Part 2 Long-term Energy Outlook and its Implication

Chapter 3 International Energy Trend

In Part 2, we will conduct analyses on long-term energy outlook for formulation of the Philippine Energy Plan running various case studies using the Energy Database, the Energy Demand Forecasting Model and the Energy Supply Optimization Model that are constructed for the purpose of this study. We will examine different forecast results on energy outlook, their implications under various economic development scenarios, effects of different energy policy options for securing energy supply, impacts on environment and so on.[4] In this chapter, as a first approach, we will review general circumstance to be considered in conducting the study such as the world energy situation, crude oil price trend and issues on global climate change.

Today, the world energy supply/demand outlook is filled with full of uncertainties. As the world economy is growing steadily led by the strong Asian development, many questions are raised if we could continue this trend into the future with stable energy supply. Anxieties are rising on sufficiency of the world oil resources. Reflecting these development, world oil price has soared more than triple in the past seven years, hit $100 per barrel marker on January 2, 2008 and exceeded $147 in July 2008. World energy security has become vulnerable and energy price volatile. Increasing fossil fuel consumption is also threatening the global climate system. The 2005 G8 Summit meeting held in Gleneagles, UK, was the turning point that the international leaders renewed their recognition of energy and environment issues as one of the most important subject facing the world. The global warming issue was intensively discussed in 2007 at Heiligendam, Germany, and in 2008 at Hokkaido-Toyako, Japan. It is now agreed that the world leaders will meet again in Italy in 2009 and discuss how to implement reduction of GHG (Greenhouse gas) emission and set out "Post Kyoto Protocol Framework" that would be adopted for the period on and after 2013. Despite the progress of dialogue, we are yet to find a clue to international collaboration, let alone the final answer.

3.1 World Energy Outlook

Since the turn of the century, the world energy demand has been accelerating its growing speed led by strong economic growth of emerging Asian countries such as China and India. On the other hand, clouds are beginning to spread over the world oil production increase. Under the circumstance, IEA in its World Energy Outlook 2007 concentrated its analysis on impact of growing China and India. According to the IEA Outlook, the world energy consumption would grow in the Reference Case from 11.4 billion toe (tonnes oil equivalent) in 2005 to 14.4 billion toe, by 26%, in 2015 and 17.7 billion toe, by 55%, in 2030. Fossil fuels remain the dominant source of primary energy, accounting for 82% of the total energy supply in 2030. Oil remains single largest fuel, though its share in global demand falls from 35% to 32%, being used mostly as transportation fuel. Oil demand is calculated to reach 116 million barrels per day in 2030.

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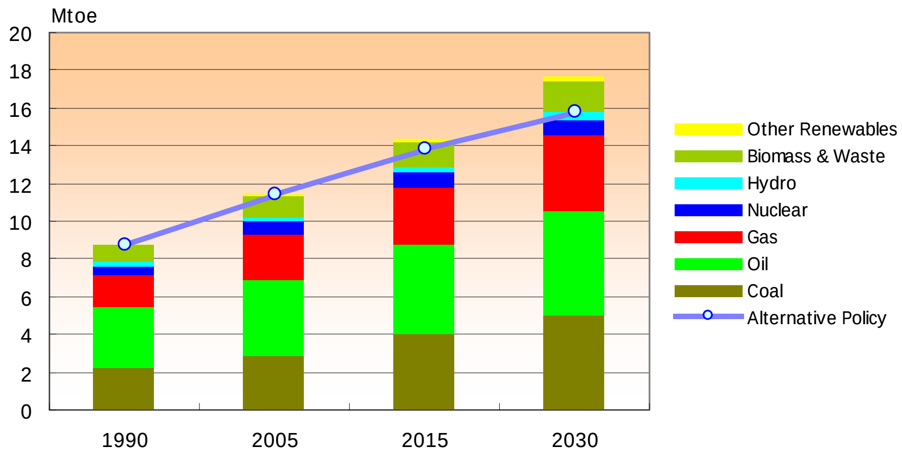
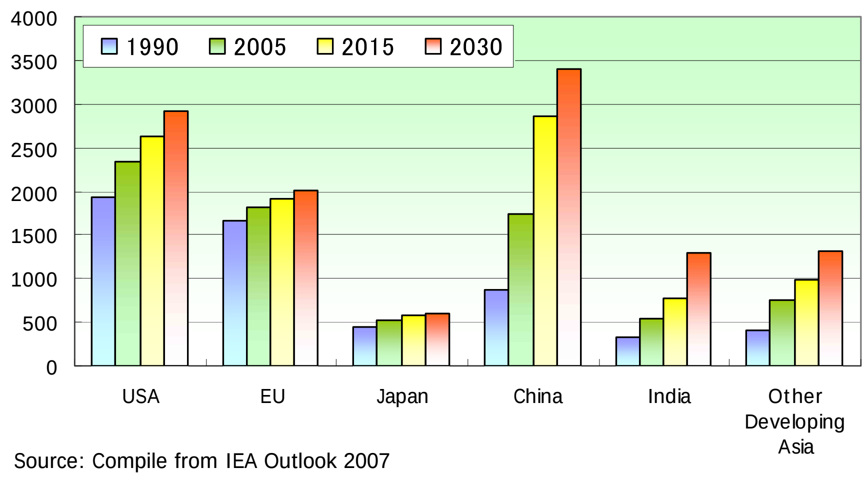
[4] Please refer to Part 3 on the detail technical aspects of these analytical tools.

However, it is uncertain if sufficient investment would be made for new oil-production capacity addition to keep pace with the projected increase in demand. A supply-side crunch cannot be ruled out.

Looking into regional distribution in the Reference Case, while energy demand in IEA countries increases only 23% between 2005 and 2030, it would double in developing countries during the same period. Energy consumption of China, India and other developing Asia would grow fastest. During the past five years from 2000 through 2005, energy demand in developing 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. The same and accelerated trend is forecast to continue for decades.



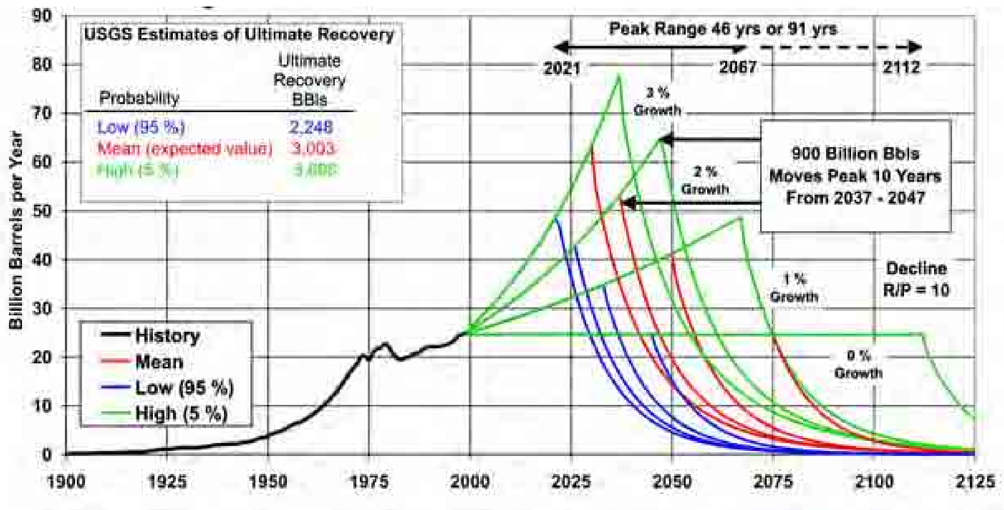


Source: Compile from IEA Outlook 2007

Figure 3.1-1 IEA World Energy Outlook 2007

On the other hand, applying measures such as promoting energy conservation, energy consumption could be reduced to 13.8billion toe in 2015 and 15.959billion toe in 2030. With enhanced efforts to develop nuclear and renewable energies, fossil fuels ratio also reduces to 76%. Global oil demand would be 14 million barrels per day lower - equal to the entire current output of North America.

Another topic recently highlighted is the oil peak theory. It is theoretically right that the world oil production would 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, not coming up to a top agenda. Despite many twists and turns, new oil discoveries have continued and the world oil production has increased past several decades. However, as the world oil production has now exceeded 80 million barrels per day aiming 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.[5] 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 3.1-2 Oil Peak projected by US DOE

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 clear prospect, the world oil price has increased more than triple since 2003 and hit $100 per barrel maker on January 2, 2008. Then, money flow into the commodity market accelerated and the WTI futures exceeded $147 per barrel by the middle of 2008.

IEA summarizes its analysis with the following words:

"Rising global energy demand poses a real and growing threat to the world's energy security. Oil and gas demand and the reliance of all consuming countries on oil and gas imports increase in all three scenarios".

"Rising CO_2 ... concentrations in the atmosphere, resulting largely from fossil-energy combustion, are contributing to higher global temperatures and to changes in climate. … Urgent action is needed if

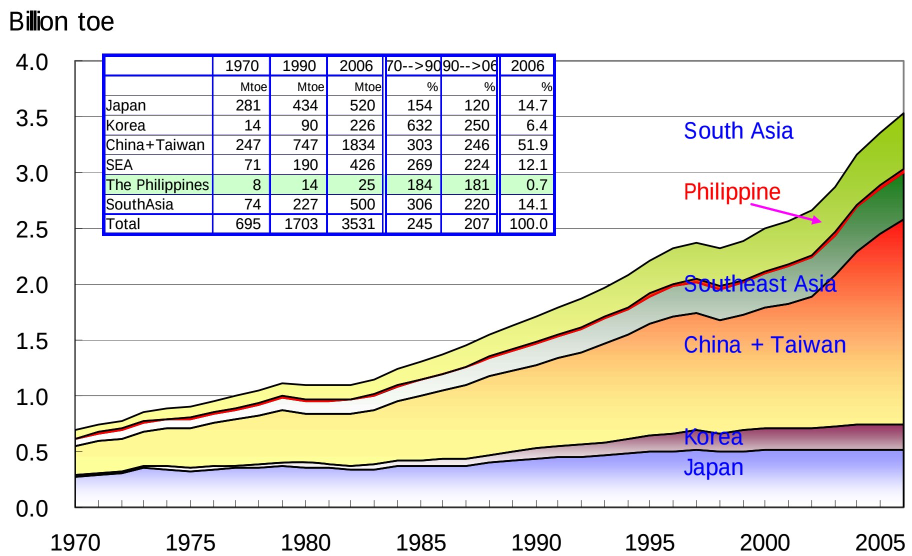
[5] The remaining years of the recoverable reserve are 65.1 years for natural gas and 155 years for coal, which are not immediate threatening. All these figures are for the end of 2005 and cited from the BP Statistical Review of World Energy 2006.

greenhouse gas concentrations are to be stabilized at a level that would prevent dangerous interference with the climate system".

"The emergence of China and India as major players in global energy markets makes it all the more important that all countries take decisive and urgent action to curb energy demand. … Investment now being made in energy-supply infrastructure will lock in technology for decades". Then,

"Many of the policies available to alleviate energy insecurity can also help to mitigate local pollution and climate change, and vice-versa. … In many cases, those polices bring economic benefits too, by lowering energy costs - a 'triple win' outcome".

Energy consumption of the Philippines has increased moderately at around annual 4% since the 1990s and its absolute quantity shares only 0.7% among Asian countries.[6] Although its share is small, given the scale of the energy challenge facing the world, it is important to carefully watch the world energy trend. The Philippines is a net energy importing country, in particular for coal and oil that supply bulk of its energy needs. Although the per capita energy consumption is less than 1/10 of that of the developed countries, energy demand and import of the Philippines will continue to increase along with its economic growth, to be more exposed to volatile movement in the world energy market.



	1970	1990	2006	70-->90	90-->06	2006
	Mtoe	Mtoe	Mtoe	%	%	%
Japan	281	434	520	154	120	14.7
Korea	14	90	226	632	250	6.4
China+Taiwan	247	747	1834	303	246	51.9
SEA	71	190	426	269	224	12.1
The Philippines	8	14	25	184	181	0.7
SouthAsia	74	227	500	306	220	14.1
Total	695	1703	3531	245	207	100.0

Source: Compiled from the BP Statistical Review of World Energy 2007

Figure 3.1-3 Asian Energy Consumption (excluding Middle East)

3.2 Energy Price Trend in the Global Market

3.2.1 Crude Oil Price:

Upon the turn of the century, price of WTI (West Texas Intermediate) crude oil listed at "Futures Market" started gradual increase and the trend turned into abrupt rise after 2003. On January 2, 2008, WTI futures

[6] According to the BP Statistical Review of world Energy 2007, which does not account for geothermal. Including geothermal, the share of the Philippines in the east Asia was 0.9% in 2006 according to IEA statistics.

at NYMEX hit the $100/Bbl benchmark first time in the history. At the Energy Summit of the Philippines held in January-February this year entitled "How to cope with the $100/Bbl Era", various stakeholders were invited to discuss the issues arising from soaring energy prices and how to response to them. While WTI futures price slightly slowed down to $90/Bbl level afterwards, it has surged again above $147 per barrel by the middle of the year; many people would agree that the high crude oil price era has started now.

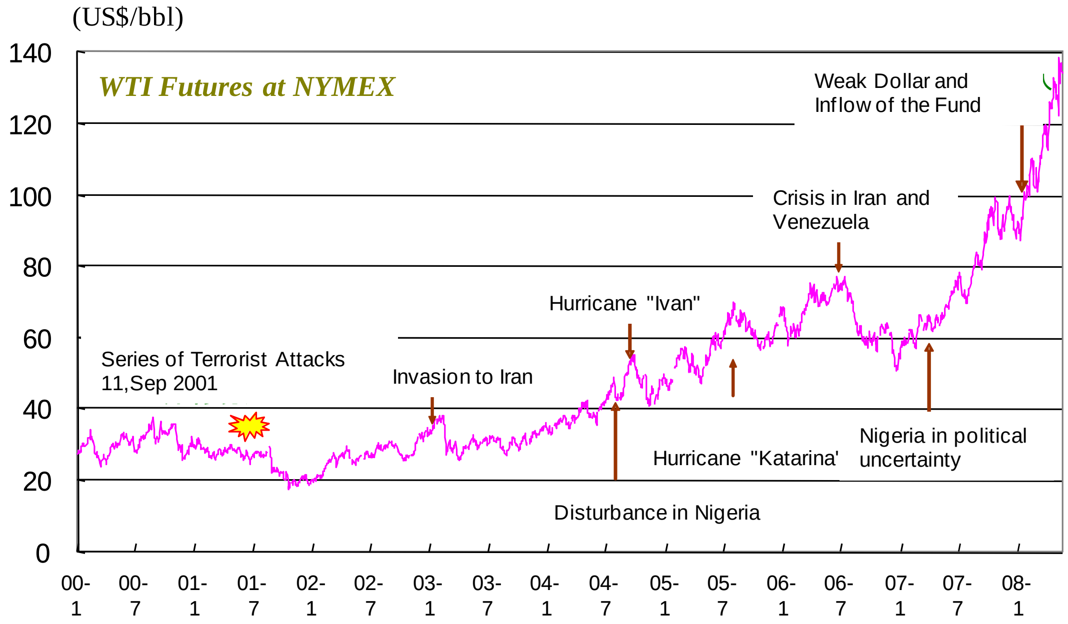


Figure 3.2-1 Trend of WTI

The world crude oil price used to be determined by the international oil companies (Majors) until *the 1973 oil crisis*, and after then by the OPEC countries (the Organization of Petroleum Exporting Countries). During the OPEC dominant time, Arabian Light crude oil (A/L) of Saudi Arabia was nominated as the "Marker Crude" oil to represent OPEC. OPEC Oil Ministers Meeting from time to time determined the price of the Marker Crude oil, and other member countries followed and decided the prices of their crude oils taking into account of the quality differences with A/L such as "API gravity[7]", "sulfur content", etc. These price differences were called "Differentials".

The OPEC crude oil pricing system collapsed in 1986 as the world oil supply/demand balance came to extremely loose, and then the OPEC's leadership in pricing was lost. Next became "oil market" to determine the world crude oil price reflecting the fundamental supply/demand balance. "Spot price", "Netback price", "Futures market price" in the market were referred to as indicators for 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 present world oil market can be roughly divided into three. They are American market, Western market and Asia-Pacific Basin market. There are

[7] 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).

typical futures markets 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.

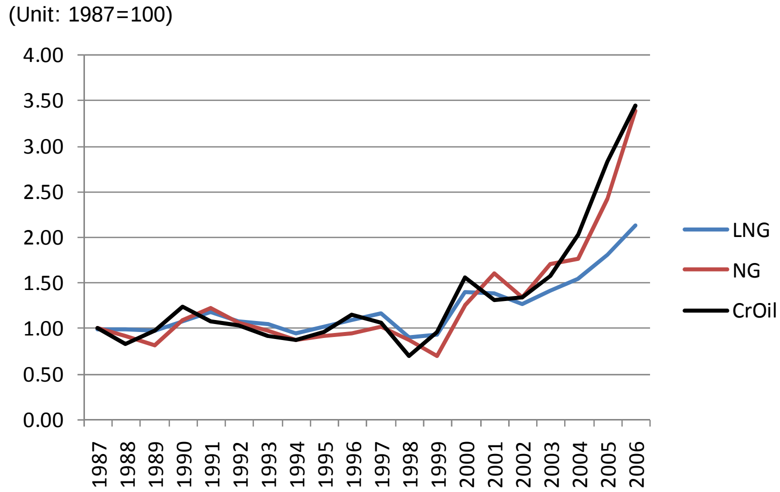
Theoretically speaking, crude oil price should be determined by supply/demand balance of oil in the market, which is provided by the relation between oil demand and the available oil production capacity. In the baseline, while increasing trend of oil demand that centred on China and the United States became stronger since 2000, delay of investment in oil resource development in the upstream, for example, decrease in surplus production capacity of OPEC, and delay of investment in refining capacity in the downstream sector, for example, shortage of upgrading capacity at refineries in the United States and China, came up simultaneously.

Uncertain prospect of Iraqi situation has been keeping fears and uneasiness on the Middle East oil supply. In addition, speculative players have entered actively in crude oil transaction in the commodity market bringing in great price volatility. Today, oil has become "sensitive commodity" as speculative investors play money games for profit irrelevant to actual supply/demand situation. As a result, crude oil price is determined with greater influence of their speculative actions in the commodity market rather than the underlying oil market supply/demand trend. The current oil price is thought to be substantially higher than the price to be defined by the fundamentals.

3.2.2 Natural Gas Price:

Natural gas trade is classified into PNG (Piped Natural Gas) and LNG (Liquefied Natural Gas). At present, piped natural gas trade shares about 70% of the total traded gas and LNG 30%. World main gas markets are European market, North American market and Asia-Pacific market. In 2006, more than 60% of LNG was traded in the Asia-Pacific market where main importers are Japan, Korea and Taiwan. Recently, India and China started import of LNG.

In the Pacific basin market, LNG price is traditionally linked to JCC, Japan Crude Cocktail or the average crude oil price CIF Japan, as the reliable statistics to show an average of bulk oil transaction. The Pacific basin LNG has been priced slightly higher than crude oil in heat value equivalent, but considerably higher than natural gas traded in the US and European market, since such high price was necessary to materialize expensive but environmentally needed LNG projects. Toward the end of the 1990s when potential LNG projects overwhelmed demand, Asian LNG price tended to reduce, and China and India were successful to fix some low price deals, although Asian LNG price started to increase upon the turn of the century reflecting tightening market.



Source: BP Statistical Review World Energy June 2007
LNG=CIF Japan, Natural Gas= CIF EU, Crude Oil= CIF OECD Countries

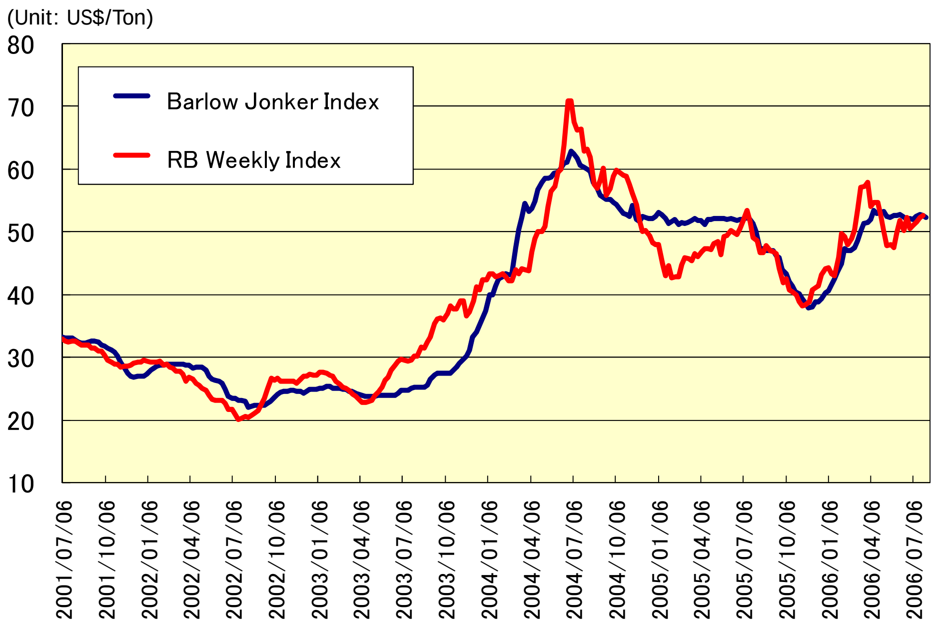
Figure 3.2-2 Natural Gas Price versus Crude Oil Price

Yet the Asian LNG price is substantially lower today compared with natural gas in other markets. Piped natural gas prices in Europe and the USA have been reflecting crude oil price hike directly. Gas price trends at NBP (National Balancing Point) in UK and Henry Hub in the USA show this clearly; natural gas price and crude oil price have followed almost same track. This is because most of the Asian LNG is traded under long-term contracts that are slow to respond to spot price changes in the market. LNG is not widely used in the transportation sector where petroleum product price has been soaring reflecting anticipation on tight oil supply. Therefore, natural gas price in the Asian market might not catch up with the oil price fully in future.

3.2.3 Coal Price:

Coal price is composed of prices under term contracts and spot transactions. Term contract prices of Australian coal, the biggest supplier in Asia, for Japan are decided through negotiation with Japanese power companies for steam coal and Iron companies for coking coal, setting out an annual term contract price or the “benchmark price”. This benchmark price system was adopted widely since late 1980’s in Japan bound trade and elsewhere in Asian market. Benchmark price was set on FOB basis for the representative coal brand and prices of other coals are decided taking into account of quality and heat value differences.

In 1996, advancing the deregulation of power industry in Japan, competitive tendering spread rapidly for steam coal as cost cutting measure and share of trading based on benchmark price has gradually decreased since then. After 1998, Japanese power companies started to negotiate individually with Australian coal shippers to decide term contact of coal. Then, the term contact price between Chubu Electric Power Company and Australian coal companies was adopted as the reference price instead of the benchmark price. After 2003, however, coal price negotiation is conducted without such a reference price.



(Note) BJI (Barlow Jonker Index) — FOB price of steam coal shipped from Newcastle Port in Australia which Barlow Jonker collects to publish (BJI spot price in the Pacific Ocean Market)

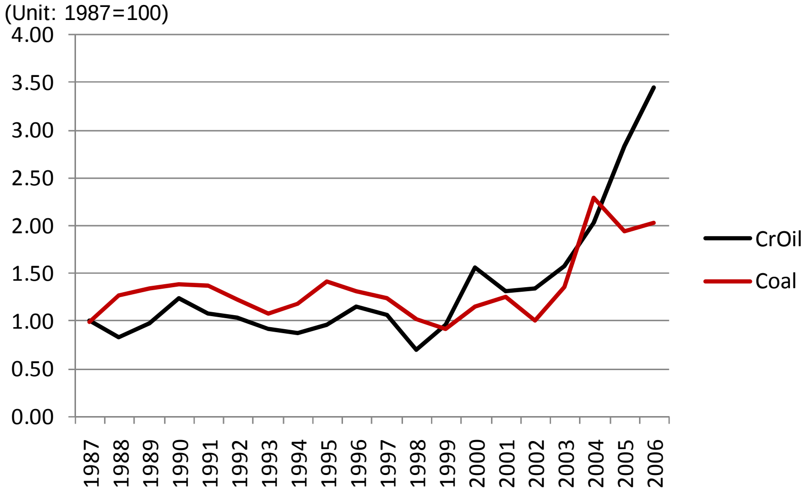
RB Weekly Index—FOB price of steam coal shipped from Richards Bay Port in South Africa which globalcoal collect to publish (BJI spot price in the Atlantic Ocean Market)

Source: Barlow Jonker「Coal Fax」and globalcoal「globalcoal Report」

Figure 3.2-3 Trends of Spot Price of Australian and South African Steam Coal

Japanese average imported coal price of steam coal rapidly increased from $36/ton in 2003 to $41/ton in 2004 and $53/ton in 2005 reflecting worldwide tightening supply/demand balance that became apparent since summer of 2003. In 2006, shippers and buyers experienced hard time to decide coal price caused by big difference in their evaluation of coal supply/demand situation; it took extraordinary long time before the coal price of $53/ton was finally agreed to in July 2006.

Spot price of steam coal is decided in principle based on market mechanism and plays a role as a preceding indicator of the benchmark price decision. In Australian steam coal pricing, spot price of steam coal in the market had not exceeded the term contract price (benchmark price or reference price) substantially. In 2003, however, Australian spot price of steam coal overtook the benchmark price and since then it continued to remain high. From 2004 to 2006, spot price of steam coal fluctuated violently between $61/ton and below $40/ton. Such fluctuation was caused by unstable supply/demand balance of coal reflecting robust demand increase and lagging supply capacity addition. Comparing coal price and crude oil price, both trends resembled each other up until 2004, since then they are following apparently different paths. However, spot price of steam coal broke through $100/ton in late 2007 and rising further closer to $200/ton in the middle of 2008. In addition to India, China has emerged as a big importer of coal in the Asian market. The world biggest coal production country is anticipated to become a net coal importer in 2008. It is necessary to watch international coal price movement carefully.



Source: BP Statistical Review World Energy June 2007

Figure 3.2-4 Coal Price versus Crude Oil Price

3.3 Global Environmental Repercussions[8]

3.3.1 Development of Global Response to Climate Change

During the 1990s, we experienced a great paradigm change relating to energy and environment issues. The dialogue on the Greenhouse Gas (GHG) has turned into actual international actions. The United Nation's Framework Convention on Climate Change (UNFCCC) adopted the Kyoto Protocol at the COP3 meeting in 1997, which was the first comprehensive international agreement with numerical goals of limiting the greenhouse gas emission. Since then, the UN Intergovernmental Panel for Climate Change (IPCC) has made several important reports on the climate change verifying that greenhouse gas concentration in the air would incur substantial increase in the global temperature bringing serious damages to the earth climate system, and that in order to slow the warming rate it is necessary to stabilize CO_2 concentrations reducing its emission substantially below current level. After decades of discussion, this recognition is now widely accepted.

However, the United States pulled out from the Koto Protocol in 2001, while 175 parties ratified it. Since then, Europe and Japan have struggled to find out solutions. Their efforts have recorded substantial progress, for example, start of EUETS (European Union Greenhouse Gas Emission Trading Scheme) and development of CDM/JI (Clean Development Mechanism/Joint Implementation) projects, though effects are still limited without having mega-emission countries that will play substantially greater role on the issue in the long run.

In 2006, Asia-Pacific Partnership (APP)[9] was organized including mega-emission countries such as the

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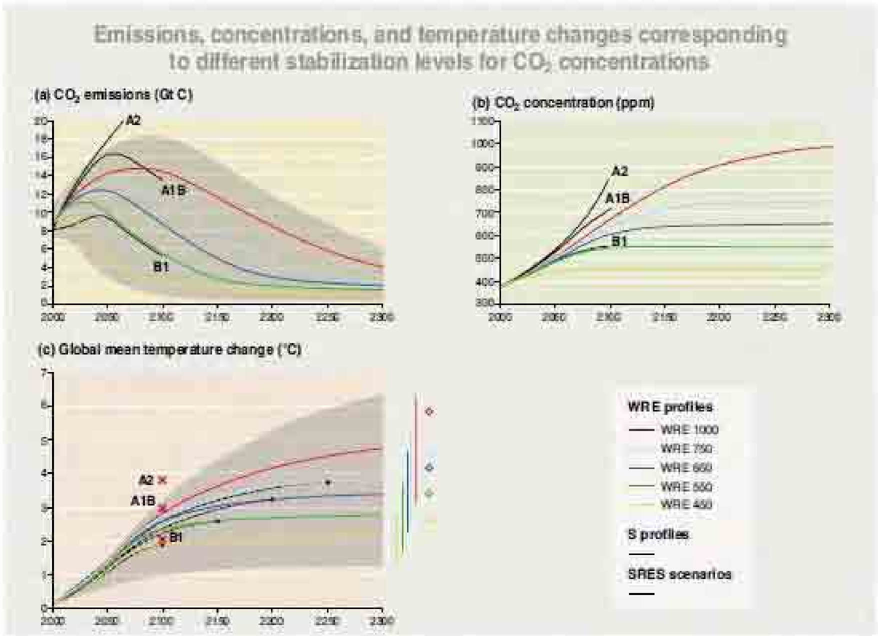
[8] Analysis here is cited from the article "Bali Roadmap to New Framework of Climate Change and the Role of Japan" by Kensuke Kanekiyo, IEEJ Homepage, February 2008.

[9] Asia-Pacific Partnership 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 and Japan were 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.

U.S., China and India, who are not obliged to GHG reduction under the Kyoto Protocol. Under the APP regime, dialogue has started on sectoral approach on improving energy efficiency. Thus, the world is today trying to tackle with climate change in two groups, the top down approach under the Kyoto Protocol (KP) and the bottom up approach under the APP.



Source: IPCC "Climate Change 2001 – Synthesis Report"

Figure 3.3-1 IPCC Third Report Scenarios for Stabilizing CO_2 Concentration

As the Kyoto Protocol regime applies top-down approach or "cap and trade" obligating quantitative target of emission reduction, APP takes bottom-up approach or "pledge and review" to improve energy efficiency in each sector under the concept of "a voluntary, non-legally binding framework". In addition, as Kyoto Protocol aims at reduction of GHG by institutional measures such as Joint Implementation (JI), Clean Development Mechanism (CDM) and Emissions Trading (ET), APP focuses on technology such as promoting technology development and deployment of available technologies, to find out clue to solution of the global warming issues based upon regional cooperation. Although approaches are different, Kyoto Protocol and APP, when combined together, cover about 2/3 of the world GHG emission.[10]

At the 2007 G-8 Summit held at Heiligendam, it was agreed that member countries will "consider seriously the decision made by the European Union, Canada and Japan which include at least a halving of global emissions by 2050". The COP13/CMP3 meeting held in Bali, Indonesia, in December 2007 reconfirmed this time schedule as *Bali Roadmap* to set out the Post-Kyoto Protocol (PKP) framework by 2009.

Thus the activity does not cover the GHG emission fully. Canada joined APP in 2007.

[10] In 2004, top 25 countries covered 82.2 % of the global CO2 emission according to IEA. Other major countries not included in either group as obligatory party are Russia (5.8%), Mexico (1.4%), Iran (1.4%), South Africa (1.3%), Indonesia (1.3%), Saudi Arabia (1.2%), Brazil (1.2%), Ukraine (1.1%), Poland (1.1%), economy of Taiwan (1.0%), Turkey (0.8%), Thailand (0.8%) and Netherlands (0.8%).

Table 3.3-1 Characteristics of CO_2 Stabilization Scenarios

Category	CO_2 concentration at stabilization (2005 = 379 ppm)	CO_2 equivalent Concentration at stabilization including GHGs and aerosols (2005 = 375 ppm)	Peaking year for CO_2 emissions	Change in global CO_2 emissions in 2050 (% of 2000 emissions)	Global average temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity	**Global average sea level rise above pre-industrial at equilibrium from thermal expansion only**	Number of assessed scenarios
	ppm	ppm	Year	Percent	℃	**metres**	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	**0.4 – 1.4**	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	**0.5 – 1.7**	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	**0.6 – 1.9**	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	**0.6 – 2.4**	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	**0.8 – 2.9**	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	**1.0 – 3.7**	5

Source: IPCC Assessment Report 4 (2007)

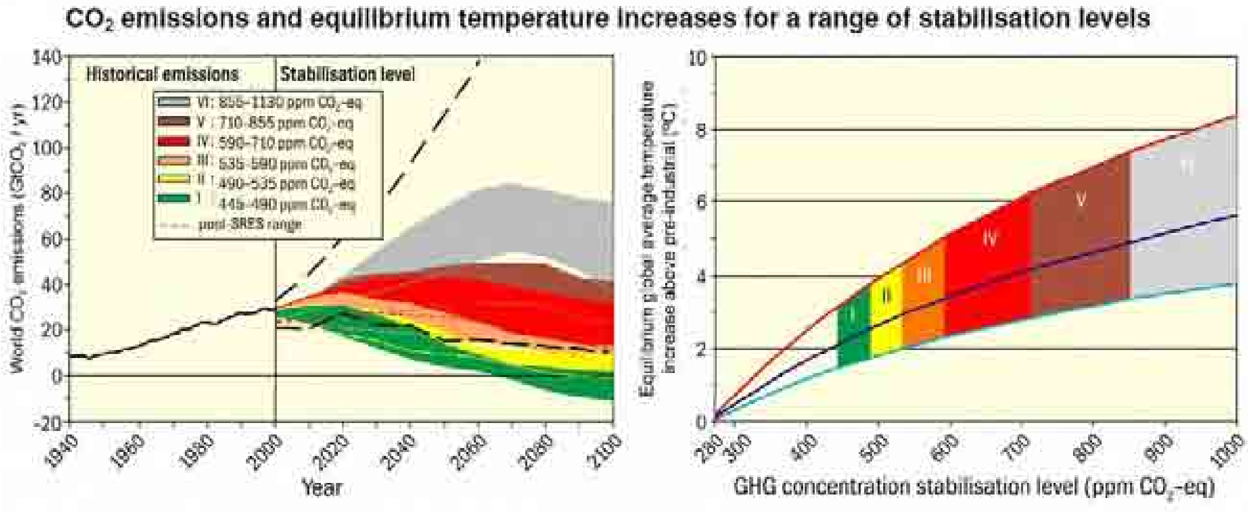
The G8 leaders in Hokkaido agreed that they should seek to share with all Parties to UNFCCC the vision of achieving at least 50% reduction of global emissions by 2050. Before this Summit meeting, according to the request made at the Gleneagles Summit in 2005, the International Energy Agency (IEA) made assessments on the alternative scenarios and reported that in their Baseline scenario the world CO_2 emission would increase from 27 Gt in 2005 to 62 Gt in 2050. The 50% emission reduction under the Blue scenario aims to reduce it to 14 Gt. The difference is enormous. To achieve the ambitious goal, IEA proposed 25 measures of improving energy efficiency and conservation and 17 measures of mitigation assessed in the Energy Technology Perspectives 2008.

In addition to the long-term vision, the leaders also agreed that they should implement ambitious economy-wide mid-term goals in order to achieve absolute emission reductions. The Bali-Roadmap timetable was reconfirmed that the international agreement on the Post Kyoto Climate Regime should be negotiated by the end of 2009.

An important note here is that, when the earlier technical assessment reports were made, it was thought that global warming would be stabilized within 2 degrees Celsius should CO_2 concentration be controlled at 550 ppm or within double of the pre-industrial level of 280 ppm.

However, Stern Review of UK in 2006 reported that, in view of recent rapid increase of emission, "the stabilization would be more appropriate at 450 – 550 ppm".[11] Yet, IPCC Assessment Report Four (AR4) of 2007 stated that stabilization should be achieved by CO_2 concentration of 350-570 ppm and CO_2-e concentration of 445-710 ppm.

[11] "The risks of the worst impacts of climate change can be substantially reduced if greenhouse gas level in the atmosphere can be stabilized between 450 and 550 ppm CO_2 equivalent (CO_2e). The current level is 430 ppm CO_2e today, and it is rising at more than 2ppm each year. Stabilisation in this range would require emissions to be at least 25% below current levels by 2050, and perhaps much more. Ultimately, stabilisation – at whatever level – requires that annual emissions be brought down to more than 80% below current level."("Stern Review on the economics of climate change" Office of Climate Change, UK Cabinet Office, 2006)



Source: IPCC Assessment Report 4 (2007)

Figure 3.3-2 CO_2 Emissions and Equilibrium Temperature

Other important findings of Stern Review are as follows.

1) It would already be very difficult and costly to aim to stabilize at 450 CO_2-e.

2) The annual costs of achieving stabilization between 500 and 550 CO_2-e are around 1% of global GDP, if we take strong action now. If we don't act, the overall costs and risks will be at least 5% of GDP, now and forever, which could rise to 20% if a wider range of risks and impacts is taken into account.

3) Even if the rich world takes on responsibility for absolute cuts in emissions of 60-80% by 2050, developing countries must take significant action too.

4) The power sector around the world would need to be at least 60% decarbonised by 2050 for atmospheric concentrations to stabilize at or below 550ppm CO_2-e.

5) Fossil fuels could still make up over half of global energy supply in 2050. Coal will continue to be important in the energy mix around the world, including fast-growing economies. Extensive carbon capture and storage (CCS) will be necessary to allow the continued use of fossil fuels without damage to the atmosphere.

IPCC estimates global macro-economic costs of mitigation as shown in Table 3.3-2, indicating that reducing the CO_2 concentration below 535ppm would be costly.

Table 3.3-2 IPCC Estimation of Global Macro-economic Costs in 2030 and 2050

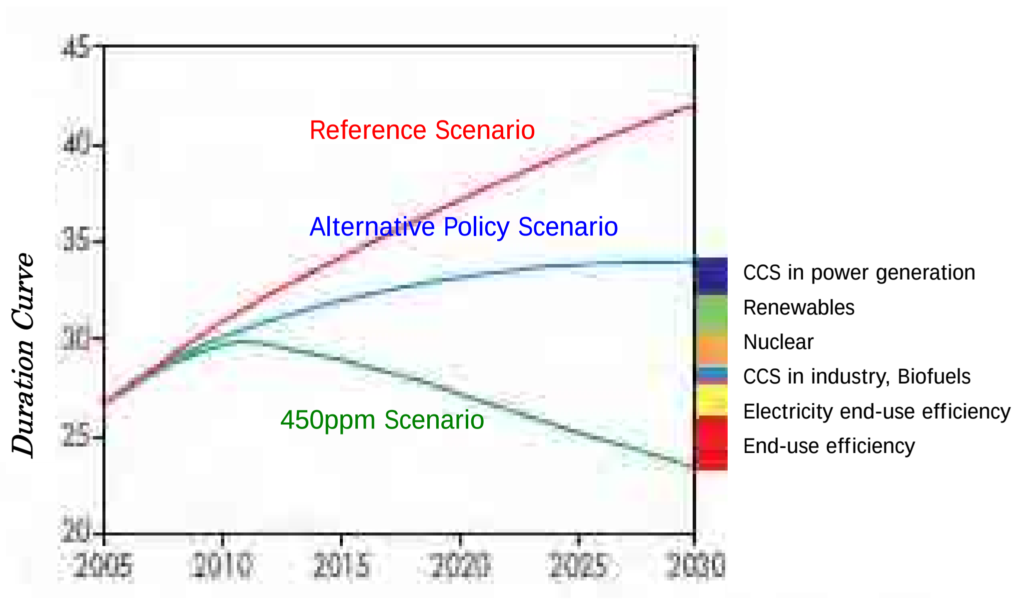
Stabilisation levels (ppm CO_2-eq)	Median GDP reduction (%)		Range of GDP reduction (%)		Reduction of average annual GDP growth rates (percentage points)	
	2030	2050	2030	2050	2030	2050
445 – 535	Not available		< 3	< 5.5	< 0.12	< 0.12
535 – 590	0.6	1.3	0.2 to 2.5	slightly negative to 4	< 0.1	< 0.1
590 – 710	0.2	0.5	–0.6 to 1.2	-1 to 2	< 0.06	< 0.05

Source: IPCC Fourth Assessment Report, Climate change 2007: Synthesis Report

IEA also examined an ambitious target of "450ppm Scenario" in its World Energy Outlook 2007. To realize this scenario, "energy-related CO_2 emissions would need to peak in 2012 at around 30Gt and then decline to 23GT in 2030 – 19Gt less than in the Reference Scenario and 11Gt less than in the Alternative Policy Scenario" as shown in Figure 3.3-3. The analysis is made with a back casting rather than forecasting method and concludes that

- Cleaner and more advanced technologies should be deployed quickly.
- Technologies that are not yet financially viable, including CO_2 captureand storage and second-generation biofuels technologies, should be widely deployed.
- Existing energy-using capital would be prematurely retired at substantial cost.

As a reality, the world is not prepared to peak out the CO_2 emission by 2012 neither deploying non-commercial technologies nor replacing the existing facilities to a substantial extent, though the above conditions could be considered as objectives of long-term energy policy.[12]



Source: IEA World Energy Outlook 2007

Figure 3.3-3 CO_2 Emissions in 450 Stabilization Case

3.3.2 Elements to be considered in Post Kyoto Consensus

The COP13 has, at least, framed a consensus with Bali Roadmap that the Post-Kyoto Protocol framework on climate change should be set up at the United Nations based on the UNFCCC principle of common but differentiated responsibilities of nations. Although it is now recognized that urgent response against climate change is necessary to assure sustainable development, worldwide discussions greatly diverse on its goal, path and responsibility. Following discussion at the Heiligendam Summit, Japanese ex-Prime Minister Mr. Abe proposed "Cool Earth 50" in May 2007, former-Prime Minister Mr. Fukuda reaffirmed this in January 2008, that the world should aim to reduce greenhouse gas emission 50% by 2050.

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[12] These discussions were further developed in particular on the technical aspects in IEA's "Energy Technology Perspective 2008", which was published in June 2008.

Stern Review indicated that developed countries would be required to take much stronger actions than previously discussed. Yet, draft of practical goal, path and responsibility need to be designed before start of discussion toward framework setting, as IPCC has so far shown us simulation results only. In order to avoid same embarrassment experienced in 2001 when the U.S. evacuated from the Kyoto Protocol, the world is needed to prepare meaningful discussion, based on the present reality, toward a practical and equitable solution.

To sort out such solution, intensive discussion will be necessary on the following points.

- The final goal of the greenhouse gas concentration and time schedule to reach the goal
- Participation of all the major nations, especially the U.S., China and India
- Fair and equitable responsibilities of nations
- Institutional system consistent with sustainable development
- Appropriate and effective enforcement system

Among them, goal setting may be the most controversial agenda. It should be discussed in a posture to find out a realistic, technically and economically feasible goal. For example, in order to control the concentration below 500ppm, it is necessary to peak out CO_2 emission by 2015, which is practically impossible unless a crush landing. Therefore, in addition to mitigation measures to curb or reduce emission, possibility of adaptation to cope with global warming should be carefully studied to identify realistic reprieve period and considered in setting the goal. At the same time, in order to assure feasibility of policy action, we should draw up roadmap with intermediate goals through the final goal, as we need to design reasonable and realistic allocation of capital, technology and resources identifying steps and goals for strategic research, technology development and implementation.

It is needless to say that participation of major emitting nations is indispensable to make the agreement thorough and effective. At least participation of core 15 countries (EU + APP + Russia + some others) may be necessary. Climate Dialogue at Pocantigo, where Pew Center plays core role, requests participation of 25 countries that would cover 83% of GHG emission, 71% of the population and 86% of GDP of the world. The U.S. insists at least more than 80% of emitters should participate. Then, as an idea to consider the common but differentiated responsibilities, participants may be divided into three groups, 1) developed countries with binding commitment, 2) emerging countries subject to pledge and peer review based on globally common and objective criteria, and 3) others (developing countries) subject to individual pledge with peer review with support of the other nations.

In order to indicate fair and equitable responsibilities, it is at first necessary to establish a system to accurately evaluate the greenhouse gas statistics. Then, a practical and highly objective *metrics* should be agreed upon, such as per capita CO_2 emission.[13] Then, based on equitable starting points to be agreed, various approaches should be examined and formulated to reach the goal. They are, in the order of easier concurrence, 1) bottom up approach focusing on technology development, 2) pledge and peer review without binding, 3) sectoral approach with top-runner standard and trade restriction, 4) introduction of internationally common standard such as CAFÉ, 5) cap & trade with CO_2 pricing or taxation. It should be

[13] This does not necessarily mean application of same number across the board. However, it is necessary to set out fair and transparent criteria to create equitable index for differentiation.

noted that sectoral analysis on energy efficiency is essential in order to set out goal of each nation for facilitating cap & trade system. Therefore, sectoral approach should be incorporated in the PKP framework complimentary with other measures.

Institutional system to facilitate reduction of greenhouse gas should be consistent with sustainable development of the world economy. In this context, it should be consistent with 1) energy security and energy selection of each nation based on development stage and geopolitical position. Other important factors may be 2) promoting development and diffusion of technologies to curb energy demand and to increase use of clean energy, 3) utilization of market mechanism for cost cutting of greenhouse gas reduction, 4) creation of incentives to participate in technology, product and market development relating to emission reduction. In particular, low-carbon technology development will have substantial impact on the emission reduction in the long run. Technologies on energy efficiency and conservation, clean coal technology (CCT), nuclear technology and development of new and renewable energies and carbon capture and storage (CCS) technology should be highlighted. In their application, pricing mechanism including taxation should be fully mobilized to realize fair and reasonable application.

Finally, appropriate and effective enforcement system is essential to materialize the agreement and the goal. In considering this, it is important to recognize that climate change response is not a process of profit distribution but allocation of negative public goods or public pains. In order to effectively materialize the goal, it is necessary to establish global system under which every stakeholder should take responsibility equitable among nations as well as generations. They should commit to *Ethics* that will play great role in facilitating the global system. In order to smoothly coordinate various factors behind the problem, economic principles and pricing mechanism should be utilized to a maximum extent.

All in all, although it is a long-term goal, in order to implement an extreme reduction of GHG emission such as 50% or 80%, it is necessary to develop revolutionary new technologies, to reform social value system and eventually to create a new civilization. In this context, we may be going to witness another Renaissance in the new millennium.

3.3.3 Way to Post-Kyoto Consensus

To find out the path to the Post-Kyoto Protocol Framework, the Japanese former-Prime Minister Mr. Fukuda requested at the 2008 Davos conference that the United Nations should examine strategies and measures to make global greenhouse gas emissions to peak in the next 10 to 20 years and be reduced by at least half by 2050. He also told that as the chair of the G8 Summit he is "resolved to take on the responsibility in working towards the establishment of a framework in which all major emitters participate as well as the setting of fair and equitable emissions target".[14]

With Bali Roadmap, the world is now set to consider the climate change in double tracks at UNFCCC. Participants are many and they greatly diverse in background and interest. It is not easy even to agree on

14 The Ministry of Foreign Affairs of Japan. At the annual meeting of the World Economic Forum held in Davos, Switzerland, on 26 January 2008, he also proposed that 1) Japan will set a quantified national target for the greenhouse gas emissions reduction, 2) the whole world must make efforts to maximize the improvement of energy efficiency and should set a global target of 30% improvement of energy efficiency by 2020, 3) Japan will establish a new financial mechanism "Cool Earth Partnership" to assist developing countries on the scale of US$10 billion, 5) in the quest for low-carbon planet, Japan will invest over the next five years approximately US$ 30 billion in technology research and development.

how to start discussion, yet we need to agree on goal, path and responsibility as soon as possible in order to establish measures to cope with this urgent problem.

