on application of appraisal, but appraisal of the scoping documents of environmental assessment by MONRI is not required legally.

While the SEA procedure is defined as above and be processed as explained in 7.4.3, method and model of the SEA is yet to be prepared. As this study aims to assist the Vietnamese Government with a technical draft to formulate the National Energy Master Plan, the study team gave explanation to MOIT and MONRE on the scoping document and the draft SEA study according to JICA environmental and social considerations guidelines. We hope the method proposed in this study will contribute to establish the method and model of SEA on National Energy Master Plan of Vietnam.

7.4.3 Competent Organizations of NEMP[22] and SEA the Study supports

1) Draft Preparation of NEMP (including the chapter of SEA) by the Study

Department of Energy and Petroleum, MOIT; IE; JICA Study Team

2) Formulation of NEMP

Department of Energy and Petroleum, MOIT

3) Formation of the SEA Working Group and Preparation of SEA

Department of Energy and Petroleum, MOIT

4) Appraisal of the SEA for NEMP

Department of Reviewing, Appraisal and Environmental Impact Assessment,
Ministry of Natural Resources and Environment (MONRE)

5) Council of SEA Appraisal

Appraisal Council is assembled by the members being the representatives of the stakeholders, qualified and experienced experts with areas of expertise relevant to the contents and

[22] NEMP stands for National Energy Master Plan.

characteristics of the project (the concerned planning) who have not participated in writing the strategic assessment report concerned.

6) Approval of NEMP

The Prime Minister

7.5 Outline of the ESC study (SEA)

7.5.1 Outline of the Study

The concerned study is being examined from the aspects of the following fields.

Energy Demand	
Energy Supply	Coal, Oil and Natural Gas, Power Generation and Supply, and Renewable

Figure 7.5-1 shows the structure for the energy demand and supply model in the study concerned. The structure will be the base for constructing the equations in the energy development optimization model. For example, the material and energy supply flow from the left side should balance with the conditions of ‘Demand Sectors’ given by ‘the Demand Forecasting Model’ and exogenous variables and preconditions. ‘Social Objective, Policy and Institution’ regarding economy, energy and environment will set possible scenarios for the whole settings of energy flows and conditions as prefaces outside calculation by the model.

In the same way, the material and energy flow will be the base for analyzing the factors or points of occasion where the potential impacts will be occurring in relation with the energy sector activities though the flow structure should be further elaborated.

Regarding Figure 7.5-1, the Energy Demand & Supply Working Group of the Study has elaborated ‘energy flow charts’ while the Energy Policy WG done (or does) ‘policy and institutional structure charts’. Each working group identifies the range of operations or activities in respective energy sub-sector, and does the scope of environmental and social impacts by respective sectors, and reflects the identified information onto charts for energy flows of respective sectors or for the linkage of policy and institutional structure.

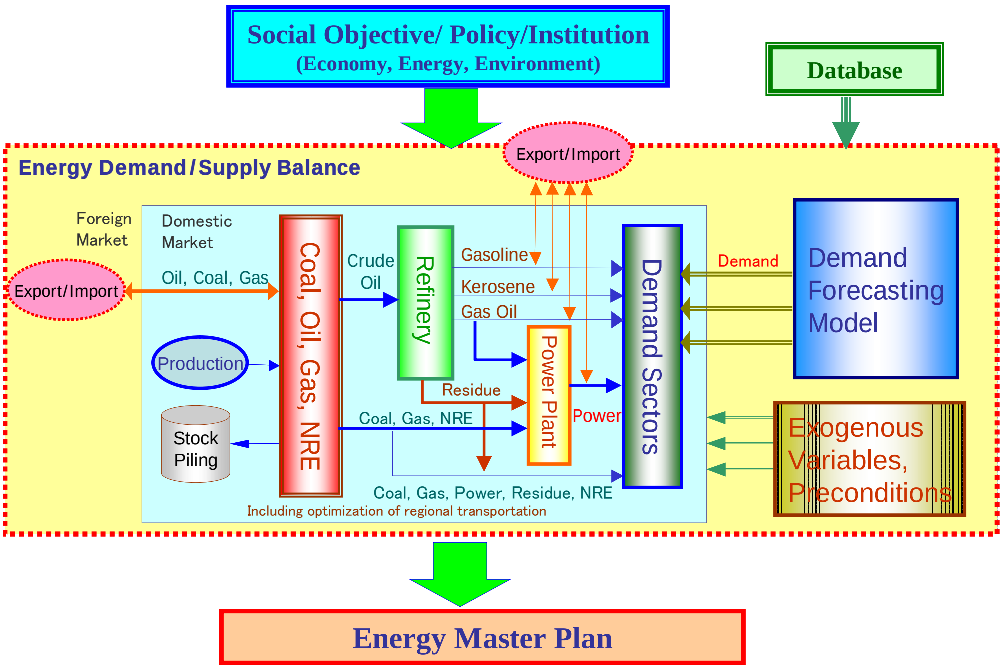


Figure 7.5-1 The Structure of the Energy Demand and Supply Model

ESC team will provide each sub-sector working group with the formats and checklists for the impact assessment, with which the respective working groups evaluate during the fourth joint work in Vietnam the magnitudes of potential environmental and social impacts assumed to be caused by alternative scenarios. The environmental and social impacts will be evaluated with the common indicators shown below by each sub-sector which is represented by the respective working group of the Study.

