Supply and Demand Analysis on Petroleum Products and Crude Oils for Asia and the World

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SUMMARY

1. Supply-Demand Balance in Various Regions in 2010 and 2015

(1) China

Refining capacity expansion projects will be carried out almost as planned to increase refining capacity (crude distillation units) to 9 million B/D by 2010 and 11 million B/D by 2015, and this nation will become a net exporter of gasoline and a minor net importer of medium distillates, thus allowing the nation to practically maintain its self-sufficiency rate.

(2) India

Refining capacity is expected to reach a total of 4.00 million B/D by 2010, which is broken down into 1.50 million B/D for the private companies and 2.50 million B/D for state-owned companies. India's export capacity (excluding exports to the South Asian region) is almost equivalent to private companies' refining capacity and comes to approximately 1 million B/D as equivalent to the amount of gasoline/middle distillate production.

(3) Middle East

Refining capacity of this region is predicted to reach approximately 8.30 million B/D by 2010 and approximately 10.40 million B/D by 2015. As the regional demand is expected to grow at a higher rate, Iran and Iraq will be confronted by a refining capacity shortage and imports of petroleum products, chiefly gasoline, from outside the region will continue. Making progress in a now delayed project to construct a new oil refinery in Saudi Arabia is the key to success in expanding the region's supplies and enhancing its product exporting capability.

(4) The United States

Demand for petroleum products will continue increasing, resulting in a shortage of refining capacity. In "Reference case," the nation's imports of gasoline in 2010 and 2015 are expected to reach approximately 1.90 million B/D, about half of which is accounted for by petroleum products.

(5) Europe

Between 2005 and 2015, gasoline demand will decrease while gas oil demand will increase slightly, so the supply-demand balance consisting of gasoline exports and middle distillate imports will continue.

(6) East Asia (Excluding China) Competing with South Asia
Exports from the East Asian region (excluding China) are mainly oriented towards China, Southeast Asia, Oceania and North America (the west coast), while exports from South Asia and the Middle East are mainly towards Europe, Africa, and Oceania. So there will be no market competition between the two regions, except for Oceania.

(7) East Asia (Excluding China)
Japan, South Korea and Taiwan will compete with one another because their markets overlap each other. In regard to Japan's exports, it may be interesting to note that in the "Reference case" that assumes a steady increase in world demand and a strained supply-demand, Japan will be able to export 0.59 million B/D of gasoline and middle distillate in 2010 and 0.77 million B/D in 2015. This represents approximately 16% of the present CDU capacity (or 20% in crude oil equivalent).

(8) Competition between South Asia and the Middle East
South Asia, which is ahead of other regions in the buildup of refining capacity, will prevail in exports to the European and American markets during the period from 2010 to 2015. However, if export-oriented oil refineries come on line from 2012 onward as planned in the Middle East region, there will be intensifying competition between South Asia and the Middle East for exports to the European and American markets.

2. Conclusions

In summary the results of optimization in the world oil refining and trade model, we have arrived at the following conclusions, focusing particularly on Japan.
(1) Japan's Surplus Refining Capacity and Export Capacity
If steady growth in the petroleum product demand in the world results in a tightening supply (Reference case), a look at Japan's refining capacity (approximately 4.80 million B/D) shows that approximately 20% of Japan's surplus refining capacity (or 16% on the gasoline and middle distillate basis) will be used fully – mainly for exports of high-quality (very low sulfur-content) petroleum products.

(2) Main Export Markets

Jet fuel, gas oil and other middle distillates will be exported mainly to the Asian region (China, ASEAN nations and Australia) while gasoline will be exported mainly to the west coast of the United States and the Australian region.

(3) Inter-Regional and Intra-Regional Competition

Regarding inter-regional competition, there will be no competition between South Asia / the Middle East, which export their products mainly to the European and African markets, and East Asia, which targets the Pacific region (including Japan, South Korea and Taiwan but excluding China), with the exception of Australia. However, analysis of the relations among three countries in the East Asian region – namely, Japan, South Korea, and Taiwan – shows that since Japan's export market overlaps with those of South Korea and Taiwan with slow growth in domestic demand and large surplus supply capacity, keener competition among these countries is most likely to occur in the years ahead.

3. Challenges Ahead

The above conclusions need to take the following constraints into account and may have to be analyzed and assessed more elaborately and accurately.

(1) Exports of Gasoline and Gas Oil from Japan, South Korea and Taiwan to the United States

(a) In the LP model, assumptions are concerned solely with refining capacity and quality standards but do not incorporate an assessment of logistics. As a result, the model tends to assume that Japan's utilization rate will increase to a level higher than the actual levels, resulting in excessive exports.

(b) Because the United States is assumed to be a single market (of uniform quality), standards (olefin content, vapor pressure, aroma content, etc.) for gasoline on the west coast of the United States, particularly gasoline in California (CARBOB), are not accounted for. Japan's standard gasoline, which comprises mainly FCC gasoline, is far from meeting the standards. In actuality, therefore, blending materials such as alkylate must be changed. Accordingly, the results of LP estimation tend to assume that exports are larger than actual levels.

(2) Treatment of Export-oriented Oil Refineries in South Asia and the Middle East

region

(a) Export-oriented oil refineries in India in South Asia are assumed to be intended solely for exports, but the oil refineries to be constructed (in 2012) in the Middle East region are not assumed to be dedicated to exports.

(b) As a result, where exports to the European and American regions actually occur, intra-regional (to Iran and Iraq, etc.) supply is assumed to occur by priority. Exports to Europe and the United States from the Middle East region are underestimated as a result.

Chapter 1: Overview of the study

1.1 Objectives of the Study

1.1.1 Petroleum Product Supply and Demand

Oil demand from Asia-Pacific nations, centering on China and India, with both countries achieving remarkable economic growth, has been growing steadily and in recent years numerous projects to construct oil refineries and build up refining capacity have been launched, with petroleum product supply capacity beginning to increase gradually.

However, the recent upsurge in crude oil prices has led to a sharp rise in the prices of materials and processing units and combined with a manpower shortage, has substantially increased the cost of constructing oil refineries.

As a consequence, numerous construction projects are now being reconsidered or inevitably postponed. Majority opinions are therefore that less progress will be made in the buildup of capacities than initially expected. On the other hand, given a slowdown in the world economy resulting from the recession of the U.S. economy and the upsurge in crude oil prices, oil demand, mostly from advanced nations, is most likely to become weaker or even decrease, so that from now onwards, the supply-demand situation will differ greatly from region to region. The future outlook for the supply and demand for petroleum products involves an increasing number of uncertain factors, both in terms of supply and demand, and uncertainty about the outlook is growing.

1.1.2 Deregulation and Liberalization of the downstream of Japan Oil Industry

Diverse measures for deregulation and liberalization surrounding the downstream petroleum sector (petroleum refining) are being pushed ahead in various countries around the world. Forging a global petroleum product trade framework smoothly and efficiently is crucial to accelerating this move. Because one of the factors disturbing product trade is the difference in efforts that countries are making to tighten quality regulations, there is a difference observed in the quality and standards of petroleum products among countries. In this regard, the impact (or effects) of quality regulations, such as the lower sulfur content of gasoline and gas oil (sulfur-free products), due to measures designed to protect the environment, must receive full attention.

1.1.3 Challenges for Japan Oil Industry and objectives of the Study

Japan, which is dependent on imports from abroad for most of its crude oil requirements while experiencing the maturity of the domestic petroleum product market and an early decline in domestic demand, needs to establish its position in the international petroleum market while securing a steady supply of petroleum products. To this end, a very important approach is to econometrically assess and comprehensively analyze the most accurate and up-to-date information on the trends in oil supply and demand and supply capacity in the world, including in the Asia-Pacific region.

The present study was carried out in order to renew the (existing) world models aimed at analyzing the supply and demand for petroleum products in various parts of the world and to consider the flow of inter-regional product trade, make analyses with this model in various case studies, and thereby grasp the ever-changing international oil supply-demand trends systematically, and come up with well-timed basic data needed to formulate future policy measures for energy sources, including petroleum.

1.2 Scope of the Study

In the present study, in order to achieve the abovementioned purpose, energy data and related statistical data on crude oil and petroleum products in the world, mostly in the Asia-Pacific region that is closely connected with Japan, were surveyed systematically and in detail, collected and analyzed. At the same time, World Energy Demand Model and World Oil Refining and Trade Model constructed in the econometric analysis model survey of petroleum product supply-demand trends, conducted in fiscal 2005 based on the latest information and the most up-to-date data on the effects of the economic situations in India and China, environmental regulations in various countries, and crude oil price trends, were further refined and with these models, short- and medium-term simulation and analyses were performed.

The present study consisted of:

(i) Collection and analysis of data on the supply and demand for energy and oil in the world, mostly in Asia;

(ii) Collection and organization of information about various countries' long-term energy and oil supply-demand outlook, and energy policies (oil policies);
(iii) Creation and revision of World Energy Demand Model and World Oil Refining and Trade Model reflecting the most up-to-date data and situations;
(iv) Using the abovementioned models, simulation of petroleum supply and demand based on various assumptions (economic growth, population, crude oil prices, refining facility projects, and various energy policies) from a medium-term perspective up to 2010 and 2015;
(v) Based on the results of the above simulation, an analysis of effects on Japan's petroleum industry and petroleum product trade flow.

The present study was conducted by the Institute of Energy Economics, Japan at the request of the Ministry of Economy, Trade and Industry in the FY2007 Study of the Petroleum Industry and Others (the Econometric Analysis Model Survey of the Petroleum Product Supply-Demand Trends). In carrying out this study, an International Working Group (the "International WG"), composed of experts working for oil companies and trading concerns and who are well versed in international oil supply and demand, was organized and has held three committee meetings since November 2007. Because of this consideration, the accuracy of the models was improved by setting cases to consider in simulation with econometric analysis models and others, and by carefully examining the results of simulation so that the study could be conducted efficiently.

Meanwhile, a project team was organized within the IEEJ's Energy Data and Modeling Center to collect and analyze, through surveys at site, the most up-to-date information and data on environmental regulations enforced by various countries, including China and India, and on the trends in crude oil prices. The econometric analytical techniques and the models constructed so far were also improved.