The immediate and most important issue is to set forth the final goal of the world on greenhouse gas emission, identifying equitable starting points and practical paths to reach it. This may be discussed separately for developed countries and developing countries. It is necessary to carefully examine if the IPCC AR4 could be the starting point of the discussion; perhaps, as former-Prime Minister Mr. Fukuda requested, much more scientific verification with realistic strategies and measures would be necessary. Then, the matter may be divided into goals of developed countries and developing countries. Among the developed countries, agreement of three cores, the U.S., Europe and Japan, is necessary. Major issues are if the U.S. could agree to any quantified target and if Japan could find a realistic and equitable goal rather than the symbolic Kyoto Protocol obligation. At first, it is necessary to find out an agreeable method or metrics to indicate the goal. Then, huge amount of scientific study would be required to set out the reasonable goal.

On the side of emerging and developing countries, it is first necessary to study and agree on the method of defining differentiated responsibility and participation. Then, as an implementation procedure, multi-stage approach may be an idea to be examined such that in Stage-1 parties have no quantitative commitment, in stage-2 they have to comply with dynamic “intensity targets” and in Stage-3 they comply with absolute emission targets. But, in view of the urgency of the matter, they should not be allowed to stay in the Stage-1 for longer time. In order to facilitate such goal setting, it is necessary to prepare viewpoints and approaching methods easy to understand and to provide policy development assistances for them. And, as a starting point, it is necessary to conduct energy survey and setup database to grasp the real position and potential of developing nations. All of them are time consuming processes.

At the 2008 G8 *Toyako Summit* Meeting, being an intermediate step between Gleneagles Summit, Heiligendam Summit and Italian Summit, the most important role expected on global climate change was to sort out *a method to set forth the long-term goal*. This is the first bridge we should cross before starting discussion on the quantitative goal as scheduled under the Bali Roadmap, while it seems extremely difficult to find a reasonable solution within limited time. However the matter is urgent, the bridge should be built firm and safe before everybody could cross it. Japan is expected to play an important role to coordinate dialogues among major players toward meaningful agreement, as the United States is expected to come back to the UNFCCC dialogue and China is needed to become an important participant in the Post-Kyoto framework.

3.3.4 Implication for the Philippines

As observed above, global climate change is the matter of world concern today and the Philippines could not stay outside of it no matter how its energy consumption is relatively small. Sea level rise is a serious concern of the archipelago country, which is in a position to ask for world collective action against it. In addition, climate change will become far greater element of the world energy market. Therefore, as an energy importer, the Philippines should closely watch the direction of the climate change issue to develop.

An important fact is that cures for issues of energy security, higher energy price and climate change work in the same direction. That is, a measure good for one disease is good for others also, making our responses easier. For the Philippines as fossil fuel importer, it is apparent that cures to curb or reduce fossil fuel import shall also work to mitigate these impacts.

In this context, creation and activation of the “Cool Earth Partnership Fund” proposed by former-Prime Minister Mr. Fukuda at the G8 Summit meeting is a practical solution to cope with global warming as well as to improve energy security. We hope that, in developing its energy policy, the Philippines will positively consider renewable energy promotion proposed in the plan, effectively incorporating the fund in technology development and social structure reform.

Chapter 4 Structure of Energy Supply/demand Analysis

4.1 Structure of Long-term Energy Model

The long-term energy model developed for the purpose of this study is designed to cover all the energy sectors as a comprehensive model, to cover the period until 2030 and to give calculated supply/demand figures for each year, which will finally be compiled as annual energy balance tables. It is designed to carry out various case studies to examine outcome of different scenarios and policy options. The model can be expanded if necessary.

Analytical tools used in this model are composed of three blocks, namely, Energy Database, Demand Forecasting Model and Supply Optimization Model as shown in Figure 4.1-1. The energy database is a tool to compile the energy data of the Philippines 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 are used from time to time being copied to these models.

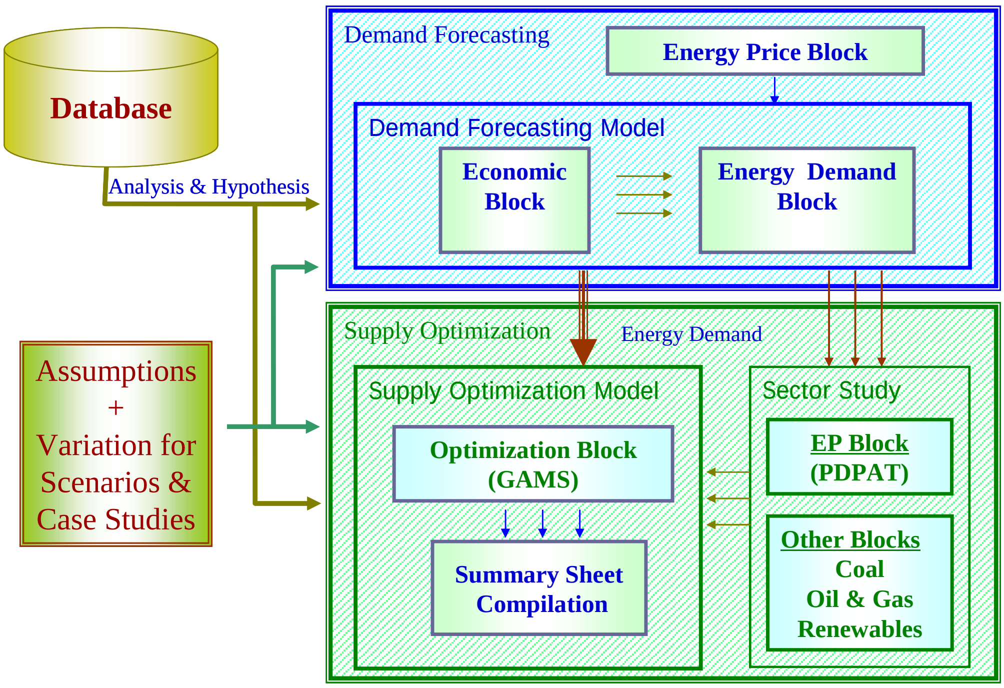

Figure 4.1-1 Composition of Long-term Energy Model

The model section is divided into two blocks, the Demand Forecasting Model and the Supply/Demand Optimization Model and adopts a one-way flow method "from demand forecasting to supply optimization" in view of operational convenience. While the first priority is given to appropriately express the energy system of the Philippines in these models, simplification is tried to the maximum extent to avoid excess enlargement of them. For example, since it is not the main objective of this study to analyze socio-economic trend of the country in detail, it is designed to give socio-economic development scenarios selectively for case studies as preconditions to the model. Starting from such preconditions, the system is designed to analyze energy demand tendencies and policy options to realize energy supply optimization.[15]

The demand forecasting model is further divided as follows. Firstly, an energy price sub-model is attached which calculates the domestic energy price movements in the Philippines referring to given assumptions on the world energy price scenario. The outcome will be used by copying the estimates into the demand forecasting model. Effects of different price scenarios could be examined repeating this process and running case studies as explained below.

The demand forecasting model is composed of the economic block and the energy demand block. While major assumptions on an economic development scenario will be given as external variables, detail economic indicators necessary for energy demand forecasting such as sector GDP are generated in the economic block for further use in the energy demand block.[16] These two blocks are combined in the model and the energy demand estimation results will be obtained simultaneously by giving major assumptions on economic and price elements. The results are output on EXCEL summary sheets to be given to the supply model as inputs.

Then, energy supply optimization calculation will be made by the Energy Supply/Demand Optimization Model (the “Supply Model”) developed for the purpose of this study using linear programming method. GAMS is used as the linear programming software. Calculation results will be output on EXCEL summary sheets including annual energy balance tables. A brief summary table is also output for easy reference to the calculated energy structure and other major indicators. In order to avoid excess expansion of the Supply Model, studies on detail aspects of energy supply system shall be conducted from time to time separately as sector studies, and the outcome will be used to define and adapt assumptions, equations and parameters in the Supply Model. For example, an electric power supply/demand analysis model “PDPAT” developed by Tokyo Electric Power Company may be used to conduct detail analysis of the power sector, and the outcome such as trend of transmission loss and fuel efficiency will be applied to fine tune the Supply Model. In-depth studies of same nature shall be carried out on coal, oil & gas, and other sectors also.

As the work procedure, in case to change the price conditions, it is necessary to run three models in the order of 1) price model → 2) demand forecasting model → 3) energy supply model. In case assumptions on the demand forecasting were changed, two models after 2) shall be run. Likewise, in case of changing energy supply conditions, the last model under 3) shall be run. As the case study procedure is a little bit complicated like this, it is designed to improve the operation and maintenance convenience by dividing the model into several blocks.

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

[16] Detail economic indices such as sector GDPs and DGE sub-items should be, by their nature, decided by study with a macro-economic model specifically designed for such purpose. It is not favorable, however, to incorporate such an economic model into the demand forecasting model since it would make the latter complicated and would cause operational troubles. Thus, the system is designed to handle these indices as exogenous variables as far as possible. As we need these macro indices to run the model, a conventional method of estimating them are shown in the next item,

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 determined 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, since assumptions and parameters are not exact but approximate values.

In the real world, it is impossible to give the model perfect assumptions and parameters. And, from model operation viewpoint, it is desirable to make the model as simple as possible. After all, we should keep it in mind that these models are the tools to evaluate differences among future scenarios and/or effects of policy options, so as to project and examine future plans for the desirable society (a dream as objective), measures to realize it (strategies) and paths toward it (roadmaps) 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, strategies and roadmaps 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.

4.2 Scope of Energy Supply/demand Analysis

In this study, it is intended that the long-term economic outlook to be provided by NEDA (National Economic Development Agency) shall be applied in due course. For the time being, however, as long-term economic outlook provided by NEDA covers only to 2010 at this moment, we will apply the following economic development scenarios for trial model run.

4.2.1 Scenarios on Economic Development

In discussion of long-term economic outlook, the Cobb-Douglas production function is often cited as shown below.

$$Y = A \cdot L^{\alpha} \cdot (\gamma K)^{(1-\alpha)}$$

where Y denotes GDP, L is Labor Force input, K is Capital Stock, A is Total Factor Productivity and γ is capital Utilization Rate. This equation can be made a linear one taking logarithm on both sides as follows.

$$\log Y = \log A + \alpha \log L + (1-\alpha) \log (\gamma K)$$

In general, contributions of factors of production such as labor force, capital stock and productivity to overall economic growth are calculated applying regression analysis on the linear equation as shown above. Applying this method, the Asian Development Bank (ADB) has estimated the contributions of these factors in the past economic development of the Philippines as shown in the Table 4.2-1.

Table 4.2-1 Contributions of Factors of Production to GDP Growth of the Philippines

	Contribution of TFP Growth	Contribution of Labor Growth	Contribution of Capital Stock Growth	Contribution of TFP and Capital Growth
	(⊿A/A)	α (⊿L/L)	(1－α) (⊿K/K)	
	(a)	(b)	(c)	(a+c)
	%	%	%	%
1961-1970	0.06	1.18	3.98	4.04
1971-1980	-0.64	1.38	4.57	3.93
1981-1990	-1.62	1.37	2.05	0.43
1991-2000	0.25	0.87	1.77	2.02
2000-2006	2.41	1.24	1.12	3.53

Source: Asian Development Bank Country Diagnostics Studies "Philippines: Critical Development Constraints", December 2007.

As analyzed above, the economy of the Philippines has returned on to a high-growth trend in 2003 after the Asian currency crisis of 1997 and is recording strong growth in these years. Real GDP growth rate rose to 5.0% in 2005 and further strengthened to 5.4% in 2006 and 7.3% in 2007. It is expected to remain high at 6.5-7.0% in 2008. Current economic boom is backed by highflying service industry such as call centers and other type of oversea services thanks to international IT development and increasing transfer by OFW (Overseas Filipino Workers). These have further induced active construction nationwide. Given that the current trend persists, real GDP growth rate between 2005 and 2010 may record a historically high rate of 6.5% per annum. However, this trend may become moderate in the long run.

In the past, the Philippines recorded very high population growth rate exceeding annual 2%, but according to the forecast of the United Nations it will slow down nearer to 1% in the long run. The world economy led by extremely strong Chinese and Indian economic growth may slow down facing various issues relating to energy supply, global financial system and climate change. Thus, we assume that the average growth rate would be 5% for the entire period of 2005 through 2030 as the base case, and 6% for a high growth case and 4% for a low growth case. However, viewing that recent skyrocketing energy price together with the US financial scandals are going to seriously affect the world economy, the long-term economic scenario should be examined carefully.

Table 4.2-2 Economic Development Scenarios

	Population	R-GDP		
		Reference	High Case	Low Case
	%	%	%	%
05 --> 15	1.7	6.0	6.8	4.5
15 --> 30	1.3	4.4	5.5	3.7
05 --> 30	1.5	5.0	6.0	4.0

Source: Population growth rates cited from UN Population Division's annual estimates and projections

Under the above scenario, the Philippines will overtake the current Thailand in aggregate GDP by 2015 and in per capita GDP by 2030. Size of the economy will expand 3.4-fold between 2005 and 2030 for the Reference Case, 4.3-fold for the High Growth case and 2.7-fold for the Low Growth case. That is, 2/3 of the 2030 economy will be totally new additions to the current one. These newly emerging economic sectors could not be projected on the extension of the past economic trend. Instead, it should be thought that future economic growth will be brought about by development of new business sectors that the past Philippine did not have such as international call centers and high grade legal services. Therefore, in compiling long-term energy outlook, it is important to imagine and draw up *the grand design of the future economy* rather than simply applying the past trend.

The greatest driving force toward such economic growth may be induced by the foreign direct investment (FDI) favoring the economic difference with neighboring countries. To attract them appropriately, however, it is very important to upgrade the quality of labor and infrastructure, and securing stable energy supply is one of important factors to realize this.

Assuming that Thailand economy would grow at 4% per annum, the above scenarios may be shown as below. The aggregate GDP, at 60% of that of Thailand in 2005, will become 76% by 2030 in the Reference Case, and catch up with Thailand by 2030 in the High Growth Case, while it remains at 60% even in 2030 in the Low Growth Case.

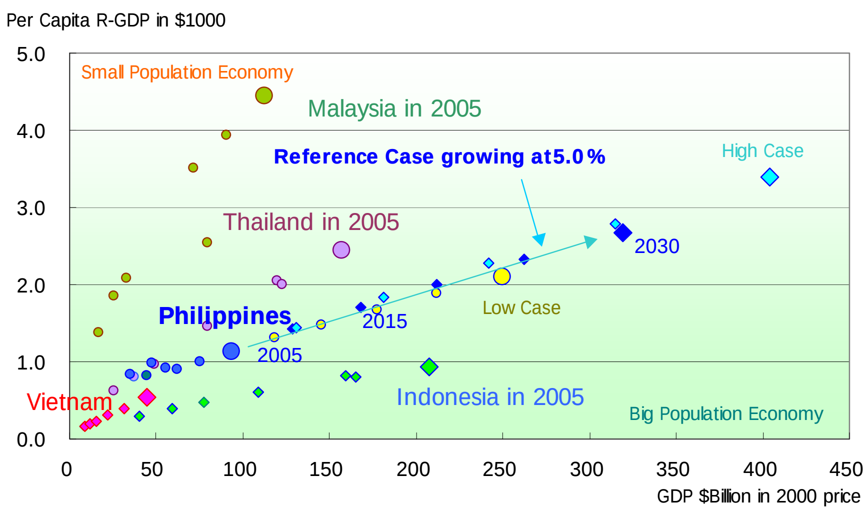


Figure 4.2-1 The Philippines and ASEAN Countries

Per capita GDP, which was slightly above $1,100 (in 2000 US dollar) in 2005, will exceed $2,000 by 2020, or it will almost double, and will come close to $2,700 by 2030. That is, assuming annual 2.5-3% inflation, nominal per capita GDP will exceed $5,000 well before 2030, which is almost double of the current level of Thailand or same with the current level of Malaysia. On the other hand, from historical observation, prices of most of modern home appliances and cars would be least affected by inflation. Therefore, we should consider that urbanization and modernization of life would progress to a great extent in the projection period reflecting robust growth of nominal income.

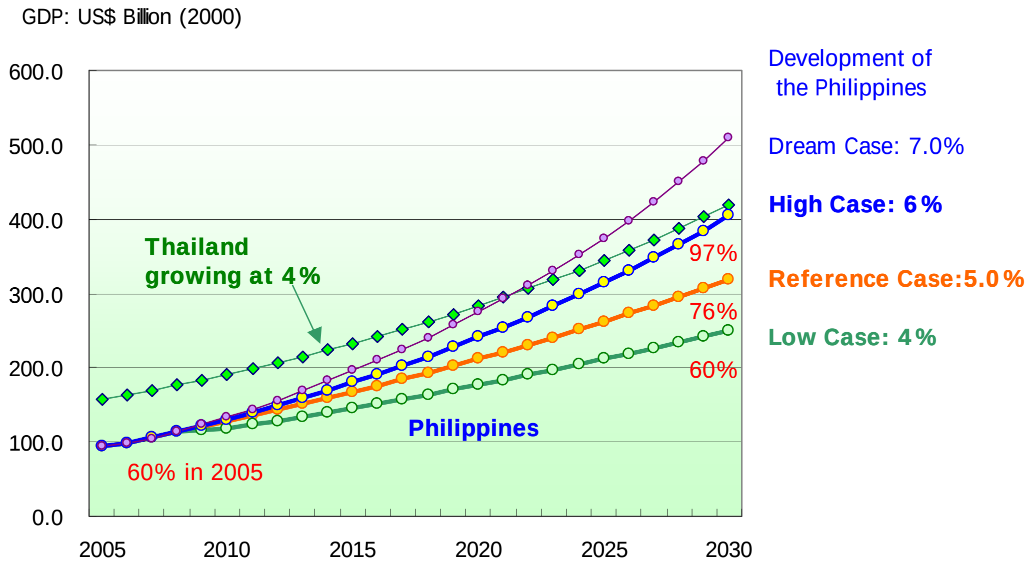
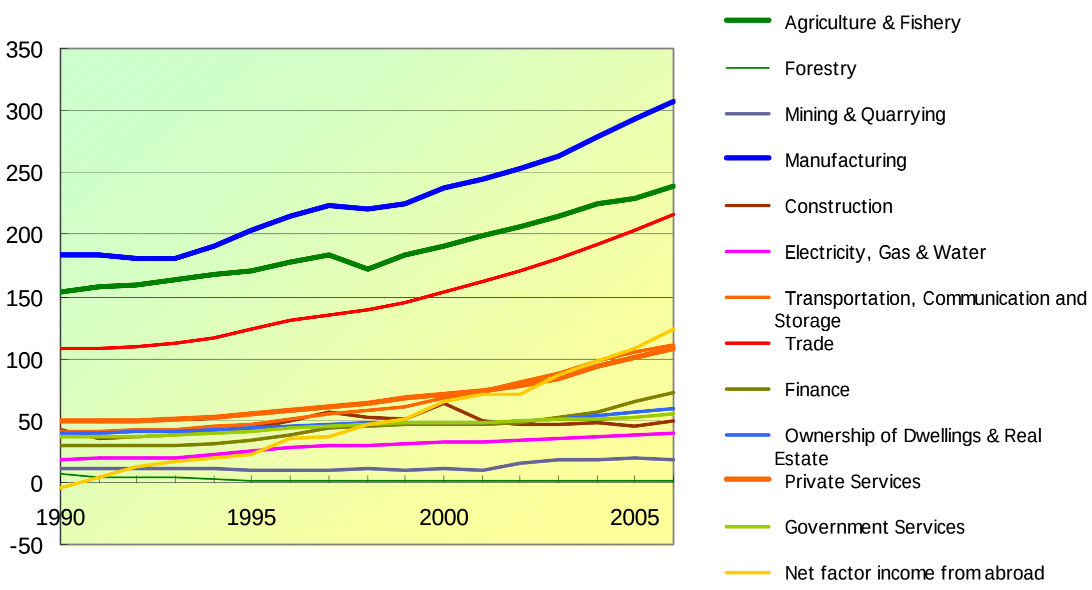


Figure 4.2-2 The Philippines catch-up Thailand

4.2.2 Projection of Sector GDPs

In considering the energy demand trend, it is important to identify which sectors would play important roles as the leading sector of economic development. Sectoral indices such as sector GDP or IIP are important to indicate characteristics of economic growth. In case of the Philippines, sector GDPs are aggregated as shown in Table 4.2-3.



Source: General Statistics Office "Philippine Statistical Yearbook"

Figure 4.2-3 Sector GDP of the Philippines

In conducting energy demand forecast, segmentation in the energy consumption statistics may give us an idea to what extent sector GDP should be segmented or aggregated. According to the 2007 energy balance table of the Philippines as shown below, the largest energy consuming sector is the transportation sector, sharing 42.8% of the total energy consumption of the country, followed by the residential sector at

Table 4.2-3 Final Energy Consumption by Sector (2007)

INDUSTRY	5232.7	21.5%
Manufacturing	5103.6	21.0%
Beverages	179.1	0.7%
Tobacco	20.1	0.1%
Coco/Vegetable Oil	38.9	0.2%
Sugar	814.1	3.3%
Other Food Processing	996.2	4.1%
Textiles/Apparel	139.5	0.6%
Wood Prod/Furniture	19.4	0.1%
Paper Prod/Printing	102.6	0.4%
Chemicals Except Fertilizer	328.3	1.3%
Fertilizer	30.4	0.1%
Rubber/ Rubber Products	21.8	0.1%
Glass/Glass Products	98.1	0.4%
Cement	1410.1	5.8%
Lube Refining	0.3	0.0%
Other Non-Metlc Minerals	122.4	0.5%
Basic Metal	287.3	1.2%
Machinery/Equipment	398.1	1.6%
Other Manufacturing	96.9	0.4%
Energy Intensive Sector Total	**3938.6**	**16.2%**
Mining	42.4	0.2%
Construction	86.7	0.4%

TRANSPORT	10406.2	42.8%
Railway	9.2	0.0%
Road Transport	7767.5	31.9%
Water Transport	1501.1	6.2%
Domestic Air Transport	46.4	0.2%
International Civic Aviation	1082.0	4.4%
RESIDENTIAL	6293.2	25.9%
COMMERCIAL	1991.9	8.2%
AGRICULTURE	134.2	0.6%
Agri Crops Product	60.0	0.2%
Livestock/Poultry	6.7	0.0%
Agri Services	52.0	0.2%
Forestry	1.3	0.0%
Fishery	74.2	0.3%
OTHERS, NON-ENERGY USE	277.4	1.1%
Net Domestic Consumption	24335.6	100.0%

Source: DOE

25.9% and manufacturing sector at 21.0%. Commercial sector shares only 8.2% and no detail sub-sector records are available.

As we will discuss the energy demand forecasting method in detail in Chapter 6, it should be noted that energy demand forecasting are being made giving emphasis on important sectors as above in a manner that analysis by transportation mode is applied for transportation fuel estimation and the energy intensive manufacturing sectors are highlighted on industrial fuel consumption estimation. In this context, Segmentation of GDP may be sufficient with following eight sectors, which are Agriculture/Forestry & Fishery, Mining, Manufacturing, Construction, Transportation & Communication, Trade & Services and Government Sector.

While the Sectoral GDP should be projected with in-depth analysis engaging econometric model, a conventional method is applied here to derive provisional assumptions for model test run giving attention on the point how each sector would perform in relation to the overall economic movement. The following equation is applied for projection of sector GDPs to consider changes in elasticity of sector GDP against the aggregate GDP.

$$Y_t = Y_{t-1} \times (1 + \text{GDP Growth Rate} \times (A - B \times \text{Year}))$$

Here, "A" is the elasticity of the sector GDP over the aggregate GDP in the previous year, and "B" is the annual change of the elasticity. In the stagnant economic sector, the current elasticity "A" is already low, and it would not change greatly in future. In the leading sector of the economy, elasticity "A" is high and would not lower in future as far as it continues to play the same role. In the emerging sector that may calm down sometime, elasticity "A" is high but slowing down speed "B" is also high. In this analysis, A is calculated as an average of the past five years since single year figures are erroneous, and B is assumed arbitrarily considering development potential and trend of each sector. It is recommended that these assumptions should be examined carefully among those concerned before running the model. Actual equations and parameters applied in this study are as follows.

Agriculture, F&F Y t = Y t-1 x (1+ GDPGR x (0.8 - (Time-2006) x 0.004))

Elasticity of sector GDP will gradually decline from 0.8.

Mining Y t = Y t-1 x (1+ GDPGR x (1.6 - (Time-2006) x 0.05))

Elasticity will keep a high level for sometime, and then slows down.

Manufacturing Y t = Y t-1 x (1+ GDPGR x (0.9 + (Time-2006) x 0.01))

Manufacturing sector has been relatively stagnant in recent years but will catch up gradually.

Construction Y t = Y t-1 x (1+ GDPGR x (0.5 + (Time-2006) x 0.015))

Construction sector may continue slow growth.

Transportation and Communication Y t = Y t-1 x (1+ GDPGR x (1.6-(Time-2006) x 0.02))

Communication sector will continue to be the leading economic sector.

Public Utilities Y t = Y t-1 x (1+ GDPGR x (0.8 - (Time-2006) x 0.01))

This sector should provide platform for the economy with steady growth.

Private Services Y t = Y t-1 x (1+ GDPGR x (1.1 - (Time-2006) x 0.005))

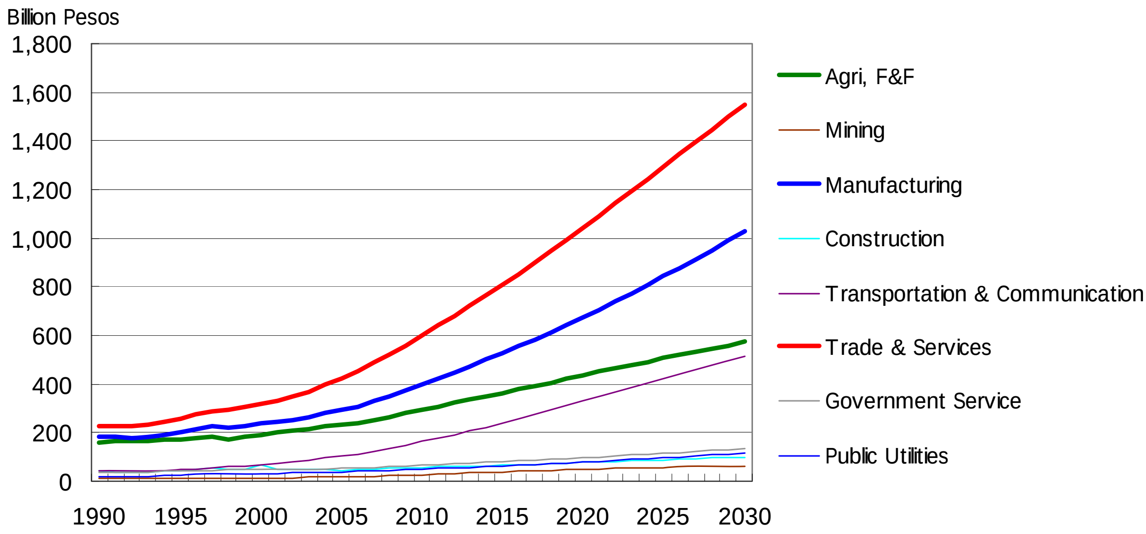
Service sector will, together with the communication sector, plays leading role in the economy.

Government Services Y t = Y t-1 x (1+ GDPGR x (0.55 + (Time-2006) x 0.01))

This sector will grow slow but steady reflecting needs of developing social welfare.

As the above assumptions are made for the Reference Case, contribution of manufacturing and services sectors as the driver of the economic growth will be greater than above for the High Growth Scenario. Likewise, contributions of these sectors will be smaller for the Low Growth Scenario, while contribution of stable sectors such as government service will be relatively higher.

Projection of sector GDP applying the above conventional method is shown in Figure 4.2-5. In terms of the relative weight over the aggregate GDP, it is assumed that contribution of the trade and services sector will be the largest followed by the manufacturing sector. We do not elaborate on the background of these assumptions here. However, in discussion of appropriateness on the long-term economic outlook, it is necessary to demonstrate the long-term grand design of the economy and examine coherence of these assumptions and projections.

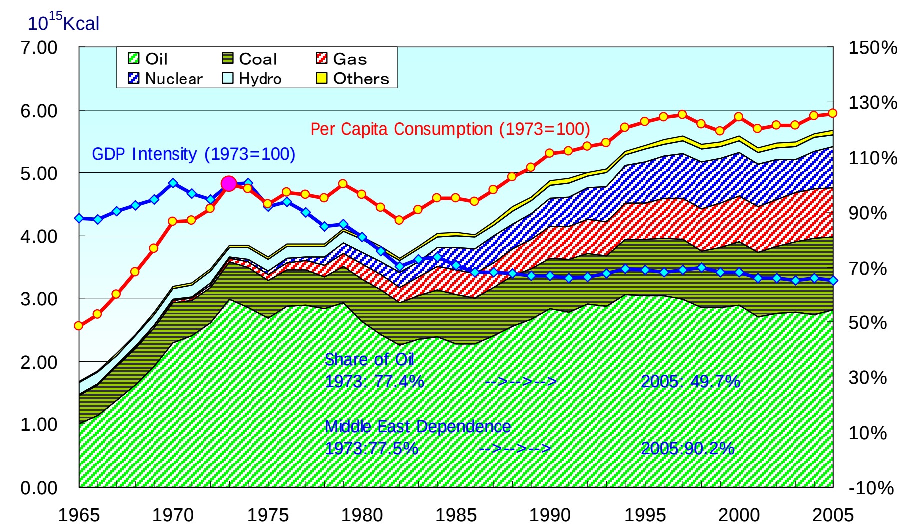


Growth Rate	Agri & FF	Mining	Manufactur -ing	Construc- tion	TranspCom	Public Utilities	Trade & Services	Govt Services	GDP
	%	%	%	%	%	%	%	%	%
1990-2006	2.5	3.4	3.3	1.0	6.4	4.9	4.4	2.6	3.6
1998-2006	4.2	7.4	4.2	-0.6	8.4	3.5	5.5	2.2	4.6
2005-2010	4.9	6.3	6.2	4.2	9.2	5.6	7.1	4.5	6.3
2010-2020	4.0	6.1	5.4	3.2	7.3	4.8	5.7	4.0	5.3
2020-2030	2.8	2.5	4.3	2.7	4.6	3.9	4.0	3.3	3.9

Figure 4.2-4 Projection of Sector GDP: Reference Case

4.3 Energy Efficiency and 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. 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.



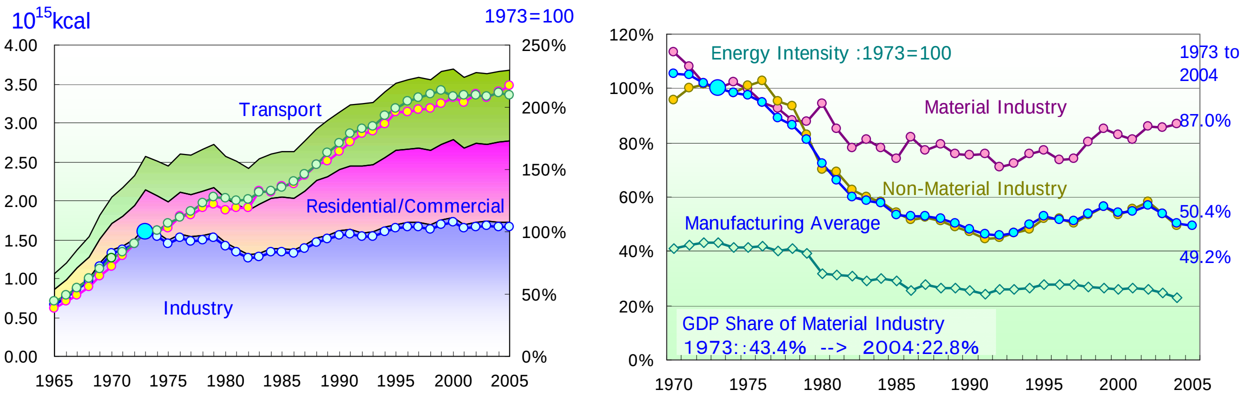
Source: IEEJ Handbook of Energy and Economic Statistics in Japan

Figure 4.3-1 Energy Consumption per GDP in Japan

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 Japan 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.

Looking into the above progress more in detail, we notice the following remarkable tendencies as shown in Figure 4.3-2.

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 4.3-2 Evolution of Energy Intensity by Sector

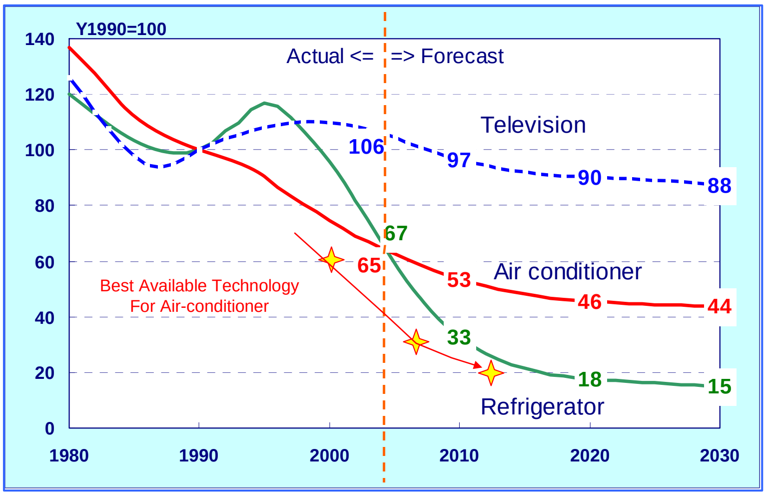
Energy conservation may be implemented through improvement of the energy efficiency of energy using appliances and equipments, high efficiency operation and effective maintenance work. Among them contribution of efficiency improvement of appliances/equipments is most effective. Since these equipments 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 and equipments reveals cumulatively. For example, suppose that the energy efficiency of the latest model of an appliance is 10% higher than the average efficiency of the social stock and the social stock may be replaced in 10 years, energy efficiency will progress 1% every year if there were no further improvement on the new models.

As shown in Table 4.3-1, 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 the efficiency of the 1998 model. Of the 2005 newest model, this is again reduced to 2/3 of the 1998 model. 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. There are committees on each item to examine the program consisting of more than 20 experts and technical 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 persevering effort of the industries toward such target, Japan has achieved the results as shown in Table 4.3-1.

Table 4.3-1 Improvement of Energy Efficiency under 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 4.3-3 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 the Philippines, since the economy is going to expand 3.4 fold in the coming 20 years, 70% 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.

4.4 Scenarios on Energy Price

4.4.1 Assumption on Crude Oil Price by International Energy Agency (IEA)

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 to forecast the future crude oil price but to assume certain scenarios, setting out price scenarios such as "Reference case (Business as usual)" and "High price case", considering the international oil market situation. The same method is adopted in this study setting out scenarios such as the "Reference Scenario (including BAU scenario)", and corresponding "High Price Scenario" and "Low Price Scenario" as explained later.

As explained in the previous chapter, WTI futures at NYMEX hit $100/Bbl in January 2008 and continued to hike exceeding $147/Bbl in the middle of the year. Prices of natural gas and coal are also

Table 4.4-1 Forecast of Fossil Fuel Prices by IEA

(unit: $/unit)

IEA Forecast							Japan CIF
BAU Case	Unit	2000	2006	2010	2015	2030	2007.12
Real Terms (year-2006 price)							
IE Crude Oil Imports	Barrel	32.49	61.72	59.03	57.30	62.00	90.79
Natural Gas							
United States Imports	Mbtu	4.49	7.22	7.36	7.36	7.88	
European Imports	Mbtu	3.27	7.31	6.60	6.63	7.33	
Japanese LNG Imports	Mbtu	5.49	7.01	7.32	7.33	7.84	9.26
OECD Steam Coal Imports	tonne	39.05	62.87	56.07	56.89	61.17	77.24
Nominal Terms							
IE Crude Oil Imports	Barrel	28.00	61.72	65.00	70.70	107.59	
Natural Gas							
United States Imports	Mbtu	3.87	7.22	8.11	9.08	13.67	
European Imports	Mbtu	2.82	7.31	7.27	8.18	12.71	
Japanese LNG Imports	Mbtu	4.73	7.01	8.06	9.05	13.61	
OECD Steam Coal Imports	tonne	33.65	62.87	61.74	70.19	106.14	
High Growth Scenario							
Real Terms (year-2006 price)							
IE Crude Oil Imports	Barrel	32.5	61.7	64.4	66.8	87.0	
Natural Gas							
United States Imports	Mbtu	4.5	7.2	8.0	8.6	11.1	
European Imports	Mbtu	3.3	7.3	7.2	7.7	10.3	
Japanese LNG Imports	Mbtu	5.5	7.0	8.0	8.6	11.0	
OECD Steam Coal Imports	tonne	39.1	62.9	57.6	60.9	72.7	

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 "IEA World Energy Outlook 2007".

soaring fast dragged by crude oil price. Compared with such market trend, most of the international price scenarios are those set out last year being deemed as already outdated. For reference, the energy price scenario set out in the “IEA World Energy Outlook 2007”is as follows.

In this study, it was assumed that an average IEA crude oil import price in the BAU Case is projected to rise slightly to $62.00/barrel in 2030 from $61.72/barrel in 2006 in real term in 2006 dollar. In a nominal price, it rises from $61.72/barrel to $107.59 /barrel during the same period on the assumption that the deflator would grow at 2.3% per year. In the IEA outlook, “High Growth Scenario” is also assumed where the crude oil price in 2030 is projected to be higher by $25/barrel in real term than the “Base Case”; that is, $87/barrel in real term, reflecting strong global demand.

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

(1) “Reference scenario”

World crude oil price fluctuates widely affected by various factors. In the “Reference Scenario”, we suppose the following factors.

a) Oil supply/demand situation (crude and refined products) will continue the present trend.

b) World economic growth will continue the present trend.

c) Speculative capital movement in the “Futures market” will continue the present trend.

Taking account of these market circumstances, many organizations such as IEA and The Institute of Energy Economics, Japan adopt “Leveling-off” or “a marginal rise in real term” price scenario as their “Reference scenario”. As the “Reference Scenario” for this study, considering the fact that 1) the actual world import FOB price was $70/barrel in 2007 (the World export FOB price of USDOE database), 2) but the recent WTI futures is at the level exceeding $130/barrel, and that 3) the crude oil price CIF Japan recorded $100/Bbl in April 2008, it is assumed that it will increase to $120/barrel in 2008 on average and, extending the current trend, it will reach $160/Bbl by 2030 in real term of 2006 value.

(2)”High price scenario” and “Super High Price Scenario”

“High price scenario” is the case that the international oil market would become very tight supply-demand situation and crude oil price would soar considerably more than the “Reference Scenario”. Background to suggest such a situation is as follows.

a) Investment in oil field development would delay while oil demand continues to increase in Asian continues, such as China and India, and the USA.

b) Constraint of oil resources would be clearly recognized worldwide as the Peak Oil theory suggests.

c) Speculative capital like investment funds would actively play around in the futures market exaggerating the price fluctuation bandage and yielding more volatile situation.

It is assumed that the oil price will rise to $200/barrel by 2030 in the High Price Scenario and $240/Bbl in the Super High-Price Scenario.

(3) "Low Price Scenario"

Judging that the present crude oil price is raised more than the expectation by factors other than the demand and supply balance, that such abrupt price hike would invite demand reduction and that supply/demand balance in the market would be restored sooner or later, it is possible to consider a scenario that crude oil price would fall back to the ordinary situation. In this scenario, we suppose preconditions as follows.

a) World economic growth would slow down reflecting the various elements such as "sub-prime loan crisis" in the USA and completion of the Beijing Olympic Game. Oil demand increase may take a breather.

b) Investment in energy supply would increase reflecting high energy price, and thus world energy supply/demand balance would loosen.

c) Speculative capitals would draw back to other markets or get short of fund.

In this scenario, crude oil price may settle down at around $120/barrel and then continue the same level up to 2030 in real term of 2006 value.

Figure 4.4-1 shows actual changes in the world crude oil import price (nominal term) and future assumptions by above price scenarios.

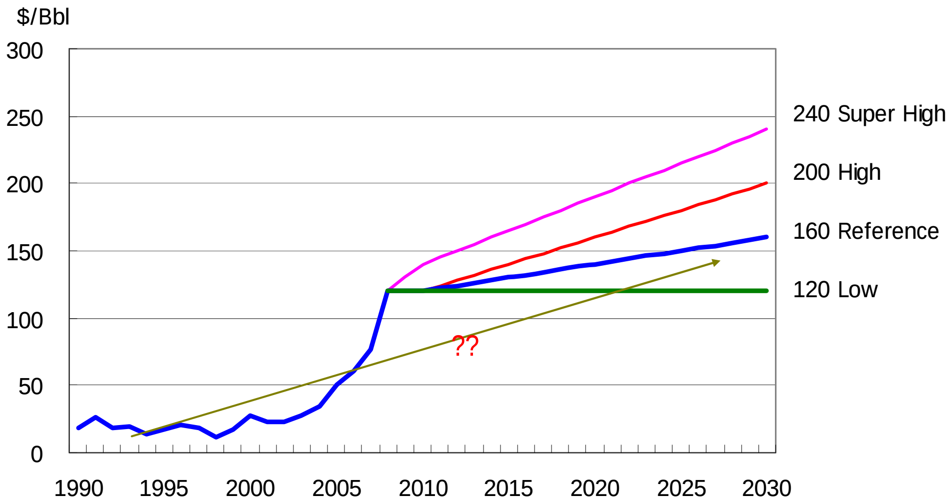


Figure 4.4-1 Actual World Average Import Price (FOB) and Forecast by Scenario

4.4.3 Future Natural Gas Price Scenarios (including LNG)

Natural gas price in the Asian market is determined referring to crude oil prices as was seen in the previous chapter. Thus, in setting scenarios for future natural gas price, it is appropriate to refer to changes of crude oil price. In this study, we set out four price scenarios on crude oil; "Reference

Scenario", "High Price Scenario", "Super High Price Scenario" and "Low price Scenario". They are applied in setting natural gas price scenarios.

Natural gas price formula is presently in transition, decoupling from crude price, reflecting greater element of spot price, etc. But it may continue to be more or less linked to crude oil price in principle. In this study, it is assumed that natural gas price changes in parallel with crude oil price changes. It is also assumed that, when natural gas is imported to or exported from the Philippine, the transaction pattern must be LNG as pipeline gas trade would not be feasible considering the geographical circumstance.

In the Reference Case, the LNG price CIF Japan is forecast to be $12.7/MMbtu in 2008 corresponding to crude oil price of $120/barrel. This price may reach $19.5/MMbtu in 2030. In the High Price scenario, it will jump to $24.3/MMbtu corresponding to crude oil price of $200/barrel and in the Super High-Price Scenario $29.2/MMbtu corresponding to crude oil price of $240/barrel. In the Low Price scenario, LNG price will be $12.7/MMbtu corresponding to crude oil price of $120/barrel. Figure 4.4-2 shows these LNG price scenarios.

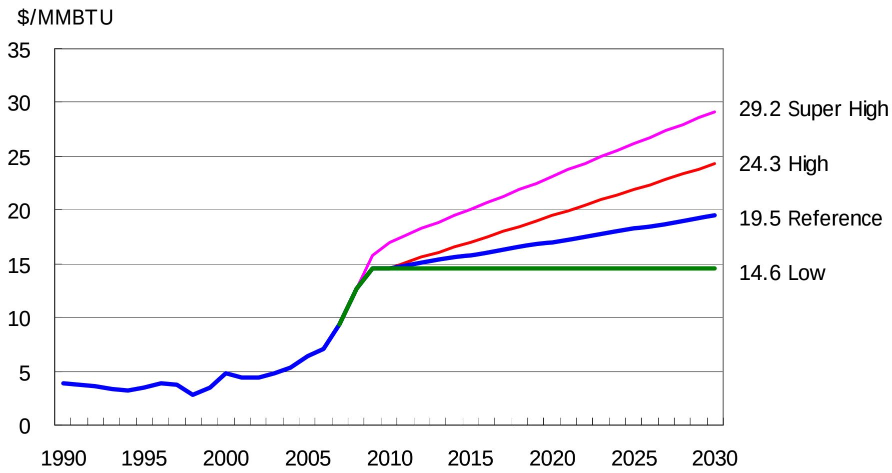
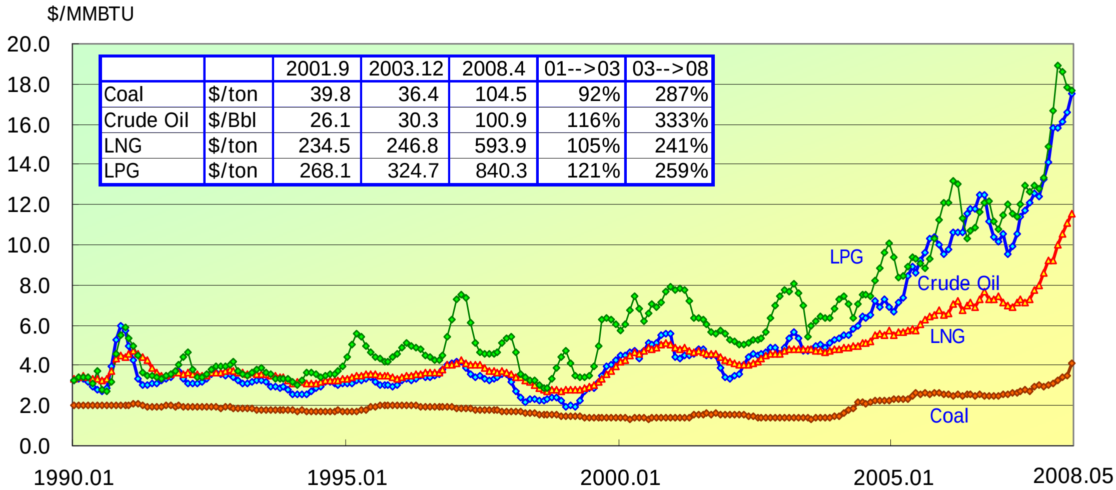


Figure 4.4-2 Actual LNG Price (CIF Japan) and Forecast by Scenario

4.4.4 LPG Price

As illustrated in Figure 4.4-3, LPG price in the international market fluctuate most roughly among various energies. This is caused by the characteristics of LPG supply. As LPG is produced at refineries, from associated gas at oil fields and at LNG plants, LPG is an associated product in all of these cases and its yield is relatively small. On the other hand, since it is a clean energy source easy to handle, its demand is growing worldwide. In the past, Saudi Arabia, being the world biggest LPG supplier exporting LPG recovered from associated gas from its huge oil production, has led decision of international LPG price. Since the world biggest LNG plants are under construction in Qatar accompanying huge incremental LPG supply, supply balance may continue to be slow by about 2010. Despite this underlying trend, its price has been fluctuating violently in the same manner as observed in the past.