Table 7.5-1 Common indicators consistent to the respective sub-sectors

① Order of the size in total amount of **greenhouse gas emission**
② Load (Impacts) on **air pollution** (SOx, NOx, Dust, etc.)
③ Load on **water environment and resources** (water consumption, water pollution, disturbance of surface and coastal water, etc.)
④ Load on **forest resources** (forest decrease, degraded function of disaster prevention)
⑤ **Social Fairness** (Uneven distribution of development area, Load on the socially vulnerable groups)
⑥ **Transformation** potential **of living space** (resettlement issues, land occupation & transformation, etc.)

Source: The Study Team *Note: Load = Burden or Potential Impacts by the Project*

The magnitude of environmental and social impacts assumed for each alternative scenario will be given through the evaluation work based on the formula below, the combination of common indicators with weights on indicators and mitigation difficulties for respective scenarios.

$$\text{ESI} = \sum_{i=1}^{n} Vi * Wi * Mi$$

$$Wi = Wi(significance)\sum_{j=1}^{3} Wij \qquad Mi = \sum_{k=1}^{3} Mik$$

ESI: **the magnitude of environmental and social impacts** to be possibly caused **by a corresponding case**

Vi: **the value** (the relative rank in alternative cases) for **the indicator-i** given on the corresponding case

Wi: **the weight** on **the indicator-i**

Mi: **the mitigation difficulty** for **the indicator-i** corresponding to the respective case

n: the number of the indicators (set as 6)

Evaluation of Weights and Mitigation Terms are given on the points below.

Weights	level of difficulty for mitigation measures
• *reach of impact area (in space)* • *duration of impact (in time)* • *irreversibility of impact* • *significance (or seriousness) of potential impact in the sub-sector concerned*	• *technical difficulty (to find any effective measures to avoid or alleviate adverse impacts)* • *economic difficulty (due to a large amount of cost for necessary measures)* • *socio-political difficulty (due to social and political hurdles in realizing and taking necessary measures)*

7.5.2 Scoping

The scoping of the study was conducted in three sub-sectors of energy, namely in the oil and gas sector, the coal sector and the power sector including renewable energy. For each sub-sector, we prepared a checklist for potential impacts assumed in respective sub-sector activities, based on the energy flowchart of Vietnam and standard items listed in the existing EIA guidelines[23] of the sectors concerned. Please refer to Appendix 7.1 for the assembled checklists, which consist of 6 categories of major indicators[24] and their sub-indicators. Those indicators represent one part of scoping results.

[23] *Referring to those of JBIC's and the World Bank's*

[24] *Those are as follows. G = Global Warming and Climate Change; A = Atmospheric Environment; W = Water Environment and Resources; F = Forest Resources and Natural Habitats; S = Social Fairness; T = Transformation of Land and Living Space*

We put three types of weights on those indicators as follows. Those weights represent the other part of scoping results. First, the sub-indicators were given weights according to their relative importance within the respective major indicators (G, A, W, F, S, T), while the six categories of major indicators were themselves assumed to have equal weight to each other. Secondly, the sub-indicators were weighted by the gravity of impacts, from four aspects that are the reach of impact, the duration of impact, the irreversibility of impact and the stochastic significance or seriousness of impact. Thirdly, the sub-indicators were weighted by the gravity of mitigation difficulty, from three aspects that are technical difficulty in mitigation, economic difficulty and socio-political difficulty.

The scoping results of three sub-sectors of energy are shown on Table 7.5-2, Table 7.5.3 and Table 7.5-4.

Table 7.5-2 Scoping Table for Oil and Gas Sector

Oil & Gas Sector

Category (Six Major Indicators)	Sub-Indicators	Relative Weight of Indicator in the Category	Wi										Mi
			W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
	Range of Value	W=0,1,2, …	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G	G1	7	5	4	4	1	13.0	10.6	3	4	4	11.0	10.1
	G2	3	4	3	4	0.7	7.7		3	3	3	9.0	
	G3	1	2	1	1	0.5	2.0		2	3	2	7.0	
		11											
A	A1	8	3	4	3	1	10.0	7.8	2	4	3	9.0	9.2
	A2	3	1	3	3	0.6	4.2		4	4	3	11.0	
	A3	1	0	1	1	0.2	0.4		2	2	1	5.0	
		12											
W	W1	8	2	2	2	0.6	3.6	3.3	2	2	1	5.0	7.1
	W2	2	2	1	3	0.6	3.6		3	4	3	10.0	
	W3	2	3	3	3	0.6	5.4		2	4	3	9.0	
	W4	0	2	3	2	0	0.0		2	3	3	8.0	
	W5	3	2	3	2	0.3	2.1		3	4	3	10.0	
	W6	1	2	3	2	0	0.0		2	2	1	5.0	
		16											
F	F1	1	3	3	3	0.2	1.8	1.7	4	3	3	10.0	9.0
	F2	1	2	3	3	0.2	1.6		4	2	3	9.0	
	F3	1	3	3	3	0.2	1.8		3	2	3	8.0	
		3											
S	S1	1	2	3	2	0.4	2.8	3.7	4	3	3	10.0	8.0
	S2	1	3	3	2	0.5	4.0		2	2	4	8.0	
	S3	1	3	3	3	0.3	2.7		4	2	4	10.0	
	S4	1	1	3	3	0.5	3.5		3	2	1	6.0	
	S5	1	1	2	1	0.1	0.4		1	2	3	6.0	
	S6	3	2	5	5	0.1	1.2		4	3	3	10.0	
	S7	3	3	2	3	1	8.0		2	1	3	6.0	
		11											
T	T1	4	2	2	2	0.4	2.4	2.7	2	2	3	7.0	8.5
	T2	5	2	4	5	0.1	1.1		4	4	4	12.0	
	T3	3	2	4	4	0.2	2.0		3	3	3	9.0	
	T4	3	1	3	5	0.4	3.6		3	3	2	8.0	
	T5	1	2	2	2	0.1	0.6		2	2	2	6.0	
	T6	3	2	3	3	0.8	6.4		3	3	2	8.0	
	T7	3	2	3	3	0.3	2.4		3	2	2	7.0	
	T8	1	1	2	1	0.4	1.6		2	3	1	6.0	
	T9	0	1	3	2	0.3	1.8		2	2	3	7.0	
	T10	0	2	3	2	0.4	2.8		2	2	2	6.0	
	T11	2	2	3	5	0.3	3.0		2	2	4	8.0	
		25											