Chapter 2: Overview of the Models

2.1 Overview of the Models

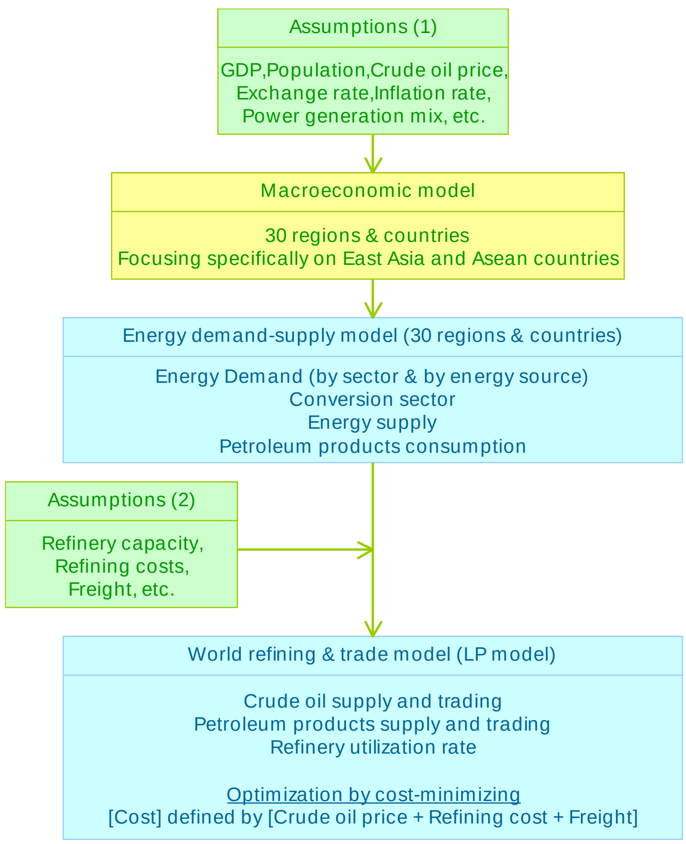
In the present estimation, based on the economic and population outlooks, world energy demand and petroleum product demand were estimated by using an econometric technique. Various countries' net positions concerning petroleum products were analyzed by using a linear programming method as well as trade flow models. The following two models were used in the present estimation:

(i) World Energy Demand Model (econometric model); and

(ii) World Oil Refining and Trade Model (linear programming model (LP)).

Figure 2-1 shows a calculation flow of the present estimation with these two models, which will be outlined individually in the ensuing sections.

Figure 2-1. The Structure of the Model and a Calculation Flow Diagram

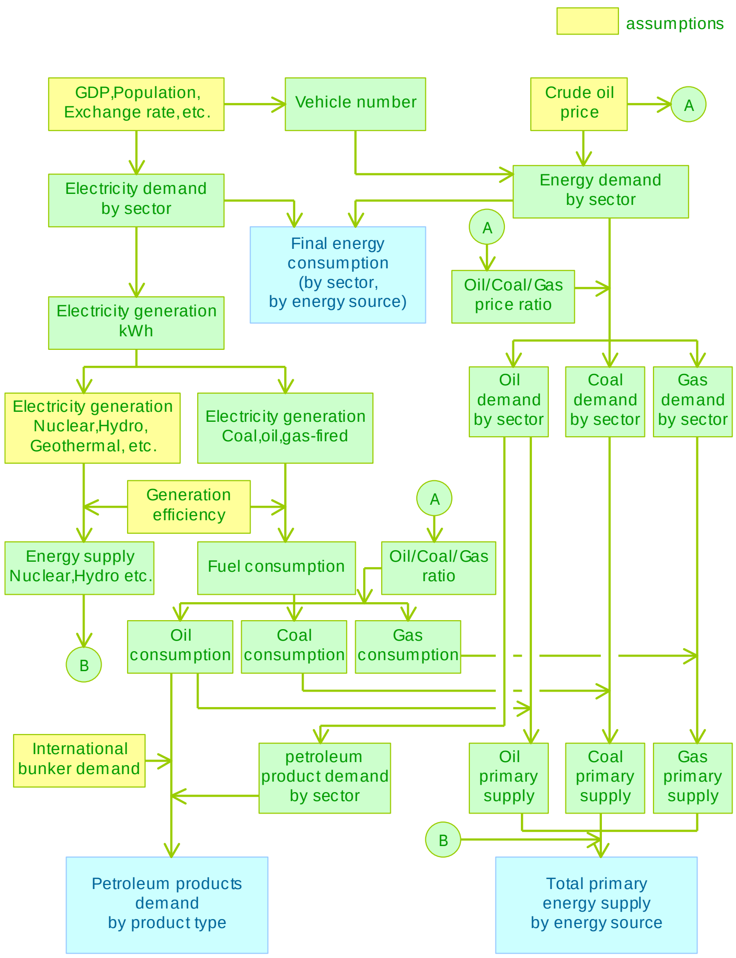


2.2 World Energy Demand Model

World Energy Demand Model is composed of demand functions by energy source and by industrial sector based on the International Energy Agency's (IEA) country-by-country energy balance table data and estimates demand by using an econometric technique. Regarding petroleum products, *inter alia*, the model is capable of estimating demand by product category after consideration of the countries' electricity demand and progress in motorization.

Regions covered by the model are not exactly the same as those for analysis withWorld Oil Refining and Trade Model, which will be described later, partly because the estimation formulas used vary, depending on the characteristics of energy supply and demand in each country (each region). The basic structure of this model is shown in Figure 2-2.

Figure 2-2. The Basic Structure of World Energy Demand Model



For energy demand forecasting, the world was divided into 30 regions for analysis. Concerning Asia, in particular, members of this region, mostly ASEAN member nations, were analyzed individually. The regions covered by the model's analysis are shown in the figure below.

Figure 2-3. Regions Covered in World Energy Demand Model

1	United States	11	Former USSR	21	Brunei
2	Canada	12	Non-OECD Europe	22	Indonesia
3	Mexico	13	Africa	23	Malaysia
4	Brazil	14	Middle East	24	Philippines
5	Other Latin Amarica	15	China	25	Thailand
6	United Kingdom	16	Japan	26	India
7	Germany	17	HongKong	27	Vietnam
8	France	18	Taiwan	28	Other Asia
9	Italy	19	South Korea	29	Australia
10	Other OECD Europe	20	Singapore	30	New Zealand

The model estimates energy demand on a bottom-up basis for the final demand sector, the conversion sector and the primary energy supply sector in the energy balance table in the order named. The GDP growth rate, energy prices (oil prices), population, and energy sources that involve significant policy elements, such as nuclear power, hydropower, and new energy, were regarded as exogenous variables. The final energy consumption sector is roughly divided into the industrial segment, the transport segment, the commercial/agricultural segment and the non-energy segment. For petroleum products, among others, demand was estimated by segment and by product category. Of the main exogenous variables, crude oil prices were estimated in reference to the U.S. Department of Energy's "Annual Energy Outlook 2006 Edition" and the IEA's views. Population was estimated in reference to the United Nations' population projections, countries' outlooks, and the IEA's outlook, while economic growth was estimated in reference to the estimates by the World Bank, the International Monetary Fund (IMF) and the Asian Development Bank.

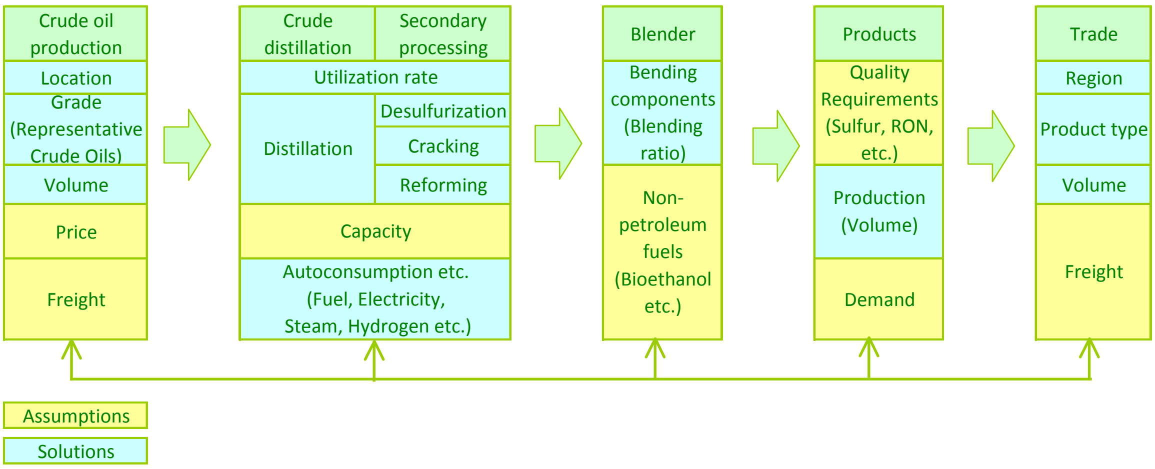
2.3 World Oil Refining and Trade Model

2.3.1 World Oil Refining and Trade Model

World Oil Refining and Trade Model is composed chiefly of the following six elements. An entire flow of processes associated with petroleum products from the selection and refining of crude oil to its exports is shown in Figure 2-4. Oil refining and trade patterns in which total costs of refining and trade, such as crude oil prices, crude refining costs, and product trade costs, can be reduced to a minimum for the world at large were calculated using the linear programming (LP) method:

(i) Selection of crude oil (crude oil type and quantity);
(ii) Installed capacity and capacity expansion plans (CDU and secondary units);
(iii) Quality standards;
(iv) Demand by region;
(v) Introduction of new fuels; and
(vi) Crude oil prices (differential between light and heavy crude oil).

Figure 2-4. A Flow of Petroleum Products and LP Optimization Calculation



2.3.2 The Structure of World Oil Refining and Trade Model

(1) Analysis of Supply-Demand Balance and Trade Flow and Split in Regions

World Oil Refining and Trade Model integrated the 30 regions of the world corresponding to those covered by World Energy Demand Model into the regions shown in Figure 2-5. Calculations were performed in the following two phases. The 14 regional models were used mainly in the analysis to consider the world trade flow:

(i) Optimization with the 14 regional models covering the ASEAN region;

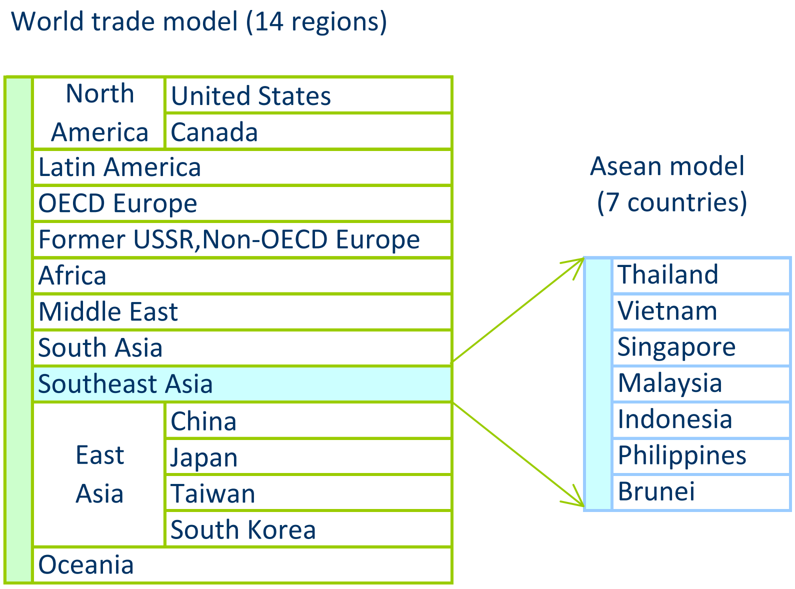
and

(ii) Optimization with the 7 regional models within the ASEAN region.

(In the present study, the ASEAN nations' supply-demand balance was checked but a simulation of detailed trade flow was not carried out.)

Note: Optimization with the intra-region detailed model in other regions is a task for future investigation.