		2001.9	2003.12	2008.4	01-->03	03-->08
Coal	$/ton	39.8	36.4	104.5	92%	287%
Crude Oil	$/Bbl	26.1	30.3	100.9	116%	333%
LNG	$/ton	234.5	246.8	593.9	105%	241%
LPG	$/ton	268.1	324.7	840.3	121%	259%

Figure 4.4-3 Energy Prices (CIF Japan)

The international price of LPG has been at around 110% of crude oil price in the international market, and this trend is adopted in the projection. It will reach $1,000/ton in response to the crude oil price of $120/Bbl in 2008, and will further rise to $1,400/ton by 2030. It is assumed to reach $1,800 in the High Price case and $2,200 in the Super High-Price case.

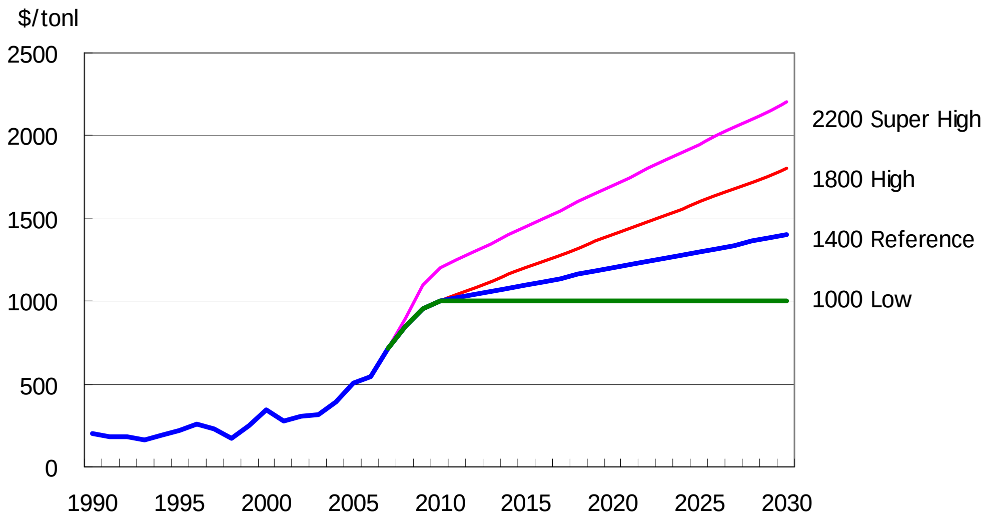


Figure 4.4-4 Actual LPG Price (CIF Japan) and Forecast by Scenario

However, it should be noted here that LPG supply balance in the international market would be affected the alternation of the existing LPG demand in emerging countries, with substantial quantities being substituted by piped gas and/or LNG as observed in China when natural gas based city gas system is introduced. LPG supply is not on the one-way trend toward tightening like this, and thus we need to watch the global market movement closely.

4.4.5 Coal Price Scenarios

Traditionally, international coal price has been substantially lower than those of oil and natural gas in heat value equivalent. This is because coal is deposited abundant and widely in the world and not clean nor convenient for use. However, even coal price is increasing rapidly in these years.

As discussed in the previous chapter, traditional style of coal price decision on term contract may continue in the Asia-Pacific market. However, participation of emerging players such as India and China may increase impact of spot transactions on it. In future, more Asian countries may enter the international coal market or increase international procurement as their energy requirements increase since coal is thought to be abundant and a relatively cheap fuel even in future. Coal in the Asia-Pacific market is full of uncertainties. In this study, it is assumed that coal price would cease to be traditional slow coach and move in parallel with changes in crude oil price because of such uncertainties.

For the Reference Case, the Australian coal price (FOB) will become \$120/ton in 2008 corresponding to crude oil price of \$120/barrel. After then it will reach \$160/ton in 2030 in real term of 2006 value. In the High Price scenario, it will jump to \$200/ton and in the Super High-Price scenario \$240/ton in 2030. In the Low Price scenario, it would remain at \$120/ton until 2030. Figure 4.4-5 shows these coal price assumptions.

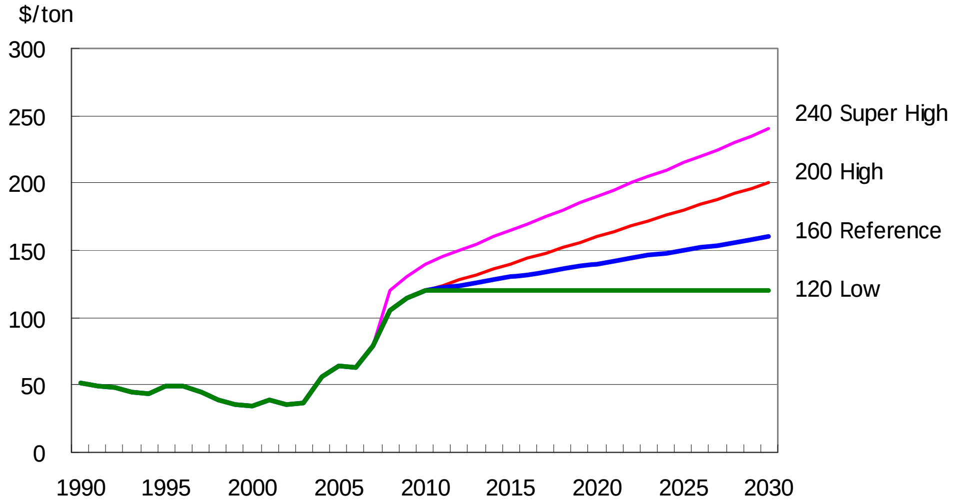


Figure 4.4-5 Actual Coal Price (FOB Australia) and Forecast by Scenario

4.4.6 Domestic Energy Price Scenarios in the Philippines

Recent movement of domestic energy prices in the Philippines compared with the international prices is as shown in Table 4.4-2. While prices of crude oil and natural gas are in the range of international prices, coal is relatively cheaper as domestic production is of low quality. The international LPG price is CIF price. On the other hand, the domestic price includes delivery and marketing cost and therefore it is about 50% higher than the international price.

Table 4.4-2 Energy Prices: International Price versus Domestic Price

		Unit	2000	2001	2002	2003	2004	2005	2006	Average
Crude oil	Intrnational	PHP/litter	7.53	7.29	7.62	9.24	12.20	17.28	19.47	11.52
	Philippines	PHP/litter	7.30	7.30	7.70	9.14	11.86	17.84	19.83	11.57
	Ratio	%	97%	100%	101%	99%	97%	103%	102%	100%
Coal	Intrnational	PHP/kg	1.53	1.99	1.85	1.97	3.12	3.54	3.26	2.47
	Philippines	PHP/kg	2.11	1.20	1.10	1.00	1.70	2.00	1.90	1.57
	Ratio	%	138%	60%	59%	51%	54%	57%	58%	64%
Natural Gas	Intrnational	PHP/MMBt	215	226	229	259	300	352	366	278
	Philippines	PHP/MMBt	192	271	260	293	318	347	380	294
	Ratio	%	89%	120%	114%	113%	106%	99%	104%	106%
LPG	Intrnational	PHP/litter	7.63	7.11	7.77	8.60	10.98	13.86	13.85	9.97
	Philippines	PHP/litter	9.90	10.60	10.40	12.30	15.40	19.10	24.30	14.57
	Ratio	%	130%	149%	134%	143%	140%	138%	176%	146%

Source: International price by IEEJ and domestic price by DOE

In the projection for this study, we assume that the domestic energy prices will in principle move linked to international prices and project as follows.

Crude oil and natural gas prices will move at almost in the same range with international prices.

Coal price may be affected by increase of export demand as well as international prices with increased import, and the ratio against the international price will increase to 70% gradually.

LPG price may, as the import CIP price soars, decrease its domestic cost ratio gradually and will become 140% of the international price.

Prices of petroleum prices such as gasoline and diesel oil will move along with crude oil price.

Same principles will apply for the High Price and Low Price cases.

Table 4.4-3 Projection of Domestic Energy Price: Reference Case

	Unit	2000	2005	2010	2020	2030	Versus 2005 2010	2020	2030
							%	%	%
Crude Oil	Peso / litter	7.3	17.8	33.9	39.5	45.2	190	222	253
Coal	Peso / kg	2.1	2.0	3.2	4.1	4.9	161	203	246
Natural Gas	Peso / mmBtu	192.0	346.9	642.1	749.1	856.1	185	216	247
LPG	Peso / litter	9.9	19.1	30.8	37.0	43.1	161	194	226
Gasoline	Peso / litter	15.0	30.7	53.1	65.3	79.9	173	213	260
Kerosene	Peso / litter	11.7	29.5	52.8	64.9	79.3	179	220	269
Jet Fuel	Peso / litter	15.2	32.6	59.6	74.1	91.6	183	227	281
Diesel	Peso / litter	12.1	28.8	50.4	61.7	75.0	175	214	260
Fuel Oil	Peso / litter	9.7	18.9	38.2	45.3	53.0	202	240	280
Electricity(Average)	Peso / kWh	4.5	6.8	12.0	14.0	16.1	176	206	236
Electricity(Residential)	Peso / kWh	4.8	7.0	12.8	14.8	16.8	182	211	240
Electricity(Commercial)	Peso / kWh	4.5	7.2	12.3	14.4	16.5	171	200	230
Electricity(Industrial)	Peso / kWh	4.3	6.2	11.2	13.1	14.9	181	211	241

Though it may be necessary to conduct in-depth analysis on the electric tariff, we set out a conventional fuel price index composed of coal, natural gas and fuel oil with a ratio of 1:1:0.5 and assume that the electricity tariff will change according to this index. However, in view that energy prices are soaring in recent years, we assume that the ratio of electricity tariff against this index would gradually go down.

Projection of the domestic energy prices applying the above method is shown in Table 4.4-3. This is at any rate a conventional projection. Domestic energy prices usually reflect important national energy policy including energy taxes and subsidies, and are of course a politically sensitive issue. Therefore, we need to carefully handle this matter. However, as seen in the demand simulation results to be discussed in Chapter 6, price effect of energy demand is relatively small. Therefore, by way of applying such conventional method, we would not incur serious difficulties in the discussion on the direction of the long-term energy policy.

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 Philippine Energy 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 Philippines economy would grow at a speed of annual 5.0% and the world energy price would remain at the current level throughout the simulation period. Preliminary energy outlook of the Philippines according to IEEJ study run in 2007 is summarized as follows.

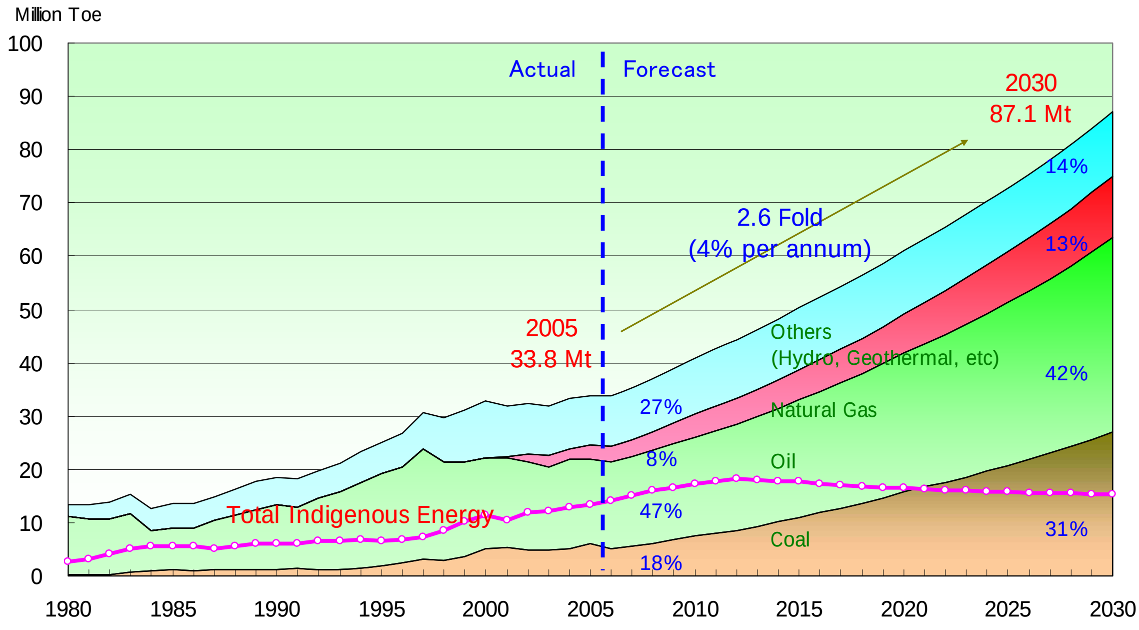


Figure 4.5-1 BAU Case versus Reference Case

1) The final energy demand will increase at an annual growth rate of 4.0%, reaching 2.6 fold of that of 2005.
2) Due to resource constraints, the domestic energy production will peak out before 2015 unless large-scale discoveries were made.
3) As a result, the self-sufficiency ratio of energy supply will decrease rapidly. The self-sufficiency ratio excluding non-commercial energy would decrease from 40% to 18% and fossil energy ratio increases

from 73% of 2005 to 86% in 2030.

As we will examine the simulation result applying the demand forecasting model in Chapter 6, the underlying trend is mostly similar. Although energy consumption trend of the Philippines is relatively moderate compared with other ASEAN counties, rise of dependence on imported fossil fuel incurred by demand increase is a threatening to its sustainable development. It would not be possible for the Philippines to continue the current trend unchecked as projected in the BAU Case, as 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 much as possible.

In this context, the Reference Case for this study is set out that, with enhanced energy conservation of annual 0.5%, energy consumption would be decreased by 8% in 2015 and by 15% in 2030 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

a. Economic growth scenario

Setting the economic growth rate for the reference Case at 5%, growth rate changes of plus/ minus 1% should be examined.

b. Energy price scenario

Setting the crude oil price at $160/Bbl in 2030 for the Reference Case, High Price case of $200/Bbl, Super High Price case of $240/Bbl and Low Price case of $120/Bbl will be examined.

c. Energy conservation scenario

Setting the annual 0.5% EEC for the Reference Case, EEC Promotion case of annual 1.0% and Super EEC case of 1.5% will be examined.

d. Motorization scenario

In addition to the Reference Case, Vehicle Plus case will be examined where car ownership may increase 10 to 25% in 2030.

2) Factors relating to change of supply conditions

a. Introduction of nuclear power plants of 1,000 MW from 2025, while the Reference Case does not include any nuclear power.

b. Natural gas utilization: Decline of domestic gas production from Malampaya gas field may occur during the projection period. In order to compensate this, LNG import may start from 2020, which may be implemented in two phases. Phase-1 starts in 2020 with 0.5 million tons per annum import and gradually build up to 1.5 Mton/year in three years. Then, Phase-2 starts in 2025 similarly building up to 1.5 Mton/year in three years.

c. Geothermal power plant scheduled to start operation in 2015 onward will be accelerated to double the currently scheduled incremental capacity.

d. Introduction of biofuel will be accelerated and the incremental quantity may become double of that assumed for the Reference Case.   In addition, various biofuel promotion scenarios will be examined.

Detail outcome of various case studies as explained above and their implications will be discussed in Chapter 6 and Chapter 7.

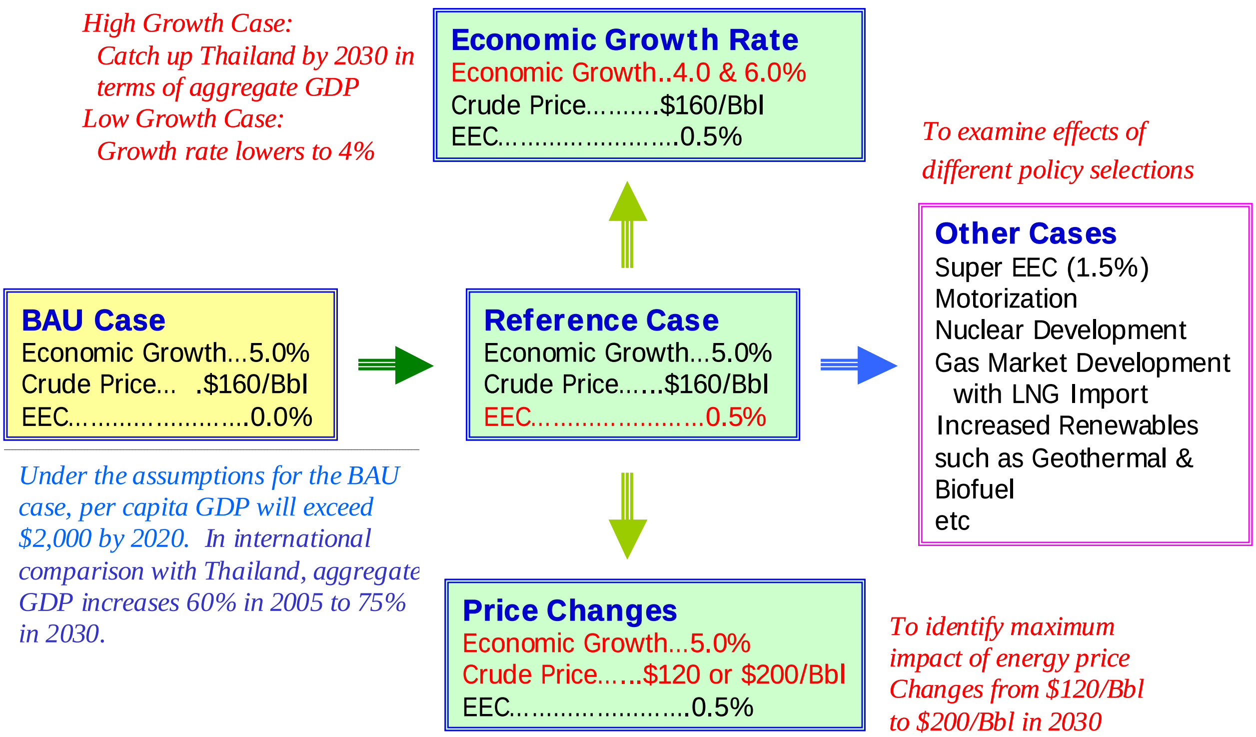


Figure 4.5-2 Case Setting

Chapter 5 Energy Supply Outlook in the Philippines

In this chapter, we will discuss on observations and assumptions on the supply of various energies that will be applied in the analysis of long-term energy outlook. These energy sources may be classified into three categories, namely, 1) fossil fuels such as coal, oil and natural gas, 2) nuclear, and 3) renewable fuels such as hydropower, geothermal power, biofuels and other various natural energy sources. In addition, since electricity is very peculiar energy and in the sense it requires huge amount of investment to reinforce the supply capacity, it is necessary to carefully look into the supply side issues facing the electricity sector.

5.1 Fossil Fuels

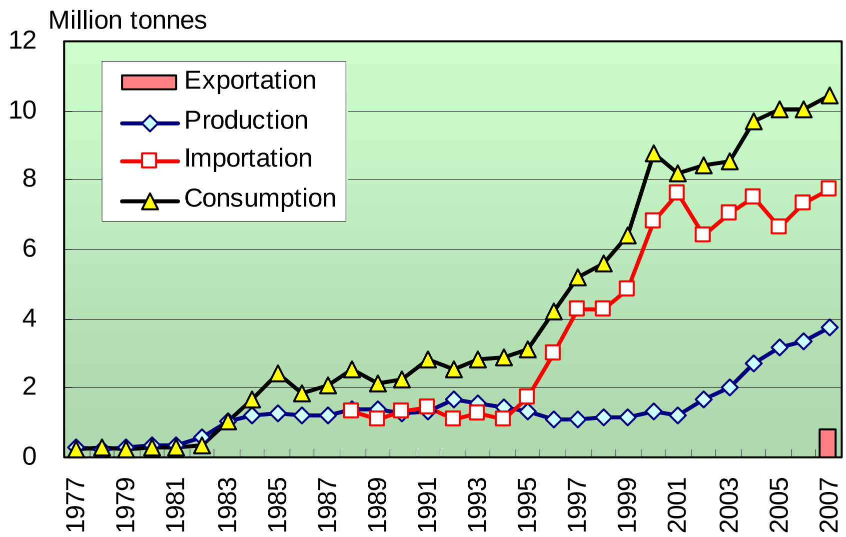
In the Philippines, major part of energy requirement is supplied with fossil fuels. It is forecast that fossil fuels will remain as the main energy source in future. As domestic energy sources are not very abundant, incremental demand needs to be supplied by import. Thus, in formulating the long-term energy strategy, it is important to understand at first the potential of indigenous energy supply as firm as possible.

5.1.1 Coal

In 2007, coal supply in the Philippines is estimated at approx. 11.4 million tons, of which 3.7 million tons or 32% is domestic coal, whereas 7.7 million tons or 78% is imported coal. Therefore two thirds of the coal supply is dependent heavily on imported coal. However, domestic coal production is increasing at an annual average rate of 20% since 2002. Domestic coal production excluding that of small-scale mines in 2007 reached the highest on record, indicating the domestic coal supply is steadily on an increasing trend. Coal imports also increased at an annual average growth rate of 31% between 1995 and 2001, although the growth slowed down since 2001. Nevertheless, coal import reached a record high in 2007. Figure 5.1-1 shows the trend of coal supply and demand in the Philippines for the past 30 years.

Semirara Mining Corporation that accounts for 94% of coal production for the whole country has a production capacity of 4.0 to 4.5 million tons in 2007. Meanwhile, domestic coal delivery in 2007 grew by 7.3% to 2.78 million tons, although it did not reach the production capacity. The production capacity at Semirara is planned to expand to 5.0 million tons per year by the end of 2008. This is based on the strategy to expand coal exports commencing from February 2007. Destinations for the exports are India, China and Hong Kong, and they are projected to continuously expand in the future.

When current pit bottom level (-260 meters) of their Paniran region goes even further, recoverable coal reserve will increase, but current stripping ratio of 11 bench cubic meters per ton would also increase. While it will be a function of the total volume of production, the economic mine life lasts only for around 10 years at an annual production rate of 3 million tons. In order to secure coal reserves, the company is studying to expand the mining area to the shore side. Concerning the newly developing Himalian area, it is necessary to remove the limestone covering the coal bed in the area, and it will not be capable of full production during the first 10 to 15years in the development stage.



Note: Production is not including small coal mine's one.
Source: GCRDD/ERDB/DOE

Figure 5.1-1 Trend of Coal Supply and Demand of the Philippines

The other coal suppliers are generally small with an annual production volume ranging from several thousand tons to around tens of thousands of tons, where their combined production volume amounts to only about 200,000 tons. Locations of production area are dispersed nationwide in such places as Cebu, Mindro, Negros, Samar, Surigao Del Sur and Zamboanga Del Sur. These coal producers basically play a role of coal supply to local consumers around the coalfield areas.

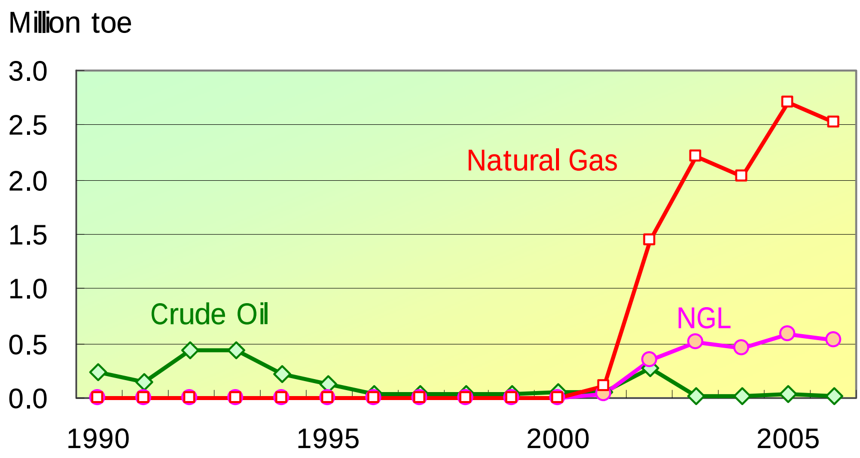
According to the coal supply plan by the DOE, coal deposits of 580 million tons will be confirmed by 2030, and it is also expected to increase the domestic production to 10 million tons annually that is 2.5 times the current level by concluding 25 coal production contracts in total. Furthermore, the DOE has a plan to approve 10 of the coal bed methane development projects between 2011 and 2030 to promote the development and utilization of the resources.

5.1.2 Oil

Crude oil production of the Philippines in 2006 was 0.18 million barrels. Most of the liquid hydrocarbon production comes from the Malampaya gas field as a form of condensate, while there is a small quantity of crude production as a lasting tail production of old oil fields. Malampaya condensate is directly exported from the offshore production facility as it is too light for processing at domestic refineries. At present, however, Galoc oil field offshore northwest Palawan is under development and expected to start production in 2009 at a rate of about 20,000 barrels per day. Nearby Octon oil field is also deemed to be prospective. As production of the leg oil at the Malampaya gas field is being discussed, technical feasibility is yet to be confirmed.[17] In addition to active seismic acquisition, 35 wells are planned for drilling between 2007 and 2014. The oil and gas sector targets to increase the country's proven oil and

17 Production test from the thin oil layer existing below the natural gas reservoir at Malampaya was conducted for three months in 2002. For continued production from such layer, it is necessary to maintain a sensitive pressure balance with the upper gas reservoir and the lower water zone to avoid their penetration, making it a technically difficult task.

gas resources to 20 percent within the planning period from 2007 to 2014. However, even if they were successful, they could be put in operation only after years from now. At any rate, the current proved recoverable reserve of the Philippines is not substantial. Based on it, oil production in the Philippines may remain in minimal quantity and most of the required oil needs to be imported.



Source: DOE

Figure 5.1-2 Oil and Gas Production in the Philippines

In view of the dependency on import, oil supply security is one of the priority issues in the energy sector, where the following items shall be considered:

1) Promotion of exploration and production of indigenous resources

2) Promotion of overseas exploration and production activities

3) Refinery expansion including regional integration with overseas sites for assured supply of petroleum products with environmentally friendly quality

4) Strategic petroleum stockpiling in the country and accommodation among regional countries

5.1.3 Natural Gas

Natural gas production from the Malampaya field started in 2001 and is now supplying a substantial quantity for power generation in the Batangas area. While the gas field is expected to reach its peak production of 400 MCFD (annual 146 Bcf) by 2010, the gas pipeline plan connecting to the metropolitan Manila area is still facing uncertainties and the gas production remains at about 80% of the plan. In addition, the gas utilization plan includes potential problem that operation of gas thermal plants are abnormally high compared with cost-friendly coal thermal plants, maybe reflecting take or pay condition of the gas purchase agreement. On the other hand, the recoverable reserve of the Malampaya gas field is estimated at around 3 Tcf. Should the plateau production reach 140 MMcfd as planned, gas production from this field may peak out at around 2015 as shown in Figure 5.1-3. If the production would be kept at the current level (80% of the original plan), it would possibly peak out before 2020.

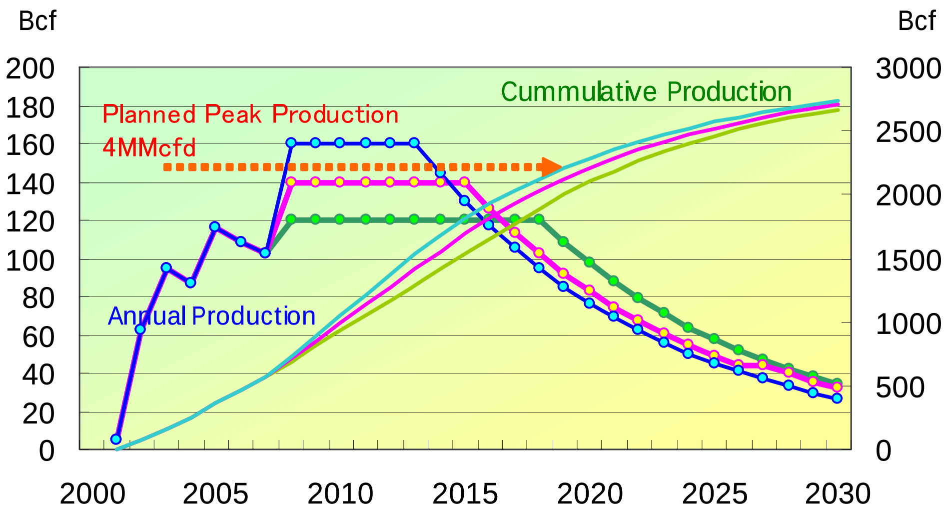


Figure 5.1-3 Production Profile of Malampaya Gas Field

Any additional gas required beyond this such as LPG substitute needs to be supplied by other sources. Exploratory drillings scheduled for 2008 are being looked forward to bring additional gas to supplement any deficit. However, if they were not successful, such deficit quantity should be supplied in the form of LNG import.

The natural gas pipeline plan in the metropolitan Manila area (Batman plans) is shown in Figure 5.1-4. Extension of the onshore pipeline from Batangas to Sucat is stranded facing various disputes. On the other hand, another option to construct an LNG receiving terminal at the Bataan peninsula is being discussed. In view that construction of LNG terminal and development of natural gas market need substantial lead time and that international LNG market is anticipated to be quite tight, in addition to the issue of successor of Malampaya, it is necessary to make decision for such project plan and commence action for procurement as soon as possible.

For such decision, it should be thoroughly examined to what extent and at what timing the Philippines should introduce natural gas even if the country needs to import it. In recent years, use of LPG as a clean fuel is developing in the country in particular at household and commercial buildings. LPG is a clean fuel and easy to use. As it does not require huge facilities in handling like LNG, it is easy to introduce. It is the most suitable fuel for cooking where firewood and charcoal were used, and as recommended under the UN Millennium Goal it will serve improving health condition of housewives at household. As introduced in Japan, it is easy to develop small regional grids with conventional system. Large scale utilization of LPG for co-generation at shopping malls and buildings may also develop in future.

On the supply side, international LPG market is getting looser reflecting natural gas conversion progressing in Japan and China. This ample supply situation may continue during the period up to 2010 as Qatar is expanding their LNG production. It should be noted, however, that LPG is quite vulnerable international commodity because it is produced only in association with crude oil and/or natural gas production. Considering the underlying supply condition like this, in promoting LPG utilization, it is necessary to study the fundamental trend of the international market and appropriate responding measures when international market turns to be tight including what should be then the appropriate energy to replace it. If the issues like economic feasibility and right of way for pipeline construction are solved, natural gas or LNG will be the most favorable alternative fuel in the metropolitan area.

Figure 5.1-4 Natural Gas Pipeline Plan in Metropolitan Manila

5.2 Renewable Energy

5.2.1 Renewable Energy in Power Sector

According to "Renewable Energy Policy Framework" (2003), DOE has set out goals for renewable energy (hereafter RE) development as below.

1) Increase RE-based power generating capacity by 100% by 2013. To this end,
   - Be the number one geothermal energy producer in the world
   - Be the number one wind energy producer in Southeast Asia
   - Double hydro capacity by 2013
   - Expand contribution of biomass, solar and ocean energy by 131 MW

2) Increase non-power contribution of RE to the energy mix by 10 million barrels of fuel oil equivalent (MMBFOE, 1,444 ktoe) in the next ten years

In term of installed capacity, the cumulative RE-based power generating capacity is forecast to reach

9,147MW by 2013, which is expected to increase by more than 100% from the 2003 level of 4,449MW. This corresponds to an additional 4,698 MW of RE-fueled power plants, which are yet to be commissioned. The table below shows required capacity by energy.

Table 5.2-1 Installed RE Generating Capacity

(Unit:MW)

Resource	Installed Capacity (as of 2002)	Target Capacity	Total Capacity
Geothermal	1,931	1,200	3,131
Hydro	2,518	2,950	5,468
Wind	0	417	417
Biomass, Solar & Ocean	0	131	131
Total	**4,449**	**4,698**	**9,147**

The government of the Philippines is prompting exploration and development of indigenous and renewable energy sources under the 2002 Investment Priorities Plan. However, little progress has been made with the framework target to date.

The supply outlooks of renewable energies by sources are as follows.

(1) Geothermal

Geothermal development plan of the Philippines is as shown in Table 5.2-2. Geothermal resources are distributed widely in this volcanic archipelago.

The Philippines is the second largest producer of geothermal power in the world next to the United States. It is already a history that, among the country's indigenous resources, geothermal is the largest supplier of electricity. It will continue to be a significant source of energy for the country in future. According to the 2006 record, geothermal generation accounted for 18.4% of the country's power mix. Apart from providing a substantial amount of electricity, geothermal resources, at the same time, help the country save huge amounts of foreign exchange through displacement of a large fraction of the imported fuels.

The country's total estimated potential of the untapped geothermal resource is about 2,600 MW. Reaching this target, plans to develop proven reserve areas shall be promoted positively to make available the maximum potential capacity of 1,200MW estimated as shown in Table 5.2-2.

Table 5.2-2 List of Available Geothermal Resources for Power Generation

Name	Installed Capacity （MW）	Name	Installed Capacity （MW）
（Luzon）	**420**	***（Visayas）***	**450**
Tanawon	40	Pataan （ Northern	80
Manito/Manito	20	Nasuji（Palinpinon II）	
Manito/Kayabon	40	Optimization	40
Mt. Natib	40	Mt. Cabalian	110
Mabini	20	Dauin	80
Batong-Buhay	60	Biliran	40
Rangas	40	Mandalagan	40
Montelago	40	Mahagnao-Bato-Lunas	60
Buguias-Tinoc	60	*（Mindanao）*	**330**
Daklan	40	Mindanao 2 Optimization	20
Baua	20	NW Apo（Tiko）	50
		Lake Wood	60
		SE Apo（Kapatagan）	60
		Amacan	60
		Mt. Ampiro	40
		Balingasag	40
		Total	**1200**

(2) Hydro Power Plant

Given the country's vast hydropower potential, it is expected that more than 10% of the electricity requirement will be supplied by hydropower generation. To meet the anticipated increase in demand for power over the planning period, a total of 2,950MW of hydropower capacity shall be made available within both on-grid and off-grid areas. Committed and indicative capacity additions will increase overall available capacity of hydropower to 5,468MW from the current installed capacity of 2,518MW. Eighteen (18) large hydropower potential sites are estimated to account for more than 90% of the possible additional capacity, while the remainder will be supplied by mini-hydro potentials. In addition, 490kW of micro-hydro power plants are targeted for installation toward the planning horizon. These micro-hydropower plants will be tapped to support the government's rural electrification program targeting 100% barangay (or village) electrification by 2006. The committed capacity addition is expected to provide 7.7 TWh of electricity per year equivalent.

Hydropower plants are classified based on their capacities as follows:

- Micro-hydro- 1 to 100kW
- Mini-hydro – 101 kW to 10MW; and
- Large hydro –more than 10MW.

The total untapped hydropower resource potential of the country is estimated at 13,097MW, of which 85% are considered large and small hydropower (11,223MW), 14% (1,847MW) as mini-hydropower while less than 1% (27MW) are considered as micro-hydropower.

(3) Wind Power

The Philippines, being situated on the fringes of the Asia-Pacific monsoon belt, exhibits a promising potential for wind energy. Data from the Philippine Geophysical Astronomical Services Administration (PAG-ASA) shows that the country has a mean average of about 31 watts per square meter (W/m^2) of wind power density. In addition, a study conducted by the US-NREL in 1999 shows over 10,000 km^2 of windy land areas estimated to exist with a good to excellent wind resource potential. Using conservative assumptions of about $7MW/km^{2.}$, this windy land could theoretically support over 70,000MW of potential installed capacity.

However, additional studies are required to produce a more accurate analysis of the wind electric potential, considering other factors such as the existing transmission grid and accessibility.

(4) Solar Power

The same study as wind power also conducted a resource assessment of solar power potential. The study showed that the country has an annual potential average of 5.1 $kWh/m^2/day$. Based on the 2001 inventory of solar technologies, a total of 5,120 solar systems have been installed as follows: 4,619 solar photovoltaic (PV) systems; 433 solar water heaters; and, 68 solar dryer systems.

(5) Ocean

The country's ocean resource area consists of $1,000km^2$, attributed mainly to its archipelagic nature. Based on a study conducted by the Mindanao State University (MSU), the potential theoretical capacity for this resource is estimated to be about 170,000MW. Although there is little available information on the potential of ocean energy, navigational experiences hypothesized that these systems present significant resource options.

However, more detail studies and technology development are needed gathering more accurate data on the actual generating capacity of these resources. It is appropriate to think that development of ocean energy may occur beyond the projection period.

5.2.2 Alternative Transport Fuels

In this section, future supply potential of alternative fuels for transport use will be looked into such as Biofuels (Bio-ethanol and Bio-diesel), Compressed Natural Gas (CNG), and AutoLPG. In addition to the strategy to reduce the country's dependence on imported oil, they are expected to provide a viable solution to cushion the impact of highly volatile petroleum prices to the economy with resource diversification as well as to promote clean and environment-friendly energies.

(1) Biofuels

Being located in the tropical area with full of sunshine and plenty rainfall, the Philippines is endowed with huge potential of biofuels. There are two major kinds in biofuels to focus upon in this study: one is

Bio-diesel which is a non-petroleum-based diesel fuel consisting of short chain alkyl (methyl or ethyl) esters, typically made by trans-esterification of vegetable oils, to be known as FAME (Fatty Acid methyl Ester). This can be used, alone or blended with conventional petro-diesel, in unmodified diesel-engine vehicles. The other one is Bioethanol that is such carbohydrates containing products as corn or sugar, fermented into ethanol and be mixed up with oil-based gasoline. In Japan, from the experience of abolishing use of MTBE (Methyl Tertiary-Butyl Ether), because ethanol or MTBE have water absorbing properties and/or water solubility, introduction of bio-ethanol in the form of ETBE (Ethyl Tertiary-Butyl Ether) with much less water solubility is planned to start in 2010.

In the Philippines, Biofuel seems to possess the competitive potentials in labor, vast lands, climate, and so on. It is beneficial in terms of energy security, fuel diversification, air pollution reduction, climate change mitigation as well as strengthening agricultural economy.

Whenever we take up Biofuels, we should pay attention to the issues of food-fuel trade-off, the conflict for limited available land and other resources between the food-aiming agriculture and the energy-aiming agriculture. While intensive research and development on the second generation biofuel technology is being undertaken worldwide, qualitative assessment/justification assuming the available technology is required to identify the potential of Biofuel production in this country.

The Philippines is the most advanced front runner among Asian countries in utilization of biofuel. The government campaign to use CME (Coco Methyl Ester) started in 2004. At present, use of biofuel is being targeted as follows.

1) Bio-diesel with 1% blend is scheduled to start soonest and the blend ratio will be raised to 2% in two years time.
2) 5% bio-ethanol blend into gasoline is scheduled within two years and the blend ratio will be raised to 10% in four years time.

1) Biodiesel

Coco Methyl Ester (CME) has been used as 1% blend (B1) Biodiesel and Jatropha is also regarded as a viable feedstock. PNOC-Alternative Fuels Corporation (PNOC-AFC) is planning to put up Jatropha plantations.

Table 5.2-3 Measurable Targets of Bio-diesel

Year	Diesel Demand (In million liters)	Biodiesel Blend (In accordance with R.A. 9367)	Fuel Displacement (In million liters)
2006	7,586.36	-	-
2007	7,664.33	1%	76.64
2008	7,879.69	1%	78.80
2009	8,195.76	2%	163.92
2010	8,510.21	2%	170.20
2011	8,830.82	2%	176.62
2014	9,919.18	2%	198.38

Note: Computations are based on DOE Demand Projection for Diesel (PEP 2006 Update) and Biodiesel mandatory blending set by the Biofuels Act of 2006.
Source: PEP 2006 Update

Biofuels Act of 2006 requested that within 3 months, a minimum 1% biodiesel by volume shall be blended into all diesel engine fuels sold in the country, and within 2 years, a minimum of 2% blend of biodiesel by volume shall be done so. Numerical targets are as given in Table 5.2-3. After investigating into the available crop area and other conditions for this purpose, the fuel displacement until 2030 to be applied in this study will be discussed and determined, including the blend ratio increase as well. To avoid oxidation (degradation), there seems to be the room to incorporate hydro-treating technology as finishing process of the products

2) Bioethanol

Biofuels Act of 2006 stipulated that "The Law mandates that within two years from its effectivity, all liquid fuels for motors and engines sold in the Philippines shall contain locally-sourced biofuels components of at least five (5) percent bioethanol in the annual total volume of gasoline fuel actually sold and distributed by each and every oil company in the country, and within 4 years the content shall be increased to a minimum of 10 percent." Numerical targets s applied in this study are as given in Table 5.2-4.

Table 5.2-4 Measurable Targets of Bio-ethanol

Year	Gasoline Demand	Bioethanol Blend (In accordance with R.A. 9367)	Fuel Displacement (In million liters)
2006	3,892.51	-	-
2007	4,090.84	-	-
2008	4,274.34	-	-
2009	4,457.84	5%	222.89
2010	4,639.49	5%	231.97
2011	4,822.99	10%	482.30
2014	5,371.64	10%	537.16

Note: Computations are based on DOE Demand Projection for Diesel (PEP 2006 Update) and Bioethanol mandatory blending set by the Biofuels Act of 2006.

Source: PEP 2006 Update

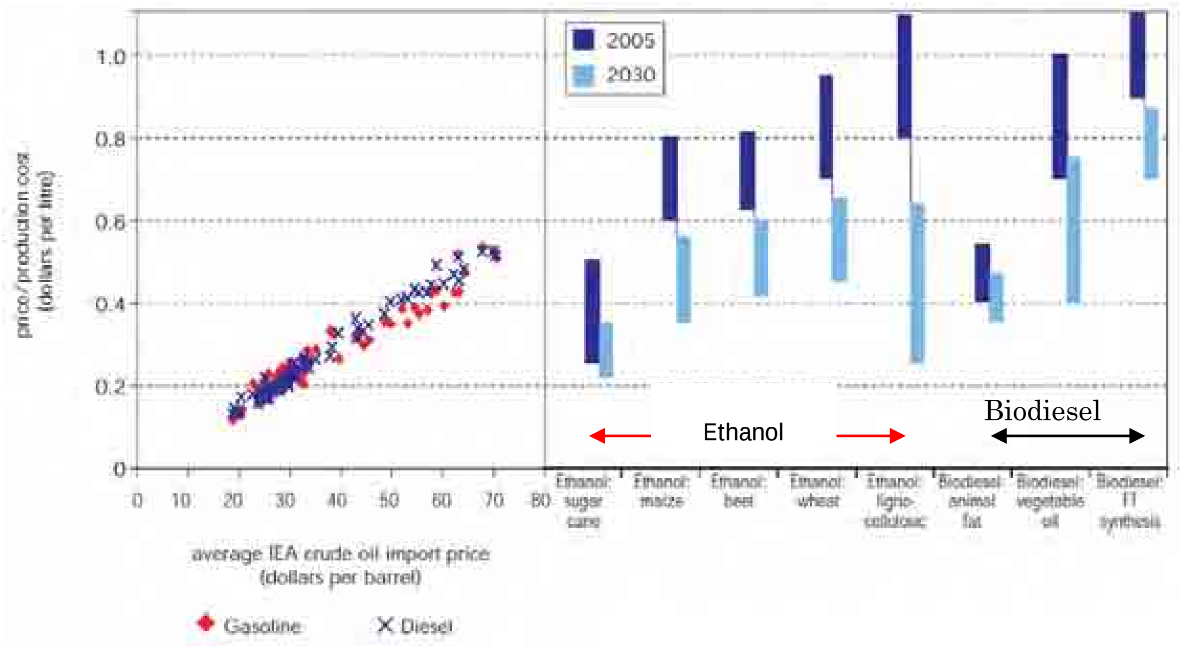
In San Carlos, Negros Occidental, 30,000kl a year of ethanol production facility is to be on stream in 2009, which supports 10% of the country's E5 gasoline demand[18]. In this country, sugar industry has the tradition and has been still maintained to the certain extent. Although its competitive edge in the world market is reviewed rather pessimistically, it may be able to survive focusing upon Bioethanol based on the recent skyrocketing oil price. After investigating into the available crop area and other conditions for this purpose, plans for possible fuel displacement and/or increase of blending ratio through 2030 will be discussed and evaluated.

In the current situation, sugar cane based ethanol shows economic advantages among other Biofuels from other sources as per Figure 5.2-1. This position will be kept even in 2030.

In the Philippines, we can find substantial advantages in promoting Bioethanol developing a further

[18] By hearing from San Carlos Bioenergy Inc. (Feb. 28, 2008)

advanced scheme. Since conflict with food-oriented crops is relatively small and existing or previous sugar cane fields still remain available to a considerable extent, additional production of fuel production feedstock could be possible after fulfilling the food-oriented demand. Adopting CDM mechanism and tie-up with Japanese stakeholders would be one of strong options to implement future projects; large-scale plantation may be established and operated in the Philippines, while the product will be regularly off-taken by CDM promoters such as Japan on long-term basis. This could be a typical win-win case, as the Philippines can secure reliable buyers for a long period and Japan can secure stable energy supply, respectively. It is needless to say that such project would substantially vitalize the agricultural sector of the Philippines.



Source: Compile from IEA Outlook 2006

Figure 5.2-1 Cost of Biofuels

The second generation biofuel technology is being focused upon as a medium or long-term technology development target, which is an ethanol production/fermentation technology of cellulose-based raw materials such as waste wood-chips or rice-plant straw. In Japan, ethanol production from waste wood from demolished buildings has started in 2007. In the United States, according to the target to displace 15% of gasoline demand by 2017 stipulated in the President’s annual state of 2007, various programs are announced on production cost reduction and assistance of commercializing cellulose based ethanol, since such feedstock utilization will be fully complimentary with food-oriented agriculture, then.

However, considerable technical development is still required for this to materialize. In Asia, Japanese ex-Prime Minister Mr. Abe at the East Asia summit Meeting held in Cebu Island in January 2007 proposed active utilization of renewable energies, in particular development of biofuels. This plan was incorporated in the Cebu Declaration. According to this declaration, the Japanese government has decided to create “Cool Earth Partnership” fund amounting to US$10 billion and enhance assistance to developing countries. The Japanese government has started “Biofuel Initiative” under this banner together with Asian countries to assist research, development and commercialization of biofuels. It is strongly desired that biofuel development will be promoted through such multilateral cooperation.

Assumption on Biofuel development

As of end 2006, local CME production reached at 111 thousand kl while sales of manufacturers/retailers reached 523 kl of pure CME and 42 kl of the CME blend (*B1*). With regard to future supply, while the source of bio-ethanol is thought to be sugar cane, Jatropha is expected to be the major source of biodiesel. However, as discussed above, there are many issues to be conquered before large scale production of biofuels become possible.

For the Reference Case, we assume that E5 to E10 (5% to 10% replacement of gasoline with ethanol or ETBE blending) and B2 (2% replacement of diesel gas oil with CME, Jatropha and or Palm oil blending) will be materialized as shown in Tables 5.2-1 and 5.2-2. In the biofuel promotion case, the blending or replacement ratio of biofuel will be raised double or further, and the outcome will be analyzed in Chapter 7.