Regarding the gravity of impacts (Wi), the weighting of indicators was conducted as below.

Evaluated weights for sub indicators according to Reach, Duration and Irreversibility of Impacts. All were given the domain of 0≦W≦5 and Integral.

Reach of Impacts (1=site specific), (2=surrounding environment), (3=basin-wide, sub-regional), (4=regional or country-wide), (5=continental or global)

Duration of Impacts: (1≦ several years), (2≦ decades), (3≦a hundred years), (a century≦4≦a thousand years), (thousands of years≦5)

Irreversibility of Impacts: (1=can be restored in a short time), (2=easy to restore), (3=not-easy or difficult to restore), (4=very difficult to restore), (5= extremely difficult or impossible to restore)

Evaluated weights of significance (probability that the incidence of the problem may occur) for sub indicators with the domain (0≦W≦1).

Took summation of reach, duration and irreversibility and multiply the sum by significance. Then took the weighted average within each main indicator, to have Wi.

Table 7.5-3 Scoping Table for Coal Sector

Coal Sector

Category (Six Major Indicators)	Sub-Indicators	Relative Weight of Indicator in the Category	W-ing in reach of impacts (Wi)	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
	Range of Value	W=0,1,2, …	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G	G1	5	5	4	4	0.7	9.1	7.2	3	4	4	11.0	9.8
	G2	1	4	3	4	0.7	7.7		3	3	3	9.0	
	G3	2	2	1	1	0.5	2.0		2	3	2	7.0	
		8											
A	A1	5	3	3	3	0.8	7.2	7.3	2	4	3	9.0	7.1
	A2	7	2	3	3	1	8.0		2	3	1	6.0	
	A3	1	1	3	1	0.6	3.0		2	2	1	5.0	
		13											
W	W1	1	2	3	3	0.8	6.4	6.4	4	3	1	8.0	7.3
	W2	1	2	3	3	0.9	7.2		2	3	2	7.0	
	W3	1	2	3	3	0.7	5.6		3	3	1	7.0	
		3											
F	F1	1	3	3	3	0.7	6.3	4.1	4	3	3	10.0	9.0
	F2	1	2	3	3	0.4	3.2		4	2	3	9.0	
	F3	1	3	3	3	0.3	2.7		3	2	3	8.0	
		3											
S	S1	2	2	3	3	0.8	6.4	3.8	3	3	3	9.0	7.9
	S2	1	1	2	2	0.5	2.5		1	2	2	5.0	
	S3	2	2	3	3	0.2	1.6		4	2	4	10.0	
	S4	1	2	3	3	0.5	4.0		3	2	1	6.0	
	S5	1	1	2	1	0.1	0.4		1	2	3	6.0	
	S6	2	2	5	5	0.1	1.2		4	3	3	10.0	
	S7	1	3	3	2	0.5	4.0		2	2	4	8.0	
	S8	2	3	2	3	1	8.0		2	1	3	6.0	
		12											
T	T1	2	1	2	2	0.4	2.0	6.1	2	2	3	7.0	8.4
	T2	3	2	4	5	0.8	8.8		4	4	4	12.0	
	T3	1	2	4	4	0.8	8.0		3	3	3	9.0	
	T4	1	1	4	5	0.5	5.0		4	3	3	10.0	
	T5	1	2	3	4	0.1	0.9		2	2	2	6.0	
	T6	1	2	4	3	1	9.0		3	3	1	7.0	
	T7	2	2	3	3	0.8	6.4		3	3	2	8.0	
	T8	1	2	3	5	0.3	3.0		2	2	4	8.0	
	T9	1	1	3	4	1	8.0		3	3	1	7.0	
	T10	1	2	4	4	1	10.0		2	3	2	7.0	
	T11	1	2	3	1	0.8	4.8		2	2	2	6.0	
		15											

Regarding the gravity of mitigation difficulty (Mi), the weighting of indicators was conducted as below.

Evaluated mitigation difficulty for sub indicators from the technical, economic and socio-political aspects. All were given the domain of 0≦W≦5 and Integral. However, they were not allowed to take zero value all at the same time.

Level of Difficulty: (1=very easy), (2=easy and to be solved by ordinal measures), (3=not-easy or difficult, and require hard efforts and measures to solve the problem), (4=very difficult, require advanced and innovative measures, or assistance from outside sources), (5=extremely difficult, require most advanced technology and very strong support from outside)

Took summation of all three mitigation difficulties for sub indicators, then we took the weighted average within each main indicator, to have Mi.