Figure 2-5. Regions in the World Oil Refining and Trade Model



(2) Refining Processing Flow

Oil refining flow in LP Model is shown in Figure 2-6. The major units include:

(i) Distillation units

Crude distillation unit (CDU) and vacuum distillation unit (VC)

(ii) Desulfurization units (UF and HTR)

Naphtha, gasoline, kerosene, gas oil, vacuum gas oil (VGO), and residual oil (TR)

(iii) Reforming units

Reforming unit (RF and CCR), Isomerization (IM), BTX unit, benzene unit, Alkylation unit (ALK), and ETBE unit

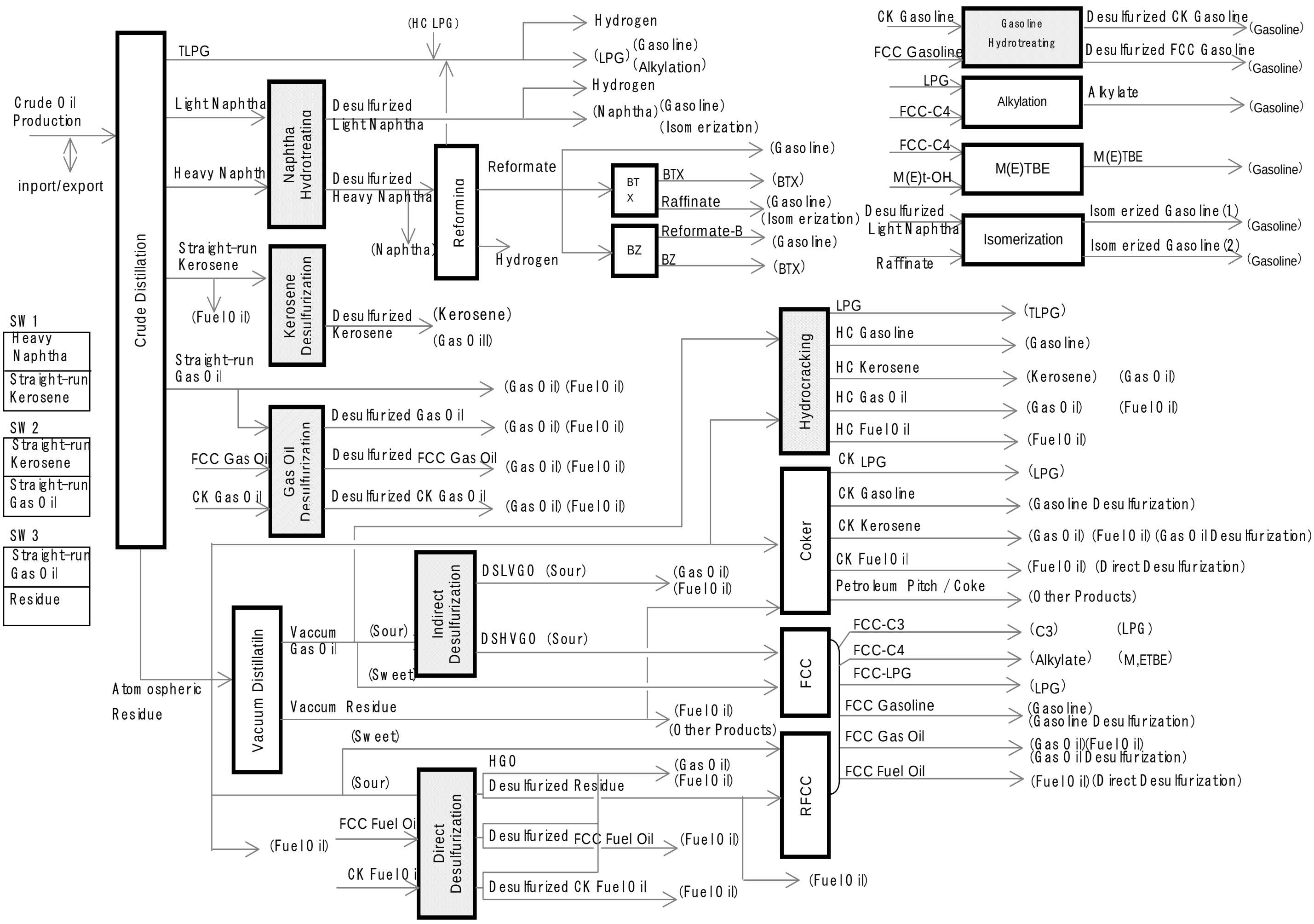
(iv) Cracking units

Catalytic cracking unit (FCC and RFCC), Delayed coking unit (TC), and

Hydro-cracking unit (HC)

(v) Blenders and Utilities.

Figure 2-6. Refining Processing Flow in LP Model



Chapter 3: Preconditions on the LP Model

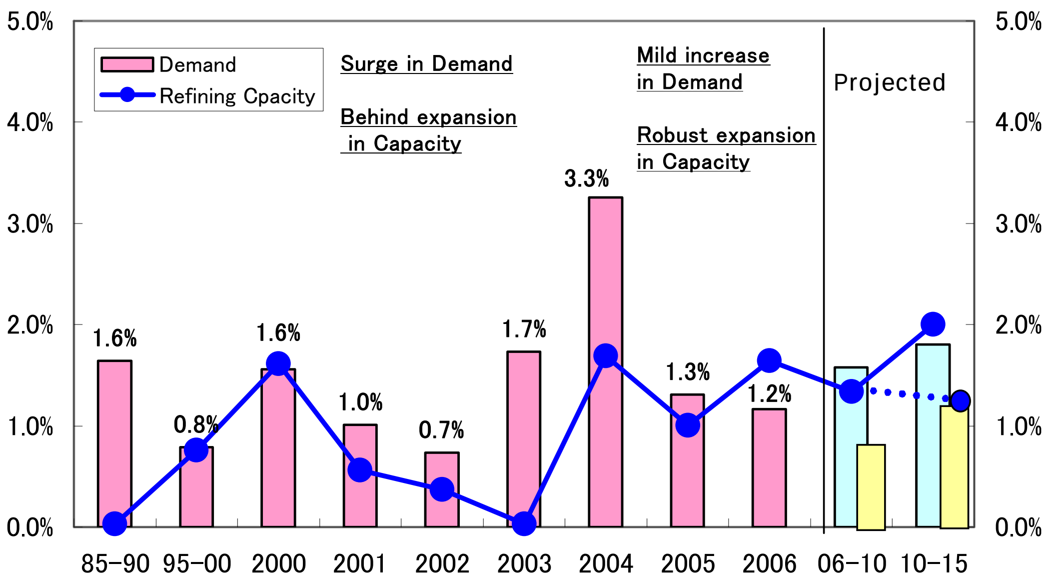
3.1 Framework of the Study

3.1.1 The Product Supply-Demand Situations Until 2005

(1) 2004 Was the Year of a Major Turnaround

First of all, the supply-demand environment in the year 2005 is reviewed. Figure 3-1 shows changes in world oil demand and oil refining capacity. A rate of growth in oil demand rose precipitously from the 1-2% levels (0.7% in 2002 and 1.7% in 2003) to 3.3% in 2004. Crude oil prices, which had wavered low in the 1990s, began to rise sharply from 2004 onward. This was primarily because the economic growth of BRICs, including China and India, contributed to a sharp increase in oil demand. Yet another reason that prevailed worldwide was a shortage of refining capacity. In addition, what is still fresh in our memory is that a hurricane and accidents shut down oil refineries in the United States, and West Texas Intermediate (WTI) crude oil prices fluctuated widely on the New York Mercantile Exchange (NYMEX).

Figure 3-1. The Rate of Growth in World Oil Demand and Refining Capacity



Sources: Actual data : IEA,OPEC   Forecast : IEEJ

Under these circumstances, capacity expansion projects, including projects to construct new oil refineries, were announced one after another in various parts of the world. Moreover, in the 2000s, industrialized countries in Europe, the United States and Japan took the lead in tightening quality regulations for the sake of environmental protection. By around 2010 sulfur-free (less than 10 ppm sulfur content) gasoline and gas oil will be produced there. Developing countries followed suit; they perceived the need to bolster the capacity of secondary units such as desulfurization units and cracking units on a global level. At this time, the oil refining industry experienced the start of an unprecedented rush to construct oil refineries.

(2) Changes in the Supply-Demand Environment

An upsurge in crude oil prices went hand-in-hand with a rise in the prices of other primary products such as raw materials and foodstuffs; the prices of raw materials for construction of oil refining plants rose significantly. The refinery construction rush led to a worldwide manpower shortage (or a rise in personnel expenses), thus increasing the amount of investment in refining unit by a considerable degree. As a result, numerous projects were rescheduled, postponed, or even abandoned, with the result that a succession of projects to substantially expand capacity was no longer possible.

However, as shown in Figure 3-1, although some projects were delayed, there was an increase in the number of projects to meet growing world demand between 2005 and 2006. Viewed macroscopically, therefore, it can be concluded that progress is being made in the buildup of absolutely necessary refining capacity.

This view originates from the fact that the rate of growth in petroleum product demand dropped from an unusually high level of 3.3% in 2004 to 1.3% in 2005 and to 1.2% in 2006. As many experts point out, as an aftermath to a serious power shortage that occurred in China in 2003 (due to the shutdown of small-scale, coal-fired power plants), oil-fueled power plants (firing gas oil and fuel oil) were put into operation urgently, resulting in a sharp increase in oil demand (especially import), which was reflected in the high growth rate registered in 2004. As normal conditions were restored in 2005, China's oil demand returned to a normal level and, consequently, the rate of growth in world oil demand declined.

3.1.2 Points of Contention

Based on the above observations, the points of contention to consider for the supply-demand balance in 2010 and 2015 can be summarized as follows:

(1) Petroleum Product Demand

Petroleum product demand in the world is increasing steadily (at the 1% mark), mostly in the Asian region, including China and India.

Accordingly, a 1% increase in demand is projected to continue through 2010 and 2015. However, as is evidenced by the recent upsurge in crude oil prices, if the $100 per barrel level continues in the years ahead, to what extent will oil demand decline?

(2) Refining Capacity

A look at the status as of the beginning of 2008 leads us to conclude that refining capacity expansion projects will generally be carried out if they are to be completed by around 2010. As for the year 2015, a key factor will be the supply-demand environment, from at least 2008 to 2010. If a drop in demand becomes very likely, numerous capacity expansion projects will be postponed.

(3) Key Points for Each Region

(i) Will China's refining capacity projects be carried out almost as planned and will this nation be able to maintain its self-sufficiency system until 2010 and 2015?

(ii) Will India's export capacity exceed 1 million B/D by 2010? If so, will India be able to establish a system (including quality) to meet its domestic demand?

(iii) Will the expansion of the refining capacity in the Middle East be in balance with the rapid growth in the petroleum products demand? (Above all, will Saudi Arabia's oil refinery projects, which are now delayed, be pushed ahead?)

(iv) The United States' demand will continue increasing, resulting in a shortage of refining capacity. To what extent will the United States be dependent on imports (gasoline, etc.) from abroad?

(v) Amid a slight decrease in demand (a decrease in gasoline demand and a slight increase in gas oil demand) in Europe, how will Europe's gasoline exports and middle distillate imports change?

(vi) Demand from Japan, South Korea, and Taiwan is expected to remain unchanged or decrease slightly and their surplus capacity will increase. Their export markets include Europe, the United States, Asia and Oceania. If this is the case, what will happen to competition with India and the Middle East?