Figure 5.2-2 Nurse Plantation of Jatropha

(2) Compressed Natural Gas (CNG)

CNG vehicles are strong tools for diversifying the oil-based transport fuel into other sources and soot-free, environment-friendly fuel. However, CNG has disadvantages such as shorter traveling miles due to the limited fuel quantity on board. Therefore, its application is relatively limited for circulating type operation such as delivery, taxi, local bus service or garbage collection in a specified area.

In order to penetrate CNG vehicles, the following support by the government side will be required:

1) To automobile fabricators: Incentives to manufacture natural gas fueled cars that are more expensive than gasoline fueled cars, consequently with less buyers.
2) To end-users: Incentives to buy and use as flexible as conventional gasoline/diesel fuel cars
3) To natural gas distributors: Incentives to invest in installment of new supply infrastructure such as filling stations

Considering natural gas market creation and development, promotion of CNG is meaningful as a measure to aggregate small individual demands. To this end, both CNG introduction and natural gas supply infrastructure/distribution network should be considered in a package. It is needless to say that stable natural gas supply should be secured on a long run basis.

(3) AutoLPG

In developing AutoLPG, it should be noted that AutoLPG supply infrastructure needs to be prepared and that surplus supply capacity of LPG would become not so ample worldwide. Therefore, it would be better not to weigh upon LPG for new demand too much. Excessive dependence upon LPG is not recommendable in terms of its supply stability.

For improving Tricycle fuel in country side but not in city centre, application of AutoLPG might be possible. New adoption/introduction of LPG for auto fuel should be limited to the case it is absolutely advantageous.

5.3 Electricity

5.3.1 Demand Forecast and Required Power Development

Peak electricity demand and aggregate electricity consumption of the Philippines as a whole country were 8,760MW and 56,784GWh as of 2006, respectively. The electric power demand has recorded steady growth during the latest two decades. The growth rate of electricity demand until 2030 is expected to be about annual 5%. When reserve margin is assumed to be approximately 25% for LOLE (Loss of Load Expectation) of 24 hours, the power supply capacity more than 14,000MW is required to be developed until 2030 (see Figure 5.3-1).

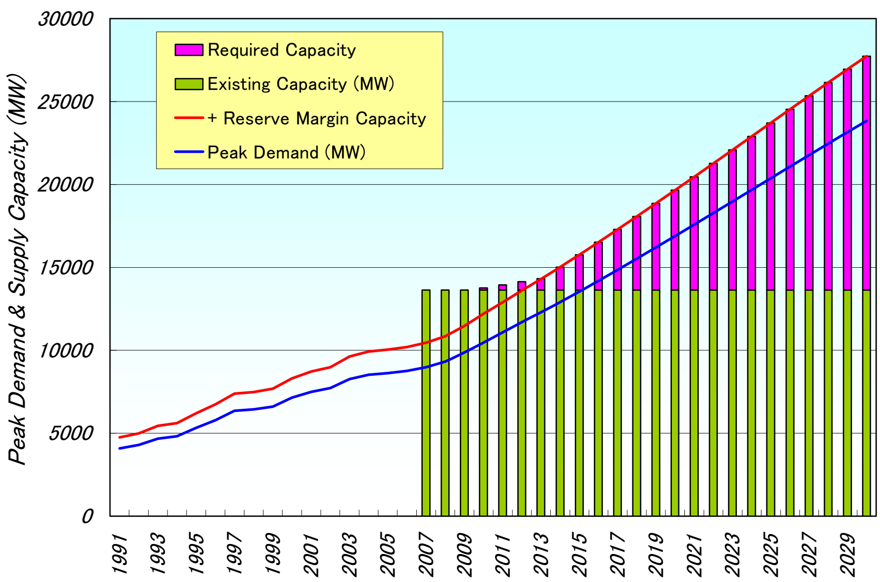


Figure 5.3-1 Peak Demand Forecast and Required Power Development

5.3.2 Generation Mixture and Implication of Power Development

Figure 5.3-2 shows the portion of the Philippines power supply capacity as of 2006. Coal fired thermal power accounted for 26.4%, contributing to the largest share of supply capacity in the Philippines power grid. Natural gas fired thermal power, geothermal power, hydropower and diesel/oil account for 17.5%, 12.5%, 20.6% and 22.3%, respectively.

On the other hand, Figure 5.3-3 shows screening curve under certain assumptions. It represents the optimal generation mixture in the Philippines. Based on the results, to institution the optimal

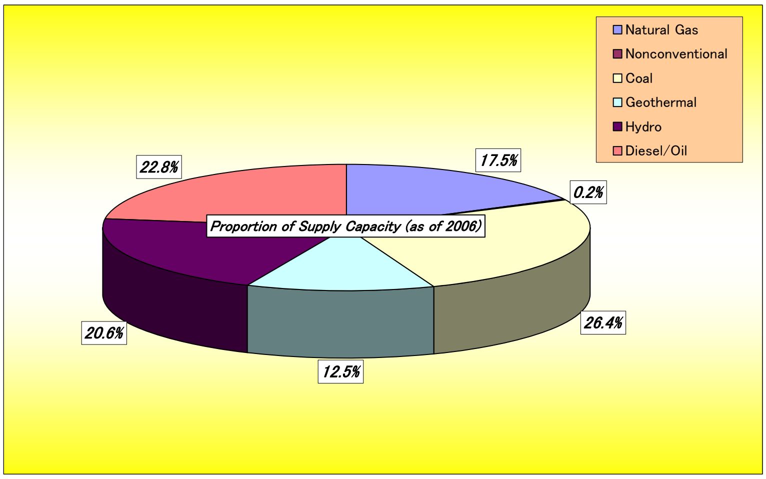


Figure 5.3-2 Proportion of Supply Capacity

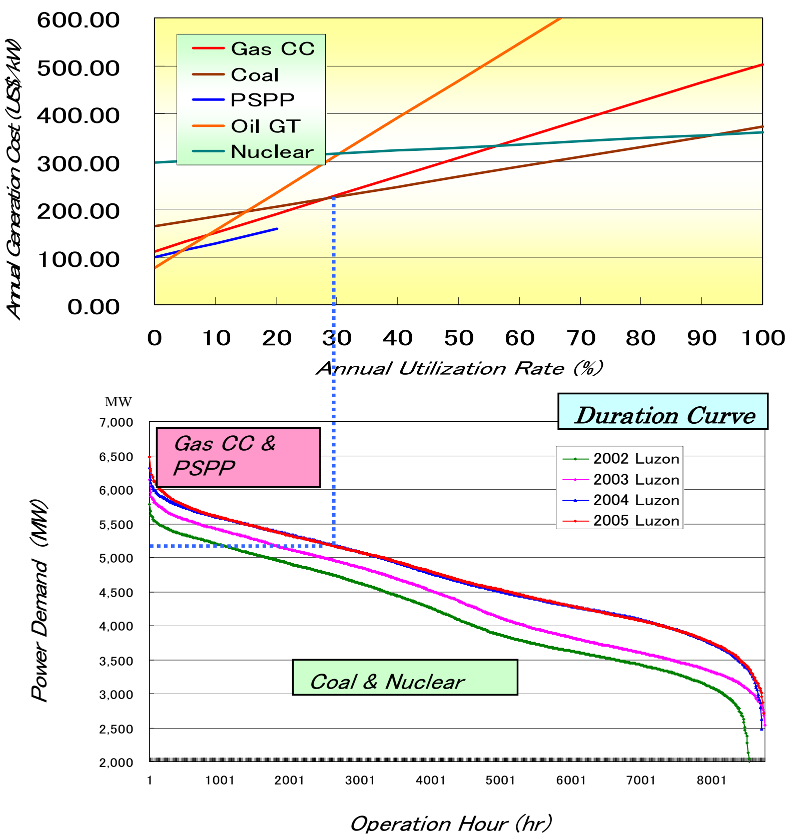


Figure 5.3-3 Example of Screening Curve

generation mixture in respect of economic aspect, some base supplies such as coal fired thermal power and nuclear power are necessary to be introduced to share more than 60% in the power supply capacity. Hence, under liberalized power market condition, compared with the current power source structure, new coal fired thermal power development would increase automatically in the Philippines in next two decades.

5.3.3 Nuclear Power:

(1) Current Status in the Philippines

In the 1970s, Philippines government planned to introduce nuclear power generation facing the world oil crisis. The PWR-type (Pressurized-Water Reactor) 620 MW nuclear power plant, manufactured by Westinghouse, was constructed in Bataan and almost completed by 1984. However, the plan was withheld in 1986 by some reasons, and the plant has been preserved since then by the Philippine Nuclear Research Institute (PNRI). PNRI, which belongs to Department of Science & Technology (DOST), is responsible for regulating nuclear generation, public relations regarding nuclear issues, human resource development regarding nuclear fields, contacting with IAEA, and making nuclear-related policies, etc.

Figure 5.3-4 shows the current photos of the Bataan nuclear plant. In this study, the JICA expert has visited on-site and conducted hearings. Although the Bataan nuclear plant has never been operated, it

Figure 5.3-4 Nuclear Reactor in Bataan

has a possibility to be operated in the short-period rehabilitation. The decision of starting nuclear plant operation in future could be made in the judgment of DOE and DOST.

For operating the nuclear generation station in future, shortage of nuclear engineers is a critical problem at the moment. Although PNRI has executed to improve the human resource under the Human Resource Development Program, the government needs to make clear the policy to train nuclear engineers more.

(2) Current Status in the World

In recent years, nuclear generation has been growing in the world because of its cheaper fuel costs and being free of CO_2 emission. Figure 5.3-5 and Figure 5.3-6 show the current number of nuclear plants and the historical trend of constructing nuclear plants, respectively. As of 8 of August 2007, 439 nuclear reactors have been operated and the operating experience reached almost 40 years. As the world trend, nuclear generation has been recognized as the proven technology with long practical history. However, it still has the risk of nuclear accident, the problem of radioactive wastes processing and nuclear weapon proliferation. In addition, if a nuclear generation plant is to be newly introduced in the future, situation of nuclear plant manufacturers has to be considered. Nowadays, many countries aim to construct new nuclear plants, while the number of manufacturers that can design and construct nuclear reactors is limited. (See Figure 5.3-7) Pending timing of order, we could not expect immediate manufacturing of equipments.

With regard to security issue of nuclear technology use, various international frameworks have been formulated in the world today. They include as worldwide ones such as NPT (Non Proliferation Treaty) and IAEA (International Atomic Energy Agency), as Asia-level ones such as FNCA (Forum for Nuclear Cooperation in Asia) and RCA (Regional Cooperative Agreement for Research,

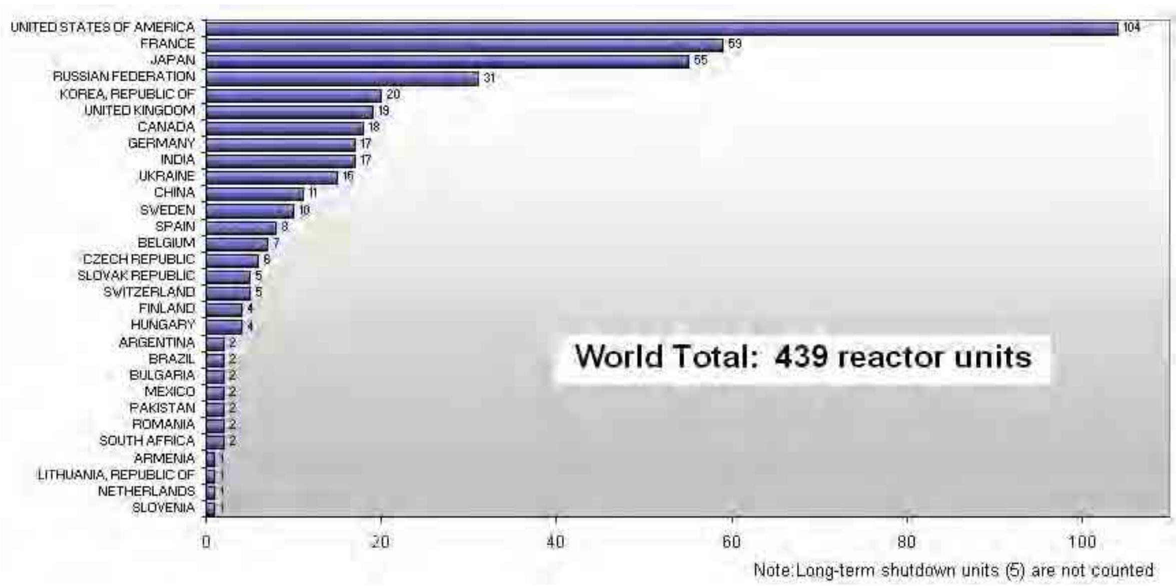
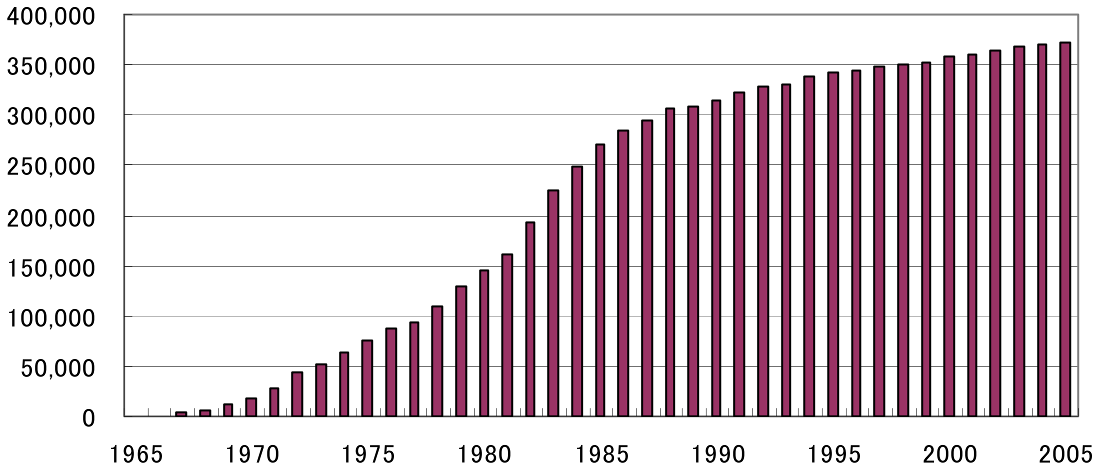


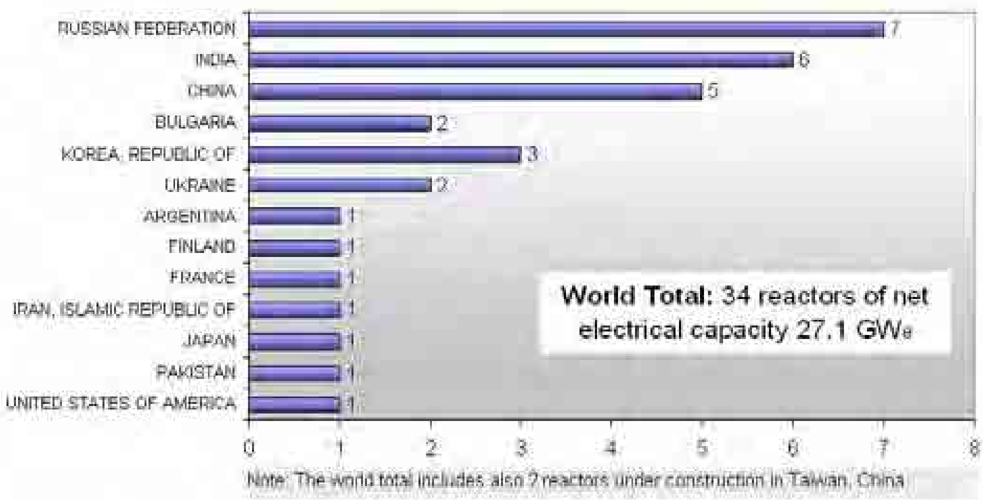
Figure 5.3-5 Number of Current Nuclear Reactors Worldwide



Source: IAEA

Figure 5.3-6 Trend of Reactor in Operation Worldwide

Development and Training Related to Nuclear Science and Technology), and as ASEAN-level one such as ASEAN Nuclear Energy Safety Sub-sector Network in 2007. Current status of participation in Asia is summarized in Table 5.3-1. Countries considering development of nuclear power generation should participate in and take advantage of these frameworks for treating issues relating to proliferation, safety administration, and research and development of technology for peaceful use of nuclear energy.



Source: IAEA, as of 7 December 2007

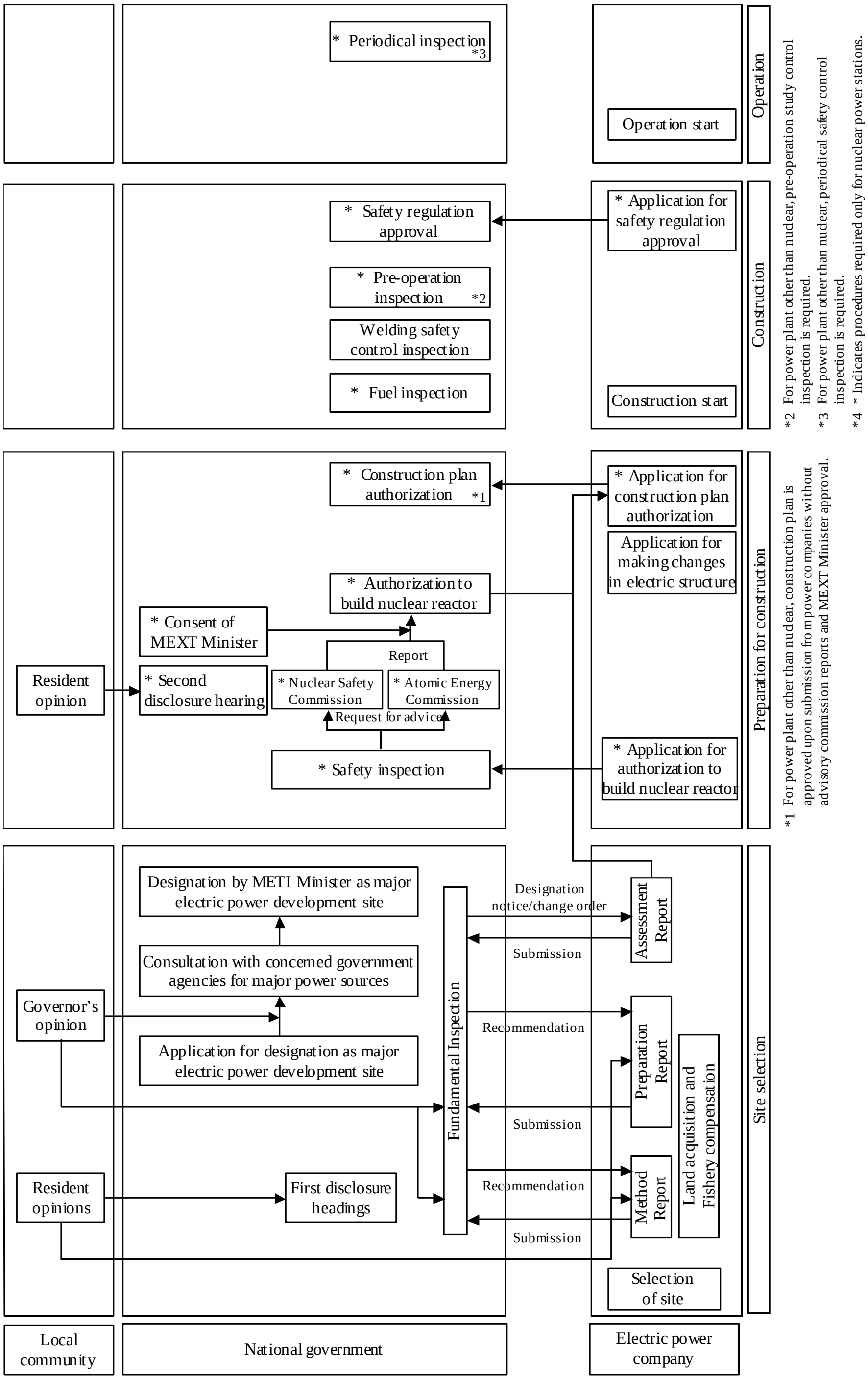
Figure 5.3-7 Number of Reactors under Construction Worldwide

Table 5.3-1 Current Status in Asian Countries Regarding International Framework

	ASEAN	Nuclear Generation	Research Reactor	NPT	IAEA Safeguards Agreement	IAEA Additional Protocol	FNCA	RCA	Note
Philippines	○			○	○	○	○	○	
Singapore	○			○	○			○	
Malaysia	○		○	○	○		○	○	
Thai	○	Plan	○	○	○	○	○	○	
Indonesia	○	Plan	○	○	○		○	○	
Vietnam	○	Plan	○	○	○		○	○	
Lao PDR	○			○	○				Nonmember of IAEA
Cambodia	○			○	○				Nonmember of IAEA
Myanmar	○			○	○			○	
China		○	○	○	○	○	○	○	
Korea		○	○	○		○	○	○	
Bangladesh			○	○		○	○	○	
India		○	○		○			○	
Pakistan		○	○		○			○	
North Korea			○		○				Nonmember of IAEA
Japan		○	○	○	○	○	○	○	

(3) Required Procedure or Milestone to Develop Nuclear Power

As a reference, an example of a nuclear power station in Japan is shown in Figure 5.3-8. In the case of Kashiwazaki-Kariwa No.1 plant, which started operation in 1985, it spent about 16 years in total from site selection to operation commencement, which may be roughly divided into 5.5 years for site selection, 3.5 years for construction preparation and 7 years for construction and commissioning. Of course, the actual period required may depend on various social and geological factors such as social acceptance, governmental commitment and geological conditions.



Source: Tokyo Electric Power Company, Inc. "TEPCO Illustrated 2006"

Figure 5.3-8 Summary of Nuclear Power Plant Site Procedure

Chapter 6 Long-term Energy Demand Outlook

In this chapter, we will look into outcome of the simulation on the long-term demand outlook calculated using the energy demand forecasting model developed for the purpose of this study. In Section 6.1, starting from the Reference Case, we will simulate various scenarios affecting demand trend with regard to economic growth, energy price and promotion of energy efficiency and conservation, examine the outcome of the final energy demand calculation and evaluate their implications. In Section 6.2 and after, we will look into trends and characteristics of individual demand sectors elaborating the Reference Case and will consider their implications.

6.1 Energy Demand Simulation and its Implication

6.1.1 Assumptions and Preconditions

As explained in Chapter 4, we have conducted the study on the long-term energy outlook of the Philippines assuming the average economic growth rate for the period of 2005 through 2030 at 5%. This is a scenario derived considering that the country's population growth will gradually slow down from the current level and be annual 1.5% for the entire projection period and combined contribution of capital stock increase and productivity improvement will continue to be annual 3.5% in real term as observed in the recent years.

We believe there is a good possibility of such high pace economic growth for the Philippines in view that the country is a bit behind fast running China and ASEAN countries at present and that development of global based high level services industry backed by development of information technology (IT) has emerged in these years blowing tail wind for economic growth. However, it is possible that the abnormal oil price hake started early 2008 may pull down the world economy and the economic growth of the Philippines would be affected for sometime. Such a scenario was examined running the demand forecasting model and the supply/demand optimization model, and looking into changes to be incurred in energy supply/demand balance in the Low Growth scenario.

Various scenarios examined here are summarized below.

1) Economic Growth・・・Economic growth rate for the period from 2005 through 2030 is assumed to be annual 5% for the Reference Case, 6% for the High Growth Case and 4% for the Low Growth Case. In the industrial structure, services industry and manufacturing industry that are based on IT will be the driver of the economic growth.

2) Energy price・・・・・ Crude oil price for 2030 is assumed at $160/Bbl for the Reference Case, $200 for the High Price Case, $240 for the Super High Price Case and $200 for the Low Price Case. Coal and natural gas price will change similarly in line with crude oil price. Domestic energy price will also change in the same manner.

3) EEC・・・・・・・・ In the BAU Case, energy efficiency and conservation (EEC) is assumed to continue to be at the same level during the projection period. Compared with the BAU Case, EEC is assumed to progress at annual 0.5% for the Reference Case, 1.0% for the EEC promotion Case and 1.5% for the Super EEC Case.

6.1.2 Outcome of Simulation

Outcome of the simulation of various cases according to the above setting is shown below. As the final energy demand in 2005 was 17,401 thousand tons oil equivalent (ktoe), in the BAU Case where no positive EEC is assumed, it will grow at annual 4.3% and will reach 49.7 million toe or 2.86-fold. However, in the Reference Case where annual 0.5% EEC is applied, the annual growth rate slows down to 3.6% and the final energy demand in 2030 will become a substantially lower amount of 41.2 million toe. This energy conservation rate compares to 8.1 million toe or 17% of the annual consumption.

Table 6.1-1 Outlook of Final Energy Consumption

	BAU	Reference	High Growth	Low Growth	High Price	Super High Price	Low Price	EEC	Super EEC
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2010	22,931	21,787	22,135	21,085	21,787	21,409	21,706	21,460	21,137
2015	29,531	27,120	28,350	24,903	26,901	26,354	27,249	26,049	25,016
2020	36,445	32,363	35,142	28,552	31,888	31,216	32,768	30,312	28,382
2025	43,253	37,148	42,165	31,872	36,413	35,628	37,866	33,930	30,975
2030	49,668	41,273	49,265	34,820	40,287	39,403	42,317	36,759	32,720
Growth Rate									
05-10	5.7%	4.6%	4.9%	3.9%	4.6%	4.2%	4.5%	4.3%	4.0%
10-20	4.7%	4.0%	4.7%	3.1%	3.9%	3.8%	4.2%	3.5%	3.0%
20-30	3.1%	2.5%	3.4%	2.0%	2.4%	2.4%	2.6%	1.9%	1.4%
05-30	4.3%	3.5%	4.3%	2.8%	3.4%	3.3%	3.6%	3.0%	2.6%

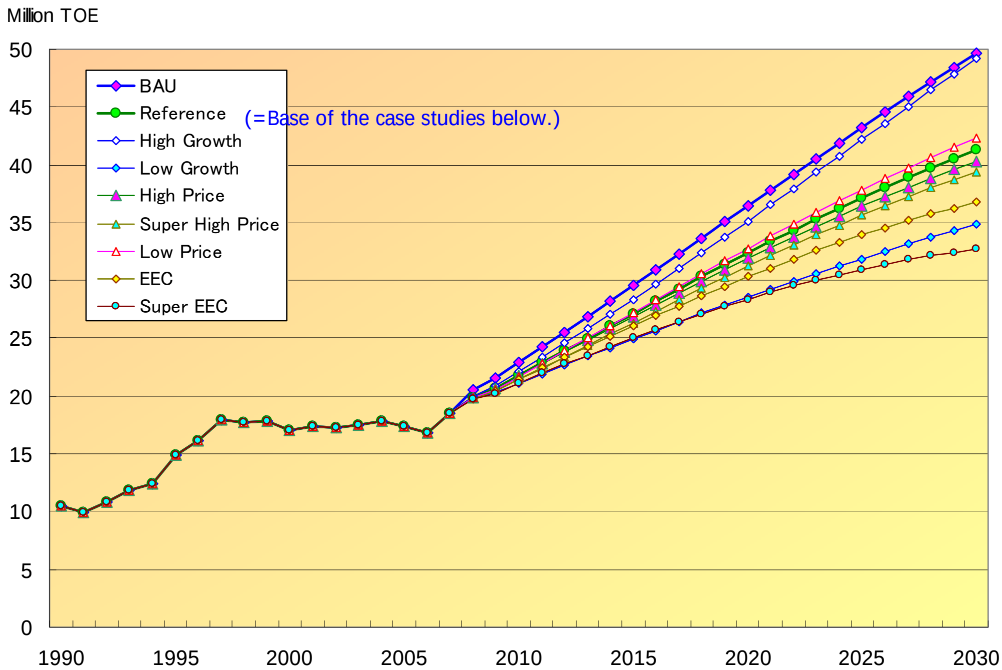


Figure 6.1-1 Outlook of Final Energy Consumption

In the next, with regard to effect of changes in factors such as economic growth and energy price, impact of economic growth change is greatest followed by the extent of EEC promotion, and the impact of energy price change is smallest. As observed in the graph, when the economic growth rate becomes 1% higher than the Reference Case, energy conservation efforts of annual 0.5% will be totally offset. Economic growth itself is a good thing improving quality of life. It is an important thing to be decided through nation-wide discussion what kind of economic policy for development should be implemented after duly considering the balance with energy and environment issues.

(1) Economic Growth Scenario

From the simulation result of the Reference Case, as the average annual growth rate of the final energy demand is 3.5% over the projection period of 2005 through 2030 against the assumed GDP growth rate of 5.0%, the GDP elasticity of the final energy demand built-in in this model is 0.70. In general, in a stage when economic growth accelerates, an economy requires materials and energy for construction of industrial and social capital, and therefore the GDP elasticity of energy demand exceeds 1.0. In case of the Philippines, weight of the energy intensive industries in its industrial structure is low, and supply of basic materials such as steel and chemical products mostly depends upon import. Drivers of its economic growth are those industries with relatively less energy intensity such as trade, high quality services and general manufacturing. At the same time, transfer from overseas workers has increased in recent years (9.6% of GDP in 2006) pushing up personal consumption. Reflecting such background, the GDP elasticity of energy demand is positioned relatively low.

Table 6.1-2 Final Energy Demand: Ratio against Reference Case

	BAU	Reference	High Growth	Low Growth	High Price	Super High Price	Low Price	EEC	Super EEC
2020	112.6%	100.0%	108.6%	88.2%	98.5%	96.5%	101.3%	93.7%	87.7%
2030	120.3%	100.0%	119.4%	84.4%	97.6%	95.5%	102.5%	89.1%	79.3%

Impact of the changes in economic growth is the largest among various factors, and thus 1% change of annual economic growth rate results in 8% to 12% changes of the final energy demand in 2020 and 16% to 19% changes in 2030. We should note, however, that, as explained in Chapter 4, we apply conventional method for projection of sector GDPs but not conducted an in-depth study. In particular, as it is known that future changes in industrial structure will give substantial effect on the energy demand, we need to look into this issue from time to time.

(2) Energy Conservation Scenario

Next important factors of long-term energy scenarios are energy efficiency and conservation (EEC) and price effect. It is not possible to obtain good (meaningful) parameters applying regression analysis on the historical data. Therefore, we adopt a method to give there parameters to the model externally. That is, the EEC effect is calculated in the model in the following manner.

1) Estimate the energy demand before EEC

2) Assuming that annual EEC rate of X % will accumulate, create a cumulative EEC factor applied each year as Y t = Y t-1 x (1-X t)

3) Energy demand after EEC is calculated as the product of the above

In this study, we have set out cases of energy conservation promotion such as annual 0.5% for the Reference Case, 1.0% for the EEC promotion Case and 1.5% for the Super EEC case. Annual 0.5% difference of EEC rate brings about 10% difference in energy demand in 2030. In terms of GDP elasticity, against 0.86 for the BAU Case, it goes down to 0.70 for the Reference Case, 0.60 for the EEC Case and 0.52 for the Super EEC Case.

Then, a question arises about possibility of realizing such energy conservation. Taking account of the recent energy price hike and increasing concern on the energy conservation, materialization of annual 0.5% energy conservation assumed for the Reference Case is fully conceivable. As seen in Chapter4, energy efficiency of home and electric appliances has been improved dramatically in recent years. It is estimated that the difference between the average energy efficiency of the social stock and that of the latest models may be more than 10% to 20%. For example, suppose that there is 5% difference of energy efficiency between the average social stock and the latest model, and that such durable goods or energy using equipments would be replaced in 10 years, annual energy efficiency improvement is 0.5%. Energy conservation of this magnitude is sufficiently possible on durable goods such as electric appliances and passenger cars as well as office equipments.

However, we need to conduct further study whether it is possible or not to implement energy conservation beyond the Reference Case assumption looking into possibility of technical improvement, change of life style and/or effect of energy conservation policies. We have run cases on annual EEC of 1.0% and 1.5% using the model in order to identify changes in the energy supply/demand structure compared with the Reference Case. This should be understood as a method to know to what extent EEC would be necessary considering the effect on the issues of energy security and global warming.

(3) Price Scenarios and Price Effects

As the price effect of energy demand is generally thought to be between -0.1 and -0.2[19], it is not easy to verify this with historical data. It is partly due to quality of energy data in the Philippines, but mainly due to the fact that energy price continued to be stagnant for a long period from the early 1980s to the early 2000s and therefore there is no actual data to reflect the effect of energy price hike, and further that the recent price hike is so abrupt that the price effect is not fully reflected in the energy demand. Under the circumstance, except for the BAU Case, price effect is set at -0.10 in this demand forecasting model. This parameter can be alternated easily in the model operation.

As a result, assuming the crude oil price of 2030 at $160 per barrel, effect of price changes of plus/minus $40 (25%) remains at only 3%. However, we should note that, when the share of an expenditure item is small among other expenditures of household or business entities, not much care is paid on such item.

[19] IEA World Energy Outlook 2006, "Chapter 11 The Impact of Higher Energy Prices"

Then, as the share of such expenditure goes up caused by price hike and possibly backed by increasing social cautions, price effect itself would increase. As energy has become one of the most concerned goods worldwide, together with energy conservation, there is a good possibility for the price effect to increase in future.

For the operation of the price effect, similar method with EEC effect calculation is adopted in the model. Suppose that price effect is A and annual price hike B, cumulative price effect is calculated as Y t = Y t-1 x (1 - A x Bt). It should be further studied how these parameters should be assessed and applied.

6.2 Energy Demand Outlook: General Sectors

In this demand forecasting model, final energy demand is estimated separately for transportation sector and other general sectors. In this section, we will look into the demand forecasting method, the result of estimation and its implication on general sectors mainly referring to the Reference Case. We will review the transportation sector in the next section.

Energy demand of general sectors is divided and separately estimated by sector, which are agriculture, forestry and fishery, six energy intensive manufacturing industries (hereinafter called "energy intensive industry"), other manufacturing industry (hereinafter called "general manufacturing"), trade and services and residential sectors. Among them, energy demand of the energy intensive industry is estimated separately and individually on six industries. It is supposed that transportation energy is not included in the energy demand of these sectors. However, statistical data are irregular and it is questionable if this definition is strictly observed.

In this block, as a fundamental approach, final demand of each sector is divided into and estimated by fossil fuel demand and electricity demand. Then, fossil fuel demand is estimated individually on each sector considering demand characteristics in each sector and each fuel.

Energy demand outlook by sector for the Reference Case is as shown in Table 6.2-1 and Figure 6.2-1. In the energy demand structure of the Philippines, transportation fuel shares very high ratio over 50%. Large scale energy intensive industry is scarce, and the total energy consumption of the whole manufacturing sector remains at around 20%. Shares of energy consumption at household and commercial sector are relatively high. This tendency is forecast to continue in future.

Table 6.2-1 Energy Demand Outlook by Sector

	Agriculture	EI Industry	Gen Mfg.	Transport	Commercial	Residential	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	313	2,653	1,430	8,940	1,660	2,405	17,402
2010	254	3,071	1,480	12,032	2,187	2,763	21,787
2020	337	4,311	2,366	17,277	3,638	4,434	32,363
2030	402	5,591	3,279	20,563	5,218	6,219	41,273
05-30	1.0%	3.0%	3.4%	3.4%	4.7%	3.9%	3.5%
Composition	%	%	%	%	%	%	%
2005	1.8	15.2	8.2	51.4	9.5	13.8	100.0
2010	1.2	14.1	6.8	55.2	10.0	12.7	100.0
2020	1.0	13.3	7.3	53.4	11.2	13.7	100.0
2030	1.0	13.5	7.9	49.8	12.6	15.1	100.0

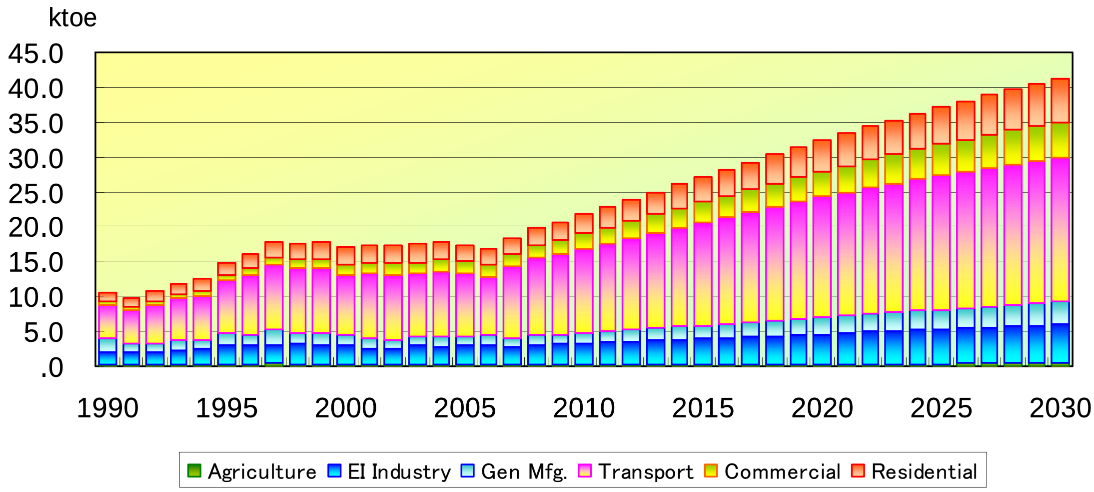


Figure 6.2.1 Energy Demand Outlook by Sector

6.2.1 Agriculture, Forestry and Fishery

Energy consumption of the Agriculture, Forestry and Fishery Sector (AFF) share merely one percent (1%) of the aggregate energy consumption, and the impact of this sector on the overall energy trend is negligible. Among fossil fuels, except for small quantity of kerosene, demand is mostly shared by diesel and fuel oil. The following equations are applied for the demand estimation.

Fossil Fuel = GDP intensity of fossil fuel demand x AFF sector GDP

Electricity = GDP intensity of electricity demand x AFF sector GDP

Total Demand = Fossil Fuel Demand + Electricity Demand

The average demand growth rate of this sector between 2005 and 2030 is 1.0%, of which it is 0.5% for fossil fuel and 3.2% for electricity. Among them, if we pick up the calculated growth rate, demand growth of diesel oil is lowest at 0.0%, but this is affected by the irregular statistics in 2006 and 2007. Demand growth rate after 2008 is 2.0% for diesel oil and fossil fuel total, and 2.3% for energy total, which would not be very small.

Table 6.2-2 Energy Demand Outlook of Agriculture, Forestry and Fishery Sector

	Kerosene	Diesel	Fuel Oil	Fossil	Electricit	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	4.5	244.2	21.8	270.6	42.2	312.8
2010	5.1	161.7	38.0	204.8	49.5	254.4
2020	6.7	209.0	49.1	264.7	72.2	336.9
2030	7.8	244.6	57.4	309.8	92.6	402.4
2005 ->30	2.2%	0.0%	3.9%	0.5%	3.2%	1.0%

It may be theoretical to think that diesel oil is used for agricultural machines and fishing boats. However, it looks difficult to grasp the usage accurately at collection of statistical data. In this sector, it is more important to identify the actual state of consumption rather than discussing demand forecasting method. For example, production of sugarcane will increase reflecting incremental sugar production required for production of fuel ethanol. Incremental supply of bagasse as biomass fuel is counted for in this model. However, since relationship of diesel oil consumption for agricultural machines is not identified well, they are not considered here.

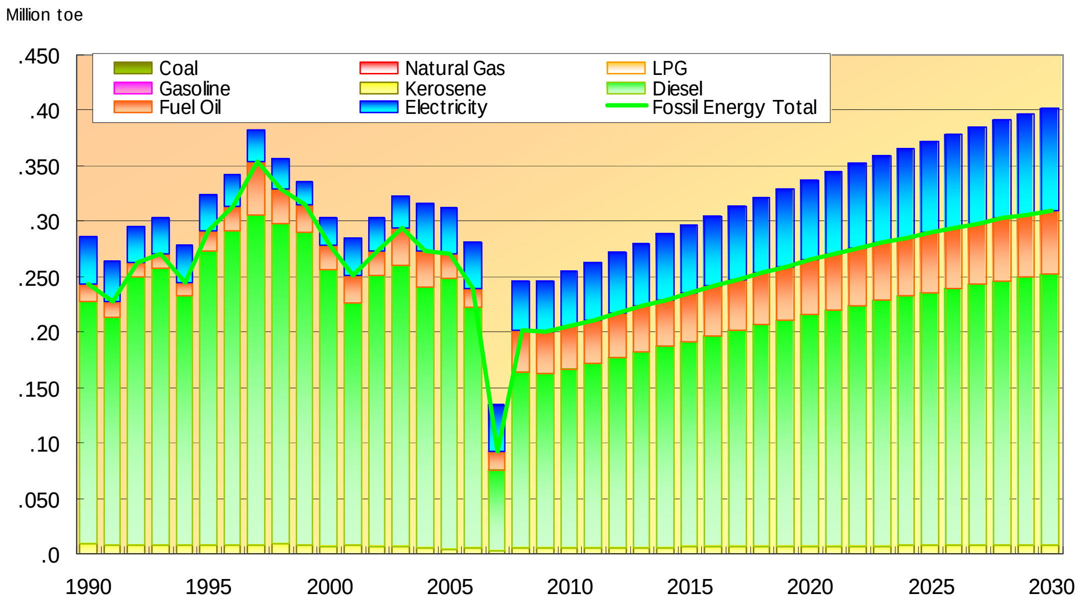


Figure 6.2-2 Energy Demand Outlook of Agriculture, Forestry and Fishery Sector

6.2.2 Energy Intensive Industry

Among manufacturing industries, energy demand by six energy intensive industries, namely, cement, paper & pulp, food processing, chemical products, sugar and steel, is estimated separately on each industry, and the aggregated amount is listed here as the total demand by the energy intensive industry.

Energy demand of the energy intensive industry will increase at annual 3.0%, and in 2030 it will amount to 2.1-fold of that of 2005. As sectors included here consume relatively greater amount of energy, consumption of coal and fuel oil shares 2/3 of the total energy consumption while the rest is shared by electricity. This tendency will be maintained in future. As explained later, substantial quantity of conventional type biomass fuel (non-commercial energy) is in this sector such as bagasse in sugar industry and coconut residue in food processing industry. They amount to 45% of the total commercial energy consumption of the six industries.

Table 6.2-3 Energy Outlook of Energy Intensive Sector

	Coal	LPG	Kerosene	Diesel	Fuel Oil	Fossil Energy	Electricity	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	1,031.2	45.7	23.0	186.8	678.2	1,964.8	688.7	2,653.5
2010	1,353.0	39.5	16.3	244.5	654.0	2,307.4	763.2	3,070.6
2020	1,953.9	88.8	19.0	368.6	868.7	3,298.9	1,012.1	4,311.0
2030	2,590.7	156.8	20.8	493.9	1,068.4	4,330.7	1,260.3	5,591.0
2005->30	3.8%	5.1%	-0.4%	4.0%	1.8%	3.2%	2.4%	3.0%

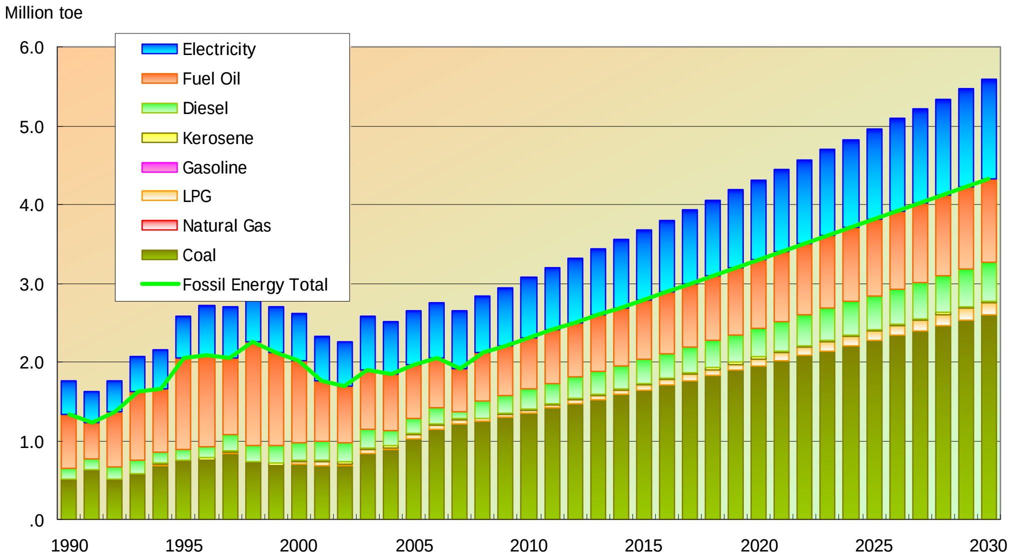


Figure 6.2-3 Energy Outlook of Energy Intensive Industry

In Japan, energy consumption of the industry sector shared 46.6% of the total final energy consumption and energy consumption of the six industries cited above shared 74.6% of the latter in 2006. In the Philippines, weight of manufacturing industry is smaller without having large scale industries such as steel and chemical products as seen in Japan. Nevertheless, the situation is same that these six industries share a large part of industrial energy consumption, which was 77.2% in 2007. Therefore, in forecasting industrial energy consumption, it is appropriate to concentrate on grasp of actual state and trend of energy consumption in these industries as specified above.

Major factors applied in energy demand forecast of these industries are summarized as below.

Cement	Cement production; construction sector GDP
Food Processing	Food production; personal consumption and CPI
Sugar	Sugar production; personal consumption, ethanol production
Chemical Products	Chemical production; manufacturing sector GDP
Steel	Construction sector GDP
Paper & Pulp	Trend and population growth

6.2.3 General Manufacturing

Energy consumption of the general manufacturing industry excluding energy intensive industries will grow at annual 4.6% and in 2030 it will reach 4.4 million toe or 3.08-fold of that of 2005. Since most of the industries included in this category are of less energy intensive, electricity demand for motors, lighting and air conditioning share 45% of the total energy consumption, followed by fuel oil for heat source at 30%.

Table 6.2-4 Energy Outlook of General Sector

	Coal	Natural Gas	LPG	Kerosene	Diesel	Fuel Oil	Fossil Energy	Electricity	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	25.3	12.2	23.6	5.0	299.8	427.7	793.6	636.7	1430.3
2010	31.2	77.4	54.7	0.0	117.2	413.1	693.6	786.4	1479.9
2020	47.2	77.4	227.1	0.0	177.1	519.6	1048.4	1317.7	2366.1
2030	62.4	77.4	463.5	0.0	234.1	548.2	1385.6	1893.6	3279.2
2005->30	3.7%	7.7%	12.6%	***	-1.0%	1.0%	2.3%	4.5%	3.4%

As detail industrial statistics such as sector GDP and/or IIP are not available in the Philippines, it is not possible to separately pick up the energy trend of the less energy intensive industry sector. Therefore, we applied statistics on the manufacturing sector total. As such, it is not possible to conduct coherent and in-depth analysis on the sector, it is desired that efforts should be made to clarify energy structure and trend of the sector, for example, utilizing the outcome of the energy demand survey conducted in this study.