Table 7.5-4 Scoping Table for Electric Power Sector including Renewable Energy

Electric Power Sector (including Renewable Energy)

Category (Six Major Indicators)	Sub-Indicators	Relative Weight of Indicator in the Category	Wi										Mi
			W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
	Range of Value	W=0,1,2, …	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G	G1	5	5	4	4	1	13.0	10.7	3	4	4	11.0	10.1
	G2	1	4	3	4	0.7	7.7		3	3	3	9.0	
	G3	1	2	1	1	0.5	2.0		2	3	2	7.0	
		7											
A	A1	10	3	3	3	1	9.0	7.7	2	4	3	9.0	8.1
	A2	4	2	3	3	0.7	5.6		2	3	1	6.0	
	A3	4	2	5	5	1	12.0		4	4	1	9.0	
	A4	1	0	1	1	0.1	0.2		2	2	1	5.0	
	A5	3	1	3	1	0.6	3.0		2	3	3	8.0	
		22											
W	W1	6	2	3	3	1	8.0	6.1	3	3	4	10.0	8.3
	W2	3	2	2	2	0.7	4.2		2	3	1	6.0	
	W3	2	2	3	3	0.7	5.6		2	3	2	7.0	
	W4	1	2	2	2	0.6	3.6		2	3	2	7.0	
	W5	1	2	3	3	0.3	2.4		3	3	2	8.0	
	W6	2	2	5	5	1	12.0		4	3	2	9.0	
	W7	1	2	2	2	0.6	3.6		2	2	1	5.0	
	W8	1	2	3	3	0.3	2.4		5	4	3	12.0	
	W9	1	2	3	2	0.3	2.1		2	2	3	7.0	
		18											
F	F1	1	3	4	4	0.3	3.3	5.9	4	3	3	10.0	9.5
	F2	1	2	3	3	0.6	4.8		4	2	3	9.0	
	F3	1	3	3	3	0.4	3.6		3	2	3	8.0	
	F4	1	2	5	5	1	12.0		4	3	4	11.0	
		4											
S	S1	2	2	3	2	0.7	4.9	5.2	3	3	3	9.0	8.6
	S2	1	3	3	2	0.5	4.0		2	2	4	8.0	
	S3	2	3	3	3	0.3	2.7		4	2	4	10.0	
	S4	1	2	3	3	0.4	3.2		3	2	2	7.0	
	S5	1	1	2	1	0.3	1.2		1	2	3	6.0	
	S6	2	2	5	5	0.2	2.4		4	3	3	10.0	
	S7	3	3	3	3	1	9.0		2	1	3	6.0	
	S8	2	5	2	2	1	9.0		4	3	5	12.0	
		14											
T	T1	3	2	2	2	0.7	4.2	6.1	3	3	4	10.0	10.2
	T2	2	2	4	5	0.2	2.2		4	4	4	12.0	
	T3	1	2	4	4	0.4	4.0		3	3	3	9.0	
	T4	1	1	4	5	0.4	4.0		3	3	2	8.0	
	T5	1	2	2	2	0.1	0.6		2	2	2	6.0	
	T6	3	2	3	3	0.8	6.4		3	3	3	9.0	
	T7	1	2	3	5	0.3	3.0		2	2	4	8.0	
	T8	1	2	3	2	0.3	2.1		2	2	2	6.0	
	T9	3	2	3	3	0.3	2.4		3	3	3	9.0	
	T10	1	2	2	1	0.8	4.0		2	2	2	6.0	
	T11	2	3	5	5	1	13.0		4	4	4	12.0	
	T12	2	3	5	5	1	13.0		5	5	5	15.0	
	T13	2	4	5	5	1	14.0		5	5	5	15.0	
		23											

7.6 Analyses and Evaluation of Alternative Cases

7.6.1 Assumption of Alternative Cases

1) BAU Case (Zero Option)

BAU Case is defined as Zero Option Case of SEA as follows.

Annual economic growth rate: 8.4% (2005-2020: 8.5%, 2020-2025: 8.0%)
Crude oil price: US$65/bbl
Energy conservation ratio: 1% annum
Power supply at 2025: 401 TWh

2) Reference Case (R Case)

GDP growth rate and crude oil price of Reference Case are same as BAU Case. However, energy conservation ratio is different from BAU Case because Reference Case is assumed that energy conservation technology of energy intensive industry such as cement, steel, and paper will be accelerated from 3% to 4%.

Annual economic growth rate: 8.4% (2005-2020: 8.5%, 2020-2025: 8.0%)
Crude oil price: US$65/bbl
Energy conservation ratio: 3%-4% annum
Power supply at 2025: 324 TWh

3) High Growth Case (HG Case)

GDP growth rate of High Growth Case is assumed at 9.4%. Other assumptions are same as Reference Case as follows.

Annual economic growth rate: 9.4% (2006-2020: 8.5%, 2020-2025: 8.0%)
Crude oil price: US$65/bbl
Energy conservation ratio: 3%-4% annum
Power supply at 2025: 544 TWh

4) Low Growth Case (LG Case)

GDP growth rate of Low Growth Case until 2010 is same as Reference Case. After 2010, however, GDP growth rate is gradually decreasing. Other assumptions are same as Reference Case as follows.