3.2 Preconditions in the LP Model

3.2.1 Main Preconditions

(1) Period to Consider

The oil supply-demand (products trade) balance in 2005 (actual), 2010(projection), and 2015(projection) is considered.

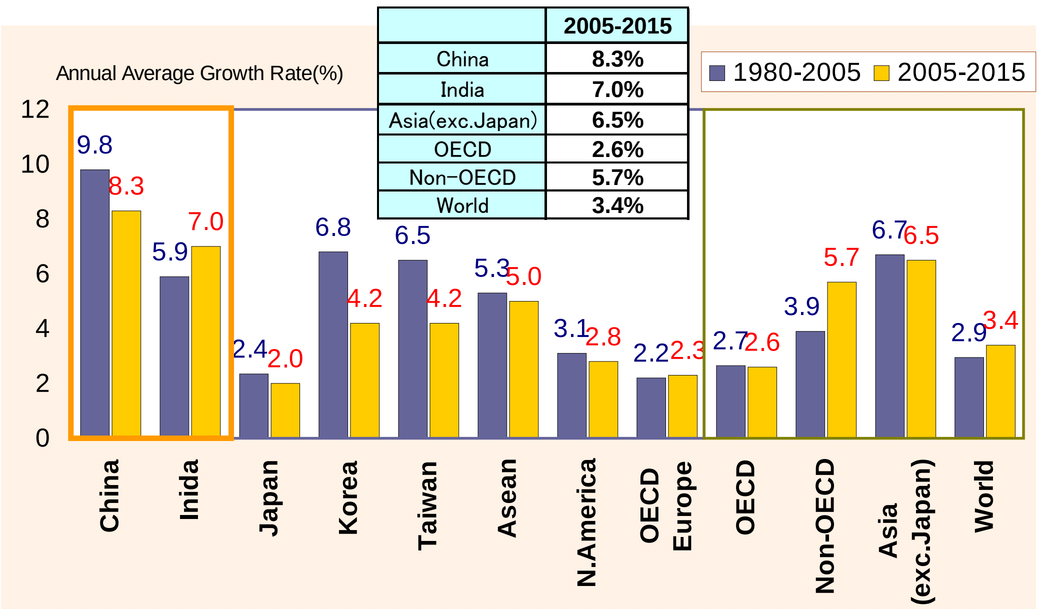
(2) Regions Covered

Fourteen regions are covered: the United States, Canada, Latin America, Europe, Russia/East Europe, etc., Africa, the Middle East, South Asia, China, Japan, South Korea, Taiwan, the ASEAN, and Oceania.

(3) The Economic Growth Outlook

The expected economic growth of each region is shown in Figure 3-2.

Figure 3-2. World GDP Growth Projection



Source: IEEJ "Asia/World Energy Outlook 2007"

(4) Crude Oil Price Estimates

The following two crude oil price scenarios are considered:

(i) Reference Case: Japan's import CIF price ($/bbl) is assumed to be 55.7 in 2005, 51.7 in 2010, and 52.1 in 2015.

(ii) High Price Case: Crude oil prices as of 2010 are assumed to rise to a level twice that of the 2005 price level and Japan's import CIF price ($/bbl) is assumed to be 55.7 in 2005, 101.4 in 2010, and 104.2 in 2015.

Table 3-1 shows differentials in benchmark crude oil prices (spot prices). The rate of increase in crude oil prices (price levels in 2010 and 2015 compared with the 2005 price level) is assumed to be the same for all types of oil. Accordingly, as price levels become higher, differentials in price between oil types (differential between light and heavy crude oil) will become wider and heavy crude oil will attain a favorable position.

Table 3-1 Benchmark Crude Oil Prices

(2005USD/bbl)

	2005	Reference		High Oil Pirce	
		2010	2015	2010	2015
WTI	56.5	51.4	52.9	102.9	105.7
Dubai	49.4	44.9	46.2	89.9	92.3
Brent	54.4	49.5	50.9	99.1	101.8
SLC	54.0	49.1	50.5	98.3	101.0

(5) Selection of Crude Oil Types

The selected crude oil includes a total of 30 different types, which are broken down into 24 of "Middle East " type (non-waxy) and 6 of "South-East Asia " type (waxy). Crude oil production in the region of interest was represented only by the production of the selected type of crude oil. For 2010 and 2015, the output of each type of crude oil was not limited as a general rule and instead, the world was divided into eight regions (North America, Latin America, Europe, Russia, Africa, the Middle East, China, and Southeast Asia) and limits were imposed on the output by each region. It may be interesting to note, in this connection, that in

2005 (actual), world crude oil output came to 71.61 million B/D and the total output of the selected 30 different types of crude oil amounted to 24.82 million B/D (with the average API of 31.4), or approximately 35% of the total.

Table 3-2. Quality and Output of Selected Crude Oils (Actual for 2005)

No.	Crude	Country	API Gravity	Sulfur %	Volume 1,000 b/d	Volume by region
1	WTI	United States	38.7	0.45	300	6,583
2	ANS	United States	30	0.93	975	
3	Cold Lake	Canada	21.2	3.69	230	
4	Syncrude Sweet	Canada	31.9	0.13	247	
5	Isthmus	Mexico	33.4	1.25	526	10,117
6	Maya	Mexico	21.8	3.33	2,350	
7	Tia Juana Light	Venezuela	31.9	1.18	240	
8	Marlim	Brazil	20	2	650	
9	Ural	Russia	32	1.35	2,500	11,083
10	Brent	United Kingdom	38.1	0.45	333	4,904
11	Ekofisk	Norway	37.8	0.21	349	
12	Iranian Light	Iran	33.1	1.5	700	22,735
13	Iranian Heavy	Iran	30.2	1.77	950	
14	Kuwait	Kuwait	32.4	2.55	2,100	
15	Oman	Oman	33.3	1.04	725	
16	Arab Light	Saudi Arabia	33	1.8	5,100	
17	Arab Heavy	Saudi Arabia	28.7	2.92	800	
18	Murban	UAE	39.6	0.73	1,050	
19	Dubai	UAE	30.4	2.13	160	
20	Suez Blend	Egipt	29.9	1.49	380	8,798
21	Es Sider	Libya	36.3	0.44	300	
22	Saharan Blend	Argeria	45.7	0.1	400	
23	Bonny Light	Nigeria	35.4	0.14	530	
24	Cabinda	Angola	32.8	0.13	325	
25	Sumatran Light	Indonesia	35	0.09	330	3,820
26	Duri	Indonesia	20.8	0.2	300	
27	Tapis	Malaysia	45.5	0.03	325	
28	Seria Light	Brunei	36.2	0.08	85	
29	Daqing	China	32.3	0.11	1,000	3,617
30	Shengli	China	24.2	0.84	560	

Sources: OPEC(2005), Crude Oil Handbook(2004)

(6) Quality Regulation Schedule by Region

The national quality standards are assumed to be as given in Tables 3-3 and 3-4 after consideration of the anticipated progress, in an effort to formulate regulations and balances for urban districts, local areas and regions as a whole.

Table 3-3. Quality Standards by Region (Gasoline)

	Gasoline								
	2005			2010			2015		
	RON	Sulfur (ppm)	Benzene (%)	RON	Sulfur (ppm)	Benzene (%)	RON	Sulfur (ppm)	Benzene (%)
North America	92	50	1.0	92	15	0.8	92	15	0.8
Latin America	90	200	2.0	90	50	1.5	90	50	1.5
Europe	94	50	1.0	94	15	0.8	94	15	0.8
Former USSR	90	200	2.0	90	50	1.5	90	50	1.5
Africa	90	200	2.0	90	50	1.5	90	50	1.5
Middle East	90	200	2.0	90	50	1.5	90	50	1.5
China	90	200	2.0	90	50	1.5	90	50	1.5
Japan,Korea,Taiwan	92	50	1.0	92	15	0.8	92	15	0.8
Asean	90	200	2.0	90	50	1.5	90	50	1.5
Other Asia	90	200	2.0	90	50	1.5	90	50	1.5
Oceania	92	50	1.5	92	15	1.0	92	15	1.0

Table 3-4. Quality Standards by Region (Gas Oil and Fuel Oil)

	Gas Oil						Fuel Oil		
	2005		2010		2015		2005	2010	2015
	Sulfur (ppm)	Cetane Number	Sulfur (ppm)	Cetane Number	Sulfur (ppm)	Cetane Number	Sulfur (%)	Sulfur (%)	Sulfur (%)
North America	50	45	10	45	10	45	3.5	3.5	3.5
Latin America	500	45	200	45	200	45	3.5	3.5	3.5
Europe	50	45	10	45	10	45	3.5	3.5	3.5
Former USSR	750	45	200	45	200	45	3.5	3.5	3.5
Africa	750	45	200	45	200	45	3.5	3.5	3.5
Middle East	750	45	200	45	200	45	3.5	3.5	3.5
China	750	45	200	45	200	45	3.5	3.5	3.5
Japan,Korea,Taiwan	50	45	10	45	10	45	3.5	3.5	3.5
Asean	500	45	200	45	200	45	3.5	3.5	3.5
Other Asia	750	45	200	45	200	45	3.5	3.5	3.5
Oceania	50	45	10	45	10	45	3.5	3.5	3.5

3.2.2. Petroleum Product Demand Scenarios

(1) Results of the Estimation with World Energy Demand Model

Based on the preconditions mentioned in Section 3.2.1, the demand for oil was estimated. Table 3-5 shows the results of the estimation of petroleum product demand in the world by oil type. For all petroleum products, “Reference case” projections dictate that demand will grow at an annualized average rate of 1.6% between 2005 and 2010 and 1.8% between 2010 and 2015. Growth in middle distillate demand is projected to exceed that of all petroleum products and the middle distillate’s share in the composition of products will increase from 37.0% in 2005 to 37.6% in 2010 and 38.3% in 2015, resulting in higher ratio of lighter components. In the high price case, meanwhile, middle distillate demand is projected to grow at a faster rate than that of all petroleum products (0.7% between 2005 and 2010 and 1.2% between 2010 and 2015), indicating that the widespread use of lighter components will accelerate.