As shown in Figure 6.2-3, the past energy consumption statistics of this sector is quite irregular and it is very difficult to obtain meaningful result applying regression analysis on them. Therefore, we apply the following hypothesis in estimation the sector energy demand.

Fossil Fuel = Energy intensity per manufacturing sector GDP which will gradually decrease

Electricity = Energy intensity per manufacturing sector GDP which will gradually decrease

Total Demand = Fossil Fuel + Electricity

With regard to fossil fuel trend, we have assumed that demand for LPG may grow to some extent. This scenario is inferred since diesel oil and fuel oil may be waived in view of recent abrupt price hike, while, reflecting increased environmental concern, fuel oil demand would become stagnant as low-sulfur fuel oil is not available in the Philippines and LPG would be preferred instead. Natural gas demand is assumed to

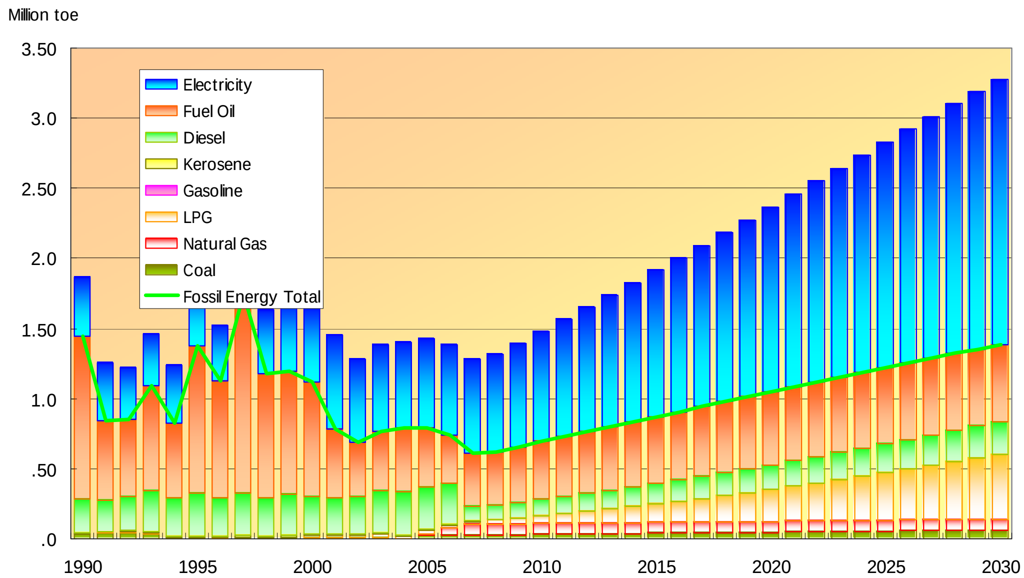


Figure 6.2-4 Energy Outlook of General Manufacturing

be flat as there is no concrete plan to develop natural gas supply at present. Possibility of natural gas penetration depends upon preparation of gas supply systems such as construction of city gas grid.

6.2.4 Commercial Sector; Trade and Services

Energy consumption of the commercial sector will grow at annual 4.7% and by 2030 it will reach 3.1-fold of that of 2005. About 70% of the energy consumption in this sector is electricity. It is understandable since main demand sectors are office buildings, shopping malls and hospitals. In future, ratio of diesel oil and fuel oil will further decline and electricity and LPG will become the core energy sources.

Table 6.2-5 Energy Outlook of Commercial Sector

	LPG	Diesel	Fuel Oil	Fossil Energy	Electricity	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	219.3	124.5	186.9	530.7	1,129.6	1,660.2
2010	507.3	70.0	127.5	704.8	1,482.1	2,186.9
2020	963.5	70.0	76.3	1,109.8	2,528.0	3,637.8
2030	1,389.3	70.0	45.7	1,505.0	3,713.4	5,218.4
2005->30	7.7%	-2.3%	-5.5%	4.3%	4.9%	4.7%

Likewise for the general manufacturing sector, it is not possible to squeeze good parameters by statistical method. However, energy consumption of the commercial sector at offices and shopping malls are expected to converge to electricity for lighting and air-conditioning and LPG for cocking. On the other hand, diesel oil and fuel oil mainly used for smaller generators and boilers may be replaced by electricity and LPG as their delivery system develops. Thus, as a demand forecasting model, we adopt hypothesis that

1) Consumption of diesel oil and fuel oil will decrease. Despite that LPG consumption may increase, overall fossil fuel intensity over GDP would decrease 3% per annum.
2) As the Philippines economy is in a developing stage, electricity intensity will rise steadily outrunning efficiency improvement of appliances; electricity demand would grow 0.5% annually.

Thus, the following equations are applied.

Fossil Fuel = Fossil fuel intensity of the previous year over commercial sector GDP x 0.97 x commercial sector GDP

Electricity = Electricity intensity of the previous year over commercial sector GDP x 1.005 x commercial sector GDP

Total = Fossil Fuel + Electricity

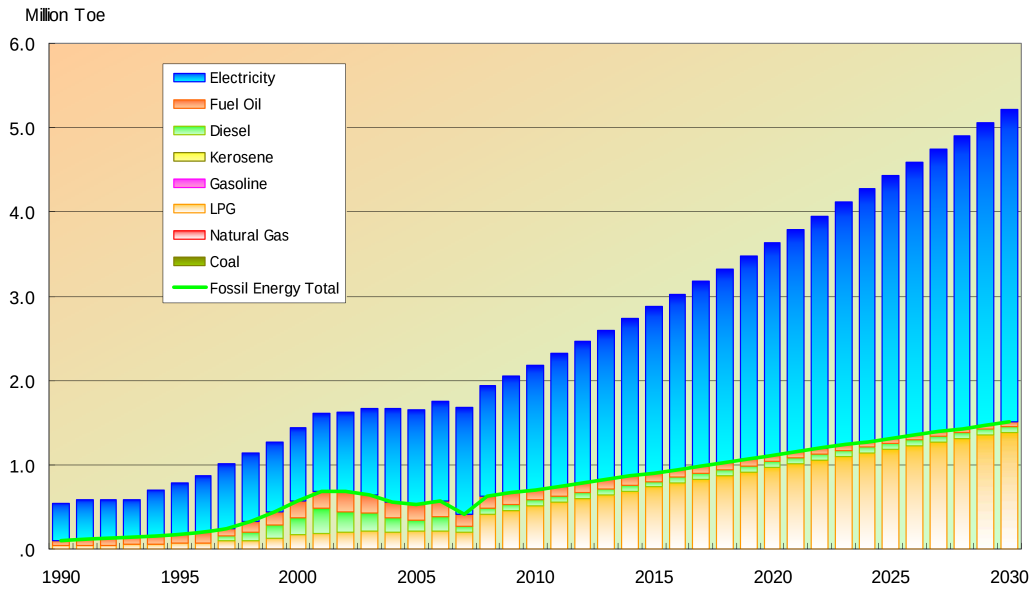


Figure 6.2-5 Energy Outlook of Commercial Sector

LPG demand in this sector is mainly for cooking use and individual outlets are generally small. As city gas grid is not developed in Manila, construction of such system to feed small unit cooking use may be very difficult. Therefore, we have not scheduled conversion of LPG to natural gas in the commercial sector in this study. However, if natural gas supply becomes available in and adjacent areas of Metro-Manila, co-generation for air conditioning purpose at hotels and hospitals may become possible in addition to cooking use. In such a case, there is a good possibility that a part of electricity demand may convert to city gas. Therefore, it is necessary to consider future energy selection coherently with natural gas market development plan.

6.2.5 Residential Sector

Most of the residential sector energy consumption comprises biomass, electricity and LPG. Biomass energy such as fuel wood and charcoal will be replaced by modern energies such as electricity and LPG in due course. Commercial energy demand of the residential sector during the projection period is estimated to grow at annual 3.9%, and it will increase 2.6-fold from 2.4 million toe in 2005 to 6.19 million toe in 2030. Since city gas service is not available, substantial part of the incremental energy demand may be supplied by LPG and electricity.

Among the commercial energies, kerosene used for lighting and cooking purpose will be replaced by electricity and LPG. Thus, the following equations are applied for demand estimation of the sector.

LPG = Number of Household using LPG x LPG consumption per household x 102.5

Kerosene = Consumption of the previous year x 95%

Fossil Fuel = Total of the above

Electricity = Electricity intensity per personal consumption expenditure (PCE) x PCE

Table 6.2-6 Energy Outlook of Residential Sector

	LPG	Kerosene	Fossil Energy	Electricity	Commercial Total	Charcoal	Fuel wood	Agri-Waste	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	773.7	252.7	1,026.4	1,378.7	2,405.1	537.1	3,373.0	0.0	6,315.2
2010	882.4	155.0	1,037.4	1,725.4	2,762.9	509.3	2,891.8	0.0	6,163.9
2020	1,523.0	92.8	1,615.8	2,818.2	4,434.0	332.4	1,887.4	0.0	6,653.9
2030	2,186.5	55.6	2,242.1	3,976.7	6,218.7	149.2	847.0	0.0	7,214.9
2005->30	4.2%	-5.9%	3.2%	4.3%	3.9%	-5.0%	-5.4%	***	0.5%

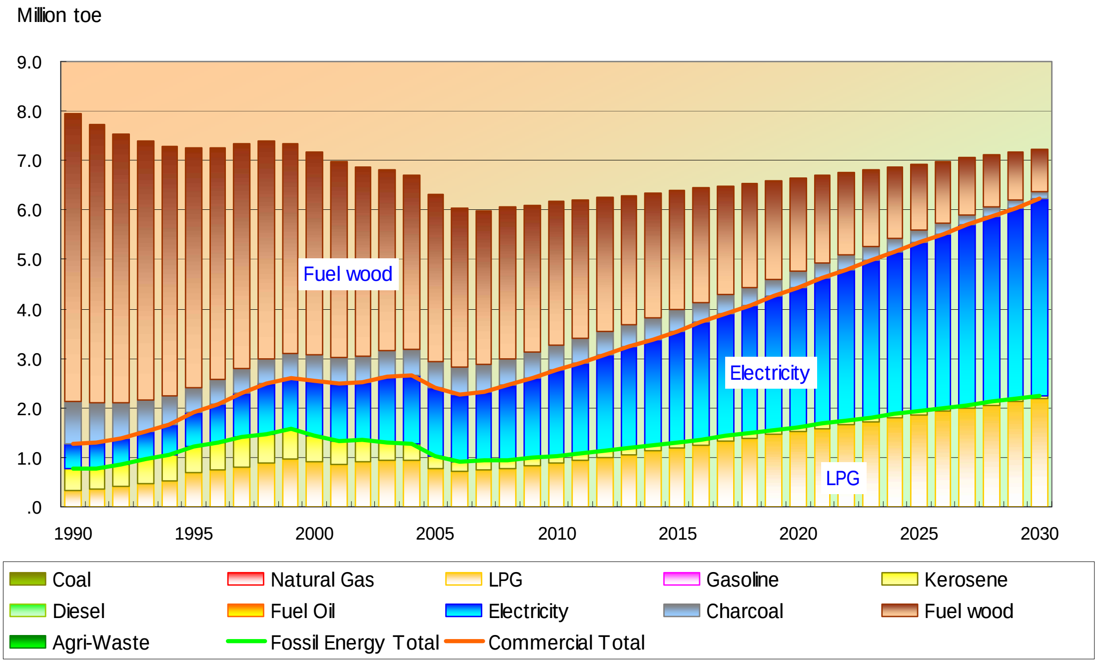


Figure 6.2-6 Energy Outlook of Residential Sector

As a result, we project that usage of the on-grid electricity will reach 90% in 2030 from the current ratio of slightly below 80%, and LPG use ratio will increase from 60% to 75% during the projection period. Electrification ratio including off-grid supply will become almost 100%. On the other hand, conventional biomass energy such as fuel wood and charcoal that shared large portion in the household energy consumption will decrease being replaced by LPG. Compared with the traditional biomass, LPG could be used only when it is needed. Therefore, we assume that biomass consumption may decrease by double quantity of the LPG consumption increase reflecting energy efficiency. This assumption needs to be verified by survey on energy efficiency.

6.3 Energy Demand Outlook of Transportation Sector

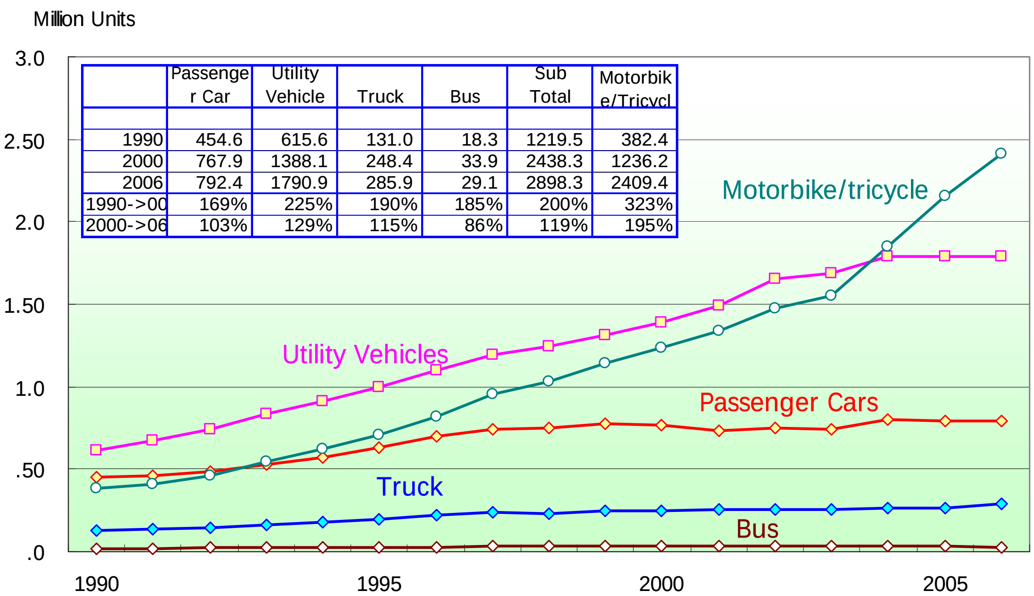
In 2007, energy consumption in the transportation sector recorded 10,416 ktoe. It is the largest energy consumption sector sharing 43% of the total energy consumption of the Philippines. Energy demand in this sector can be divided into four sectors, that is, those for motor vehicles, railway, marine transportation and aviation services. In 2007, fuel consumption for motor vehicles shared 75% of the transportation sector energy use, while marine fuel shared 14% and aviation fuel 11%, and energy for railway was merely 0.09 % (9.2 ktoe).

In the energy demand forecast of the transportation sector, 1) for the motor vehicle use that shares substantial portion we have adopted the method to consider motor vehicle ownership and fuel consumption mileage, and 2) for marine, aviation and railway services we have adopted methods to consider relationship with transportation quantity and passenger numbers. Since relevant statistics are not available or substantially irregular, we need to introduce hypothetical equations daringly. However, we should note that the motor vehicle diffusion in the Philippines is still in an early stage at present, and it is difficult and not appropriate to estimate to what extent it would develop applying the historical data. It is desired that comprehensive future design should be drawn up with thorough discussion on life style, business style, transportation policy, etc., and fuel policy should be set out based on such investigations.

6.3.1 Number of Automotive Vehicles

Numbers of automotive vehicles in the Philippines are 2.9 million units of four wheeler or larger vehicles and 2.4 million units of motorbike and tricycles.

Trucks for freight transportation are mainly large sized vehicles and less than 300,000 units. Number of vehicles doubled during the 1990s, but the increasing pace has slowed down since 2000. Number of bus is decreasing and passenger car is stagnant. Among them, utility vehicles (those vehicles with passenger capacity of less than 18 such as jeepneys, wagons and SUVs) are increasing steadily. In addition, number of motorbike is increasing fast suggesting a possibility of explosive diffusion as seen in Thailand and Vietnam. There is also a possibility that, from the examples of Japan and front running ASEAN countries, number of light truck may increase in future, though any sign of such tendency is not found yet in the Philippines.



	Passenger Car	Utility Vehicle	Truck	Bus	Sub Total	Motorbike/Tricycl
1990	454.6	615.6	131.0	18.3	1219.5	382.4
2000	767.9	1388.1	248.4	33.9	2438.3	1236.2
2006	792.4	1790.9	285.9	29.1	2898.3	2409.4
1990->00	169%	225%	190%	185%	200%	323%
2000->06	103%	129%	115%	86%	119%	195%

Figure 6.3-1 Historical Record of Motor Vehicle Ownership

6.3.2 Number of Automotive Vehicles and Fuel Consumption

In general, motor fuel consumption is estimated by a method of "number of automotive vehicles" times "fuel consumption per unit", and the latter is the product of fuel mileage and operation rate of a car. Both of number of automotive vehicles and unit fuel consumption are generally stable. Number of vehicles as durable goods does not change abruptly every year. Fuel mileage is fixed when a vehicle is bought. Usage of a vehicle follows daily life style or business pattern, which would not change suddenly but relatively stable. However, if we draw graphs on these statistics of the Philippines, we find that fuel consumption record is considerable unstable while vehicle number is relatively stable. Estimating fuel demand, we need to verify how to assess the relationship of these statistics.

In order to verify the relationship between the vehicle number and fuel consumption, unit fuel consumption is illustrated in Figure 6.3-2, which are calculated per passenger car equivalent gasoline vehicles and per truck equivalent diesel vehicles. For this aggregation, Japanese statistics of fuel consumption by vehicle type is applied as explained later. While unit fuel consumptions are on the declining trend both for gasoline and diesel oil in the recent years, they are substantially below the trend in these years. For example, two lines are illustrated in the graph to show the hypothetical gasoline and diesel oil demand assuming that the unit fuel consumptions were kept at the level of 2000 and another case that they were improved annual one percent or 6.8% during six years. Actual records of both gasoline and diesel oil consumption in 2005 and 2006 substantially undershoot these trends. It is curious enough that diesel oil consumption suddenly returned to this trend line in 2007, though gasoline continued undershooting. Perhaps, it may be appropriate to think that oil statistics would be problematic from the above investigation.

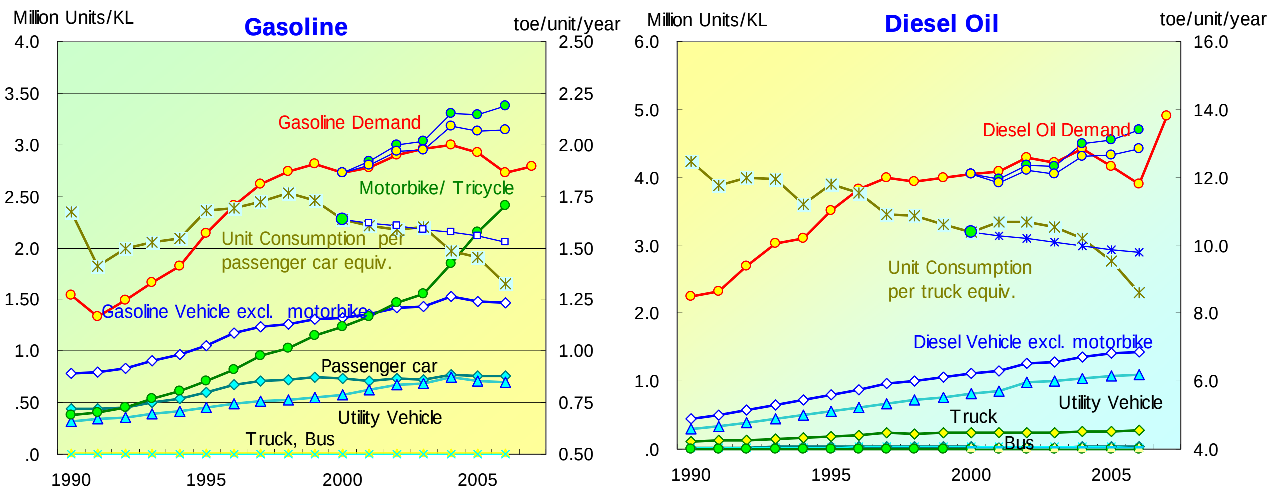


Figure 6.3-2 Number of Vehicles and Fuel Demand

6.3.3 Outlook of Automotive Fuel Demand

Estimated number of automotive vehicles and fuel consumption are shown in Table 6.3-1 and Figure 6.3-3 below.

Table 6.3-1 Outlook of Automotive Vehicles

	Passenger Cars	Utility Vehicles	Trucks	Buses	Motorcycles/Tricycles	Total	Passenger Car Equiv.
Gasoline Vechicles : 1000 units							
2005	756	708	9	1	2158	3632	2013
2010	825	897	16	3	3610	5351	2588
2020	1307	1299	21	4	6497	9127	4082
2030	1816	1516	23	5	8010	11370	5131
2005->30	3.6%	3.1%	3.7%	6.8%	5.4%	4.7%	3.8%
							Truck Equiv.
Diesel Vehicles : 1000 units							
2005	32	1084	258	30	0	1404	420
2010	37	1537	341	28	0	1944	557
2020	39	2645	484	30	0	3199	835
2030	41	3267	572	32	0	3913	1000
2005->30	1.0%	4.5%	3.2%	0.2%	***	4.2%	3.5%

With regard to the number of gasoline vehicles, passenger cars and utility vehicles such as one box cars and SUV will be the popular vehicles. At present the total number of both type amounts to 1.5 million units. This will increase at a speed of annual 3.5% and reach 2.6 million units in 2020 and exceed 3.3 million units in 2030. Another surprise anticipated in the gasoline sector is fast increase of motorbike as seen in ASEAN countries such as Thailand and Vietnam. In this study, we have projected that the current diffusion rate of 30.4 units per 1,000 persons would increase to 65 units in 2030. Yet, it is substantially below the level of Thailand, which is close to 300 units per 1,000 persons.

Large trucks and buses will continue to be the core user of diesel oil, while big increase may be expected in the number of one box cars and Sporting Utility Vehicles. They are quite popular in the Philippines and may increase fast. On the other hand, trend of light truck is not transparent. In case of Japan, as the number of large size trucks was 2.45 million units, number of smaller trucks was 4.28 million units or 1.74-fold of large sized trucks and gasoline-driven light trucks 9.38 million units or 3.83-fold. At present we do not find any sign that light trucks would increase like this. As jeepneys and tricycles are playing the role in the Philippines, we need to watch any changes in the trend.

In the estimation of automotive fuel demand, we have adopted the method that, at first, numbers of each vehicle type should be aggregated into passenger car equivalent for gasoline driven vehicles and truck equivalent for diesel oil driven vehicles, and then trend of the converted unit fuel consumption should be looked into.

As shown in Figure 6.3-3, we observe substantial irregular fluctuations in the past figures. These may be deemed as a matter of quality of statistics rather than economic phenomenon. Thus, we have projected that the converted unit fuel consumption would gradually decrease at a steady pace, namely at the EEC progress rate applied to each case (0.5% for the Reference Case). We have applied Japanese motor fuel consumption statistics as the conversion ratio for aggregating different type vehicles as shown below, as reliable statistics are not available in the Philippines.[20]

[20] Energy demand survey conducted in this study includes energy consumption data at transportation industries ans certain data

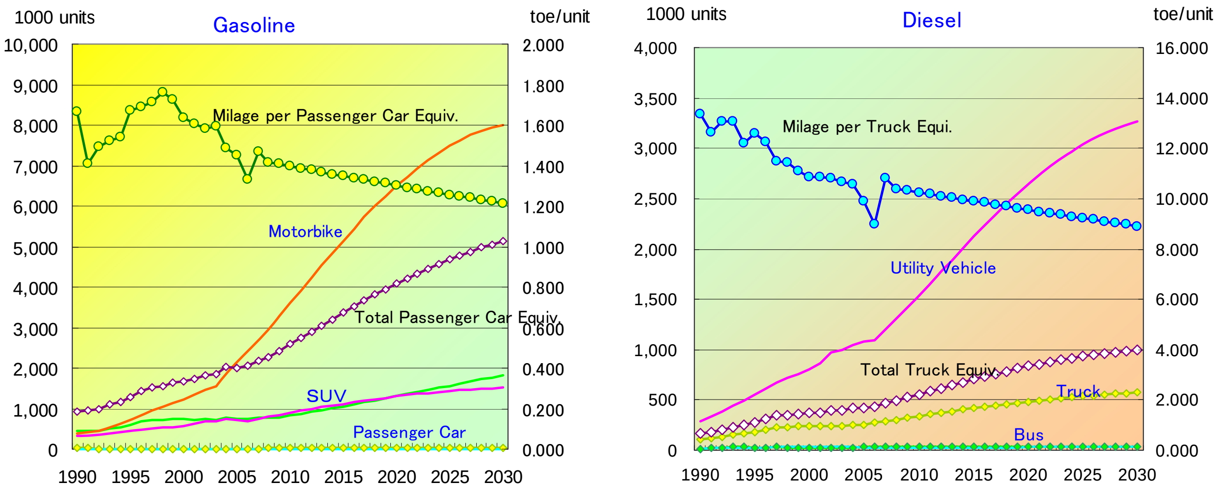


Figure 6.3-3 Automotive Vehicles and Fuel Demand

Table 6.3-2 Motor Fuel Consumption by Vehicle Type

	Passenger Car	Utility Vehicle	Truck	Bus	Motorbike
	litters	litters	litters	litters	litters
Gasoline	1460	1725	2677	3650	270
Diesel	1186	1356	12191	11771	***
Conversion Rate					
Gasoline	100.0	118.2	183.4	250.0	18.5
Diesel	9.7	11.1	100.0	96.6	2.2

Source: Ministry of Transportation "Automotive Transportation Statistics"

Then, with regard to introduction of biofuels, we have assumed according to the target set out under the Biofuel Act of 2006 as follows.

1) Bio-ethanol will be introduced 5% in 2009 and expanded to 10% from 2011

2) Bio-diesel is deemed to have been introduced to 1% in 2007 already, and this ratio will be raised to 2% from 2009.

With regard to gaseous fuels, we assume that CNG and LPG will be introduced mainly in gasoline driven vehicles such as taxi. CNG is already introduced into buses, but it is assumed for the Reference Case that the quantity may remain minimal. However, pending future energy policy, gaseous energy would be introduced much more than what is assumed here. Several cases where biofuel would be introduced in more accelerated speed would be examined as explained in Chapter 7.

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on fuel consumption at commercial truck and bus businesses are obtained. However, since fuel consumption data of passenger cars, utility vehicles and trucks that share substantial part of fuel consumption is no available, the result of the energy demand survey was not adopted this time. It is desired that such survey should be expanded to obtain more accurate and coherent data covering necessary sectors.

Table 6.3-3 Motor Fuel Demand by Fuel Type

	CNG	LPG	Gasoline	Ethanol	Diesel	Bio-Diesel	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	-	1	2,923	1	4,168	-	7,094
2010	5	72	3,362	181	5,594	114	9,329
2020	31	106	4,669	531	7,797	160	13,294
2030	101	124	5,463	622	8,647	178	15,136
2005->30	***	20.5%	2.5%	27.6%	3.0%	***	3.1%
Composition	%	%	%	%	%	%	%
2005	0.0	0.0	41.2	0.0	58.8	0.0	100.0
2010	0.1	0.8	36.0	1.9	60.0	1.2	100.0
2020	0.2	0.8	35.1	4.0	58.7	1.2	100.0
2030	0.7	0.8	36.1	4.1	57.1	1.2	100.0

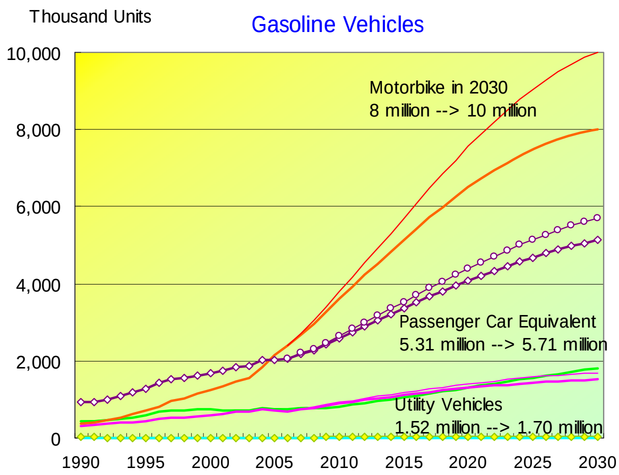
Outlook of motor fuel demand under the above consideration is shown in Table 6.3-4. As introduction of gaseous fuels and biofuels is stipulated in the Philippine Energy Plan, the aggregate share of these new motor fuels is only 6%. It is necessary to further investigate into possibilities and pros and cons of boosting of such targets including studies in the aspects of commerciality, energy security and environmental impacts.

6.3.4 Study on Increased Vehicles Case

The diffusion speed of automotive vehicles in the Philippines will be affected by people's preference of life style and public transportation policy, since its economy is still in development stage.

Therefore, let us examine the case where popular vehicles such as SUV and motorbike would increase faster. We examine the case here that, compared with the case projected for the Reference Case, number of truck and SUV increases 12 to 13% and that of motorbike 25%.

Under the above projection, gasoline demand in 2030 will increase 11.3% and diesel oil 12.4%. It is a bit difficult to read if motorbike would increase fast like in other ASEAN countries, the difference



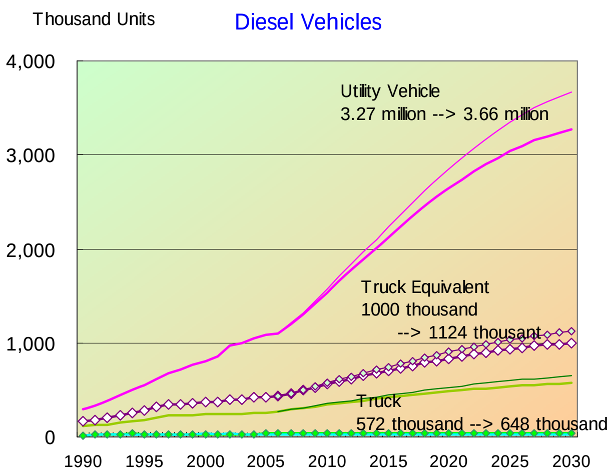


Figure 6.3-4 Vehicle Plus Cases

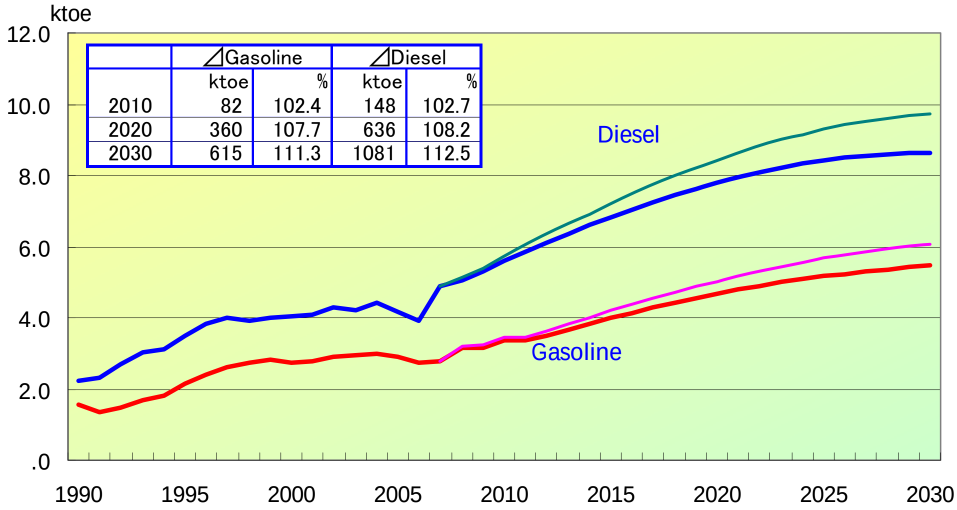


Figure 6.3-5 Possibility of Automotive Fuel Demand Increase

of its plateau level at 8 million units or 10 million units will give a substantial impact on the gasoline demand. From these observations, we can say that with regard to automotive fuel tendency, we should watch carefully on the trend of 1) biofuels, 2) motorbike and 3) SUV and light trucks.

6.3.5 Other Transportation Fuels

Other transportation fuels share 1/4 of the total transportation fuel consumption. Being an archipelago country, demand of marine and aviation fuels is big in the Philippines. On the other hand, railway system is limited to the Manila area and its energy demand is minimal.

Table 6.3-4 Outlook of other Transportation Fuels

	Aviation Fuel	Marine Diesel	Marine Fuel Oil	Rail	Total
	ktoe	ktoe	ktoe	ktoe	ktoe
2008	1136	300	1300	9	2746
2010	1245	258	1191	10	2703
2020	1828	500	1643	12	3983
2030	2494	845	2075	13	5428
2005->30	3.6%	4.8%	2.1%	1.6%	3.1%

As shown in Figure 6.3-6, record of marine fuel consumption shows extraordinary fluctuation. In particular, demand of fuel oil for long haul vessels fluctuates greatly, maybe because these vessels are able to choose refueling port considering the available fuel prices inside or outside of the country. In addition, refueling could be made not at a fixed point but flexibly with refueling boats. Therefore, accuracy of actual marine fuel demand is generally problematic. Compared with this, aviation fuels with fixed refueling points at airports show relatively steady figures.

As irregularities are found in statistics like this, method of extending the demand basis 2007 actual quantity is adopted on these fuels. In each sector, marine fuel demand is estimated in relation with marine freight quantity and aviation fuel with air traffic passengers. Demand increase during the projection period is about annual 3%. As we use such estimation method, since statistics on

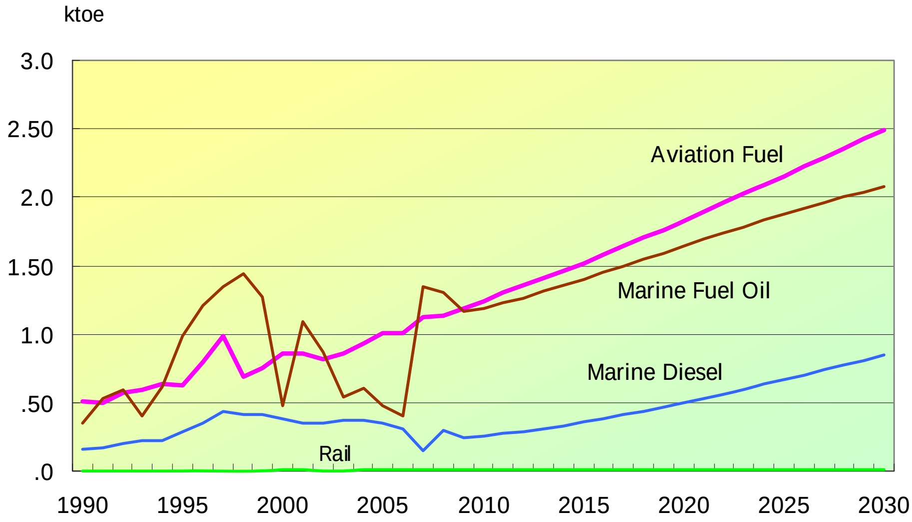


Figure 6.3-6 Fuel Demand for Marine, Aviation and Railway

passengers and freights transported are not necessarily stable, improvement of their quality is an essential problem. In addition, development of public transportation system such as railway will have substantial impact on the automotive fuel demand, it is necessary to consider the fuel demand tendency in close relation with transportation and traffic policy.

6.4 Energy Demand Outlook by Fuel

Let us look into the energy demand trend by energy source, next. Energies are used in various fields according to their characteristics, convenience and economics. In the field of automotive fuel, gasoline and diesel oil are used because of portable convenience, fuel oil and coal are used at large scale plants because they are cheap though they need large scale equipments, and LPG is preferred in the household sector because it is clean and easy to use. Such energy selection changes with time reflecting technology progress, consideration on environment and other elements. Please take note that figures shown in the following analysis are those before energy supply optimization, and that adding the fuel consumption and energy losses in the transformation sector, the primary energy supply will be calculated.

6.4.1 Electricity Demand

In the Philippines where large scale manufacturing industry is scarce, the largest electricity consumption sector is the residential sector followed by manufacturing and commercial sectors. As railway service is quite limited, electricity consumption at the transportation sector includes very small quantity for driving power and is mostly for use at offices and service facilities.

Future electricity demand will occur mainly in the services sector and general manufacturing sector for business use, as these industries are expected to be leading sectors of the future economic growth. Since technology progress of energy efficiency in equipments and electrical appliances used in these sectors is fast, these sectors are expected to be the area the greatest impact of energy efficiency and conservation may occur. In this context, demand trend in these sectors should be looked into carefully.

Table 6.4-1 Electricity Demand by Sector

	Agriculture	EI Industry	Gen Mfg.	Transport	Commercial	Residential	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	42.2	688.7	636.7	7.8	1,129.6	1,378.7	3,883.7
2010	49.5	763.2	786.4	9.8	1,482.1	1,725.4	4,816.4
2020	72.2	1,012.1	1317.7	11.7	2,528.0	2,818.2	7,759.9
2030	92.6	1,260.3	1893.6	13.4	3,713.4	3,976.7	10,950.0
05-30	3.2%	2.4%	4.5%	2.2%	4.9%	4.3%	4.2%
Composition	%	%	%	%	%	%	%
2005	1.1	17.7	16.4	0.2	29.1	35.5	100.0
2010	1.0	15.8	16.3	0.2	30.8	35.8	100.0
2020	0.9	13.0	17.0	0.2	32.6	36.3	100.0
2030	0.8	11.5	17.3	0.1	33.9	36.3	100.0

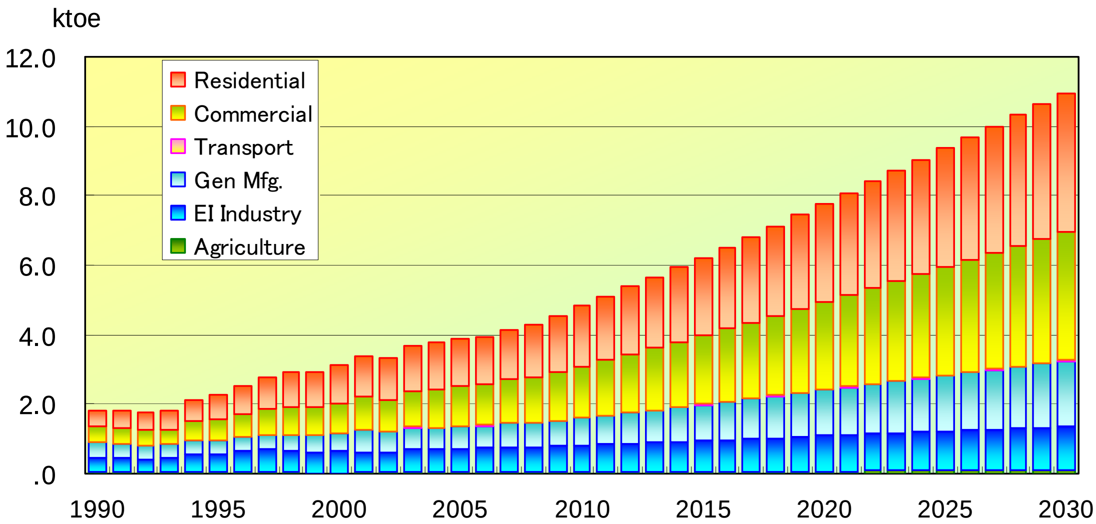


Figure 6.4-1 Electricity Demand by Sector

6.4.2 Coal Demand

For other than electric power generation, coal is used mostly by the cement industry with minimal quantity by general manufacturing. This tendency will continue in the Philippines where large manufacturing industry does not exist. Therefore, coal consumption in the general sector is estimated in relation to cement production as shown in Figure 6.4-2.

Table 6.4-2 Coal Demand by Sector

	Agriculture	EI Industry	Gen Mfg.	Transport	Commercial	Residential	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	0.0	1,031.2	25.3	0.0	0.0	0.0	1,056.5
2010	0.0	1,353.0	31.2	0.0	0.0	0.0	1,384.3
2020	0.0	1,953.9	47.2	0.0	0.0	0.0	2,001.2
2030	0.0	2,590.7	62.4	0.0	0.0	0.0	2,653.1
05-30	***	3.8%	3.7%	***	***	***	3.8%
Composition	%	%	%	%	%	%	%
2005	0.0	97.6	2.4	0.0	0.0	0.0	100.0
2010	0.0	97.7	2.3	0.0	0.0	0.0	100.0
2020	0.0	97.6	2.4	0.0	0.0	0.0	100.0
2030	0.0	97.6	2.4	0.0	0.0	0.0	100.0

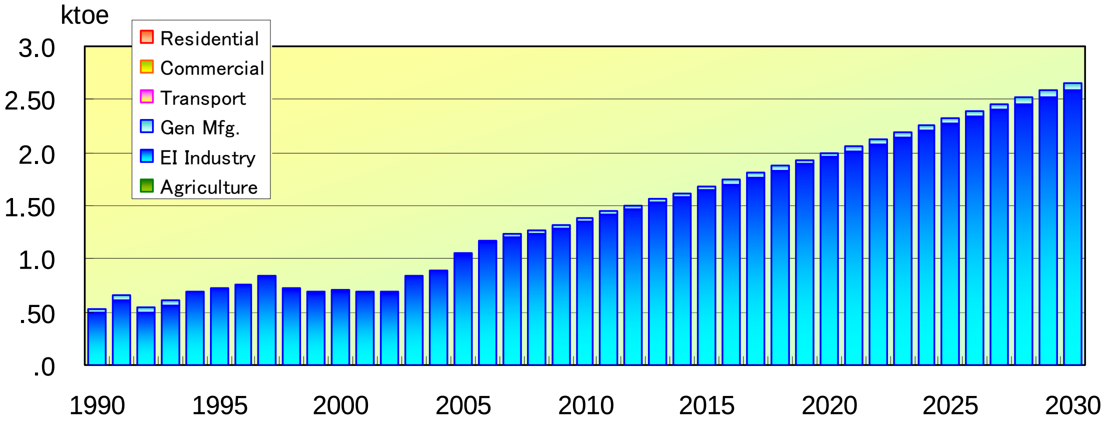


Figure 6.4-2 Coal Demand by Sector

6.4.3 Gas Demand

In the Philippines, natural gas is mostly used for power generation, and only a limited quantity is used in other sectors at Batangas, the landing point of the gas pipeline from the Malampaya field. There is no plan to develop industries to use natural gas in a big quantity as chemical feedstock or energy source. On the other hand, use of LPG is developing in commercial and residential sectors and this trend is expected to continue. In other areas, CNG and LPG use is starting in the transportation sector, though the demand is small at present.

Table 6.4-3 Gas Demand by Sector

	Natural Gas			LPG						Grand
	Gen Mfg.	Transport	Total	EI Industry	Gen Mfg.	Transport	Commercial	Residential	Total	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	12.2	0.0	12.2	45.7	23.6	1.2	219.3	773.7	1,063.5	1,075.7
2010	77.4	5.1	82.4	39.5	54.7	72.3	507.3	882.4	1,556.2	1,638.7
2020	77.4	31.0	108.4	88.8	227.1	106.3	963.5	1,523.0	2,908.5	3,016.9
2030	77.4	100.8	178.1	156.8	463.5	124.5	1,389.3	2,186.5	4,320.6	4,498.8
05-30	7.7%	***	11.3%	5.1%	***	20.5%	7.7%	***	5.8%	5.9%
Composition	%	%	%	%	%	%	%	%	%	%
2005	1.1	0.0	1.1	4.2	2.2	0.1	20.4	71.9	98.9	100.0
2010	4.7	0.3	5.0	2.4	3.3	4.4	31.0	53.8	95.0	100.0
2020	2.6	1.0	3.6	2.9	7.5	3.5	31.9	50.5	96.4	100.0
2030	1.7	2.2	4.0	3.5	10.3	2.8	30.9	48.6	96.0	100.0

It is expected that consumption of gaseous energy, clean and easy to use, will continue to develop at a certain pace. In the transportation sector, large scale introduction of CNG buses and LPG vehicles is planned. If city gas grid were constructed in the metropolitan area, good chances would come up that co-generation would develop at office buildings, large scale shopping facilities, hospitals and medium/small factories to realize high energy efficiency producing heat and power simultaneously.

In other aspect of the Philippines, as the country comprises many islands, regional demand centers are relatively small and scattered except for the Metro-Manila region, and hence LPG may be more convenient fuel than natural gas in transportation and handling. It is possible to use LPG as a gas source for small scale gas grid in regional cities and towns. However, there are many uncertainties on the future supply trend of LPG and natural gas within Philippine and in the international market. Considering these elements, it is necessary to carry out detail study on the possibility and direction of developing domestic gas market together with evaluation of various supply options.

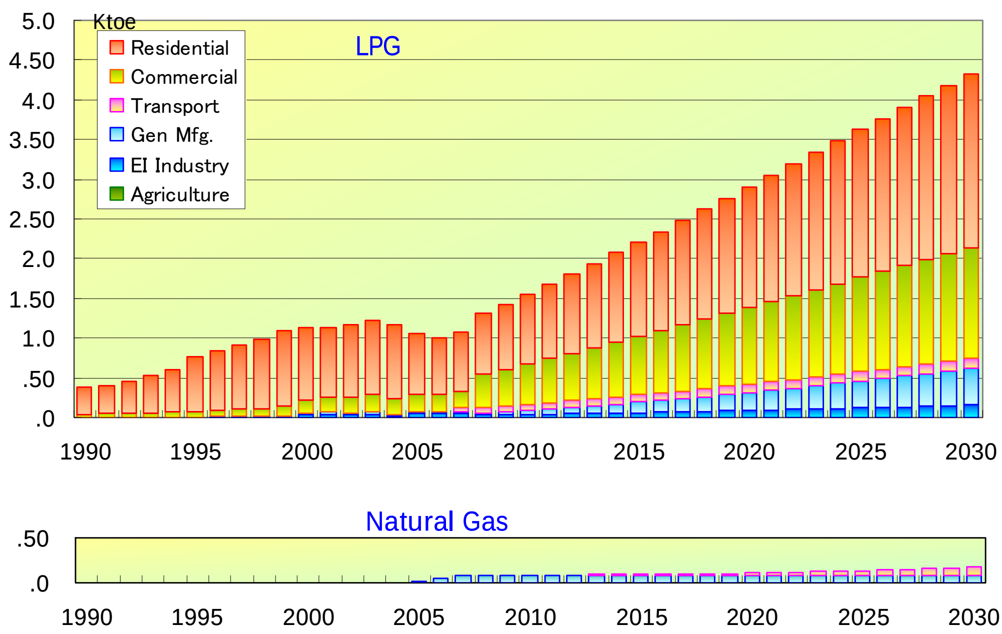


Figure 6.4-3 Gas Demand by Sector

6.4.4 Petroleum Products Demand

In the Philippines, almost 80% of the petroleum products excluding LPG is used in the transportation sector. In addition that energy intensive industry is relatively small, coal and bagasse are used as source of heat in cement and sugar industries. Though fuel oil is used in food processing and paper & pulp industries, their demand is relatively small. Quantities of petroleum products such as diesel oil statistically classified as industrial use are limited, as they are used for operations inside manufacturing facilities as well as outgoing transportation. On the other aspect, kerosene use for lighting and cooking in commercial and residential sectors are being replaced with electricity and LPG. This trend will continue. With the recent oil price boost, petroleum products demand in the Philippines will tend to concentrate in the transportation use further.