Annual economic growth rate: 7.4% (2006-2010: 8.5%, 2010-2015: 7.8%, 2015-2020: 7.0%, 2020-2025: 6.5%)
Crude oil price: US$65/bbl
Energy conservation ratio: 3%-4% annum
Power supply at 2025: 259 TWh

5) High Price Case (HP Case)

After 2010, High Price Case is assumed that crude price rise US$75/bbl. As the result, GDP growth rate will be decrease by 0.5% and average GDP growth rate until 2025 is 1% lower than Reference Case. However, a rate of coal price rising is a half of crude oil because there are a lot of coal reserves in the world compared with oil.

6) Low Price Case (LP Case)

Low Price Case is assumed that crude oil price gradually decrease US$50/bbl by 2010 and crude oil price is stable afterward. In this case, energy consumption will increase compared with Reference Case because energy conservation technology is not accelerated and industry structure is not changed.

7.6.2 Evaluation of Alternative Cases

As for above-mentioned 6 cases, the magnitude of environmental and social impacts is compared based on the results of the supply optimization model (refer to Appendix) and weighting coefficients (Wi and Mi). The magnitudes of environmental and social impacts for 6 cases are evaluated by three sectors (oil & gas, coal, and electricity including renewable energy). These 18 evaluation sheets are shown in Appendix.

7.6.2.1 Environmental and social impacts by 6 cases

Comparing the results of 6 environmental and social impacts, the BAU Case indicates the largest index of 5,079. Next large index is 5,068 of High Growth Case with 9.4% of GDP growth rate and 3-4% of energy conservation ratio (refer to Table 7.6-1). Looking at sub-sectors, the largest indices appear in power sector as 1,963 of BAU Case and 1,964 of High Growth Case. For the coal sector, the largest index is 1,705 of BAU Case and for the oil & gas sector are 1,442 of High Growth Case respectively.

Range of ESI (Environmental and Social Index) is between 0 and 8,100 theoretically. Maximum ESI with 8,100 is the worst-case scenario with 5 of weighting coefficient and level of difficulty. How about 1,964 of High Growth Case in power sector? This figure is second or third environmental burden among 6 cases and all weighting coefficients and level of difficulties are 3 (see Table 7.6-2). When Wi and Mi is 3, we have to consider countermeasure to reduce the effects on the environment. Generally, if Vi, Wi, and Mi shows 3.5, 2, and 2 respectively, ESI becomes 756. In this case, it is said that the environmental problems appear. Looking at the least impacts, it is 1,839 of Low Growth Case in total sector and 299 of Low Growth Case in coal sector.

Table 7.6-1 Environmental and Social Index (ESI) by 6 Cases

Sub Sector \ Case	BAU Case	Reference Case	High Growth	Low Growth	High Price Case	Low Price Case
	BAU	**R**	**HG**	**LG**	**HP**	**LP**
Oil and Gas	1410	893	1442	439	725	1211
Coal	1705	915	1663	299	618	1292
Electric Power	1963	1510	1964	1101	848	1209
Total of all energy sectors	**5079**	**3318**	**5068**	**1839**	**2191**	**3712**

Table 7.6-2 Range of ESI

0 < Range of ESI ≦ 8100 = 6*6*15*15 = (6 indicators)*(Max Vi)*(Max Wi)*(Max Mi)			
4320 = 6*5*12*12	1944 = 6*4*9*9	1701 = 6*3.5*9*9	756 = 6*3.5*6*6

7.6.2.2 Impacts by indicator

Comparing environmental and social impacts by each indicator, G-indicator (Global warming factor) is the most effective factor in all sectors (refer to Table 7.6-3). G-indicators of oil & gas, coal, and power sectors show 639, 418, and 649 respectively. The reason of G-indicator impact is that Wi factor (affected area, affected time, difficulty of recovery, and appearance ratio of effect) and Mi factor (level of difficulty) in G-indicator is higher than other indicators.

Table 7.6-3 Value of Vi, Wi, Mi, and ESI by sub-sector

Oil & Gas Sector — Vi,Wi,Mi Value for respective indicators

	Vi						Wi	Mi
	BAU	R	HG	LG	HP	LP		
G	5.8	3.4	6.0	1.0	2.1	4.7	10.6	10.1
A	5.8	3.2	6.0	1.0	3.0	5.1	7.8	9.2
W	5.1	3.1	5.2	1.8	2.6	4.3	3.3	7.1
F	3.5	3.5	3.5	3.5	3.5	3.5	1.7	9.0
S	3.5	3.5	3.5	3.5	3.5	3.5	3.7	8.0
T	4.2	3.3	4.3	2.7	3.1	3.9	2.7	8.5

Oil & Gas Sector — ESI for respective indicators

	ESI					
	BAU	R	HG	LG	HP	LP
G	620.7	363.0	639.0	106.5	223.7	503.1
A	415.4	225.1	424.7	71.0	210.3	360.2
W	120.3	72.8	122.3	41.8	61.8	100.6
F	54.6	54.6	54.6	54.6	54.6	54.6
S	104.4	104.4	104.4	104.4	104.4	104.4
T	94.8	73.6	97.0	60.9	70.2	87.7

Coal Sector — Vi,Wi,Mi Value for respective indicators

	Vi						Wi	Mi
	BAU	R	HG	LG	HP	LP		
G	6.0	3.2	5.9	1.0	1.8	4.6	7.2	9.8
A	6.0	3.2	5.9	1.0	2.7	4.9	7.3	7.1
W	6.0	3.2	5.8	1.0	2.1	4.4	6.4	7.3
F	6.0	3.2	5.8	1.0	2.1	4.4	4.1	9.0
S	5.6	3.2	5.4	1.4	2.4	4.2	3.8	7.9
T	6.0	3.2	5.8	1.0	2.1	4.4	6.1	8.4