Table 3-5. World Petroleum Product Demand

(million barrels per day)

	2005	Reference Case		High Oil Price Case		Annual Growth Rate（%）			
						Reference Case		High Oil Price Case	
		2010	2015	2010	2015	2005-10	2010-15	2005-10	2010-15
Gasoline	19.9	21.5	23.6	20.7	22.0	1.6	1.8	0.8	1.3
Middle Distillates	28.5	31.3	34.9	29.8	32.1	1.9	2.2	0.9	1.5
Fuel Oil	8.6	8.7	9.0	8.3	8.2	0.3	0.7	-0.7	-0.1
Other Products	20.1	21.8	23.7	21.0	22.3	1.7	1.6	0.9	1.2
Total	77.1	83.3	91.1	79.7	84.6	1.6	1.8	0.7	1.2

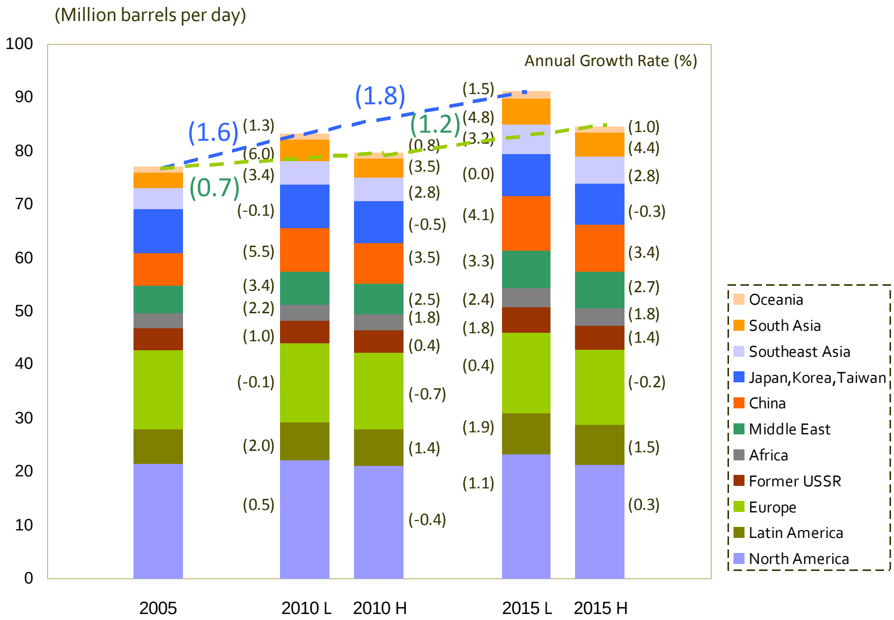
Figure 3-3 shows demand and the demand growth rate by region. Three of the high-ranking regions that show a high rate of demand growth in petroleum products (between 2005 and 2010, and between 2010 and 2015) are South Asia, including India, China and the Middle East.

South Asia, including India:
6.0% and 4.8% (Reference case), 3.5% and 4.4% (High price case)
China:
5.5% and 4.1% (Reference case), 3.5% and 3.4% (High price case)
The Middle East:
3.4% and 3.3% (Reference case), 2.5% and 2.7% (High price case)

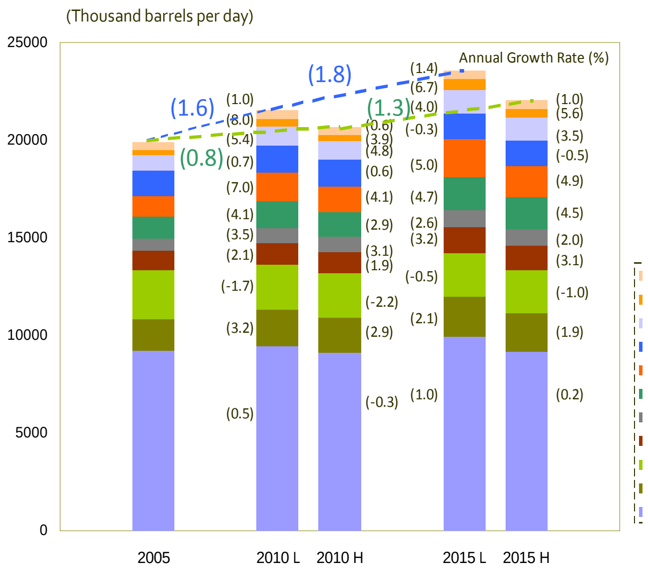
On the other hand, the regions where demand is projected to decline are Japan and the European region.

Figure 3-3. Petroleum Product Demand by Region

Total Products



Gasoline



Middle Distillate

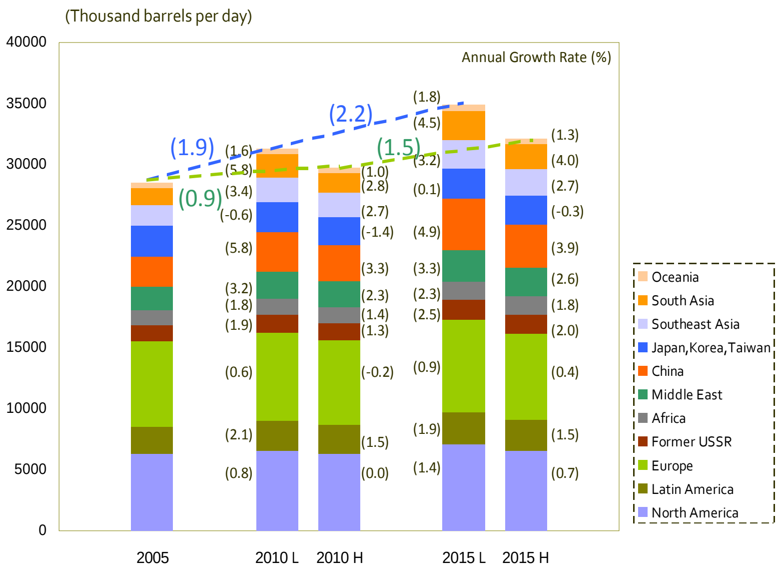


Table 3-6 shows the results of the estimation of demand by product category and by region in the reference case. (Refer to Annex 2 for the estimation results in High price case.)

Table 3-6-1. Product Demand Outlook by Region – 2005

1,000 b/d

		Gasoline	Naphtha	Kerosene	Diesel	Fuel Oil	LPG	Other Products	Total
1	United States	8,567	359	1,714	3,994	898	2,821	1,174	19,527
2	Canada	665	65	121	521	134	442	160	2,108
3	Latin America	1,569	277	271	1,912	867	1,174	318	6,388
4	Europe	2,537	1,080	1,201	5,805	1,625	1,692	835	14,775
5	Former USSR	990	35	280	1,062	604	764	387	4,121
6	Africa	644	21	261	958	397	370	99	2,750
7	Middle Ease	1,133	195	408	1,449	1,106	711	153	5,155
8	China	1,052	677	322	2,174	760	864	434	6,283
9	Japan	991	797	688	1,085	504	759	211	5,034
10	Taiwan	176	230	51	105	177	93	60	892
11	South Korea	156	735	194	397	359	294	49	2,182
12	Asean	764	218	433	1,274	744	371	54	3,858
13	Other Asia	268	283	336	1,081	348	430	227	2,973
14	Oceania	381	1	113	316	37	114	42	1,005
15	Total	19,893	4,972	6,394	22,133	8,561	10,899	4,202	77,054

Table 3-6-2. Product Demand Outlook by Region – 2010 Reference Case

1,000 b/d

		Gasoline	Naphtha	Kerosene	Diesel	Fuel Oil	LPG	Other Products	Total
1	United States	8,764	369	1,861	4,137	848	2,743	1,304	20,026
2	Canada	700	76	122	477	118	462	169	2,125
3	Latin America	1,840	306	290	2,135	869	1,269	360	7,070
4	Europe	2,333	1,105	1,310	5,894	1,572	1,673	849	14,736
5	Former USSR	1,100	34	345	1,127	538	773	422	4,339
6	Africa	765	22	252	1,080	400	432	110	3,060
7	Middle Ease	1,382	243	433	1,742	1,278	836	166	6,081
8	China	1,474	1,051	452	2,851	819	1,045	504	8,196
9	Japan	1,009	753	716	907	481	756	197	4,818
10	Taiwan	185	280	59	118	141	92	70	944
11	South Korea	172	760	204	437	357	323	53	2,307
12	Asean	995	265	507	1,511	808	399	73	4,558
13	Other Asia	393	448	464	1,413	416	537	315	3,987
14	Oceania	400	1	133	332	38	124	44	1,071
15	Total	21,513	5,713	7,148	24,162	8,681	11,465	4,635	83,317

Table 3-6-3. Product Demand Outlook by Region – 2015 Reference Case

1,000 b/d

		Gasoline	Naphtha	Kerosene	Diesel	Fuel Oil	LPG	Other Products	Total
1	United States	9,203	405	2,019	4,451	855	2,817	1,391	21,140
2	Canada	745	84	128	482	115	485	177	2,217
3	Latin America	2,038	349	314	2,354	944	1,374	399	7,772
4	Europe	2,271	1,125	1,427	6,115	1,528	1,670	862	14,998
5	Former USSR	1,286	36	443	1,220	518	773	475	4,752
6	Africa	871	22	257	1,238	418	503	127	3,437
7	Middle Ease	1,739	289	470	2,092	1,427	952	182	7,150
8	China	1,882	1,231	594	3,607	845	1,269	610	10,038
9	Japan	982	725	723	827	444	746	195	4,642
10	Taiwan	189	324	69	124	132	93	79	1,010
11	South Korea	177	782	219	497	353	337	56	2,420
12	Asean	1,211	311	609	1,756	892	452	109	5,341
13	Other Asia	543	625	580	1,764	482	642	406	5,041
14	Oceania	429	1	157	350	38	136	45	1,155
15	Total	23,567	6,310	8,008	26,877	8,991	12,248	5,112	91,113

3.2.3. Oil Refining Capacity Scenarios

(1) Main Units

The main refining units in the LP model include the following (capacity estimation was done for the underlined units):

(i) Distillation units:

Crude distillation unit (TP) and vacuum distillation unit (VC);

(ii) Desulfurization units (UF and HTR):

Naphtha, gasoline, kerosene, gas oil, vacuum gas oil (VGO), and residual oil (TR);

(iii) Reforming units:

Catalytic reforming unit (RF and CCR), Isomerization unit (IM), BTX and benzene unit, alkylation unit (ALK), and ETBE unit;

(iv) Cracking units:

Catalytic cracker unit (FCC and RFCC), delayed coking unit (TC), and Hydro-cracking unit (HC);

(v) Blenders and Utilities

(2) Installed Capacity in 2005

Table 3-7 shows the installed capacities by region and by unit as of the end of 2005.

Table 3-7. A List of Installed Capacity by Main Units and by Region (2005)

	Crude distillation	Vacuum distillation	FCC	Reformer	Coker	Hydro-cracker	Desulfurization				Alkylation	Isome-rization
							Naphtha	Middle distillates	Others	Total		
United States	17,202	7,814	5,823	3,636	2,339	1,396	4,148	4,503	3,175	11,826	1,172	650
Canada	1,946	654	476	368	111	180	453	455	164	1,072	80	77
Latin America	8,530	3,781	1,827	871	1,190	125	1,088	1,812	459	3,359	155	175
Europe	16,004	5,892	2,472	2,448	1,937	709	3,261	5,233	1,668	10,162	283	682
Former USSR	9,190	3,613	802	1,231	821	55	1,323	1,874	577	3,774	24	74
Africa	3,332	607	243	455	141	100	529	380	68	977	21	55
Middle East	7,156	2,004	294	780	521	491	1,064	1,040	406	2,510	29	58
China	6,861	3,964	1,878	598	760	294	614	1,149	359	2,122	39	5
Japan	4,764	1,734	983	777	119	105	996	3,053	795	4,844	95	23
Taiwan	1,300	207	246	200	51	0	203	276	372	851	28	31
S.Korea	2,836	338	190	275	19	109	302	754	288	1,344	8	0
Asean	4,375	1,047	336	630	410	294	842	921	248	2,011	10	62
Other Asia	3,016	1,281	393	225	339	165	227	538	186	951	0	4
Oceania	911	235	237	209	0	46	250	213	28	491	23	39
World	87,423	33,171	16,200	12,703	8,758	4,069	15,300	22,201	8,794	46,295	1,967	1,935

Indicators showing the secondary unit ratios include the cracking unit ratio, the reforming unit ratio, and the desulfurization unit ratio, which are defined as follows, and are shown by region in Figure 3-4:

(i) Cracking unit ratio (cracking unit capacity ÷ CDU capacity):
An indicator shows the fuel oil cracking rate and the rate of increase in the production of middle distillates. A cracking unit represents a total of FCC, delayed coking units and hydrocracking units.