Table 6.4-4 Petroleum Product Demand by Sector (excluding LPG)

	Agriculture	El Industry	Gen Mfg.	Transport	Commercial	Residential	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	270.6	887.9	732.5	8,930.5	311.4	252.7	11,385.6
2010	204.8	914.8	530.3	11,944.9	197.5	155.0	13,947.4
2020	264.7	1256.2	696.7	17,127.8	146.3	92.8	19,584.6
2030	309.8	1583.1	782.3	20,324.5	115.7	55.6	23,171.0
05-30	0.5%	2.3%	0.3%	3.3%	-3.9%	-5.9%	2.9%
Composition	%	%	%	%	%	%	%
2005	2.4	7.8	6.4	78.4	2.7	2.2	100.0
2010	1.5	6.6	3.8	85.6	1.4	1.1	100.0
2020	1.4	6.4	3.6	87.5	0.7	0.5	100.0
2030	1.3	6.8	3.4	87.7	0.5	0.2	100.0

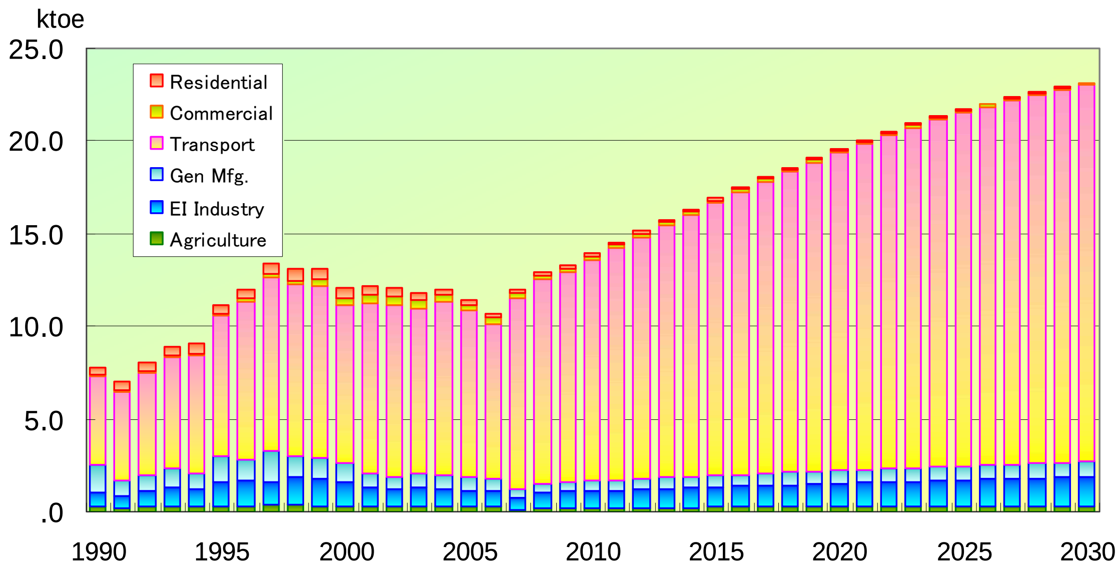


Figure 6.4-4 Petroleum Product Demand by Sector (excluding LPG)

Looking into the fuel type distribution of petroleum products, major demand increase is expected in LPG for cooking, gasoline and diesel oil for automotive vehicles, jet fuel and marine fuel oil. In the fuel type distribution, fuel oil decreases its share while jet fuel increases steadily to enhance shift to lighter products. However, since introduction of biofuel will progress, shift to lighter products will proceed moderately. In the petroleum products composition excluding biofuel and LPG, share of gasoline will increase by 1% from 23.4% in 2005 to 24.4% in 2030, and that of middle distillates by 2.5% from 56.1% to 58.6% while fuel oil decreases from 20.5% to 17.0%. On the other hand, LPG use will further develop in commercial and residential use and its ration on the total petroleum products consumption will double during the projection period. As we cannot expect big supply increase from domestic gas fields (at present), the incremental LPG demand needs to be supplied by import.

It should be noted here that figures shown in Table 6.4-5 represent the final demand for these products but do not include consumption at transformation sector such as fuel for power generation and own use at refineries.

Table 6.4-5 Petroleum Product Demand by Fuel Type

	Aviation gasoline	Gasoline	Ethanol	Jet fuel	Kerosene	Diesel	Bio-diesel	Fuel Oil	Total	LPG
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2007	3.8	2789.5	2.0	1124.6	199.8	5375.5	0.0	2452.9	11948.0	1073.8
2010	4.3	3362.2	180.8	1240.4	176.5	6445.5	114.2	2423.5	13947.4	1556.2
2020	4.3	4668.7	531.3	1823.5	118.5	9121.8	159.6	3156.8	19584.6	2908.5
2030	4.3	5462.6	622.4	2489.7	84.1	10534.9	178.2	3794.7	23171.0	4320.6
2005->30	0.6%	3.0%	28.4%	3.5%	-3.7%	3.0%	***	1.9%	2.9%	6.2%
Composition	%	%	%	%	%	%	%	%	%	%
2007	0.0	23.3	0.0	9.4	1.7	45.0	0.0	20.5	100.0	9.0
2010	0.0	24.1	1.3	8.9	1.3	46.2	0.8	17.4	100.0	11.2
2020	0.0	23.8	2.7	9.3	0.6	46.6	0.8	16.1	100.0	14.9
2030	0.0	23.6	2.7	10.7	0.4	45.5	0.8	16.4	100.0	18.6

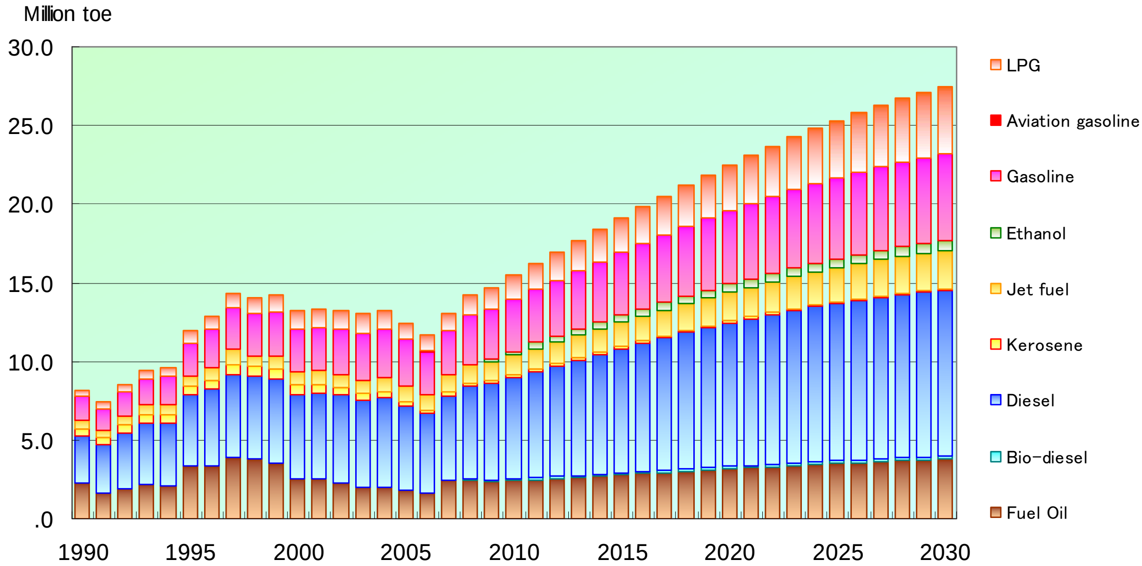


Figure 6.4-5 Petroleum Products Demand by Fuel Type

6.4.5 Biomass Energy Demand

Historically, biomass energies have been used mainly at household. As discussed in the previous section, they are being replaced with modern and healthy energy such as electricity and LPG. In other sectors, production of sugar and coconuts will increase as materials for biofuels and their residues such as bagasse and coconuts residue will be utilized in the industrial sector. Overall, however, use of biomass is on the declining trend.

Table 6.4-6 Biomass Energy Demand by Sector

	Agriculture	Energy Intensive Industry				General Manufacturing	Commercial	Residenntial	Non-commercial Biomass Total
		Total	Bagasse	Coconut residue	Others				
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	0.0	1201.7	711.2	299.3	191.2	10.0	298.2	4256.5	5766.3
2010	0.0	1681.4	1053.3	386.2	241.9	247.8	282.7	3688.6	5900.6
2020	0.0	2790.2	1752.6	637.9	399.7	412.4	184.5	2407.5	5794.6
2030	0.0	4028.8	2513.8	931.4	583.5	591.5	82.8	1080.4	5783.5
2005 ->3	***	5.0%	5.2%	4.6%	4.6%	17.7%	-5.0%	-5.3%	0.0%

Looking into sector distribution, it is curious that biomass consumption at the agricultural sector is defined to be zero in the statistics, but it is true that it is extremely difficult to obtain or define accurate quantity of biomass used in this sector. Residential use of fuel wood and charcoal will decrease, while industrial use of bagasse and coconuts residue will increase instead. In the Reference Case, we assumed that ethanol blending into gasoline will start in 2009 (E5 or 5% blending will start in 2009 and it will be upgraded to E10 or 10% blending in 2010), and the required quantity will be totally from sugarcane, enhancing supply of bagasse. Sugar for food is assumed to increase in relation to personal consumption growth. As consumption of bagasse in the general industry is not listed in the past statistics, we have allocated that 15% of bagasse supply would be supplied to general manufacturing incorporating hearing at sugar industries.

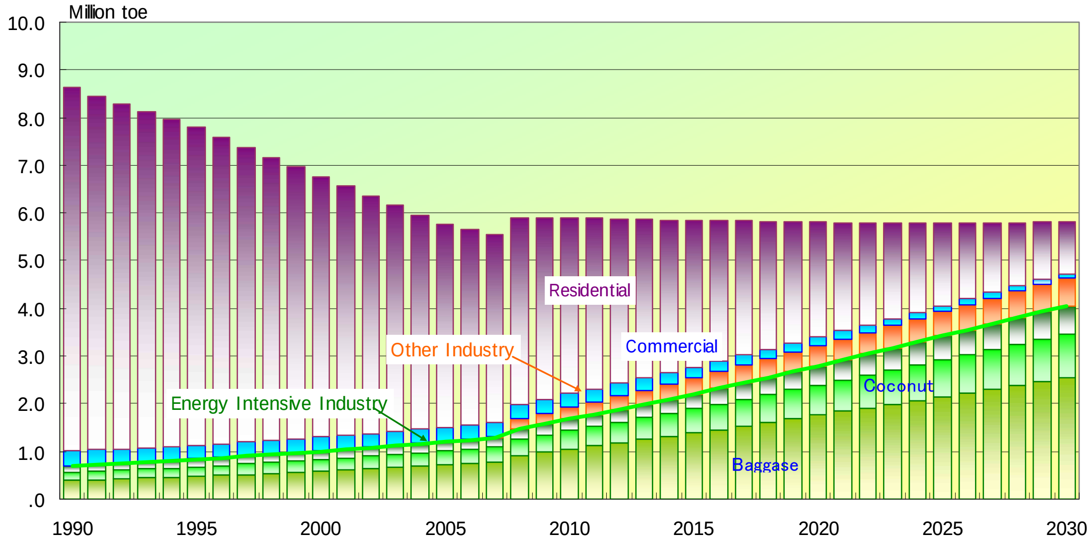


Figure 6.4-6 Biomass Energy Demand by Sector

At present, CME (Coco Methyl Ester) is used as biodiesel, which replaced 1% of the diesel oil demand in 2007 and is scheduled to increase to 2% in 2007. However, it is not clear to what extent this plan is realized, and that how the coconuts residue is utilized. Therefore, the relationship of coconuts residue and biodiesel is not considered yet.

As fuel wood and charcoal are currently being used in the commercial sector, they will decrease being replaced by LPG. It is assumed here that the biomass use in the commercial sector will decrease at the same pace considered for the residential sector.

Table 6.4-7 Biomass Demand by Fuel

	Rice hull	Charcoal	Fuel wood	Bagasse	Agri-waste	Animal waste	Non-commercial Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2005	48.0	677.3	3669.2	711.2	645.7	15.0	5766.3
2010	55.1	644.2	3220.0	1301.2	673.7	6.4	5900.6
2020	81.8	420.5	2291.2	2164.9	825.6	10.6	5794.6
2030	113.2	188.7	1345.1	3105.3	1015.7	15.5	5783.5
2005 ->30	3.5%	-5.0%	-3.9%	6.1%	1.8%	0.1%	0.0%

Among type of biomass, fuel wood and charcoal that shared most of the biomass supply will decrease and the ratio of bagasse and coconuts residue will increase resulting from increased production of biofuels. However, estimation of biomass residues being incurred like this is still very bold. In addition, pending biofuel supply plan, supply of bagasse and residues of coconuts and Jatropha will change substantially. In order to evaluate effect of them, as well as to utilize these fuel sources effectively together with biofuel promotion, it is necessary to conduct in-depth technical study for development of comprehensive biomass energy industry.

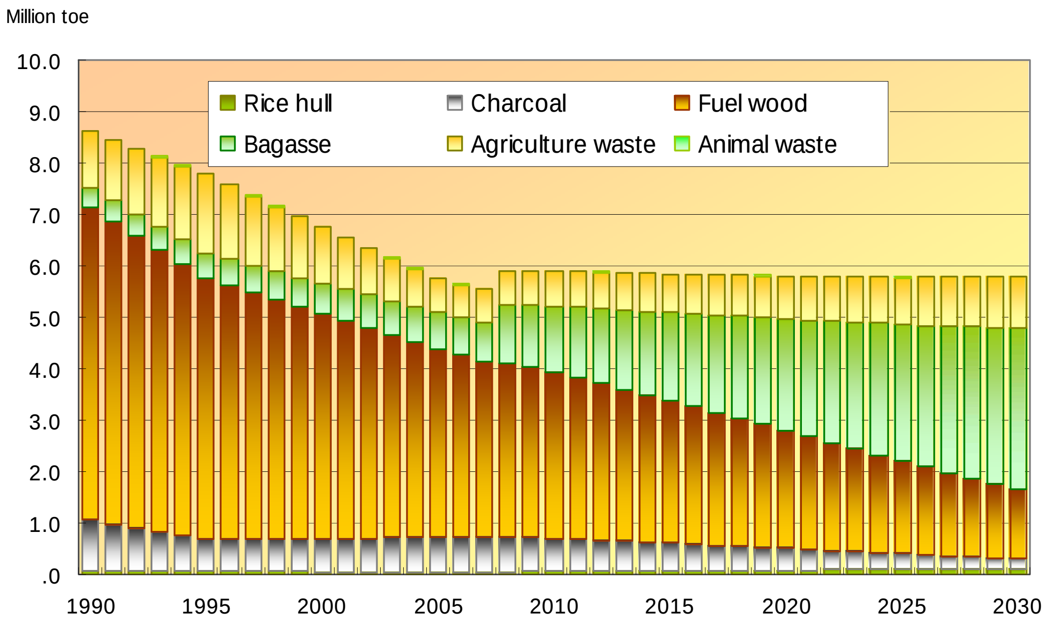


Figure 6.4-7 Biomass Energy Demand by Type

Chapter 7 Long-term Energy Supply/Demand Outlook

In this chapter, energy supply/demand trends up to 2030 are estimated based on the energy supply/demand optimization model exclusively developed in this project, in accordance with several demand scenarios studied in the previous chapter. Further in section 7.5, various case studies for supply condition changes have been executed, and the implications are examined. The data before 2006 is quoted from the past record.

7.1 Assumptions on Energy Supply Condition

Standard supply conditions for various kinds of energy adopted in the Reference Case of this study are described hereunder:

7.1.1 Assumptions on Oil Supply

1) Domestic refining capacity is kept at the present level without change. Refining capacity increase case will be described in section 7.5.
2) It is assumed that 0.25% of the total crude oil refined at the domestic refineries is indigenous, which quality is the same as the imported crude oil. Since the production rate of the indigenous crude oil in Philippines is small, with light and sweet (low sulfur content) quality, this assumption is applied for the simplification in the modeling.
3) Various petroleum products from the refinery can be exported with no bindings.
4) Strategic petroleum stockpiling started in 2006.
5) The amount of the petroleum stockpiling is determined based on the annual petroleum product consumption, which is converted to daily consumption amount of crude oil to be stored. Some 95% of the processed crude oil is assumed to convert into petroleum products, and 4% is used for self-consumption inside the refinery buttery limit.
6) Product yield at the refineries are given paying particular attention to yields of gasoline and diesel gas oil, considering such factors as unit configuration of the existing refineries, available past record in the Philippines, and in-house data of JICA team based on the overall Japanese experiences.
7) Amount of biofuel is assumed as the percentage portion (%) of the gasoline and diesel oil demand. The figures in demand estimation are directly quoted and retrieved into the supply.
8) Considering that the world LPG market fluctuates drastically, we have put a yardstick or maximum condition on the import quantity at 2 million tons per year and examined if more import is necessary beyond this amount. For the sake of the modeling convenience, it is assumed that some alternative fuel for LPG (LPG substitute, kerosene is assumed in this model considering the fuel quality) will be

automatically supplied when the LPG requirement exceeds sum of the domestic production and possible import.[21]

7.1.2 Assumptions on Natural Gas Supply

1) Domestically produced natural gas is supplied with priority, followed by imported LNG in the case of domestic gas shortage.[22]
2) In this study, LNG import is assumed to start in 2020 into the greater Manila area with an ultimate contract size of 3 million tons per year, following the step-wise considerations as follows: The introduction will be considered in 2 phases[23], i.e., 1.5 million tons per year for the Phase-1 period with two year "build-up period". Phase-2 will start five years later and will follow the same build-up pattern.
3) The heating value of domestic gas and import gas are assumed same.
4) Condensate from gas field should all go to export, same as present.
5) 3 Tcf reserve is assumed for the domestic Malampaya gas field, and production profile is taken as per Figure 7.1-2 below, to start declining from 2019.

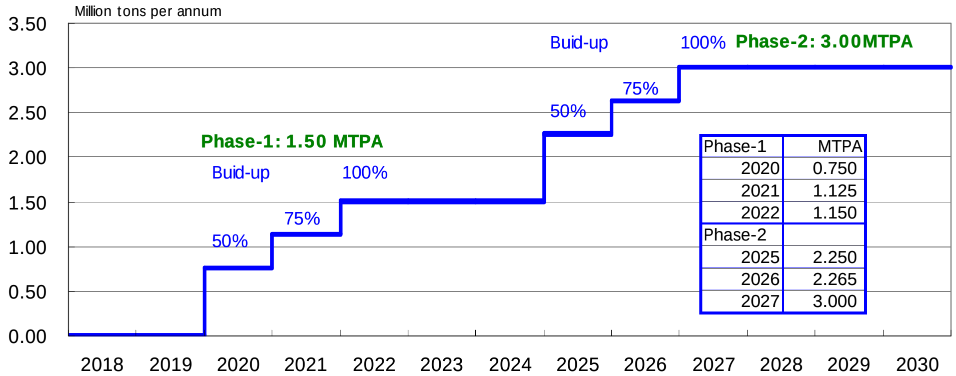


Figure 7.1-1 LNG Introduction Schedule

[21] It is realistic to assume that town gas (natural gas) is introduced with the required infrastructure preparation and substitutes for LPG when LPG demand increases beyond certain level in urban area. However, gas penetration in the Philippines has not made progress as originally expected. Thus, larger demand at industrial or commercial sectors is assumed to introduce kerosene for LPG when their LPG demand increases.

[22] Although the major portion of LNG supply may still based on long-term, take-or-pay contracts in Asia-Pacific region, trade flexibility is expected to increase around 2020 as global LNG market will expand substantially. Upon LNG introduction, more precise and practical study will be required.

[23] In storage tank construction, they are assumed to be installed in 2 phases, for example, 3 of 100 thousand kl tanks will be constructed in 1st phase, and the same sets will be installed in 2nd one, etc.

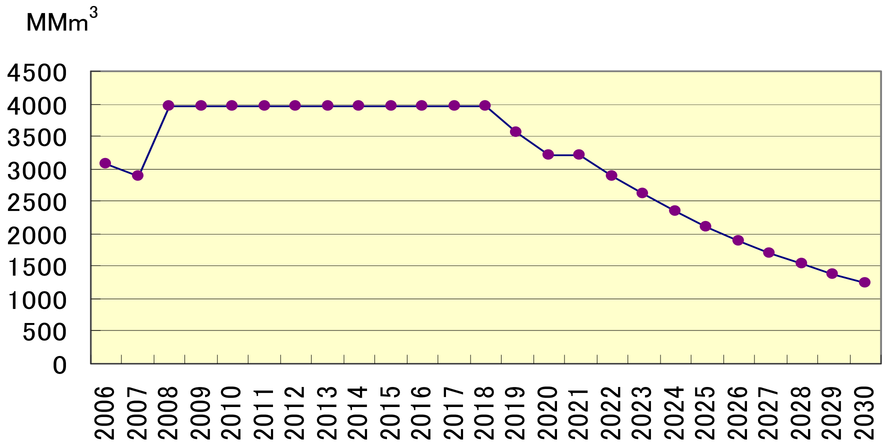


Figure 7.1-2 Maximum Domestic Gas Supply

7.1.3 Assumptions on Coal Supply

Coal production is summarized in Figure. 7.1-3, as per the coal development plan informed by DOE.

- No limitation is set for coal import.
- The heating values of domestic coal and import coal are different.[24]
- As coal demand is given in the heating values basis, physical coal amounts of domestic and import coals are calculated applying respective heat values.

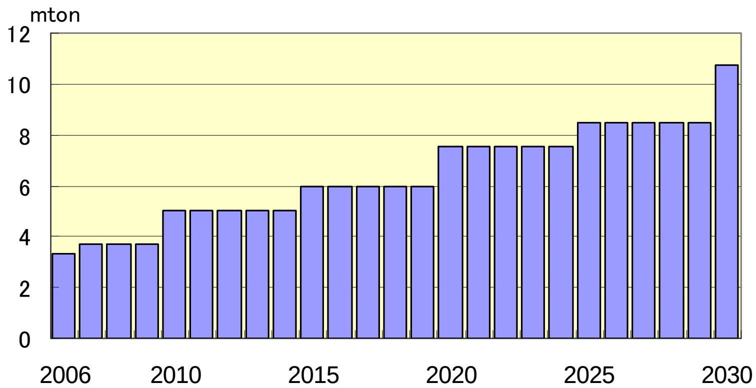


Figure 7.1-3 Maximum Domestic Coal Supply

7.1.4 Assumptions on Electric Power Supply

In the optimization model, thermal power plants are classified into 4 types based on fuel kinds; or coal, gas, diesel and fuel oil power plants, where coal and gas are classified as middle load source and oil is peak one. Nuclear power plant introduction case is studied in section 7.5.

Different thermal efficiencies are applied for existing and newly installed ones; thermal efficiency for new gas and coal power plants are 63% and 47%, respectively, which is quoted 5% higher than the existing plants.

Power supply of hydro, geothermal, wind and nuclear is given based on a separated study. The

[24] 5,557 kcal/kg for domestic coal and 6,835 kcal/kg for import coal are taken. Since alkaline content of domestic coal is high, which causes scaling on the outer surface of the heat transfer tubes, maximum mixture ratio of domestic coal is set as 20%.

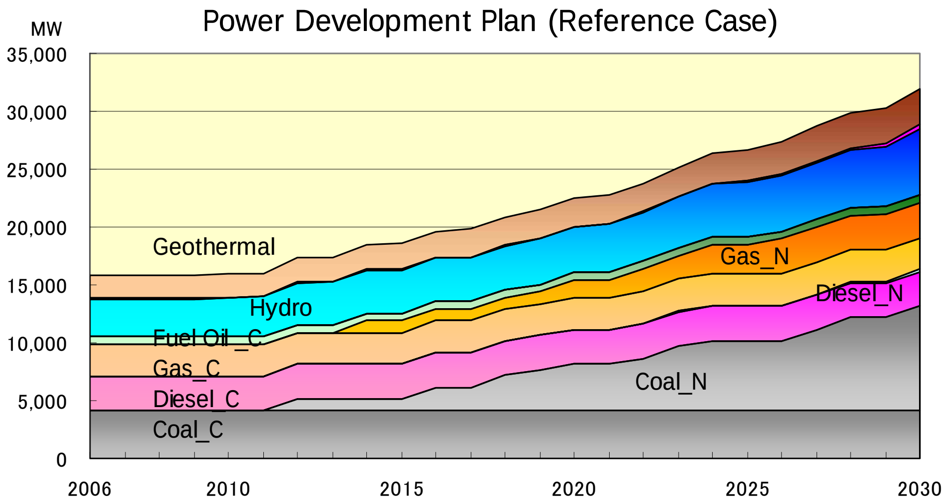
remaining balance, which is practically amount of thermal power, is optimized among oil, coal, and gas.

When new power sources are introduced, sources will be seceding in the following order: 1) diesel, 2) fuel oil, 3) gas and 4) coal. Plant capacity and maximum supply limit due to the domestic production are also taken into account.

While domestic coal is used, it shall be mixed with imported coal with its portion less than 20%, due to the alkaline content as per the footnote.

Diesel power plant is installed in isolated islands in many cases. As there may be no alternate sources, it is assumed that minimum 10% of the diesel capacity always keeps working in the model.

In the Reference Case, nuclear power plant would not be commissioned yet during the projection period. Power source installation plan is shown in Figure 7.1-4 below.



Note: "_C" denotes existing facility in 2006 and "_N" denotes new facilities

Figure 7.1-4 Outlook of Power Source Mix in Reference Case

7.2 Long-term Energy Supply/Demand Outlook

In this section, the calculation result on the Reference Case based on the assumptions indicated in the previous section and its implication are discussed.

7.2.1 Trend of Primary Energy Supply

Primary energy supply consists of domestic fossil fuel production (oil, coal and natural gas), imported energy (oil, coal, natural gas and petroleum products), hydro, geothermal, other renewable, and nuclear, etc. Here, we will mainly look into changes in supply balance and combination of oil, coal, and natural gas, giving some assumptions on non-fossil fuel supply.

Primary energy supply for the Reference Case is shown in Figure 7.2-1. It tells that domestic coal production may keep its robust increasing pace, while gas production will start decreasing from 2019 due to its limited reserve amount.

Indigenous crude oil production in the Philippines is quite limited. Calculation result indicates that crude oil import remains almost the fixed level, and simple increase of petroleum products import occurs after

2008. The backgrounds are as follows. Expansion of the domestic refining capacity is not considered even in the future at all. Therefore, after all the capacity is fully utilized in 2007, increasing demand will be simply supplied by the increase of petroleum product import. At this moment, no foreign petroleum companies seem to be interested in investing to this country, and no specific plan for new installation or expansion of refining facility is proposed. However, since such situation looks abnormal and may be amended considering supply/demand balance as well as energy supply security, a case study is run as explained in Section 7.5 with regard to refinery capacity.

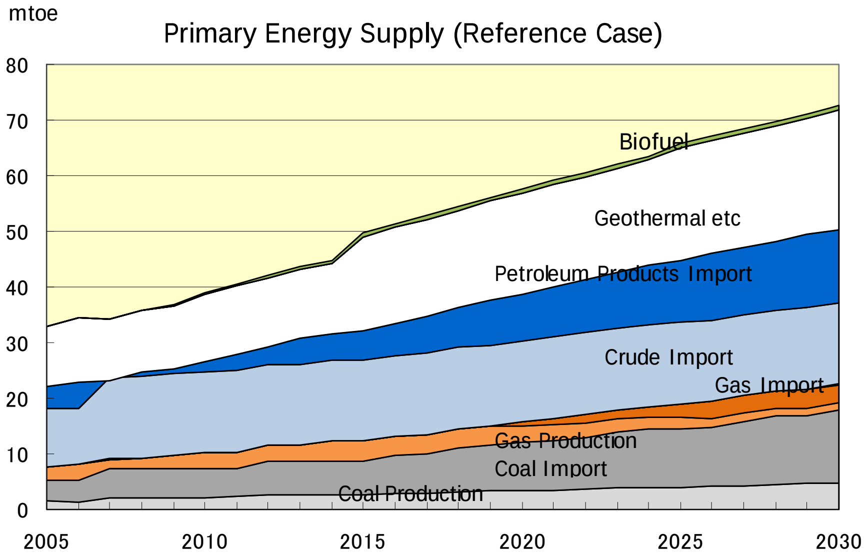


Figure 7.2-1 Primary Energy Supply in Reference Case

Primary energy supply configuration in the Reference Case is shown in every five years in Table 7.2-1. Although more geothermal and biofuel are introduced, fossil fuels such as coal, oil and gas will keep playing the major role in energy supply for 25 years from now through 2030.

Table 7.2-1 Primary Energy Supply in Reference Case (%)

	Coal	Gas	Oil	Geothermal etc	Biofuel
	%	%	%	%	%
2005	16.0	7.6	44.0	32.4	0.0
2010	19.0	7.2	42.2	30.9	0.8
2015	17.5	7.3	39.7	34.3	1.2
2020	20.9	6.5	39.9	31.5	1.2
2025	22.2	6.8	39.2	30.7	1.2
2030	24.7	6.2	38.3	29.7	1.1

7.2.2 Trend of Power Source

Trend of the power source configuration during the projection period is shown in Figure 7.2-2 and Table 7.2-2.

Although renewable energies such as geothermal and hydro are given due focus in the Philippines, there are ultimate limitations in their supply potential. Consequently, a considerable part of the power demand growth shall be supplied by fossil fuels. It should be noted that almost 99% of coal and 97% of natural gas supply go for power generation, and their consumption for other purposes is quite limited. This situation will not change and the prospect is that increase of thermal power will continue to be supported by the coal-fired thermal power. Supply condition change other than coal will be discussed in Section 7.5 later.

Among petroleum products, diesel gas oil and fuel oil are adopted in the power generation. Except for off-grid power sources in isolated islands and villages, existing power plants using these petroleum products are relatively old, inefficient and high-cost in general, they are regarded as peak load sources. Consequently, as far as coal and gas power could cover the demand, oil power does not need to operate. However, operation at minimum load has to be maintained standing-by for peak demand.

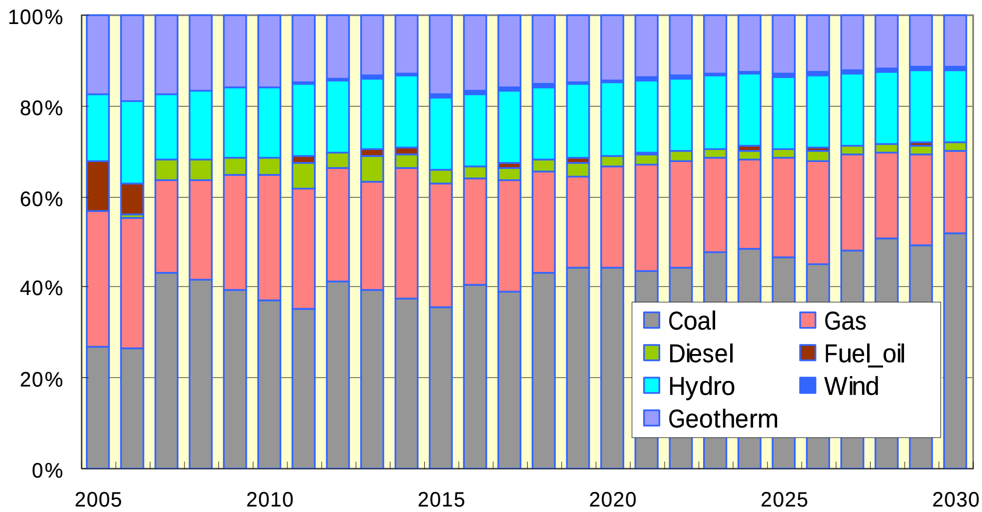


Figure 7.2-2 Power Source Mix (Share)

Table 7.2-2 Distribution Share of Power Source

	Coal	Gas	Diesel	Fuel Oil	Nuclear	Hydro	RNE	Geotherm.
	%	%	%	%	%	%	%	%
2005	27.0	30.0	0.0	10.7	0.0	14.8	0.0	17.5
2010	37.2	27.5	3.8	0.0	0.0	15.5	0.3	15.7
2015	35.7	27.3	2.9	0.0	0.0	16.0	0.5	17.6
2020	44.5	22.2	2.3	0.0	0.0	16.0	0.6	14.3
2025	46.7	21.7	2.0	0.0	0.0	16.0	0.7	12.9
2030	51.8	18.4	1.8	0.0	0.0	15.9	0.7	11.4

7.2.3 Trend of Petroleum Products Supply

Oil refinery capacity in the Philippines is very limited compared to the domestic oil demand, while the existing refineries are at almost full operation. However, looking at the balance of each product, imbalances are observed like that excess naphtha or fuel oil production is exported in earlier stage of the projection period. Practically speaking, there is a fact that certain amount of these products is imported due to mal-specification or inferior quality of the domestic petroleum product. Thus, appropriate interpretation/understanding on the supply/demand balance here is rather sensitive. In the Reference Scenario, as refining capacity increase is not considered corresponding to the demand increase, export decreases and product import increases monotonously along with lapse of time. As described later, the world trend of refining facilities is toward larger scale and high efficiency, in-depth precise studies will be required which way the Philippines should follow either increasing dependence upon petroleum product import from overseas refineries or expansion of domestic refining capacity.

Contents of petroleum product demand are different from those of coal and gas. Use for transportation purpose is dominant and demand for power generation or industrial use is limited. Among others, demand of diesel oil is the largest followed by gasoline. This trend seems to continue even in the increase of petroleum product import.

Current quality standard of motor fuel in the Philippines is modestly set at the EURO-2 level (sulfur content is at 500ppm level). However, regulation on this standard is in the direction to be strengthened to the EURO-3 or -4 level (sulfur content is 50 and 10ppm level, respectively) even in Southeast Asian region.[25] With regard to fuel oil, as the market for conventional high sulfur fuel oil (sulfur content at 3% level) is diminishing the Philippines reflecting environmental regulations, it is necessary to look into possibilities and necessity of installing secondary facilities for cracking and desulfurization, in addition to the study on increase of topper capacity.

LPG demand, which is classified as a petroleum product in the statistics, will be increasing at relatively high pace in future. It is necessary to look into the possible trend of LPG supply/demand balance independently, as its background and trend in both supply and demand sides are totally different from those of diesel oil or gasoline.

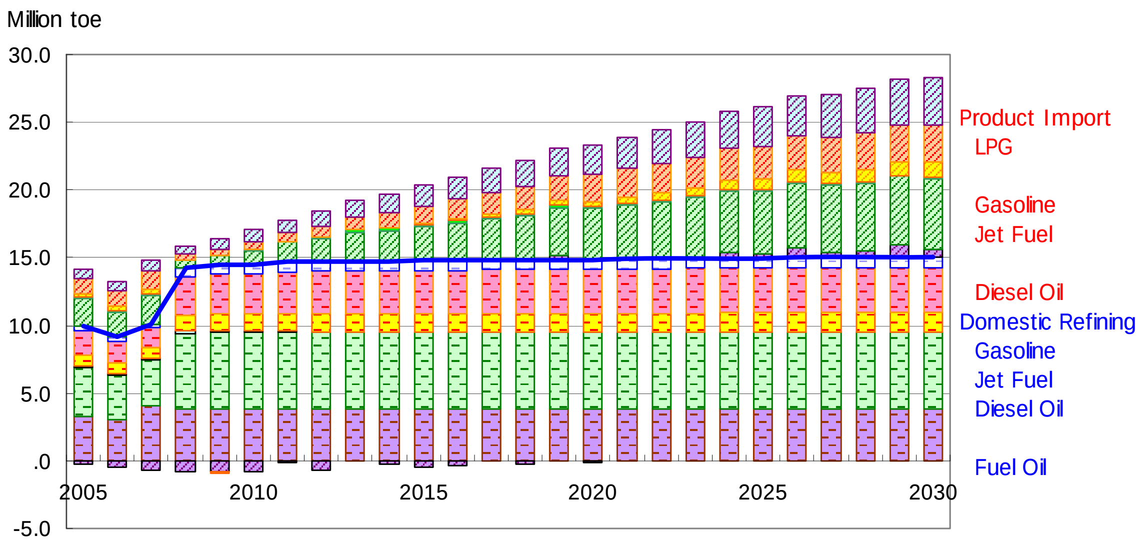


Figure 7.2-3 Petroleum Product Supply

[25] In Japan, sulfur-free gasoline and diesel oil with sulfur contents less than 10 ppm were started January 2005, and in China implementation of EURO-3 standard is planned to start in three metropolitan areas, namely, Beijing, Shanghai, and Guangzhou.

7.3 Supply / Demand Balance by Energy

7.3.1 Crude Oil

The crude oil supply/demand balance is shown in Figure 7.3-1, which includes the portion of oil import for stockpiling. The supply optimization model determines the optimum balance for oil production, import, export, and stockpiling according to the objective function to minimize the energy cost.

In Figure 7.3-1, the upper bar above the abscissa axis shows supply or outputs as production and import. On the other hand, the lower bar shows demand or outputs as consumption, export and stockpiling. Hereafter, supply/demand balance will be illustrated in this pattern. While the Figure for 2006 is quoted from the actual recorded data, those from 2007 through 2030 are estimated by the model. In the Reference Case, as the refinery capacity is set at a fixed figure, petroleum product import is monotonously increasing in response to the demand increase, with refineries at full operation mode.

The petroleum stockpiling trend is shown in Figure 7.3-2. The amount of the petroleum stockpiling is determined based on the annual petroleum product consumption, which is converted to daily consumption amount of crude oil to be stored. In this calculation it is assumed that 95% of the processed crude oil would be converted to, therefore equivalent to, petroleum products. The stockpiling starts storing oil in 2006, and the storage amounts are calculated as a sum of 7 days of the LPG demand and 15 days for other petroleum products and converted into crude oil equivalent quantity. No withdrawal from the inventory is considered.

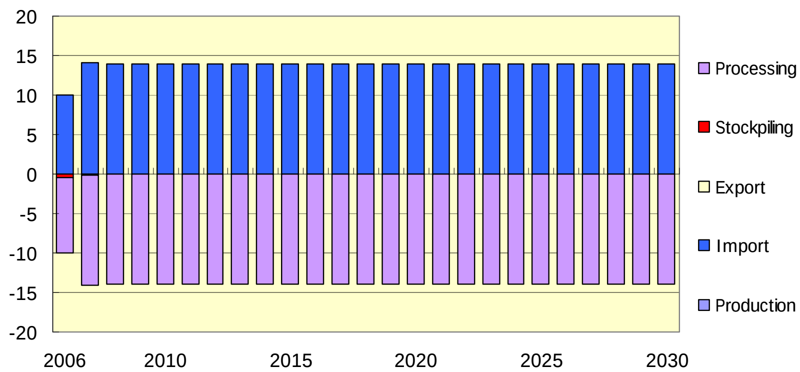


Figure 7.3-1 Crude Oil Balance

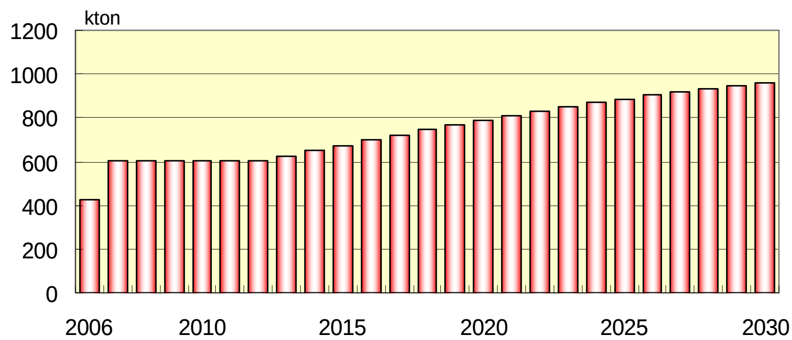


Figure 7.3-2 Petroleum Stockpiling

7.3.2 Coal

The coal supply/demand balance is shown in Figure 7.3-3. Most of the coal is used for power generation. The price advantage over other kinds of energies works strongly, and thus coal thermal power will play core role in the future expansion of thermal power generation capacity. Due to high alkaline-containing property of the domestic coal, there is a limitation that domestic coal must be kept at 20% or less of the whole at the time of combustion at power plant. Therefore, as the coal demand increases, the required quantity of imported coal also increases.

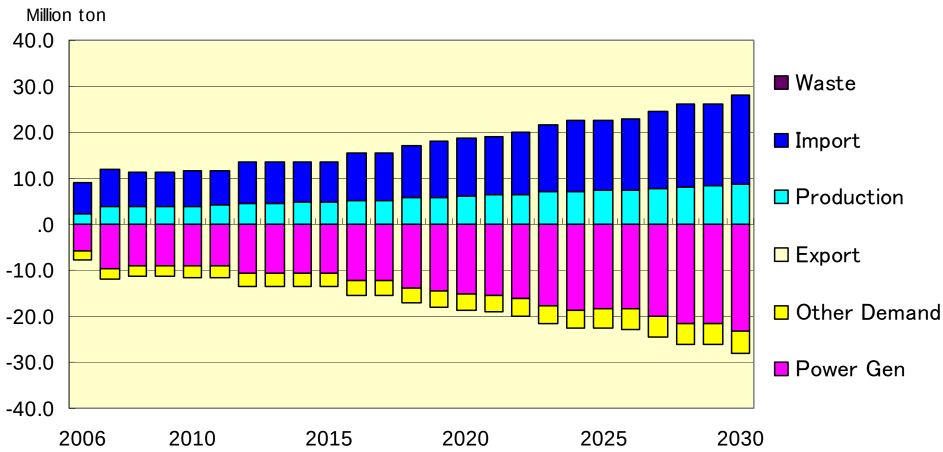


Figure 7.3-3 Coal Balance

7.3.3 Natural Gas

The natural gas supply/demand balance is shown in Figure 7.3-4. In the Reference Case, production from the domestic Malampaya gas field is anticipated to start declining from 2019. In order to compensate this, it is deemed in this model that import of natural gas shall start in 2020. Moreover, since the production from the domestic gas field in 2020 and afterwards will be on a decline trend, priority is given that the gas field shall continue full capacity production in accordance with maximum producible quantity separately examined for each year.

The quantity of LNG that must be imported increases gradually, as explained in Section 7.1.2, and the calculation is made on the conditions that LNG will be imported up to the necessary quantity within the range slated for each year. Under such conditions, whenever new coal thermal power plant starts the operation along with the Electric Power Development Plan, operation of gas power plant falls, resulting in fluctuation of the gas demand for power generation. Since the calculation result is incurred by combination of complicated elements such as supply contract of LNG and operation conditions of coal and gas power plants, we would like to focus here mainly on grasping the fundamental trend that would affect the supply/demand trend of natural gas, rather than looking into detail background of the calculated fluctuation in the natural gas supply/demand balance.

Anyway, unless a new natural gas field is discovered in the country, it is a matter of time that the Malampaya gas field starts to deplete shortly. Therefore, it is urged to seriously consider now how to procure fuels to supplement for operation of the existing gas fired power plants. Although global LNG production is on the increasing trend, it still needs a long preparation period to procure and accept LNG physically. Recognizing this issue properly, it is important to advance discussion and examination on the matter at an early timing.

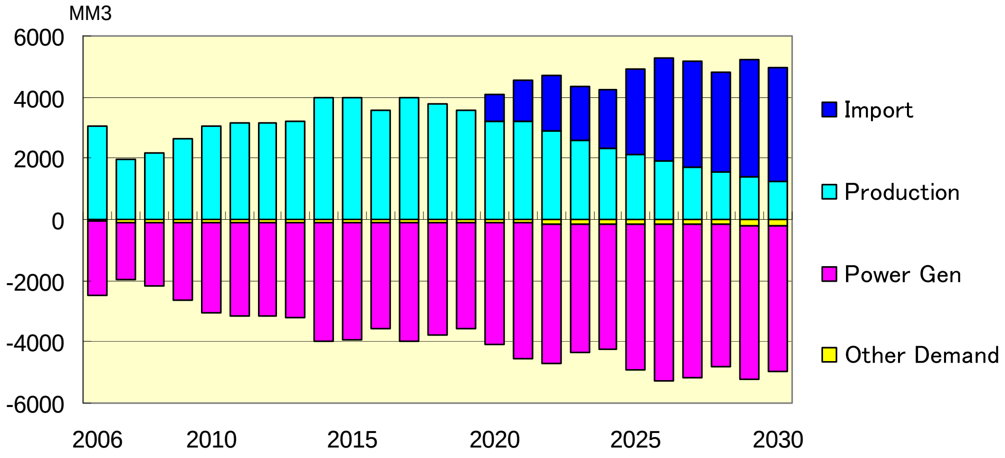


Figure 7.3-4 Natural Gas Balance

7.3.4 LPG

LPG is not recovered directly from the domestic Malampaya gas field. In this model, therefore, LPG is produced only at oil refineries in the Philippines. Moreover, since fluctuation is fierce in the international LPG market, as a yardstick of the maximum possible import quantity 2 million ton per year is assumed. When the demand exceeds this level, alternative fuel for LPG may be imported. In the model, kerosene is assumed as the LPG substitution fuel. The required import quantities of the LPG alternative fuel are as shown in 7.3-5.

Although import of kerosene is assumed as LPG substitution here, it shall be more favorable as a realistic option to construct natural gas infrastructure and set up town gas system including natural gas delivery grid by this time and develop natural gas use in residential, commercial and industrial sectors besides power generation.

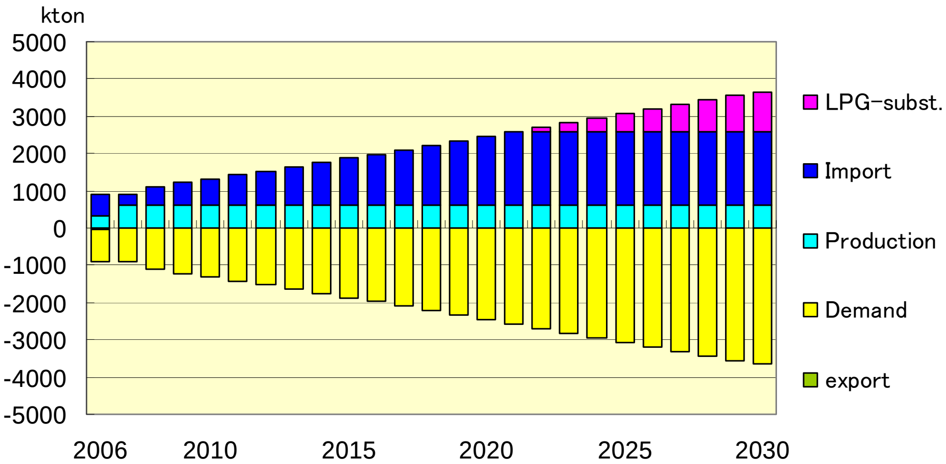


Figure 7.3-5 LPG Balance

7.3.5 Gasoline

In Figure 7.3-6, the gasoline supply/demand balance is shown, in which bio-ethanol is contained in the gasoline supply. In this model, the quantity of bio-ethanol should be decided by the policy option and is given as a ratio to the total gasoline demand corresponding to scenarios. Since gasoline demand is in the trend of monotonous increase, supply deficit beyond domestic production shall depend upon import. As the required import is eased by introduction of bio-ethanol while composition of oil demand tends to be lighter, introduction of bio-ethanol should also play an important role to mitigate the pressure on refining sector. Detail discussion will be made on the matter in Section 7.4.