Coal Sector — ESI for respective indicators

	ESI					
	BAU	R	HG	LG	HP	LP
G	418.3	223.9	413.3	69.7	122.2	319.0
A	310.3	166.6	302.8	51.7	137.2	252.7
W	281.6	148.8	272.7	46.9	100.1	206.3
F	219.6	116.0	212.7	36.6	78.0	160.9
S	166.9	96.4	162.2	42.3	70.5	126.9
T	308.8	163.1	299.1	51.5	109.7	226.2

Electric Power Sector — Vi,Wi,Mi Value for respective indicators

	Vi						Wi	Mi
	BAU	R	HG	LG	HP	LP		
G	5.9	3.5	6.0	1.0	2.1	4.8	10.7	10.1
A	5.5	4.1	5.5	2.9	1.5	2.2	7.7	8.1
W	4.8	4.1	4.7	3.6	2.3	2.5	6.1	8.3
F	5.4	4.7	5.3	4.1	1.6	1.8	5.9	9.5
S	3.5	3.5	3.5	3.5	3.5	3.5	5.2	8.6
T	4.4	4.0	4.3	3.8	2.6	2.7	6.1	10.2

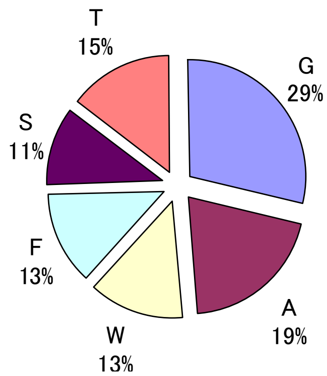
Electric Power Sector — ESI for respective indicators

	ESI					
	BAU	R	HG	LG	HP	LP
G	640.2	376.0	649.4	108.2	228.0	517.6
A	347.8	254.7	344.4	180.2	91.2	137.9
W	240.1	206.3	238.3	182.7	113.7	127.5
F	302.5	261.8	300.1	233.0	91.5	98.7
S	158.6	158.6	158.6	158.6	158.6	158.6
T	273.9	252.8	272.7	238.0	164.9	168.6

Table 7.6-4 Effects of 6 indicators in Reference Case (%)

	Oil and Gas	Coal	Electric Power	Total Energy
G	363.0	223.9	376.0	962.8
A	225.1	166.6	254.7	646.4
W	72.8	148.8	206.3	427.9
F	54.6	116.0	261.8	432.4
S	104.4	96.4	158.6	359.3
T	73.6	163.1	252.8	489.5

	Oil and Gas	Coal	Electric Power	Total Energy
G	40.6	24.5	24.9	29.0
A	25.2	18.2	16.9	19.5
W	8.2	16.3	13.7	12.9
F	6.1	12.7	17.3	13.0
S	11.7	10.5	10.5	10.8
T	8.2	17.8	16.7	14.8
Total	100.0	100.0	100.0	100.0



Magnitude of indicator depends on energy sector. In oil and gas sector, F-indicator (effect of forest and ecology) is low in all alternative cases. Minimum index in oil and gas sector is W-indicator (effect of water environment) of Low Growth Case. In coal sector, S-indicator (effect of social justice) is low in all alternative cases. Minimum index in coal sector shows F-indicator of Low Growth Case. In the power sector, there is no low indicator.

Focusing Reference Case, G-indicator shows a high effect in all sub-sectors and 29% of total impacts come from G-indicator (refer to Table 7.6-4) followed by W-indicator with 19%, T-indicator (effect of housing) with 15%.

7.6.2.3 Contribution of three Sub-sectors on the Total energy Sector

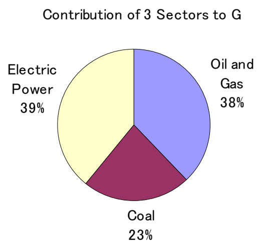
Next, result of evaluating contribution of lower three sectors over the total energy sector is as follows. Regarding G indicator (global warming factor), power sector contributes most while oil and gas sector does almost same. Same trend is observed on A indicator (air quality factor), though contribution of coal sector increases slightly. Regarding W indicator (water quality factor), power sector will be responsible for almost half followed by coal sector.

Same trend is seen on F indicator (forest and ecology factor), yet power sector contribution substantially increases to 60%. Same trend is also seen on T indicator (factor to represent increasing burden or risk on transforming living sphere), and power sector is responsible over 50%. In S indicator (social fairness and equality factor), social impacts are in the order of electric power sector, oil & gas sector and coal sector.

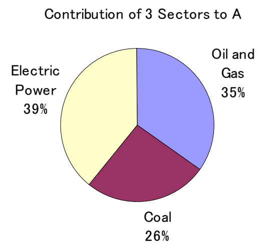
Table 7.6-5 Effects of 3 Sub-sectors (%) in Reference Case

	Oil and Gas	Coal	Electric Power	Total Energy
G	37.7	23.3	39.0	100.0
A	34.8	25.8	39.4	100.0
W	17.0	34.8	48.2	100.0
F	12.6	26.8	60.5	100.0
S	29.0	26.8	44.1	100.0
T	15.0	33.3	51.6	100.0
Total	26.9	27.6	45.5	100.0