(ii) Reforming unit ratio (reforming unit capacity ÷ CDU capacity):
An indicator shows an improvement in the octane number of blending materials for gasoline and represents a total of Reforming units, Alkylation units and Isomerization units.

(iii)Desulfurization unit ratio (desulfurization capacity ÷ CDU capacity):
An indicator shows a degree of desulfurization and represents a total of naphtha, gasoline, kerosene, gas oil and fuel oil desulfurization units.

CDU will come to approximately 87 million B/D for the world at large and for the secondary unit ratio, the cracking unit ratio will reach 33.4%, the reforming unit ratio 19.1%, and the desulfurization unit ratio 54%, respectively.

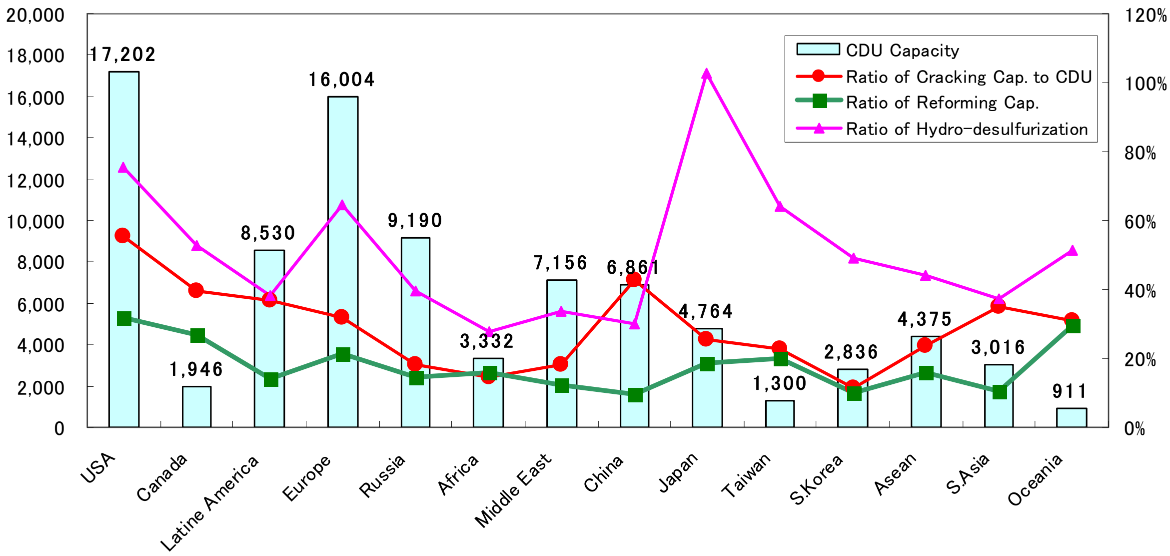
(a) The United States

The United States has the largest CDU capacity, being approximately 17 million B/D. It also has the highest secondary unit ratio, with a cracking unit ratio of 55.6% (first place), a reforming unit ratio of 31.7% (second place), and a desulfurization unit ratio of 75.2% (second place). While demand will continue to expand, new oil refinery projects will not be carried out, so a substantial increase in refining capacity is unlikely.

(b) China, South Asia (including India), and the Middle East

These three regions together will have combined CDU capacity of approximately 17 million B/D, representing much the same capacity as that of the United States. In comparison with other regions of the world, these three regions are expected to experience a high rate of growth in demand and will be able to expand installed capacity at a faster rate.

Figure 3-4. Comparison of the Secondary Unit Ratio by Region (2005)



(c) Europe, Japan, South Korea and Taiwan

Europe has CDU capacity of approximately 16 million B/D, while Japan, South Korea and Taiwan together have CDU capacity of about 8.9 million B/D. Environmental regulations will become stringent and the cracking and desulfurization unit ratios will be high. Demand will remain unchanged or increase slightly and there will be an insignificant increase in installed capacity in the years ahead. Japan has the highest desulfurization unit ratio, because the Japanese petroleum industry is required to treat high sulfur-content Middle East crude oil and comply with stringent environmental regulations. Sulfur-free product regulation, which was initially intended to become effective in 2008, was enforced in 2005 and sulfur-free products have been produced successfully.

(3) The Current Status of India's Refining Capacity and Prospects for Capacity Expansion

(a) According to a survey, as shown in Table 3-8, the national oil companies' refining capacity exceeded 2.3 million B/D at the end of fiscal 2007. Under the government's plan, the national oil companies will exclusively supply for the domestic demand after around 2008.

Table 3-8. Changes in the Buildup of Refining Capacity by Company in India

(1,000B/D)

			1999FY	2000FY	2001FY	2002FY	2003FY	2004FY	2005FY	2006FY	2007FY	2008FY
State Company	IOC	IOCL	509	715	747	747	747	747	928	947	1,007	1,007
		CPCL	140	140	140	140	140	208	210	210	210	230
		BPRL	47	47	47	47	47	47	47	47	47	47
	HPC	HPCL	198	260	260	260	260	260	260	260	325	325
	BPC	BPCL	120	120	120	120	120	120	240	390	390	390
		NRL		60	60	60	60	60	60	60	60	180
		KRL	150	150	150	150	150	150	150	150	150	150
	ONGC	ONGC				2	2	2	2	2	2	2
		MRPL	73	194	194	194	194	194	194	194	194	194
	S-TOTAL		1,237	1,686	1,718	1,720	1,720	1,788	2,091	2,260	2,384	2,524
Private Company	Riliance	RIL		536	536	536	536	660	660	660	660	1,240
	Essar	ESSAR							210	210	280	280
	S-TOTAL		0	536	536	536	536	660	870	870	940	1,520
TOTAL			1,237	2,222	2,254	2,256	2,256	2,448	2,961	3,130	3,324	4,044

Note: 2006(FY)::actual, 2007:estimation, 2008:projection

Sources:1999-2004:Petrofed,2005:FACTS,2006-2008:IOC,Mministry of Petroleum and Minerals

(b) By fiscal 2010, national oil companies' refining capacity is planned to be increased by approximately 700,000 B/D and reach 3 million B/D in parallel with the growth in the domestic demand. However, the present LP model assumes that this capacity will reach approximately 2.5 million B/D by 2010, given a delay in the plan.

(c) When the capacity of Reliance's second oil refinery (capable of exporting sulfur-free gasoline and gas oil), which will be completed at the end of fiscal 2008, is added, the refining capacity of private oil companies will reach approximately 1.5 million B/D by fiscal 2010. National and private oil companies together will have a capacity of more than 4 million B/D by 2010.

(d) Private oil refiners are export-oriented refiners designed to produce products, except for some supplies like LPG, for export to overseas markets and there is almost no exchange of products between national and private oil companies. Accordingly, private oil companies' refining capacity of 1.5 million B/D (around 1 million B/D in terms of gasoline and middle distillates) will be appropriated for exports.

(e) On the other hand, while there is a gap between domestic supply and demand, national oil companies will import products so that viewed on the whole, exports and imports will occur in parallel.

(4) China's Refining Capacity Expansion Plans and Prospects for 2010 and 2015
Table 3-9 shows refining capacity estimates during the period of the 11^{th} five-year program (2005 – 2010). The China Petroleum & Chemical Corporation (SINOPEC) and the China National Petroleum Corporation (CNPC) closed small oil refineries under their control and are working to expand their refining capacity mainly through the construction of new large oil refineries. SINOPEC- and CNPC-affiliated oil refineries together amounted to approximately 6.2 million B/D in 2005 and will be expanded to approximately 7.6 million B/D by 2010. Simple oil refineries, mostly located in Tsingtao, inporting fuel oil and producing middle distillates with simple toppers, are estimated to have had a capacity of approximately 600,000 – 800,000 B/D (in 2005) and this capacity will remain at the same level in 2010.

CNPC's Petroleum Economics & Technology Research Center's estimates of refining capacity are given in Table 3-10. These estimates are almost consistent with the IEEJ's projections; refining capacity is projected to reach approximately 8.9 million B/D by 2010 and approximately 10.9 million B/D by 2015.

Table 3-9. Changes in Refining Capacity by Refinery in China

(thousand barrels per day)

(Sinopec)	2005	2010	(CNPC)	2005	2010
Yanshan Petrochemical	190	200	Daqing Petrochemical	120	120
Tianjin Petrochemical	100	250	Daqing Refine & Chemical	110	110
Qilu Petrochemical	320	320	Jilin Petrochemical	130	240
Qingdao Petrochemical	60	260	Liaoyang Petrochemical	110	200
Yangzi Petrochemical	320	320	Dailian West Pacific Petrochemica	200	240
Jinling Petrochemical	260	260	Dailian Petrochemical	210	410
Shanghai Gaoqiao Petrochemical	226	226	Jinzhou Petrochemical	120	120
Shanghai Petrochemical	280	280	Jinxi Petrochemical	120	200
Zhenhai Refine & Chemical	400	400	Dushanzi Petrochemical	120	200
Fujian Refine & Chemical	80	240	Lanzhou Petrochemical	210	290
Wuhan Petrochemical	100	160	Guangxi Petrochemical		
Guangzhou Petrochemical	160	320	Sichuan Petrochemical		
Maoming Petrochemical	280	400	Others	1,101	854
KPC JV	0	300			
Others	854	664			
Sinopec Total	3,630	4,600	CNPC Total	2,551	2,984
			Others	670	1,372
			Total	6,851	8,956

Sources : 11th 5-year program , "Others" are estimated by IEEJ.
Note : "Others" include simple refineries.

Table 3-10. Refining Capacity Outlook for 2010 and 2015 in China

(1,000B/D)

	2005	2006	2010	2015
CNPC Estimation*	–	6,903	8,926	10,910
IEEJ Projection				
Base Case	6,861	–	8,956	11,060
High Price Case	6,861	–	8,956	10,706

Note: Most Likely Case

Sources:

①WorkShop by IEEJ and CNPC (in Beijin on Dec.4 – 5 of 2007)

②WorkShop by IEEJ and CNPC (in Tokyo on Feb.28 of 2008)

(5) The Middle East Region's Refining Capacity and Export Capacity

Table 3-11 shows projections for the Middle East region's refining capacity expansion. As of 2005, Saudi Arabia held first place at about 2.1 million B/D, followed by Iran at about 1.6 million B/D. The major five Middle East countries together hold refining capacity of 5.9 million B/D, representing about 82% of the region's total refining capacity. Towards the year 2010, focus will be placed on the expansion of small capacities as represented by Iran's plan to expand the capacity of existing oil refineries. Large oil refinery projects are in most cases deferred to 2010 onward.