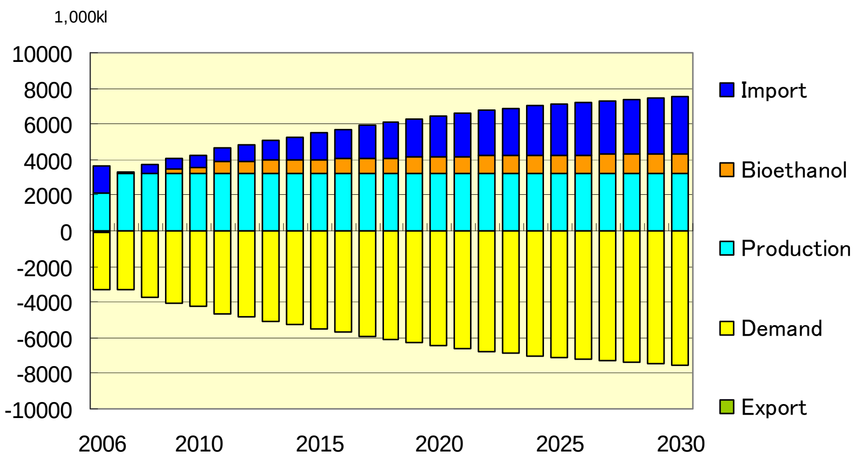


Figure 7.3-6 Gasoline Balance

7.3.6 Kerosene and Jet Fuel

In the Philippines, the demand of kerosene is limited extremely. As it used to be applied for lamplight and cooking, electricity and LPG are rapidly replacing it in respect of their convenience. As a result, most of the demand for lighter middle distillates (equivalent to jet fuel and kerosene) will become jet fuel. In view of the situation, kerosene and jet fuel are treated in the model as equivalent in both quality and price for simplification. That is, in consideration of production balance, total sum of kerosene and jet fuel is put together and the optimization calculation is performed. The individual quantity of kerosene and jet fuel production is obtained s a result of product allocation that makes the energy cost of the objective function minimum.

The calculation result of kerosene and jet fuel is shown in Figures 7.3-7 and 7.3-8, respectively. Although decline of kerosene demand is remarkable, demanded of kerosene itself is small from the beginning. On the other hand, growth of jet fuel consumption is large and the overall demand for lighter middle distillates increases. Reviewing such tendency of kerosene and jet fuel demand, effective use of lighter middle distillates has to be considered.

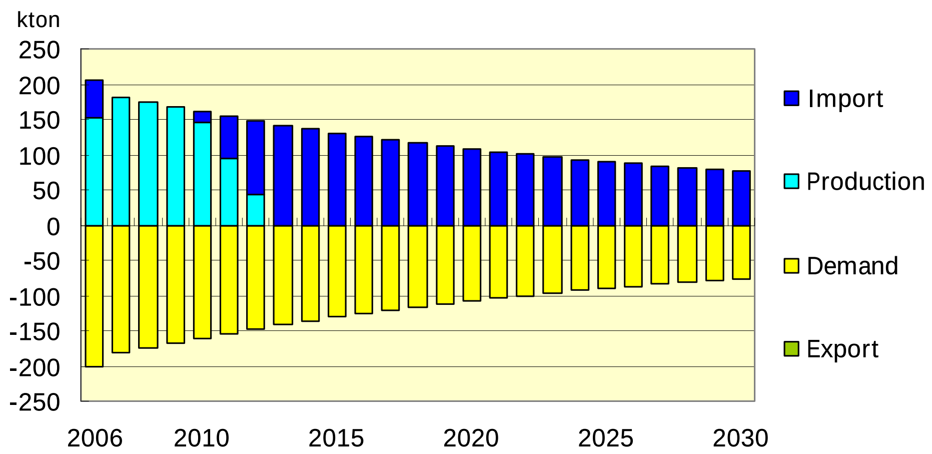


Figure 7.3-7 Kerosene Balance

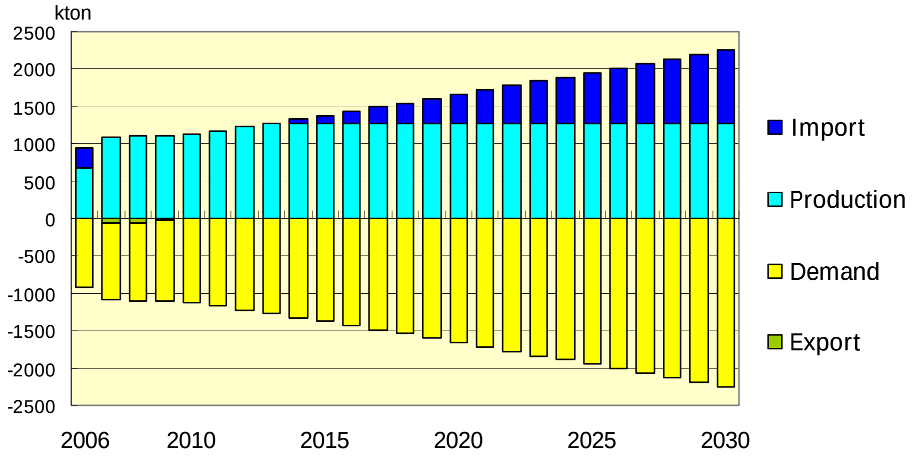


Figure 7.3-8 Jet Fuel Oil Balance

In the estimation here, an assumption is made that "the value of jet fuel is higher than kerosene (import cost of jet fuel is more expensive than kerosene". This is intended to reflect the observation in the market that jet fuel must be procured according to the demand growth while kerosene is sold at a cheap price only. As a result, when the demand of jet fuel is first fulfilled from the total lighter middle distillate production, kerosene could be produced only in case of existence of any spare production capacity there. For this reason, when it is impossible to fulfill the jet fuel demand by domestic production, import of jet fuel will start, and domestic production of kerosene becomes zero. In a trial calculation, there is some kerosene production till 2011, although it becomes zero after then.

7.3.7 Diesel Gas Oil

The diesel oil supply/demand balance is shown in Figure 7.3-9.

Although the greatest demand sectors of diesel oil are automobile fuel for trucks and buses, there are other types of demand for general use and power generation in other sectors. About diesel power generation, it is assumed in a model as already described that 10% of the total installed capacity should always be operating as smaller generators installed in isolated islands and villages need to

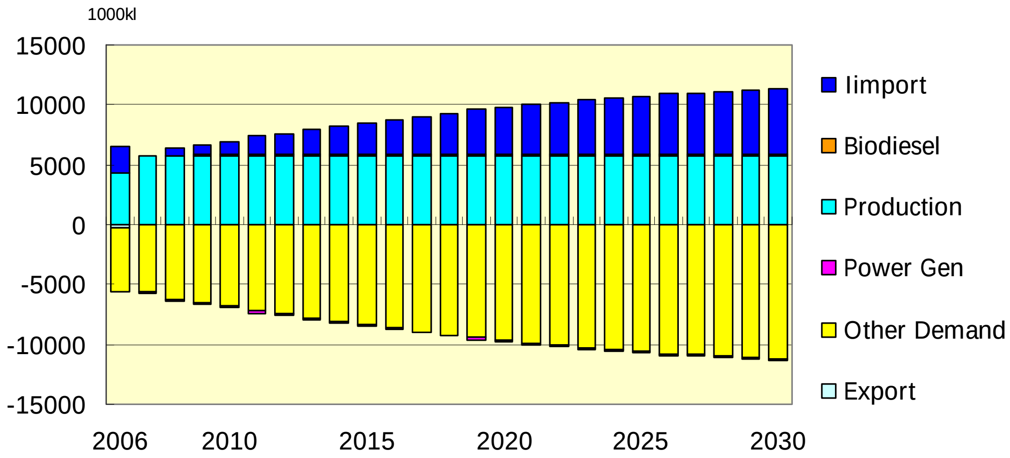


Figure 7.3-9 Diesel Oil Balance

supply power demand there. However, since the quantity is very small, it can be hardly recognized on the graph, as some trace appears for only 2011 and 2013. In addition, conversion of a part of diesel oil demand to bio-diesel is incorporated into the model as a policy objective condition. The supply amount of bio-diesel is given as equal to the demand that is assumed in the demand model.

Since the refining capacity is kept at the fixed level and oil refinery is at full operation after 2007, there is no room of change (increase) in production. Therefore, diesel oil production is almost constant in the calculation result. However, in a scenario of expanded refining capability, it is an important study subject how to supply middle distillates, mainly diesel gas oil, efficiently.

7.3.8 Fuel Oil

The fuel oil supply/demand balance is shown in Figure 7.3-10. Since oil refineries are at full operation since 2007, the production amount is constant almost every year. It is observed that a certain amount of fuel oil is consumed for power generation every year. This is because diesel power plants are assumed to keep working 10% at least, and 85% of its fuel is fuel oil. Since the power

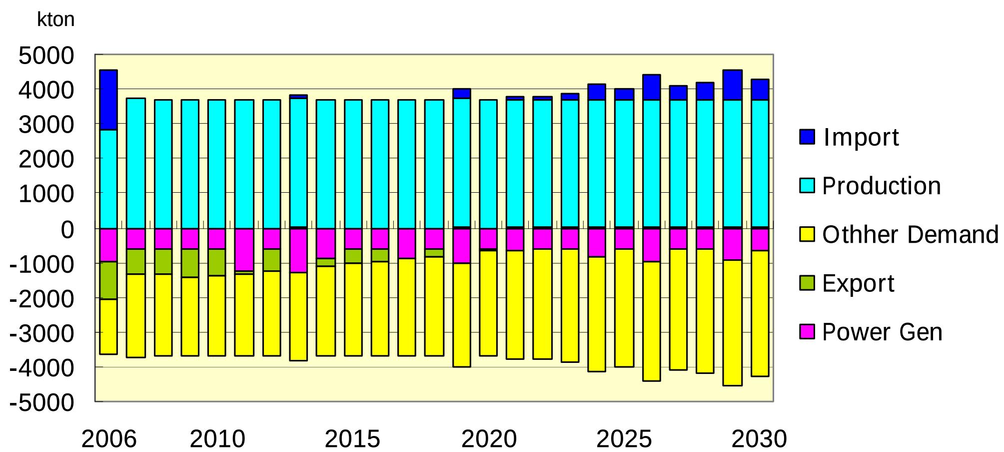


Figure 7.3-10 Fuel Oil Balance

generation by fuel oil is allocated for peak shaving, fuel oil consumption fluctuates according to the balance of the power station development plan and the power demand. However, impact of the power sector demand is small, because oil based generation capacity is originally small (650 MW).

7.3.9 Electric Power Supply

The electric power supply/demand balance is shown in Figure 7.3-11. This figure also shows that fossil fuels play a major role in power generation. The growth of coal is especially large. Since coal power has been regarded as advantageous in economics compared with oil or gas from various examinations, coal power is mainly chosen in this model as the newly installed power supply source in response to the power demand increase.

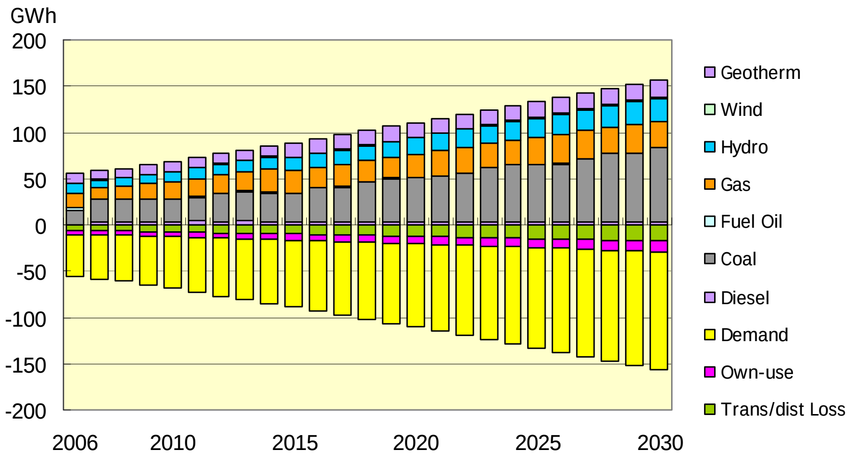


Figure 7.3-11 Electric Power Balance

However, in the choice of power supply sources, it is necessary to consider issues relating to energy security, modernization of energy structure and global warming in addition to economic performance. In this regard, there should be certain role of natural gas power. However, since domestic natural gas may start depleting sometime, import of gas shall be considered, then. Among renewable energy power generation, geothermal and hydropower share majority, while proposed wind power may add up though a small quantity.

7.3.10 Other Indicators

(1) CO_2 emission and other various indicators

CO_2 emission is shown in Figure 7.3-12.

Figure 7.3-13 shows three sorts of indices, 1) CO_2 emission per primary energy supply (as oil equivalent ton) or ratio of CO_2 to total energy supply, 2) CO_2 emission per GDP of 1,000 dollars (CO_2 per GDP unit), and 3) CO_2 emission per population. Although per capita CO_2 emission is increasing reflecting the increase in energy consumption, the CO_2 emission per GDP of 1,000 dollars is decreasing slightly. The CO_2 emission per unit primary energy supply of is leveling off.

As the CO_2 emission per GDP is decreasing, it is because the growth rate of energy demand increase is smaller than the economic growth. This is because energy intensive manufacturing industry is small in the Philippines, and less-energy consuming manufacturing industry or service industries are supposed to lead future economic growth. This fact is working in the direction to reduce the energy consumption rate as a whole economy as well as CO_2 emission per GDP. On the other hand, per capita CO_2 emission is increasing because per capita energy consumption increases with increase of income and resultant admiration toward living standard improvement. As achieving higher living standard is a social requirement, in order to achieve this requirement and simultaneously to suppress the energy consumption increase as much as possible, the energy efficiency improvement of electric apparatus used at offices and home will be a big issue.

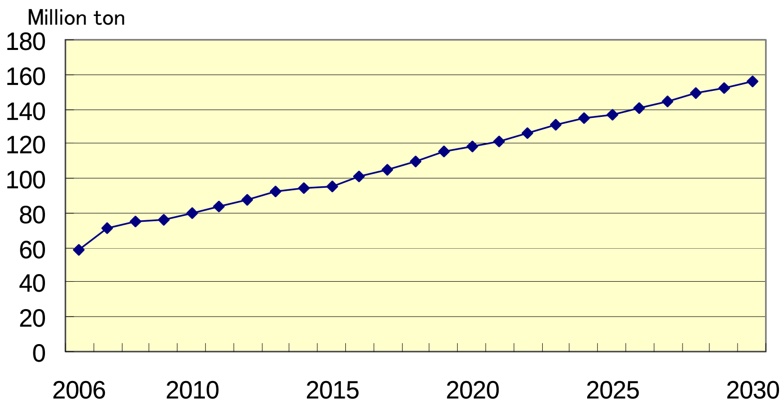


Figure 7.3-12 CO_2 Emission

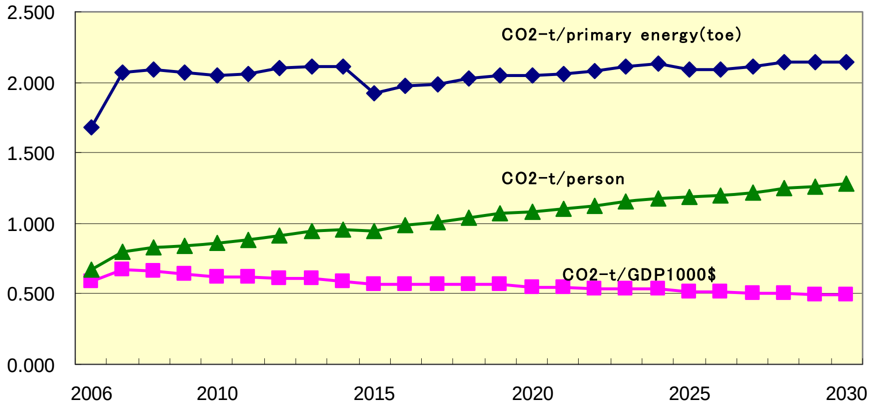


Figure 7.3-13 CO_2 Emission by Energy Intensity

The CO_2 emission per primary energy supply is more or less leveling off. This may be interpreted that CO_2 emission structure in the energy sector would not change so much since incremental electricity demand will be supplied with coal power plant in future. In case biofuel, nuclear or LNG would increase in future, this index will go down. However, nationwide discussion will be required to resolve the complex and interrelated issues of energy cost control, energy security and global warming.

(2) Energy Cost

Annual energy cost in the Reference case is shown in Figure 7.3-14.

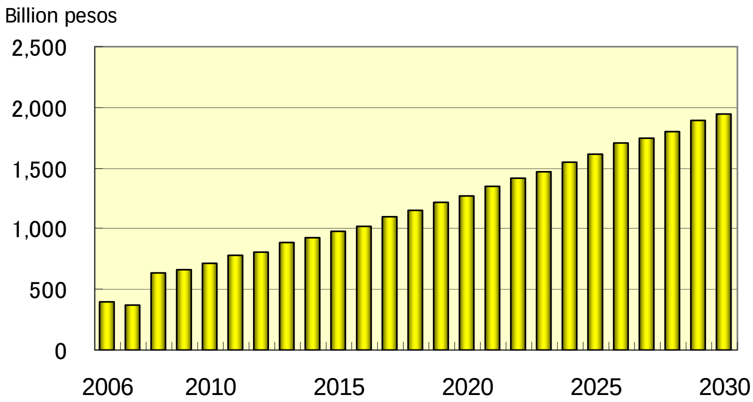


Figure 7.3-14 Annual Energy Cost

Similar to CO_2 emission, three kinds of indices on energy cost are shown in Figure 7.3-15. According to this chart, per capita energy cost will increase more than double, i.e., from 7,000 pesos per year in 2008 to 16,000 pesos per year in a real price in 2030. It is important also from a viewpoint of national economy, to decrease the energy cost by energy saving. Furthermore, the energy cost per primary energy supply (as in oil equivalent ton) increases from 18,000 pesos to 27,000 pesos and becomes about 1.5 times caused by the rising energy prices. In addition, since the investment expenditure required building additional energy supply facilities is not included in the above-mentioned costs, actual energy cost may soar more than what stated here.

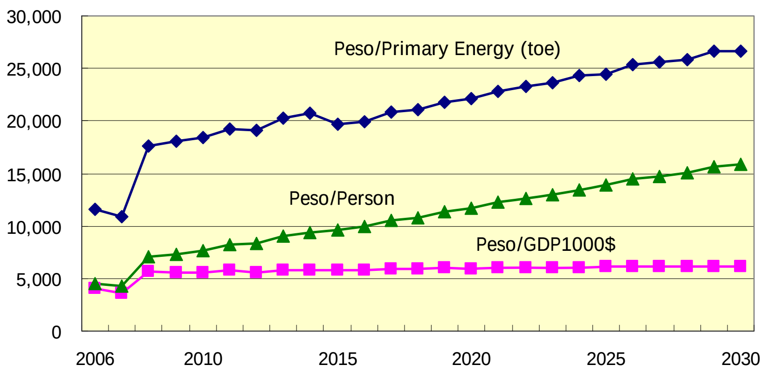


Figure 7.3-15 Energy Cost by Energy Intensity

7.4 Various Demand Scenarios and Energy Outlook

In this report, case studies are carried out starting from the Reference Case. They will be divided into two groups as shown in Figure 4.5-2. The first group includes those studies about the factors affecting energy demand where variables are economic growth rate, energy price, energy-saving rate, or fuel mileage for cars (as the specific demand change). In the second group, various supply options are studied such as nuclear introduction, LNG introduction (import of natural gas), renewable energy promotion and so on with energy demand being kept same with the Reference Case. Optimization is made by the energy supply/demand optimization model calculating the energy balance that shall minimize the fuel procurement cost, and discussion are attempted comparing the outcomes on the primary energy supply balance, CO_2 emissions and other factors.

In this section, we will examine case study results on demand change. We will discuss case studies for supply options in the next section. The following 10 cases are reviewed as case studies on demand change.

Please refer to Section 6.1.1 for the assumptions for these cases.

1) BAU Case
2) High Growth Case,
3) Low Growth Case
4) High Energy Price Case,
5) Super-High Energy Price Case
6) Enhanced EEC Case,
7) Super-EEC Case
8) Vehicle Increase Case
9) Bio-Ethanol-20% Case,
10) Bio-Ethanol-85% Case

The differences of these cases appear mainly as the differences in motor fuel and electricity demand. The primary energy consumption required for power generation is large, and the power source distribution among various kinds of energies is determined by prices (as explained in Chapter 6) and plant capacities of respective sources. The power generation capacity of each year is given as the sum of the existing generation capacity and those to be newly installed. In the preliminary study by the supply/demand optimization model, differences of electricity demand among cases turn out to be differences of coal power generation that plays a role of the base load power supply.

With this observation, we apply in running the model such assumptions on generating capacity that the power development plans for gas, diesel, geothermal, hydro and wind separately studied using PDPAT should be applied commonly for all the study cases while different power generating capacities among cases are applied only for coal thermal power plants as shown in Table 7.4-1 below. In other cases not mentioned in Table 7.4-1 (cases of low-growth, high price, low price, super-high price, EEC, super-EEC, increased automotive vehicle, E20/B20 and E85/B20), the same capacity of coal power plants adopted in the Reference Case is applied.

Table 7.4-1 Outlook of Coal Power Development (MW)

year	Reference	BAU	High Growth	Low Price
	MW	MW	MW	MW
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	1,000	1,000	0
2012	1,000	2,000	2,000	1,000
2013	1,000	2,000	2,000	1,000
2014	1,000	2,000	2,000	1,000
2015	1,000	2,000	2,000	1,000
2016	2,000	3,000	3,000	2,000
2017	2,000	3,500	3,500	2,000
2018	3,000	4,500	4,500	3,000
2019	3,500	6,000	6,000	3,500
2020	4,000	6,000	6,000	4,000
2021	4,000	7,000	7,000	4,000
2022	4,500	7,000	7,000	4,500
2023	5,500	8,500	8,500	5,500
2024	6,000	9,500	9,500	6,500
2025	6,000	9,500	9,500	6,500
2026	6,000	10,000	10,000	7,000
2027	7,000	11,000	11,000	7,000
2028	8,000	12,000	12,000	8,000
2029	8,000	13,000	13,500	8,500
2030	9,000	14,000	14,500	9,500

(note) The capacity of coal power plant in the reference case is same as following cases such as low-growth, high price, low price, super-high price, EEC, super-EEC, increased automotive vehicle, E20/B20 and E85/B20
Hereafter, we will examine the case study result.

7.4.1 Primary Energy Supply in Various Cases

Figure 7.4-1 shows the primary energy supply of 12cases projected using the energy supply/demand optimization model. In terms of larger primary energy supply in 2030, these cases may be lined up in the following order.

High Growth > BAU > Low Price > Increased Automotive Vehicle > Reference > E20/B20 > E85 > High Price > Super-High Price > EEC > Low Growth > Super-EEC

Based on the demand size, they may be divided into the following four groups:

1) High Growth Group (High Growth, BAU)
2) Reference Group (Low Price, Increased Automotive Vehicle, Reference, E20/B20, E85/B20, High Price, Super-High Price)
3) EEC Group
4) Low Growth Group (Low Growth, Super-EEC)

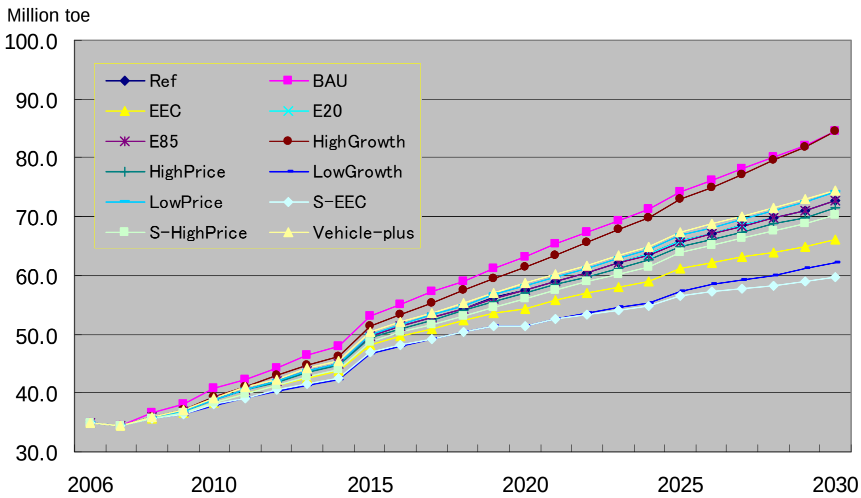


Figure 7.4-1 Primary Energy Supply in Various Cases

From the above grouping, as seen in Chapter 6, we can observe that effect of price hike is smaller than those of economic growth rate and energy conservation rate. The high growth case and the BAU case are in the same cluster, and the effects of economic growth rate of annual 1% and EEC rate of annual 0.5% are same. We observe unnatural jumps of primary energy supply in 2015 in all cases. This is because geothermal capacity is expanded in this year and its thermal efficiency is calculated at 10%. Although the standard of IEA is applied here, we may need to reconsider this principle.

We will review energy supply trends projected for various supply cases in the following sections.

7.4.2 Coal

Simulation result of coal production trend is shown in Figure 7.4-2.

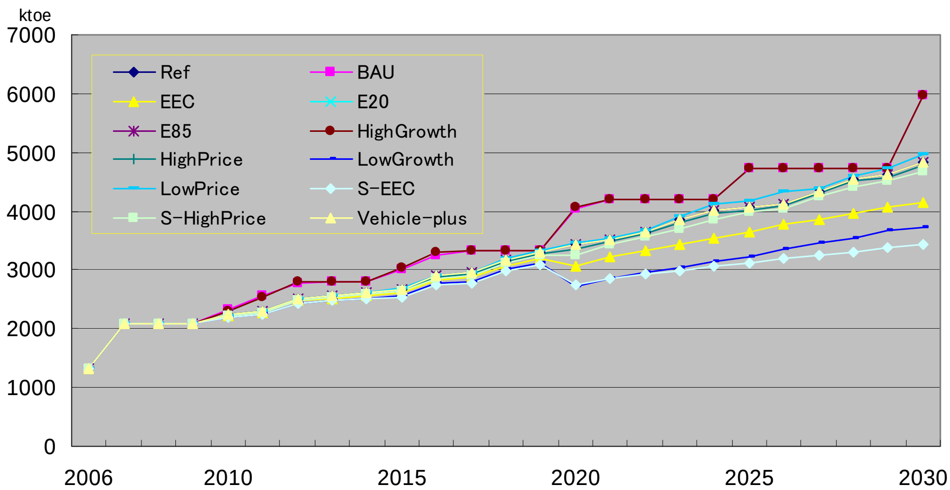


Figure 7.4-2 Indigenous Coal Production

In the above chart, step-wise increases of domestic coal production are seen in the High Growth Case. This illustrates that as domestic coal production is supposed to increase stepwise in every 5 years based on the development plan of DOE such as 1.3 million tons in 2010, 0.95 million tons in 2015, 1.55 million tons in 2020, 0.95 million tons in 2025 and 2.25 million tons in 2030, the maximum coal production in the year of production capacity increase is immediately consumed up because of high demand. This is more clearly indicated in Figure 7.4-3, which shows trend of the utilization rate of coal production capacity.

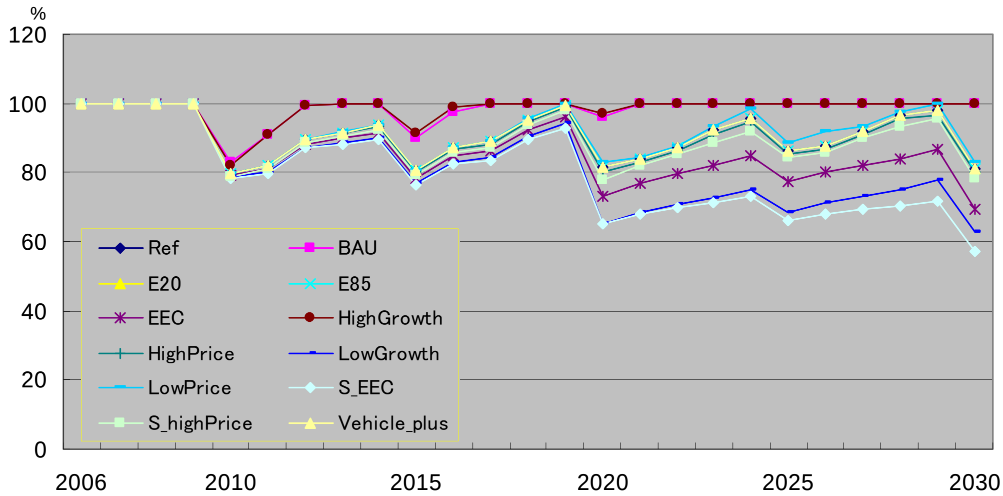


Figure 7.4-3 Utilization of Coal Production Capacity

In other cases, utilization rate of coal production lowers in years of production capacity increase and then gradually approaches the maximum capacity. While we may need to speed up production capacity expansion if energy demand increases fast as observed in the High Growth Case, for the cases such as the Reference Case and the EEC Case, we may rather slow down the pace. With regard to such adjustment of development speed, we need to run in-depth studies elaborating on various factors relating to coal demand and supply.

7.4.3 Natural Gas

Simulation result of the natural gas supply trend is shown in Figure 7.4-2.

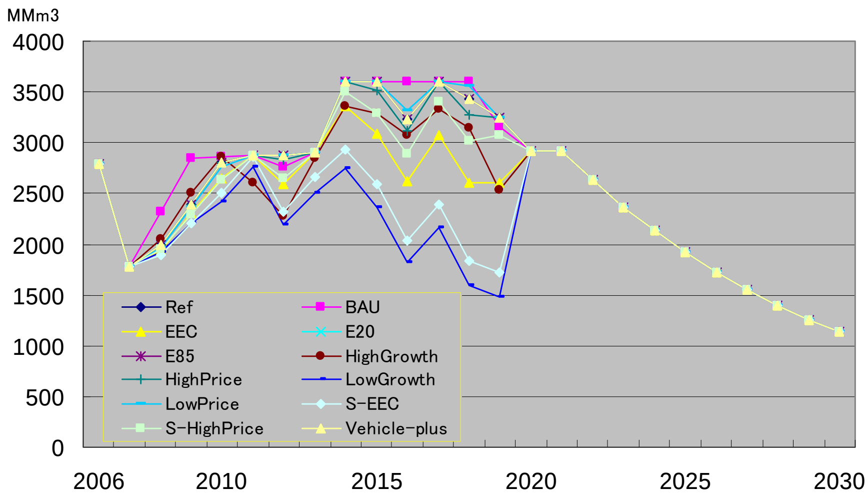


Figure 7.4-4 Natural Gas Production

In this model, optimum supply of natural gas is simulated within the range of the maximum possible production until 2019. During this period, except for a case of strong power demand like the BAU Case, coal power generation is taken in first as far as there is available supply capacity, and gas power works as back up. However, due to the binding of "Take or Pay" clause in the purchase contract, gas power is actually operated rather rigidly like base load power source. When natural gas production starts declining in 2020, the full amount of maximum possible production is taken in as the production, considering supply decrease and efficiency of gas field operation. The same rule is applied for the Low Growth case and EEC cases that the maximum possible production is taken in as the actual production.

Operation performance of coal and natural gas power stations are shown in Figure 7.4-5 and 7.4-6. Operation rate of the gas power is directly proportional to the amount of power generation by natural gas, since the generation capacity is kept fixed same for all the cases. On the other hand, since different generation capacities are projected for coal power generation, the correlation between generation capacity and operation rates is a little bit complicated as shown below. .

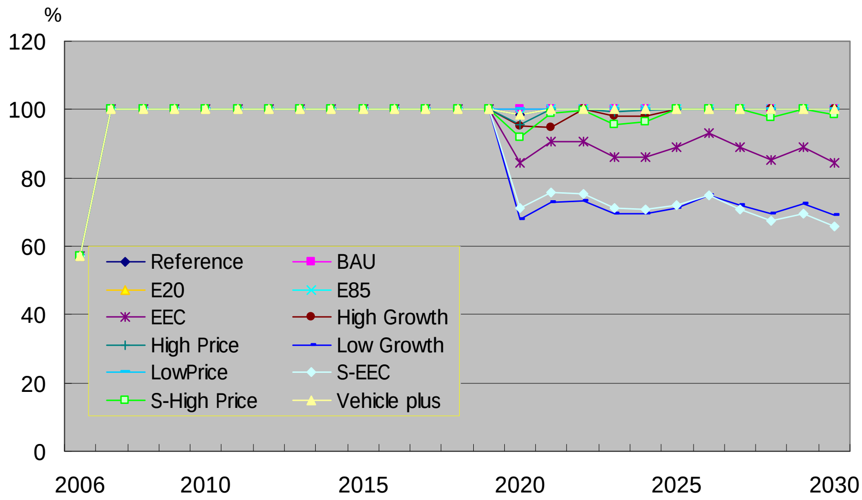


Figure 7.4-5 Coal Power Plant Operation

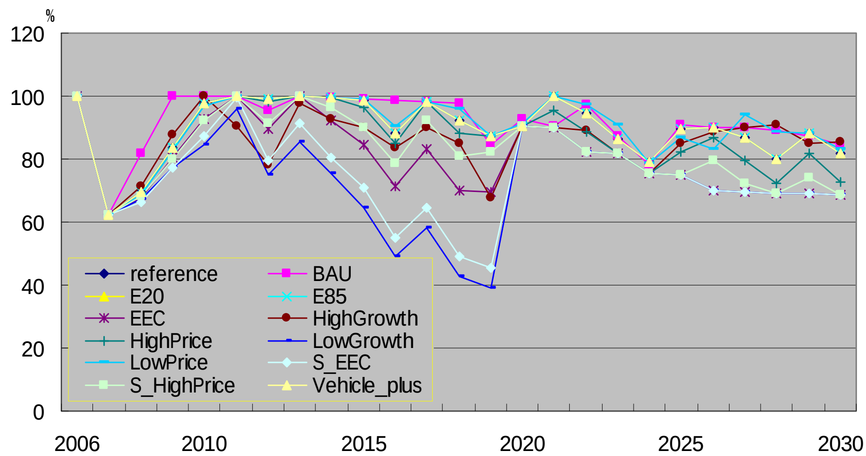


Figure 7.4-6 Gas Power Plant Operation

There are some cases where gas power generation (= operability) is higher although power demand is lower as observed for 2021 in the BAU and E20/B20 cases. In 2021, coal power generation capacity greater by 3,000 MW in the BAU Case as shown in Table 7.4-1 that that for the Reference Case. In power source selection of both cases, minimum 10% of the diesel power generation capacity is taken in first and then coal power will be operated to the maximum extent. After then, gas power is picked up and, if there still exist unsatisfied requirement, oil power will be called for finally. In the BAU case, gas power generation may be called for after the larger capacity of coal power is fully utilized, and thus demand is fulfilled before gas is used up to the maximum capacity. On the other hand, E20/B20 Case, as the coal power capacity is smaller than that of the BAU Case, electricity demand is not fully supplied even with maximum operation of both coal and gas powered stations. Consequently, oil power plants are called for to operate exceeding the minimum 10% operation. Therefore, focusing on gas power, gas power is required to operate at higher rate in the E20/B20 Case even with smaller power demand compared with the BAU Case. Similar logic is applicable in other cases. These outcomes suggest that there are still some elements to be fine-tuned in the model setting and operation.

From the above case studies, we learn that we should set out greater capacity for newly starting power plants when greater electricity demand in anticipated. In addition, the “take or pay” clause is deemed as an important element of natural gas development where coherent project formulation from upstream through downstream is required. Thus, it is necessary to conduct comprehensive evaluation of relevant conditions relating to power source selection such as overall supply/demand balance of electricity, environmental measures and priorities of individual projects.

7.4.4 CO_2 Emission

Simulation results on CO_2 emission trend is indicated in Figure 7.4-7. CO_2 emissions in 2030 for various cases and their ratio relative to the Reference Case are summarized in Table 7.4-2 in the order of small to larger emission amount.

In Table 7.4-2, cases positioned on the upper side of the Reference Case are those where reduction of CO_2 emission could be expected. The table also suggests that energy conservation will have greater effect on the CO_2 emission reduction.

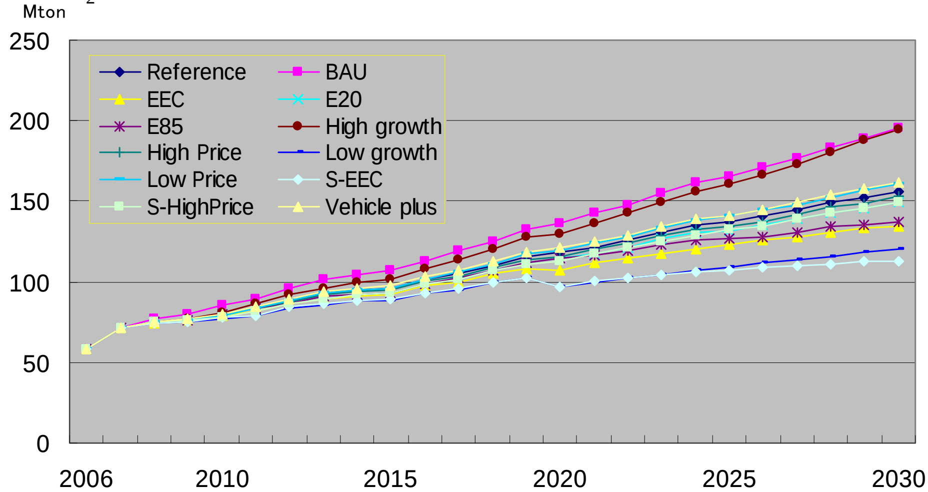


Figure 7.4-7 CO_2 Emission

Table 7.4-2 CO_2 Emission in 2030

Case	CO_2 Emission	Comparison
	Million CO_2-ton	%
Super-EEC	113.09	72.40
Low Growth	119.88	76.74
EEC	134.40	86.04
E85/B20	137.68	88.14
Double RE	148.76	95.23
Super High Price	149.32	95.59
E20/B20	149.42	95.65
High Energy Price	152.96	97.92
Reference	**156.21**	**100.00**
Low Energy Price	160.74	102.90
Vehicle Plus	161.39	103.32
High Growth	194.40	124.45
BAU	195.13	124.92

7.4.5 Increased Biofuel Supply

While biofuel supply is assumed to replace 10% of gasoline and 2% of diesel oil, respectively, in 2030 for the Reference Case, we examine accelerated biofuel cases here, namely, the E20/B20 Case where ethanol and bio-diesel are blended in gasoline and diesel by 20%, respectively, and the ambitious E85/B20 Case where ethanol is blended in gasoline by 85%.

Effects of accelerated biofuel development on gasoline and diesel demand are shown in Figure 7.4-8 comparing the Reference Case and the E20/B20 Case. As indicated, the impact of accelerated biofuel introduction is greater on diesel oil than gasoline, since only 2% blending is assumed in the Reference Case and the diesel oil demand is greater than that of gasoline.

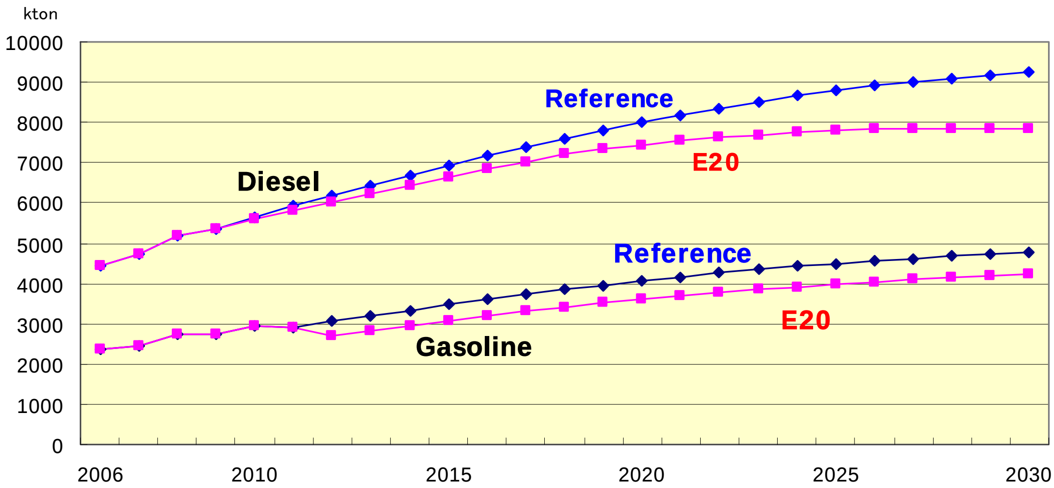


Figure 7.4-8 Gasoline and Diesel Demand in E20/B20 Case

As a result, primary energy supply for these cases will change as shown in Figure 7.4-9. Although biofuel portion is relatively high in E20/B20 case, majority of the primary energy supply increase must be supplied by fossil fuel as an overall trend. On the other hand, in the E85/B20 Case where ambitious biofuel introduction is projected, 85% of gasoline demand will be coming from non-petroleum origin. Consequently, petroleum product balance at refineries will be seriously affected. This matter will be discussed in the next section more in detail.

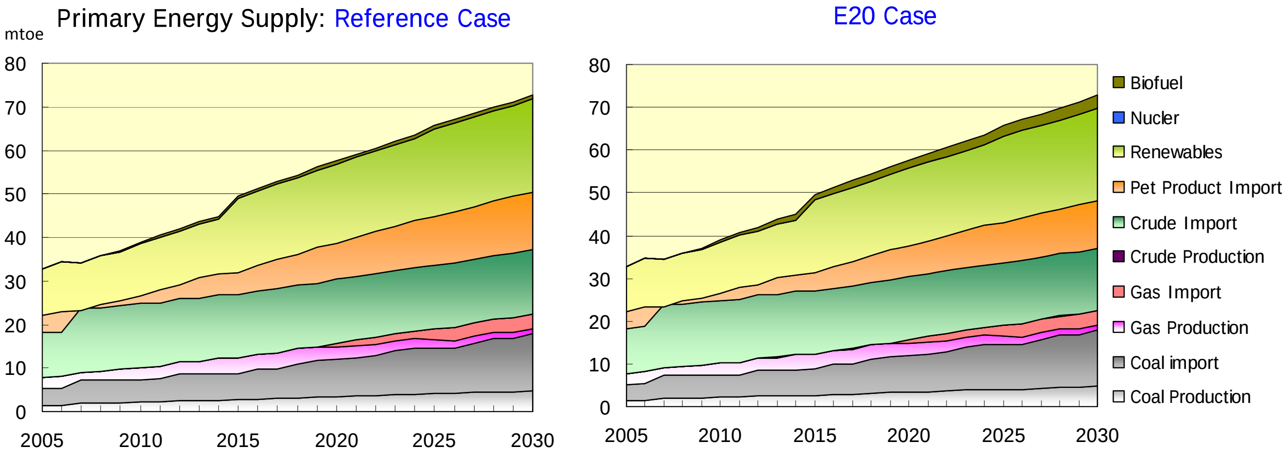


Figure.7.4-9 Comparison of Primary Energy Supply (REF, E20)

Although effect of biofuel introduction is not so large from the overall viewpoint of the primary energy supply, there are favorable effects in energy security and global warming issues such that the amount of gasoline and diesel oil equivalent to the introduced biofuel will be certainly reduced and similar reduction of CO_2 emission can be expected. In Table 7.4-3, biofuel portion in the primary energy supply is indicated in the right row.

Table 7.4-3 Primary Energy Supply (E20)

	Coal	Gas	Oil	NRE	Biomass
	%	%	%	%	%
2005	16.0	7.6	44.0	32.4	0.0
2010	19.0	7.2	42.1	30.9	0.9
2015	17.5	7.2	38.2	34.3	2.7
2020	20.9	6.4	37.9	31.5	3.2
2025	22.0	6.6	37.1	30.5	3.7
2030	24.3	6.0	36.3	29.3	4.1

As indicated in Figure 7.4-10 and Table 7.4-4, CO_2 emission is reduced by 4.3% in 2030 compared to the Reference Case and the reduction increases year by year.

Table 7.4.4 further illustrates the equivalent amount of coal and gas when the same amount of CO_2 emission is reduced by saving of coal and gas consumption. This suggests that, accelerating biofuel introduction, reduction of 6.78 million tons of CO_2 emission in 2030 can be expected compared with the Reference case. If we are to reduce the same quantity of CO_2 emission by reducing coal power generation, 2.5 million tons of coal have to be cut off (6.8 million ton in the E85/B20 Case), or it will be 3.2 million m^3 of gas if reduced at gas power generation (8.7 million m^3 in the E85/B20 case).

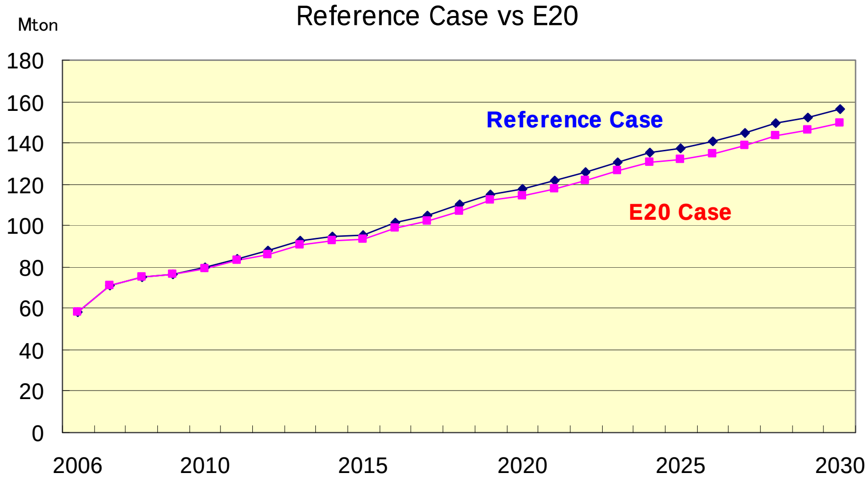


Figure 7.4-10 CO_2 Emission by Energy Intensity (E20)

Table 7.4-4 CO_2 Emission Reduction and Amount of Coal or Gas Reduction to Reduce CO_2 Emission

	CO2 Emission		Reduction ratio	Equivalent	
	Reference	E20		Coal	Gas
	mton	mton	%	ktoe	MMm3
2010	79.64	79.46	0.2	66	84
2015	95.64	93.35	2.4	845	1,071
2020	118.02	114.49	3.0	1,303	1,650
2025	137.16	131.97	3.8	1,916	2,426
2030	156.21	149.42	4.3	2,506	3,174

Figure 7.4-11 presents three kinds of indices on CO_2 emission. The upper most group in the graph indicates CO_2 emissions per primary energy supply in oil equivalent ton. This index shows 2.05 ton/toe as an average for 25 years from 2006 through 2030 in the Reference Case, and 2.0 ton/toe (1.97 for E85 case) in the E20/B20 Case.