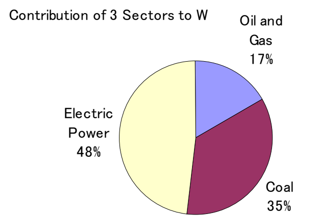
G-indicator



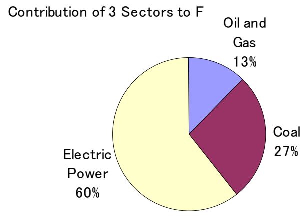
A-indicator



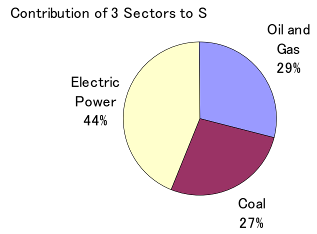
W-indicator



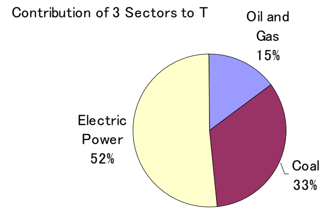
F-indicator



S-indicator



T-indicator



From the above comparative analysis, impact of energy consumption increase is greatest. Therefore, energy efficiency and conservation must be considered with first priority in the long term energy policy. Then, among energy sectors, the impact of the electric power sector is greatest followed by the coal sector, while high activity of the latter is induced mainly by high demand for electricity. Among factors, their impact on G factor is greatest. Thus, promotion of non-fossil power supply should be considered seriously in the energy policy. These observations shall be reflected in formulation of principal energy policy to be discussed in Part-3.

7.7 Role and Result of the Stakeholder Meetings (SHMs)

7.7.1 Objectives of the SHMs and Workshop

In the SEA (Strategic Environmental Assessment) Study to relating the Master Plan formulation, it is a very important process to obtain understanding with and participating of the stakeholders. In principle, we must hold first the stakeholder meetings where the alternative cases, common assessment indicators, standard and method are discussed and decided to recommend to the Master Plan formulation. In this study, we set the workshop partly as the alternative process of the stakeholder meeting because as there was time constraint and this was the elementary and first case to conduct SEA on nationwide energy plan in Vietnam. We held totally four workshops with participation of various stakeholders and we explained and discussed the SEA at every workshop.

7.7.2 Discussions about SEA at Workshop

During the first workshop held on December 19, 2006, the concept, approach and method of the Master Plan Study including the SEA concept were explained and discussed at the Q/A session. As for the SEA, this is the starting point to give an explanation to the stakeholders/participants. In response to comments raised by stakeholders, consideration on the different regional climate condition was discussed. This item was included in the SEA evaluation as F-indicator (forest and ecology factor) or one of six indicators of the SEA evaluation.

During the second workshop held on August 15, 2007, the progress report was explained with regard to basic five cases (BAU Case, Reference Case, High Growth Case, High Price Case and High EEC Case) referring to different demand outlook as the main objective of examination in the Master Plan study. These cases were adopted as alternative cases for the SEA evaluation. Discussion was also made with stakeholders and participants to obtain understanding and consensus on the SEA method and the common indicators. Through these discussions, it was recognized that this Energy Master Plan contains the strategic environmental assessment (SEA) and it is a very new approach and commendable one. The issue of taking steps against global warming is important and it is one of the main targets of the impact evaluation presented in the SEA system. The global warming factor is considered as G-indicator of the SEA evaluation.

During the third workshop held on October 23, 2007, the interim report was presented including structure of Master Plan, draft roadmap and action plans. With regard to the SEA, outline of the evaluation result on the main six cases was explained to stakeholders/participants and recognition was shared on method and evaluation result through ardent questions and answers.

For example, the following items were discussed and answered.

Q) Whether the nuclear power generation is examined in the SEA evaluation, or not?

A) Nuclear power is included as the relevant sub-indicators in the SEA evaluation.

Q) How to choose the six major indicators, the way of weighting indicators, how to decide in the scaling values for evaluation, the implication of calculation results.

A) We set the six indicators and weighting method according to the guidelines established by the World Bank and JBIC (the Japan Bank for international Cooperation) especially with consideration on energy and environmental issues.

Q) Is there any difference between the SEA evaluation systems in the world?

A) There is still no common guideline for evaluation of the SEA method. In future, we would like to improve it with your cooperation.

Finally, during the forth workshop held on January 23, 2008, the draft final report was presented and discussed to obtain good understanding of participants. As for the SEA, the result of basic evaluation on the environment was explained to all the participants including the stakeholder. Interactive discussions were made on calculation method and other recommendations on environmental institutions and organizations.

During four workshops, the MOIT invited several regional specialists of hydropower and private company experts of oil industry as stakeholders relating to the Master Plan formulation. This is the first time for Vietnam to consider the SEA evaluation in formulating the Energy Master Plan of Vietnam and for the local peoples to participate in formulating process as the stakeholder. Through these activities, Vietnam people have made certain progress in understanding what is SEA and how to adopt it with their Energy Master Plan. This is a small but the first result from evaluation of the SEA method.

7.8 Issues and Challenges on Energy Supply/Demand and Environment

7.8.1 Mitigation Method of Major Environmental and social Impacts brought by the National Energy Master Plan

Here, we will consider the mitigation methods of the Environmental and social impacts for the Reference Case (R Case), which is the standard case of the draft National Energy Master Plan.