Three of the projects hold the key to success in expanding refining capacity from 2010 onward; these are the Al Zoor oil refinery with refining capacity of 600,000 B/D, to be constructed in 2011 (including the closure of superannuated Shuaiba oil refinery with capacity of approximately 190,000 B/D) in Kuwait, and two export-oriented oil refineries to be completed between 2011 and 2012 in Saudi Arabia, which are the Yanbu oil refinery with capacity of 400,000 B/D (by Conoco-Phillips), and the Jubail oil refinery with capacity of 400,000 B/D (by Total).

Table 3-11. Refining Capacity Buildup Outlook in the Middle East

(1,000B/D)

<table>
<tr><th rowspan="2"></th><th rowspan="2">2005</th><th rowspan="2">2010</th><th rowspan="2">Diffrences</th><th>2015</th><th rowspan="2">Diffrences</th><th>2015</th><th rowspan="2">Diffrences</th></tr>
<tr><th>Bsae Case</th><th>High Price Case</th></tr>
<tr><td>UAE</td><td>620</td><td>760</td><td>140</td><td rowspan="6">8,436</td><td rowspan="6">1,795</td><td rowspan="6">8,282</td><td rowspan="6">1,641</td></tr>
<tr><td>IRAN</td><td>1,619</td><td>2,072</td><td>453</td></tr>
<tr><td>IRAQ</td><td>644</td><td>714</td><td>70</td></tr>
<tr><td>KUWAIT</td><td>915</td><td>915</td><td>0</td></tr>
<tr><td>SAUJI ARABIA</td><td>2,100</td><td>2,180</td><td>80</td></tr>
<tr><td>S-TOTAL</td><td>5,898</td><td>6,641</td><td>743</td></tr>
<tr><td>OTHERS</td><td>1,258</td><td>1,691</td><td>433</td><td>2,000</td><td>309</td><td>1,800</td><td>109</td></tr>
<tr><td>TOTAL</td><td>7,156</td><td>8,332</td><td>1,176</td><td>10,436</td><td>2,104</td><td>10,082</td><td>1,750</td></tr>
</table>

(6) Refining Capacity Projections for 2010

Estimates of main unit capacity expansion between 2005 and 2010 are shown in Table 3-12. Figure 3-5 compares the rates of growth in the capacity of crude distillation, cracking, reforming unit and desulfurization unit capacities and growth in petroleum product demand by region.

(a) Crude Distillation Units:

For the world total, CDU capacity expansion is projected to come to approximately 6 million B/D and grow at the annualized average rate of 1.4%. China will be able to achieve capacity expansion of about 2 million B/D, India (South Asia) approximately 1.2 million B/D, and the Middle East approximately

1.2 million B/D, respectively; the three regions together will achieve a combined capacity expansion of 4.4 million B/D, accounting for 73% of the world's total. In the reference case, oil demand is expected to grow at a rate of 1.6%, thus a little lower than the growth rate of capacity expansion (high price case projections expect oil demand to grow at a rate of 0.7%).

(b) Cracking Units:

For the world total, cracking capacity expansion is projected to come to approximately 3.9 million B/D and grow at the annualized average rate of 2.5%. China will be able to achieve capacity expansion of about 700,000 B/D (at a growth rate of 4.4%), India (South Asia) approximately 850,000 B/D (at a growth rate of 12.5%), and the Middle East approximately 300,000 B/D (at a growth rate of 4.1%), respectively; the three regions together will account for nearly 47% of the world total. In addition, the European region is projected to attain capacity expansion of approximately 730,000 B/D (at a growth rate of 2.7%) and an increase in the production of middle distillates like gas oil is expected to progress.

(c) Reforming Units:

For the world total, reforming capacity expansion is expected to reach approximately 1.5 million B/D (to grow at an annualized rate of 1.7%). The three regions of China, India (South Asia) and the Middle East together will be able to expand their reforming capacity by approximately 900,000 B/D, thus accounting for 60% of the total.

(d) Desulfurization Units:

For the world total, desulfurization capacity will be expanded by approximately 11.8 million B/D (3.2%), reaching a level about twice as high as that of crude oil processing capacity expansion. The three regions of China, India (South Asia), and the Middle East together will be able to achieve desulfurization capacity expansion of about 6.3 million B/D, accounting for 54% of the total. By region, desulfurization capacity expansion will be achieved as follows. In the regions where demand grows at a slower rate (there will be no new oil refinery projects), capacity expansion will progress and the production of low-sulfur petroleum products will be accelerated to meet environmental regulations that become more stringent worldwide.

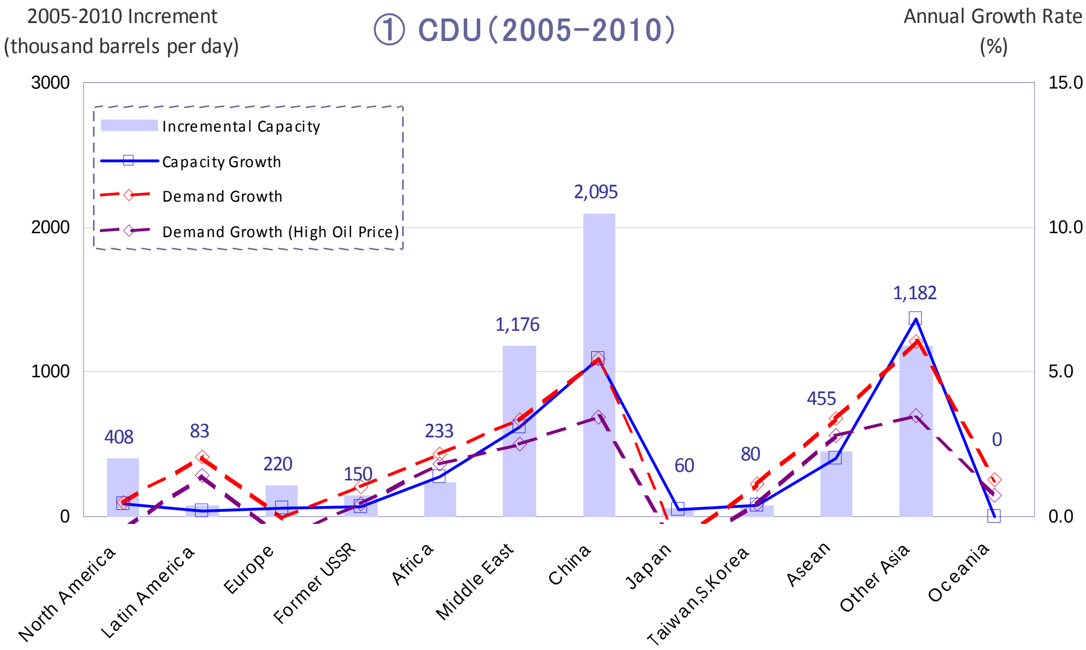
- China, India (South Asia), and the Middle East:
  Approximately 4.4 million B/D in CDU capacity, and about 6.3 million B/D in desulfurization capacity.
- Other regions:
  About 1.6 million B/D in CDU capacity, and about 5.47 million B/D in desulfurization capacity.

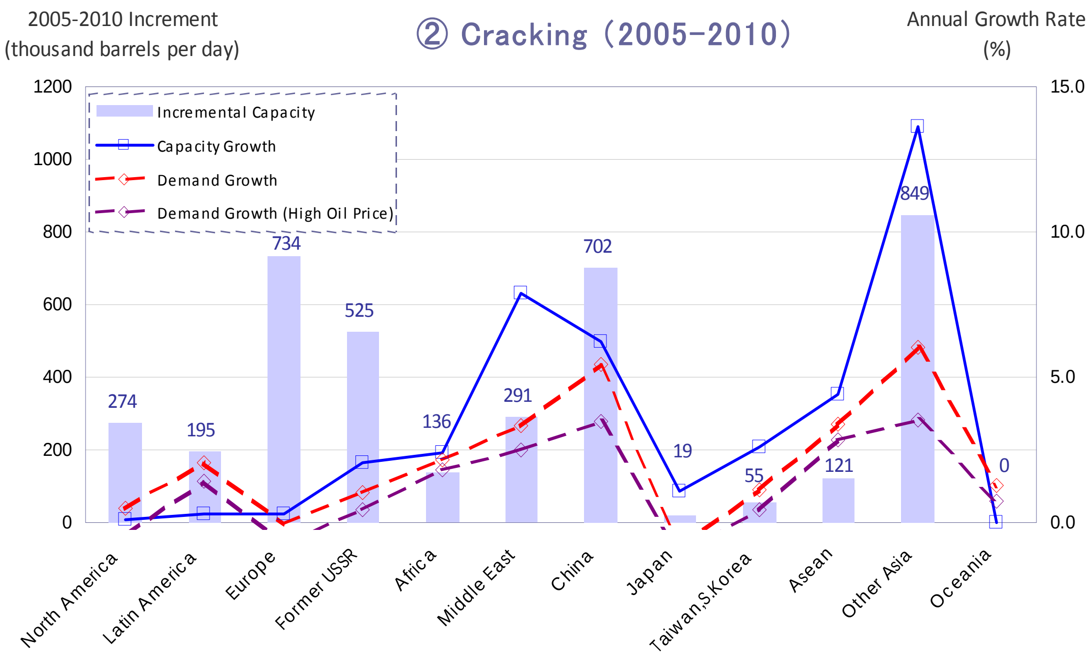
Table 3-12. Buildup of Installed Capacity by Main Units and by Region (2005-2010)

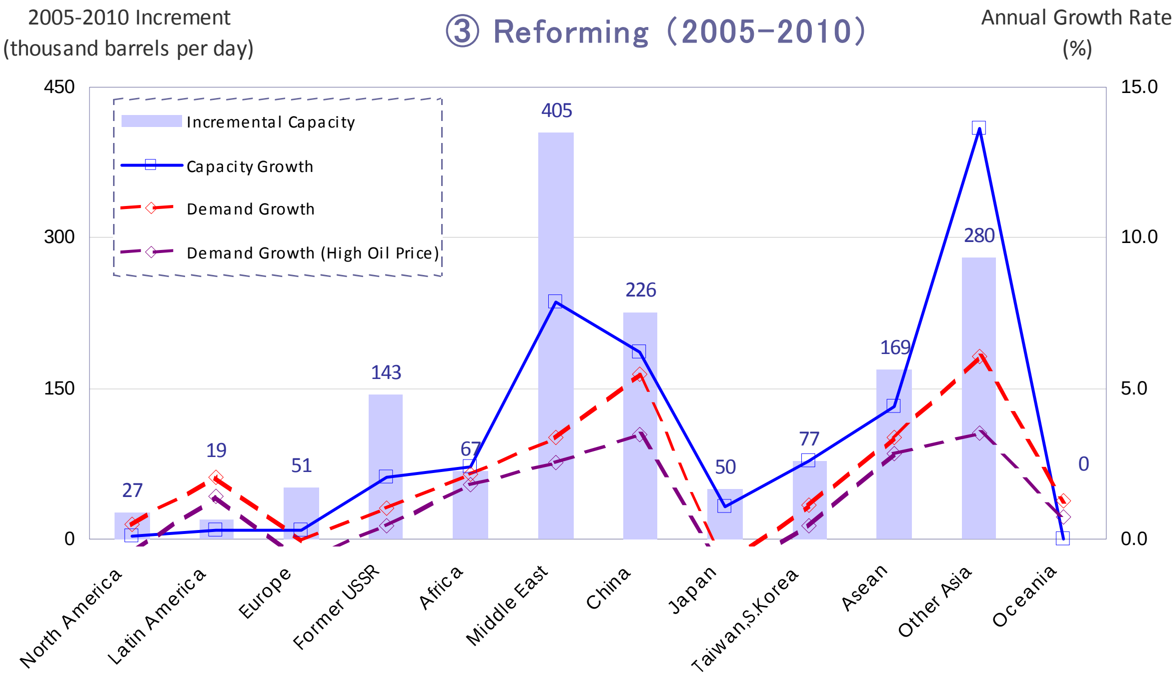
(thousand barrels per day)