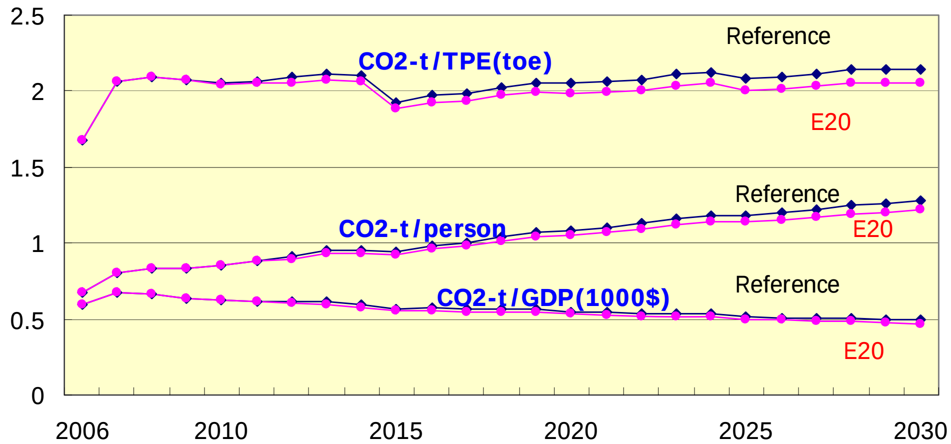


Figure 7.4-11 CO_2 Emission Indices

In the second group, CO_2 emission per population is compared with the Reference Case. The average emission per population through the whole period is 1.04 ton in the Reference Case and 1.01 tons in the E20/B20 Case and 0.99 tons in the E85/B20 Case. The third group shows figures of CO_2 emissions per GDP of US 1,000 dollars (CO_2 per GDP unit). These differences illustrate the advantages of biofuel introduction in terms of CO_2 emission.

7.4.6 Energy Efficiency and Conservation (EEC)

In the EEC Case, it is assumed that energy conservation is enhanced to annual 1.0% from 0.5% in the Reference Case. The result is shown in Figure 7.4-13 in terms of a ratio of general sector energy demand except power generation being compared with the Reference Case.

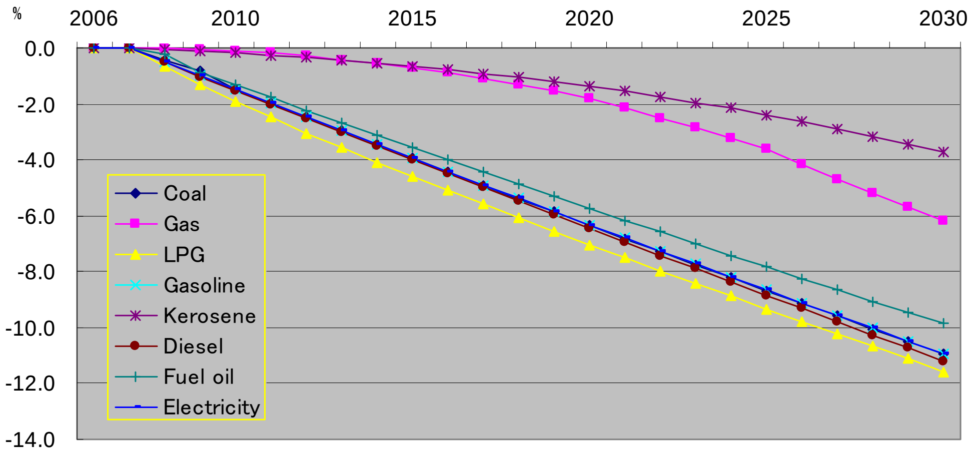


Figure 7.4-12 Ratio of General Sector Demand of EEC Case Compared with Reference Case

As observed here, greater reduction ratios are seen in the order of LPG, diesel oil, coal, gasoline, electricity, fuel oil, kerosene, and gas. No change is projected in jet fuel since drastic change of

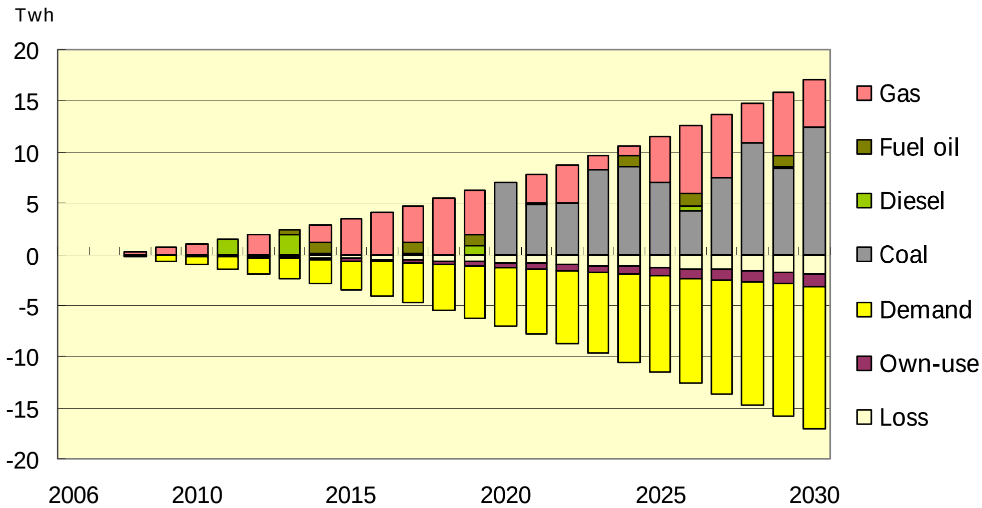


Figure 7.4-13 Power Generation Difference between EEC and Reference Case

airplane model or efficiency improvement is hard to expect. In Figure 7.4-14, effect on power generation source when power demand is decreased by energy conservation is shown. Since the distribution of power sources are determined by the balance between the power demand and the power development plan, the trend is not very stable. Most of the demand decrease reveals to be coal power reduction with slight affects on gas power. However, decrease of gas demand observed here after 2020 is the decrease in LNG import.

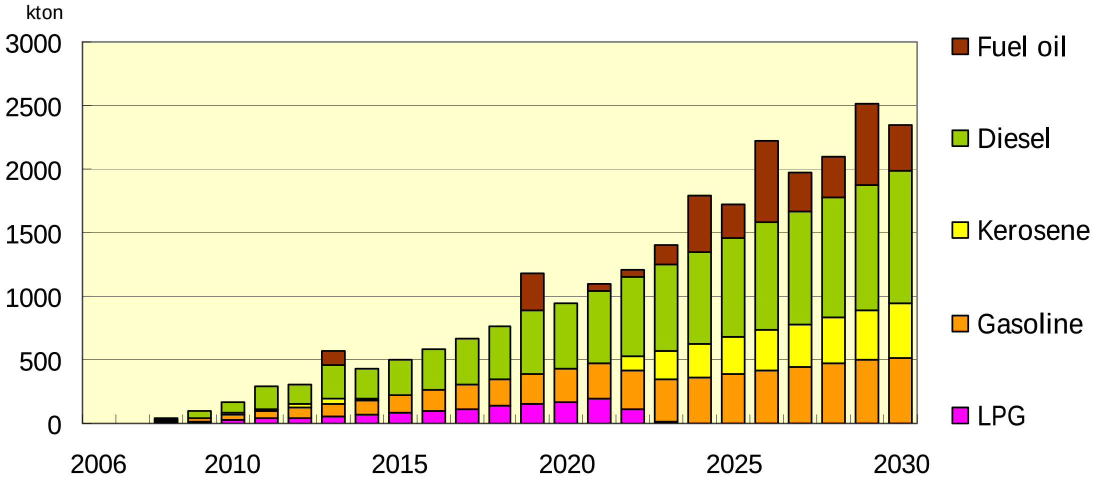


Figure 7.4-14 Petroleum Product Import Difference in EEC and Reference Case

Due to balancing of power supply under the power development plan, temporally operation of oil-based power plants is observed in the Reference Case, which is typically indicated in Figure 7.4-15. This will in turn reveals to be differences in petroleum product import.

7.5 Various Supply Scenarios and Energy Outlook

Starting from the Reference Case, effects of primary energy supply changes are studied on four cases such as nuclear introduction, LNG introduction, accelerated renewable energy use and refinery expansion cases. Gist of them is described as follows:

7.5.1 Nuclear Power

Introduction of nuclear power is examined from the viewpoint that it will enhance energy supply diversification and CO_2 emission reduction. In the Philippines, a nuclear power plant with a capacity of 620 MW was built in the Bataan Peninsula in the 1980s, but it has been mothballed without any operation. Setting aside the matter if this plant should be operated or not, we assume a new 1,000MW nuclear power plant will be introduced at the same area as necessary infrastructure is prepared. Operation is assumed to start in 2025 giving sufficient time allowance for construction.

Figure 7.5-1 shows changes in operation of other power sources, that is, fossil fuels composition such as coal and natural gas to be incurred when a nuclear power station of 1,000 MW would start operation in 2025 at 80% operability. Supply increase by nuclear power introduction causes minimization of diesel power, shutdown of fuel oil power, and turndown of gas power in this order, and finally balanced by coal thermal power. Oil power plant operates very rarely in the Reference Case, except at isolated islands and villages. Since electricity generation cost at gas power station is assumed in this model to be more expensive than that of coal, introduction of nuclear power results in turndown of gas power at first. The case that gas power operation is given a priority will be examined in next section.

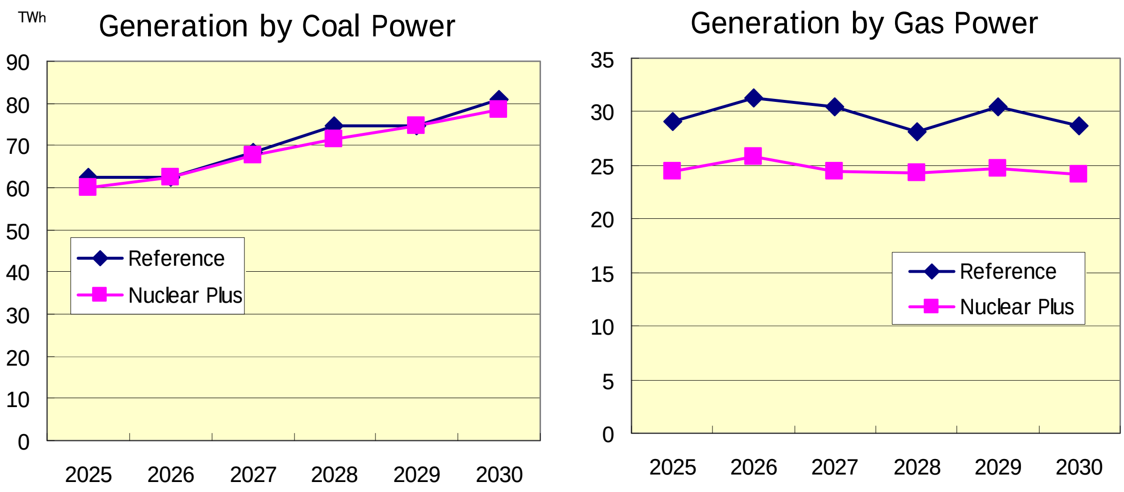


Figure 7.5-1 Trend of Coal and Gas Power Generation

Primary energy supply in the Nuclear Introduction Case is shown in Figure 7.5-2 compared with the Reference Case. Although the introduced nuclear power occupies only 2.4% of the primary energy supply in 2030, this will reduce natural gas by 1%, import coal by 0.7% and domestic coal by 0.1%.

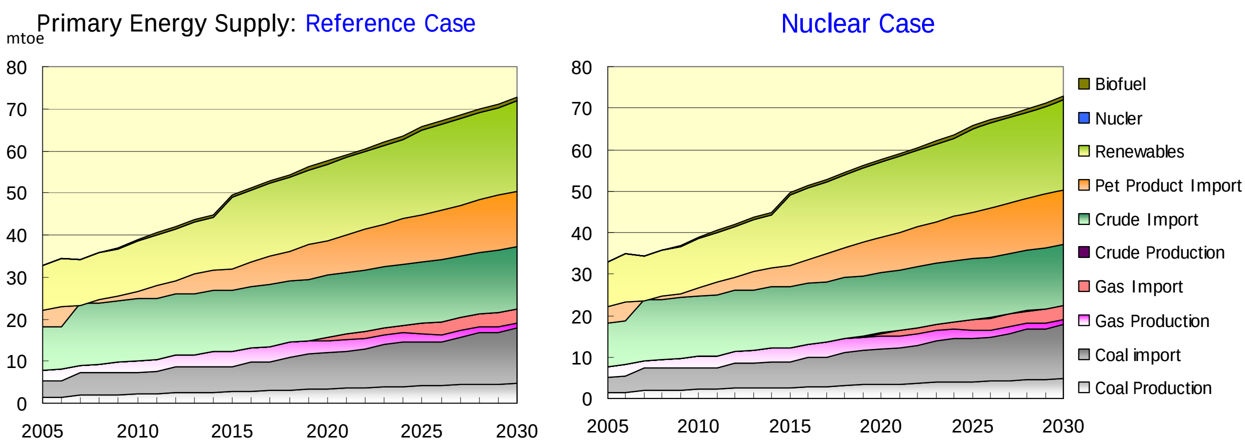


Figure 7.5-2 Comparison of Primary Energy Supply (REF, Nuclear)

The apparent primary energy supply in the Nuclear Introduction Case is larger than that of the Reference Case. This is resulting from the difference in power generation efficiency applied to different power sources. As the power generation amount by nuclear is converted to primary energy with 33% of the thermal efficiency, future power plants are expected to realize much higher efficiency. In this mode,

Table 7.5-1 Primary Energy Supply (Nuclear Introduction：2030)

Case	Domestic Coal	Imported Coal	Oil	Biofuel	Natural Gas	Hydro & Geotherm	Nuclear	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Reference	4825	13143	27841	899	4509	21544	0	72762
Nuclear	4749	12682	27841	899	3786	21544	1826	73327
Change	-76	-461	0	0	-723	0	1826	566
Composition	%	%	%	%	%	%	%	%
Reference	6.6	18.1	38.3	1.2	6.2	29.6	0.0	100.0
Nuclear	6.5	17.4	38.0	1.2	5.2	29.4	2.5	100.0
Change	-0.1	-0.7	-0.3	0.0	-1.0	-0.2	2.5	0.0

38-47% is assumed for coal thermal power plants and 55-60% for natural gas power plans, respectively.[26]

Comparison of CO_2 emission with the Reference Case is shown in Figure 7.5-3, where 156.2 million tons of CO_2 is exhausted in the Reference Case, while it will be reduced by 4.3% to 149.4 million tons of CO_2 in the Nuclear Introduction Case. We find that nuclear introduction will bring certain amount of CO_2 reduction. As it is apparent that nuclear power will bring CO_2 reduction to a certain extent, careful review is necessary on the size of the overall power grid and efficient operation of various power sources when we consider introduction of giant scale power source such as nuclear.

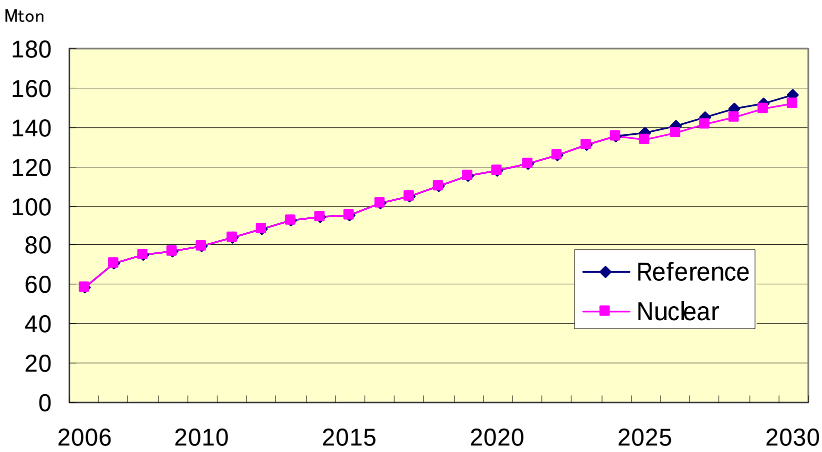


Figure 7.5-3 CO_2 Emission (Nuclear Introduction Case)

7.5.2 Liquefied Natural Gas (LNG)

LNG import is assumed to start in 2020 into the greater Manila area, responding to potential increase of gas demand and production depletion of the Malampaya gas field. The ultimate contract size will be 3 million tons per year, with step-wise increase of supply. The introduction will be implemented in two phases, i.e., 1.5 million tons per year for the Phase-1 period from 2020 with two year “build-up period”.

[26] The other thermal efficiencies applied in this study are as follows: oil including diesel: 30-35%, geothermal: 10%, hydro: 35%, wind: 100%, solar: 100%. There are several different conversion methods for geothermal or nuclear such as the IEA method and Japanese method. Consequently, the converted primary energy supply amount differs in each case. This fact needs to be shared and agreed in advance in conduct of energy study. Otherwise it might incur unnecessary confusion. Also, it is preferable to apply a system that would not bring unnecessary difference caused by efficiency or conversion rate assumptions.

Phase-2 will start five years later and will follow the same build-up pattern. From 2025, 1000 MW nuclear power plant will be added as a base load plant as described in the previous section.

Although LNG supply contract may assume long-term commitment with take-or-pay clause in principle, for smooth introduction without giving unfavorable impact on domestic gas production, above-mentioned build-up period is considered with stepwise increase of supply. In the LNG introduction case, it is assumed that all the amount of imported LNG shall be used up in addition to the domestic gas production scheduled in the Reference Case. This examines the case that gas thermal power is introduced and operated with political consideration accelerating conversion from coal to gas and reducing coal power generation. It is assumed in the Reference Case that, after start of gas field depletion, domestic gas will be used up to the maximum limit at first and only the deficit amount will be filled by imported LNG. In this case, LNG import would not reach the given maximum limit since coal power is taken up with priority. In the LNG introduction case, it is different from the Reference Case that the imported LNG is fully consumed under political guidance and nuclear power is already introduced as studied in the previous section.

Figure 7.5-5 shows the trend in power generation by coal and gas. The requirement for coal thermal power is reduced remarkably after 2025, with substantial difference of 8330 GWh compared with the Reference Case.

Primary energy supply for this LNG introduction case is compared with the Reference Case in Figure 7.5-6 and Table 7.5-2. As nuclear is already introduced to share 2.5% of the primary energy supply, LNG is introduced in addition causing considerable reduction of coal lowering the share of import coal by 2.1% and domestic coal by 0.4%.

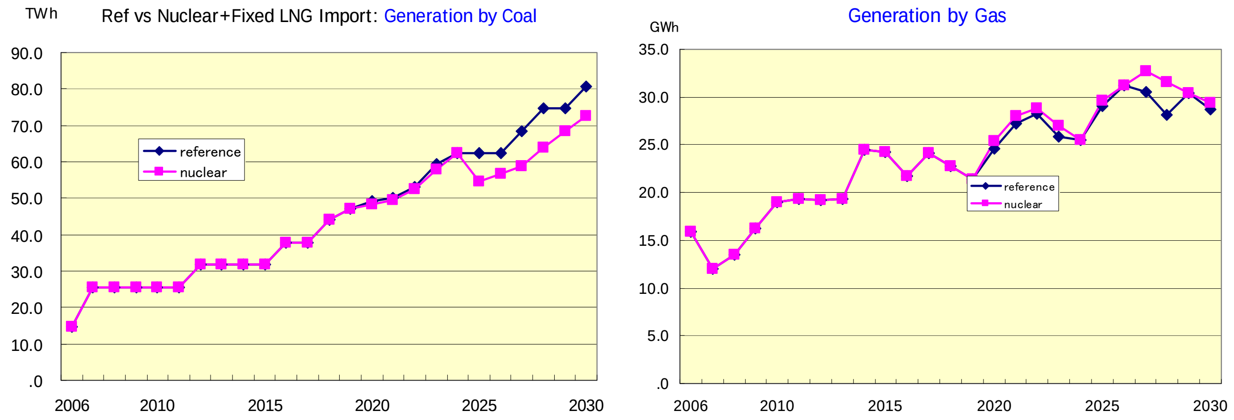


Figure 7.5-4 Coal, Gas and Nuclear Power Generation（GWh）

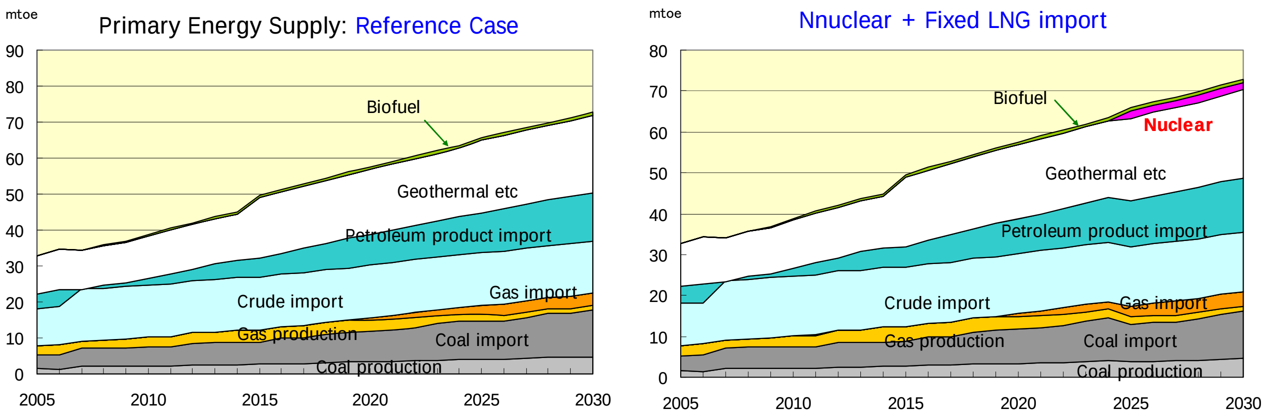


Figure 7.5-5 Comparison of Primary Energy Supply (REF versus LNG)

Table 7.5-2 Primary Energy Supply (LNG Introduction：2030)

Case	Domestic Coal	Imported Coal	Oil	Biofuel	Domestic Nat Gas	Imported LNG	Hydro & Geotherm	Nuclear	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Reference	4825	13143	27841	899	1132	3377	21544	0	72762
LNG	4582	11672	27841	899	1132	3500	21544	1826	72996
Change	-243	-1471	0	0	0	123	0	1826	234
Compositior	%	%	%	%	%	%	%	%	%
Reference	6.6	18.1	38.3	1.2	1.6	4.6	29.6	0.0	100.0
LNG	6.3	16.0	38.1	1.2	1.6	4.8	29.5	2.5	100.0
Change	-0.4	-2.1	-0.1	0.0	0.0	0.2	-0.1	2.5	0.0

CO_2 emission in the LNG introduction case is shown in Figure 7.5-7, where 156.2 million tons of CO_2 is exhausted in the Reference Case, while it is reduced by 4.3% to 149.4 million tons of CO_2 in the LNG introduction case combined with introduction of nuclear power.

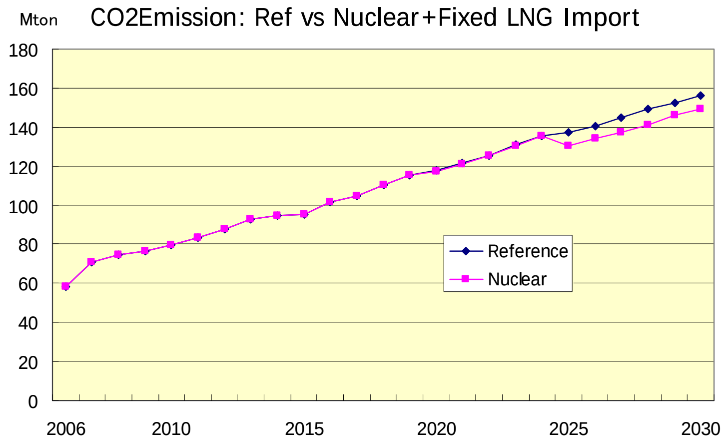


Figure 7.5-6 CO_2 Emission (LNG Introduction)

7.5.3 Accelerated Renewable Energy Use

Power development plan using renewable energies such as geothermal, hydro and wind until 2030 is set out by DOE as shown in Table 7.5-3 and Figure 7.5-8. Corresponding amount of power generation by geothermal, hydro and wind is projected in the Reference Case with consideration on the status of the existing facility and realistic operation level.

Table 7.5-3 Power Development Plan: DOE (Renewable)

	2008-2010	2011-2015	2016-2020	2021-2025	2026-2030
	MW	MW	MW	MW	MW
Geothermal	90	680	40	190	90
Hydro	3100				
Wind	415				

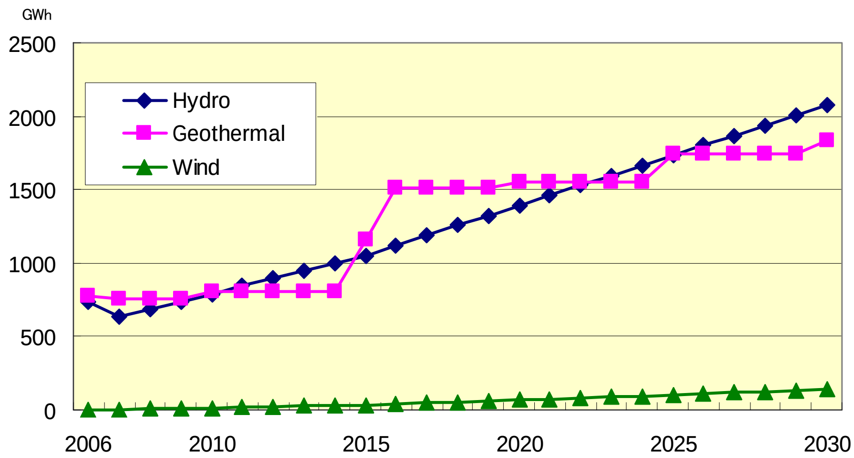


Figure 7.5-7 Power Development Plan: DOE (Renewable)

In the Accelerated Renewable Energy case, challenging increase of renewable energy capacity substantially exceeding the above-mentioned development plan is considered. The same numbers are applied for the period before 2015, since it may not be realistic in the earlier period to advance the current facility construction/installation plan. However, after 2016, capacity expansion is set larger than the Reference Case to increase renewable energies to the maximum extent; geothermal is double, hydro is 30% up, wind is double.

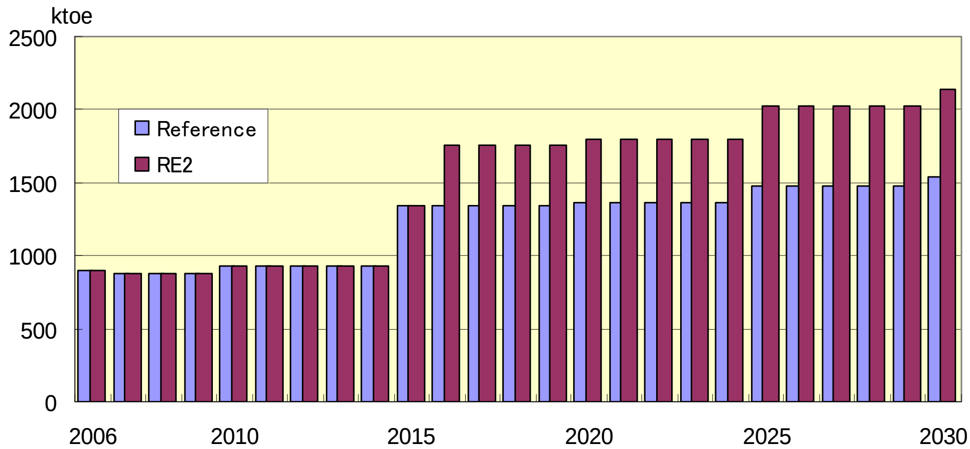


Figure 7.5-8 Introduction of Geothermal

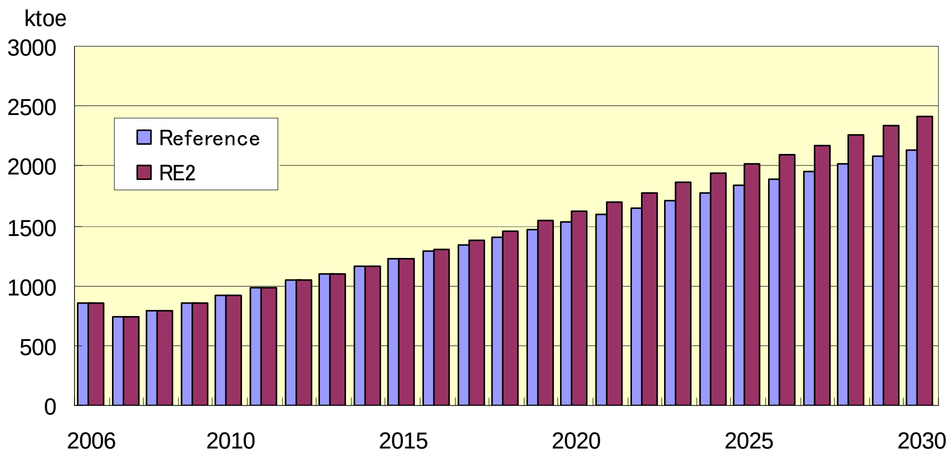


Figure 7.5-9 Introduction of Hydro

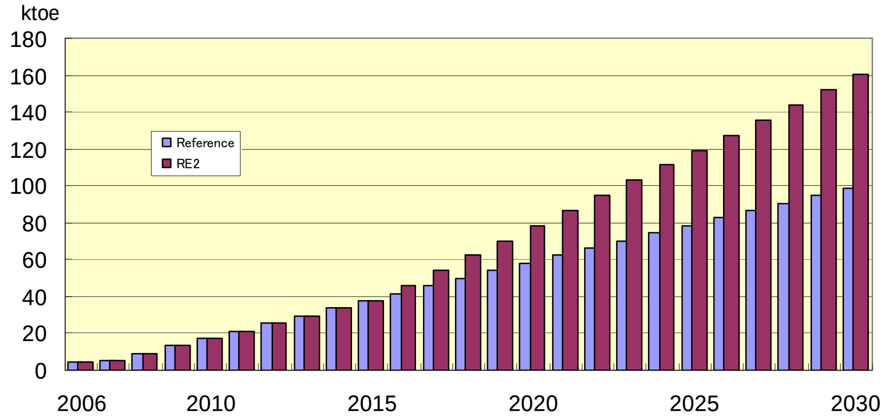


Figure.7.5-10 Introduction of Wind

The schedule of renewable energy introduction in the Accelerated Renewable Use case is summarized in Figure 7.5-9, 7.5-10 and 7.5-11 on geothermal, hydro and wind, respectively.

Figures 7.5-12 indicates trends of power generation by coal and gas, where both of them are remarkably reduced after 2020, and the difference in 2030 amounts to 6,330GWh for coal and 4,570GWh for gas, respectively.

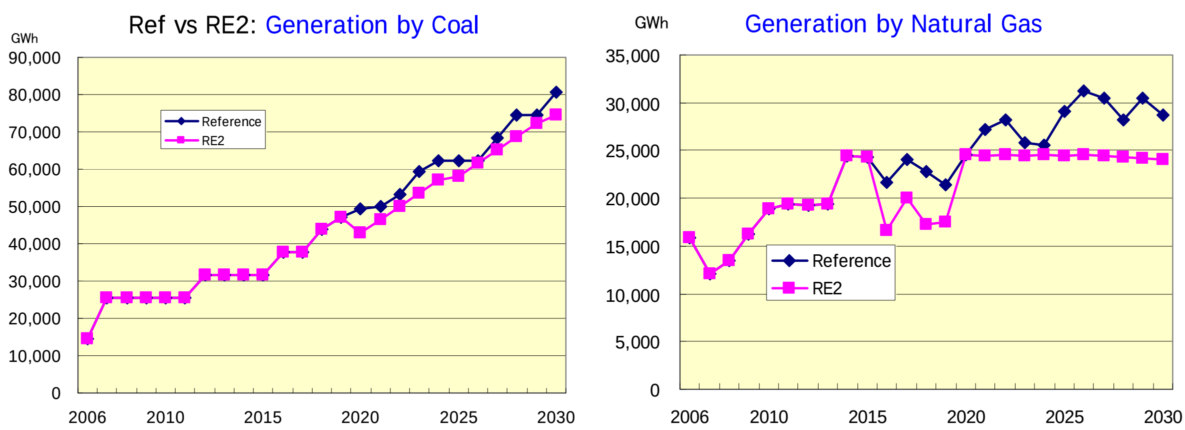


Figure 7.5-11 Coal Power Generation（GWh）

Primary energy supply for the Accelerated Renewable Energy is shown in comparison with the Reference Case in Figure 7.5-13 and Table 7.5-4.

In the Accelerated Renewable Energy Case, share of renewable energy in the primary energy supply increases up to 36.0% in 2030 with a substantial increase of 6.9% compared with the Reference Case, resulting in reduction of thermal power; domestic coal decreases its share by 0.6%, import coal 2.6%, oil 2.4%, and natural gas 1.3%.

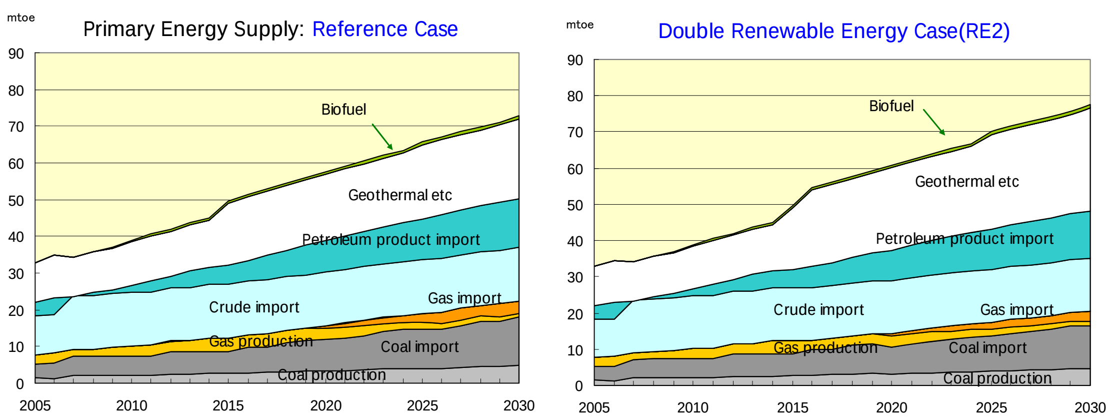


Figure 7.5-12 Comparison of TPE (REF, RE2)

Table 7.5-4 Primary Energy Supply (Renewable Max.: 2030)

Case	Domestic Coal	Imported Coal	Oil	Biofuel	Natural Gas	Hydro & Geotherm	Nuclear	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Reference	4,825	13,143	27,841	899	4,509	21,544	0	72,762
Renewables	4,627	11,945	27,841	961	3,786	28,364	0	77,523
Change	-198	-1,198	0	61	-723	6,820	0	4,762
Composition	%	%	%	%	%	%	%	%
Reference	7	18	38	1	6	30	0	100
Renewables	6	15	36	1	5	37	0	100
Change	-1	-3	-2	0	-1	7	0	0

CO_2 emission in the Accelerated Renewable Use case is shown in Figure 7.5-14. As 156.2 million tons of CO_2 is emitted in the Reference Case, it will be reduced by 4.8% to 148.8 million tons in the Accelerated Renewable Use case as a result that fossil fuel consumption is further reduced in addition to introduction of nuclear energy.

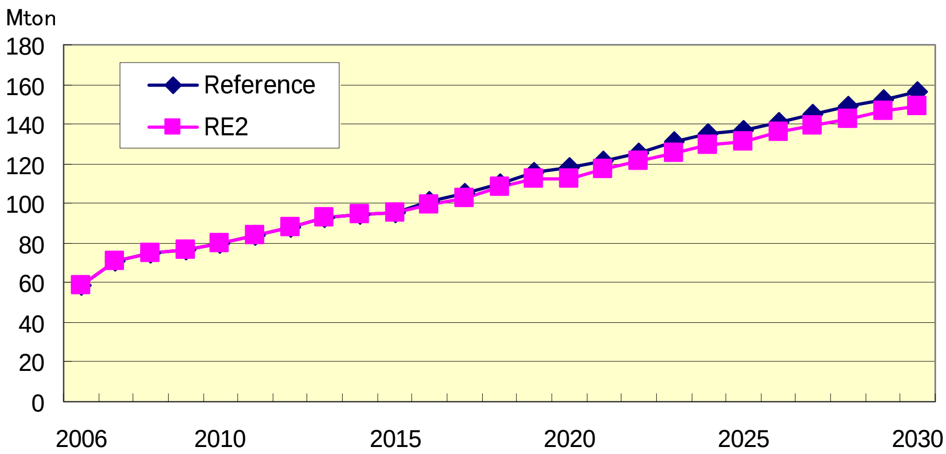


Figure 7.5-13 CO_2 Emission in Accelerated Renewable Use

7.5.4 Refinery Expansion

Since no refining capacity increase is taken into account in the Reference Case, demand growth of petroleum products, in particular motor fuels such as gasoline and diesel gas oil, could not be covered by domestic refineries. Since the domestic refining capacity is limited, import of gasoline and diesel oil will be monotonously increasing toward 2030 reflecting the demand increase. Under the circumstance, it is desirable to consider expansion of domestic refining capacity provided that favorable investment conditions should be prepared.

Considering that availability of manpower and vendors for EPC work for construction of refinery is presently extremely tight in the world, it seems very difficult to commission new refinery before 2015. Thus, it is assumed in the Refinery Expansion case, refining capacity expansion of 100,000 B/D in 2020 is assumed in a form of “scrap and build” that a new refinery with a capacity of 200,000 B/D will be constructed in place for the existing 100,000 B/D capacity.

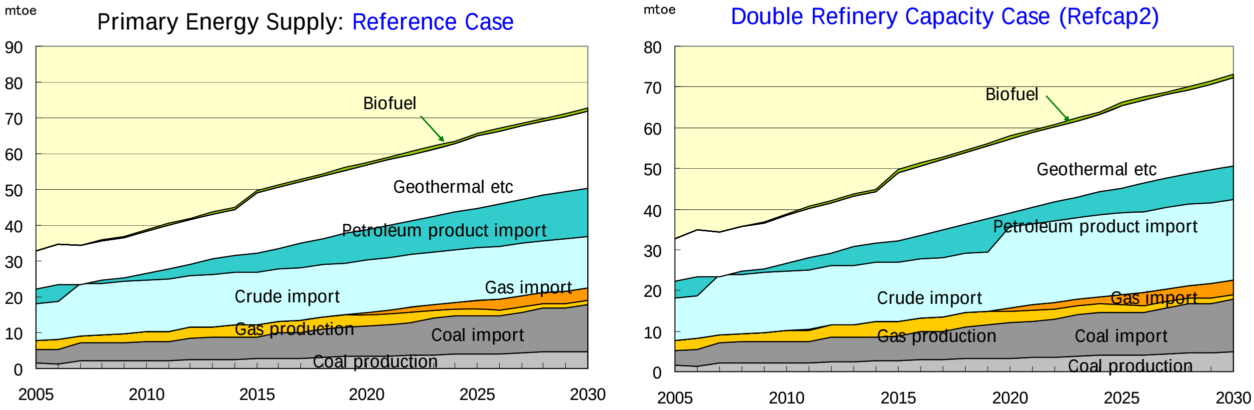


Figure 7.5-14 Comparison of TPE (REF, RE2)

Table 7.5-5 Primary Energy Supply (Refinery Expansion ： 2030)

Case	Coal	Crude Processing	Imported Oil Products	Biofuel	Natural Gas	Hydro & Geothermal	Nuclear	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Reference	17,968	14,621	13,220	899	4,509	21,544	0	72,762
Refining Expansion	17,968	19,914	8,308	899	4,509	21,544	0	73,142
Change	0	5,293	-4912	-0	0	0	0	381
Composition	%	%	%	%	%	%	%	%
Reference	24.7	20.1	18.2	1.2	6.2	29.6	0.0	100.0
Refining Expansion	24.6	27.2	11.4	1.2	6.2	29.5	0.0	100.0
Change	-0.1	7.1	-6.8	0.0	0.0	-0.2	0.0	0.0

Primary energy supply for this Refinery Expansion case is shown in Figure 7.5-16 and 7.5-17 and Table 7.5-5 in comparison with the Reference Case. In 2030, Petroleum product import will decrease by6.8% from 18.2% down to 11.4% of the primary energy supply and crude processing will increase by 7.1% from 20.1% to 27.2%. This is the only different point from the Reference Case, and other energy sources such as coal, gas and renewable and CO_2 emission will remain unchanged. However, the petroleum product import reaches 48% of the crude processing amount in 2030. This suggests that the above-mentioned refining capacity expansion is not sufficient and further expansion of 100,000 B/D needs to be considered. Under the circumstance, it is required to conduct in-depth study on the refinery capacity expansion to identify appropriate size and timing.

Then, supply/demand balances of gasoline and diesel oil are compared with the Reference Case in Figure 7.5-16 for gasoline and Figure 7.5-17 for diesel oil, respectively. In the Reference Case, both gasoline and diesel oil import are increasing monotonously since refining capacity remains fixed. In the Refinery Expansion case, on the other hand, petroleum product import decreases from 2,385 ktoe to 1,476 ktoe for gasoline and from 4,539 ktoe to 2,797 ktoe for diesel oil, respectively, by about 40%. However, petroleum product import ratio in whole demand is still high, and further expansion of refining capacity shall be considered as mentioned above.

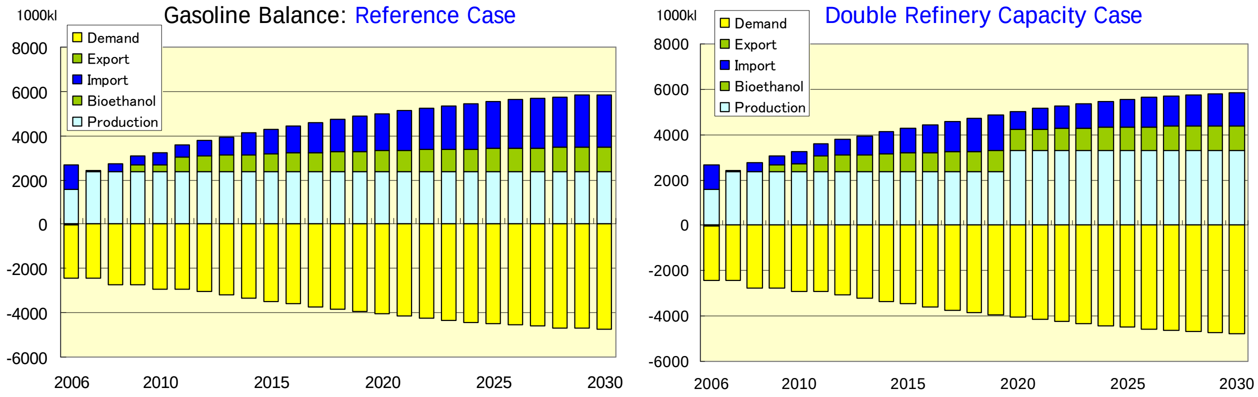


Figure 7.5-15 Comparison of Gasoline (REF, RE2)

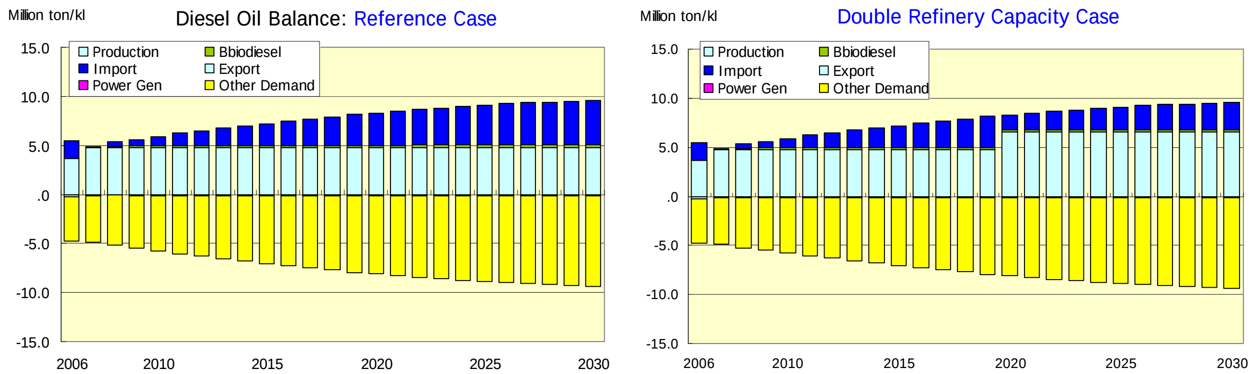


Figure 7.5-16 Comparison of Diesel Oil (REF, RE2)

In addition to the above cases, increase of biofuel supply is also considered from a viewpoint of reducing the volume of import of gasoline and diesel. Table 7.5-6 shows the summary of comparison with cases of 1) biofuel supply increase volume, in particular E85 is taken up as an extreme case and 2) the refining capacity expansion.

Table 7.5-6 Effect of Biofuel Introduction on Gasoline Import (2030)

(Unit:ktoe)

	Production			Import			Export		
	Reference	E85	Ref.Cap	Reference	E85	Ref.Cap	Reference	E85	Ref.Cap
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
LPG	795.3	795.3	1255.2	2360.0	2360.0	2360.0	0.0	0.0	0.0
Gasoline	2723.9	2723.9	3768.9	2743.0	0.0	1698.0	0.0	1924.8	0.0
Bio Ethanol	622.4	5290.2	622.4	-	-	-	-	-	-
Kerosene	0.0	0.0	0.0	1249.5	1249.5	789.6	0.0	0.0	0.0
Jet Fuel	1399.5	1399.5	1665.7	1090.2	1090.2	824.0	0.0	0.0	0.0
Diesel	5486.2	5486.2	7472.2	5261.3	3657.5	3275.2	0.0	0.0	0.0
Bio Diesel	178.2	1782.4	178.2	-	-	-	-	-	-
Fuel Oil	3858.7	3858.7	5013.4	602.1	602.3	0.0	0.0	0.0	552.5
FG	260.0	260.0	440.5	-	-	-	-	-	-

The extreme increase of bio-ethanol supply results in gasoline export of 1,925 ktoe that is equivalent to 70% of the domestic production at 2,724 ktoe as exceeding the domestic demand. On the other hand, 3,658 ktoe of diesel oil, equivalent to 67% of the domestic production at 5,486 ktoe, is still in short and requires import. Production balance is quite abnormal between gasoline and diesel. Considering that petroleum products are so-called chain-products linked each other, this result suggests that extremely high bio-ethanol blending would cause serious problems. Or, this result suggests that we should consider simultaneously well-balanced production yields for gasoline and diesel oil in planning ambitious biofuel promotion.