In order to search the items on which it is necessary to consider abatement and mitigation methods of environmental and social impacts at the strategic planning stage, lower indicators to satisfy the following conditions in the Reference Case are extracted.[25]

(a) ESI value of individual indicator > 198.45=3.5 x 0.7 x (3 x 3) x (3 x 3)

(b) Weight of the indicator among major indicators is greater than 1/10

The above (a) implies a condition that the indicator would have impacts greater than the median of V, W and M on average and the concerned event would occur at probability of 70%. Indicators falling under this condition are found as follows. Indicators in parenthesis are those that satisfy condition (a) but do not satisfy condition (b). On these indicators, we need to study mitigation methods of their environmental and social impacts.

Oil & Gas Sector: G1, G2, A1

Coal Sector: G1, G2, A1, F1, T2, (T3), (T6), (T10)

Electric Power Sector[26]: G1, G2, A1, A3, W1, W6, F2, F4, S8, T6, (T11), (T12), (T13)

[25] Lower index group for six major indicators. For individual indicator, please refer to Appendix 6.1 Indicators for Scoping and Evaluation by Lower Sector.

[26] The power sector evaluation includes renewable energy sector.

1) G indicator requiring mitigation measures

G1 (common for three sectors): Activities to emit certain amount of CO_2

G2 (common for three sectors): Activities to emit certain amount of methane, mono oxide nitrogen and other greenhouse gases

2) A indicator requiring mitigation measures

A1 (common for three sectors): Activities to emit certain amount of air polluting substances such as SOx, NOx, particulates, dusts (including heavy metals such as nickel and vanadium), hydrocarbons and hydrogen sulfide

A2 (power sector): Nuclear power plant plan that needs monitoring of radioactive level of the exhaust gas during operation.

3) W indicator requiring mitigation measures

W1 (power sector): Creation of dam lake or water reservoir for hydropower.

W6 (power sector): Nuclear power plant plan that needs monitoring of radioactive level of the wastewater during operation.

4) F indicator requiring mitigation measures

F1 (coal sector): Big scale development requiring cutting down of primary jungles and tropical natural forests widely

F2 (power sector including renewable sector): Development plans to be located within natural reserves, habitat of extinctive spices, and habitat of ecologically important creations such as coral reef, mangroves and lagoons

F4 (power sector): Nuclear power plant plan that needs monitoring of radioactive level of the surrounding environment during operation.

5) S indicator requiring mitigation measures

S8 (power sector): Nuclear power plant plan that needs concurrence of IAEA and understanding of international society and other organizations.

6) T indicator requiring mitigation measures

T2 (coal sector): Development plans close to world heritage and important cultural heritages (archaeological, historical, cultural and religious)

(T3) (coal sector): Development plans to be located on or to give serious impact to famous and/or precious scenic spots.

T6 (power sector including renewable sector): Site selection plan to secure land and system to appropriately process and dispose wastes.

(T6) (coal sector): Site after closure of mine that needs appropriate environment protection such as land reclamation, reforestation and processing of mine wastewater.

(T10) (coal sector): Candidate dump site for waste mud and stone or waste mine processing ponds that would be vulnerable for collapse of slope and soil wash away

(T11) (power sector): Technical background to secure safe operation that should be prepared in the nuclear power plant plan.

-- Necessary institution (law and regulation, safety standard, guidelines)

-- Development of organization and workforce

-- Accumulation of knowledge on worldwide accident record in the sector

(T12) (power sector): Site selection of nuclear power station

-- Thorough and proper survey of geology, hydrogeology and geography.

-- Securing of unloading port, transport route and storage of nuclear fuel

(T13) (power sector): Carefully worked out plan on disposal process of nuclear fuel including final disposal site of nuclear fuel waste, processing cost, transportation and temporary storage. Study on final closure plan of power station after expiration of facility life.

-- Low level wastes (LLW)

-- High level wastes (HLW)

In preparation of sector development plans to follow the action plans discussed in Chapter 10, mitigation measures on the above issues should be given particular considerations.

7.8.2 Monitoring Plan for Environmental Management

In implementation of the Energy Master Plan of Vietnam, there should be an official system to monitor and audit performance of environmental factors that were evaluated in the SEA and/or to check if there is any unexpected development. Result of regular monitoring and auditing should be published periodically. Environmental status of major projects described in the Energy Master Plan should be from time to time reported to stakeholders. These observations should be reflected in the future energy policies including necessary countermeasures.

At first, it is necessary to establish the concept of energy and environment database to structure the monitoring and audit process. Then, collected data and observed environmental status shall be reported to the central government that checks these data, examines mitigation policy and implements the environmental protection. A series of these activities should be based on the database system on energy and environment, which is presently insufficient in Vietnam in terms of both quality and quantity.

Under the circumstance, it is necessary to establish an environment management system with monitoring and auditing functions as follows;

1) Database

After setting the fundamental concept of the energy-environment database, data collection system should be established including those collected through the monitoring system. The database should be opened to the public for free access.

2) Monitoring system

After setting important monitoring elements, regular and precise observation should be conducted on them. The outcome of the above monitoring as well as other relevant data should be compiled and reported to the society.

3) Auditing system

Data and information collected as above on general national environment status as well as major energy projects should be periodically examined and audited for further study and consideration of policy actions. In such auditing, it is desirable to collect and consider views and opinions of scientists, experts and stakeholders as much as possible.

To support and amplify the above activities, it is desirable to establish a multi-layer organization to periodically review status of environmental and social considerations on general energy policy as well as major energy projects comprising national and regional energy-environment committees. Such system should be organized with coherence including relevant government and regional offices, scientists and experts from academies and business entities and various stakeholders.