	Incremental Capacity (2005-2010)				Annual Growth Rate (%)			
	CDU	Cracking	Reforming	Desulfurization	CDU	Cracking	Reforming	Desulfurization
United States	408	231	27	1,410	0.5	0.5	0.1	1.6
Canada	0	43	0	389	0.0	1.1	0.0	4.8
Latin America	83	195	19	800	0.2	1.2	0.3	3.0
Europe	220	734	51	825	0.3	2.7	0.3	1.0
Former USSR	150	525	143	784	0.3	5.6	2.0	2.7
Africa	233	136	67	367	1.4	5.1	2.4	5.1
Middle East	1,176	291	405	2,022	3.1	4.1	7.9	9.7
China	2,095	702	226	2,077	5.5	4.4	6.2	10.5
Japan	60	19	50	181	0.3	0.3	1.1	0.5
Taiwan	80	0	40	174	1.2	0.0	2.8	3.0
South Korea	0	55	37	14	0.0	3.2	2.4	0.1
Asean	455	121	169	331	2.0	2.2	4.4	2.2
Other Asia	1,182	849	280	2,181	6.8	12.5	13.6	16.9
Oceania	0	0	0	217	0.0	0.0	0.0	5.7
World	6,142	3,901	1,514	11,773	1.4	2.5	1.7	3.2

Figure 3-5. Buildup of Installed Capacity by Region






2005-2010 Increment
(thousand barrels per day)
③ Reforming（2005-2010）
Annual Growth Rate
(%)
Incremental Capacity
Capacity Growth
Demand Growth
Demand Growth (High Oil Price)
450
300
150
0
15.0
10.0
5.0
0.0
27
19
51
143
67
405
226
50
77
169
280
0
North America
Latin America
Europe
Former USSR
Africa
Middle East
China
Japan
Taiwan,S.Korea
Asean
Other Asia
Oceania

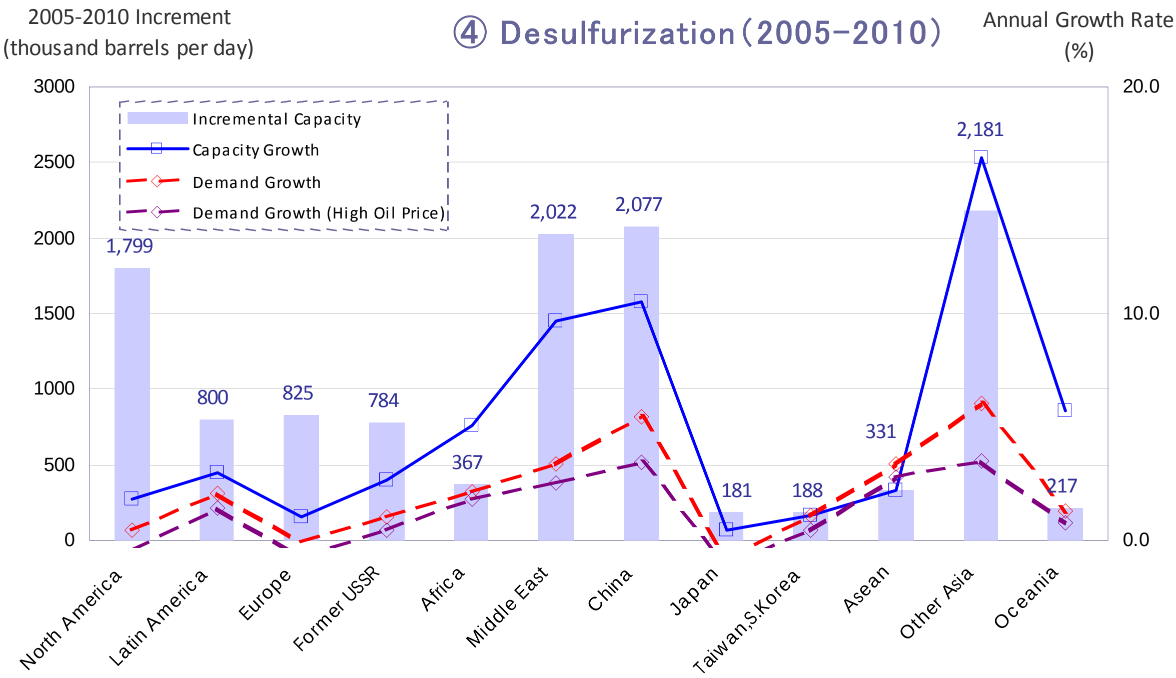
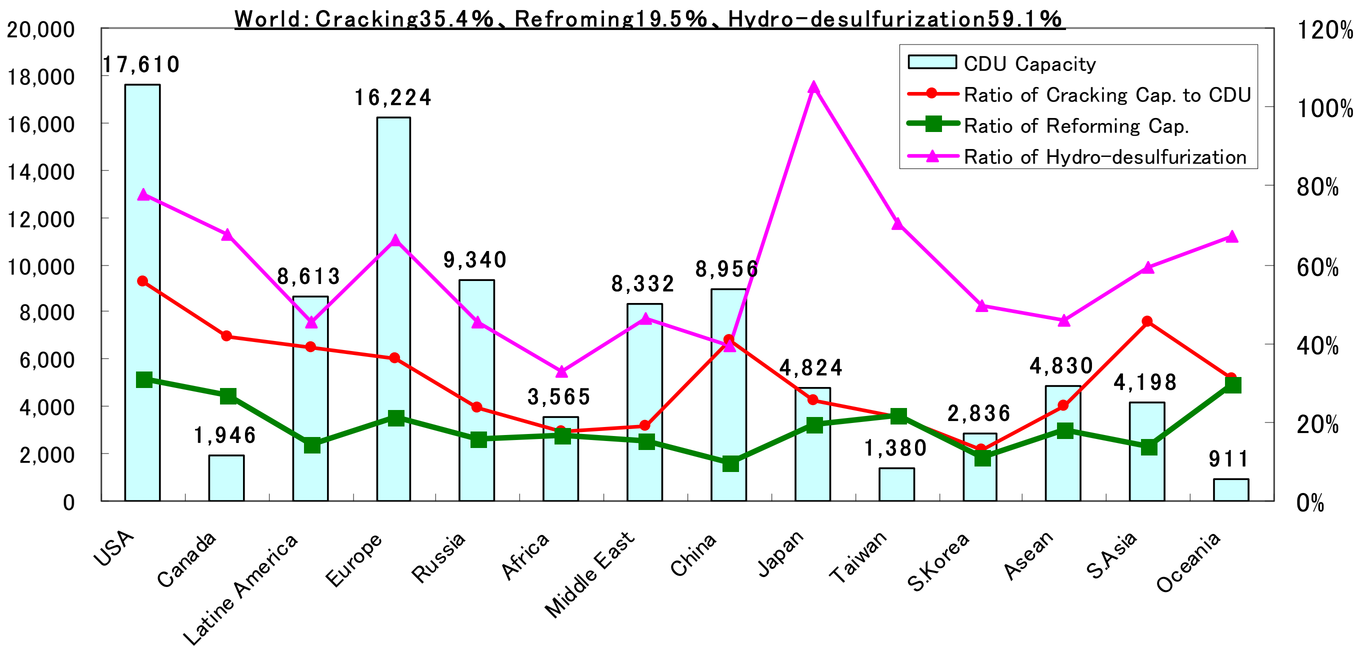

2005-2010 Increment
(thousand barrels per day)
④ Desulfurization（2005-2010）
Annual Growth Rate
(%)
Incremental Capacity
Capacity Growth
Demand Growth
Demand Growth (High Oil Price)
3000
2500
2000
1500
1000
500
0
20.0
10.0
0.0
1,799
800
825
784
367
2,022
2,077
181
188
331
2,181
217
North America
Latin America
Europe
Former USSR
Africa
Middle East
China
Japan
Taiwan,S.Korea
Asean
Other Asia
Oceania

Figure 3-6 shows the expected secondary unit ratios in 2010 by region. Compared with 2005, the world cracking unit ratio will rise by 2% to 35.4%, the reforming unit ratio will rise by 0.4% to 19.5% and the desulfurization unit ratio will increase by 5% to 59.1%. A marked increase in the secondary unit ratio will be observed in India (South Asia).

Figure 3-6. Comparison of the Secondary Unit Ratio by Region (2010)



(7) Refining Capacity Projections for 2015

Refining capacity in 2015 will vary greatly depending on whether projects, which are to be completed by around 2012 to 2015, are carried out as they are, postponed or abandoned and more importantly, depend heavily on the supply-demand environment that will arise from around 2010 onwards. In the reference case that assumes a steady growth in demand, therefore, capacity expansion through the completion of large projects will progress (Table 3-13). Conversely, in the high price case that assumes a slow growth in demand, capacity addition through large projects will be delayed (Table 3-14) and installed capacity expansion will be pushed ahead, depending on the rate of growth in demand between 2010 and 2015.

Table 3-13. Buildup of Installed Capacity by Main Unit and by Region
Reference Case (2010-2015)

(thousand barrels per day)

	Incremental Capacity (2005-2010)				Annual Growth Rate (%)			
	CDU	Cracking	Reforming	Desulfurization	CDU	Cracking	Reforming	Desulfurization
United States	1,075	597	340	1,151	1.2	1.2	1.2	1.2
Canada	84	35	23	81	0.8	0.8	0.8	0.8
Latin America	908	352	133	618	2.0	2.0	2.0	2.0
Europe	319	115	69	322	0.4	0.4	0.4	0.4
Former USSR	1,024	241	163	691	2.1	2.1	2.1	2.1
Africa	407	71	68	191	2.2	2.2	2.2	2.2
Middle East	1,549	297	238	1,016	3.5	3.5	3.5	3.5
China	2,104	854	204	1,242	4.3	4.3	4.3	4.3
Japan	0	0	0	0	0.0	0.0	0.0	0.0
Taiwan	0	0	0	0	0.0	0.0	0.0	0.0
South Korea	0	0	0	0	0.0	0.0	0.0	0.0
Asean	867	208	157	571	3.4	3.4	3.4	3.4
Other Asia	1,182	537	120	1,134	5.1	5.1	3.8	5.1
Oceania	71	22	21	70	1.5	1.5	1.5	1.5
World	9,590	3,330	1,536	7,086	2.0	1.9	1.6	1.7

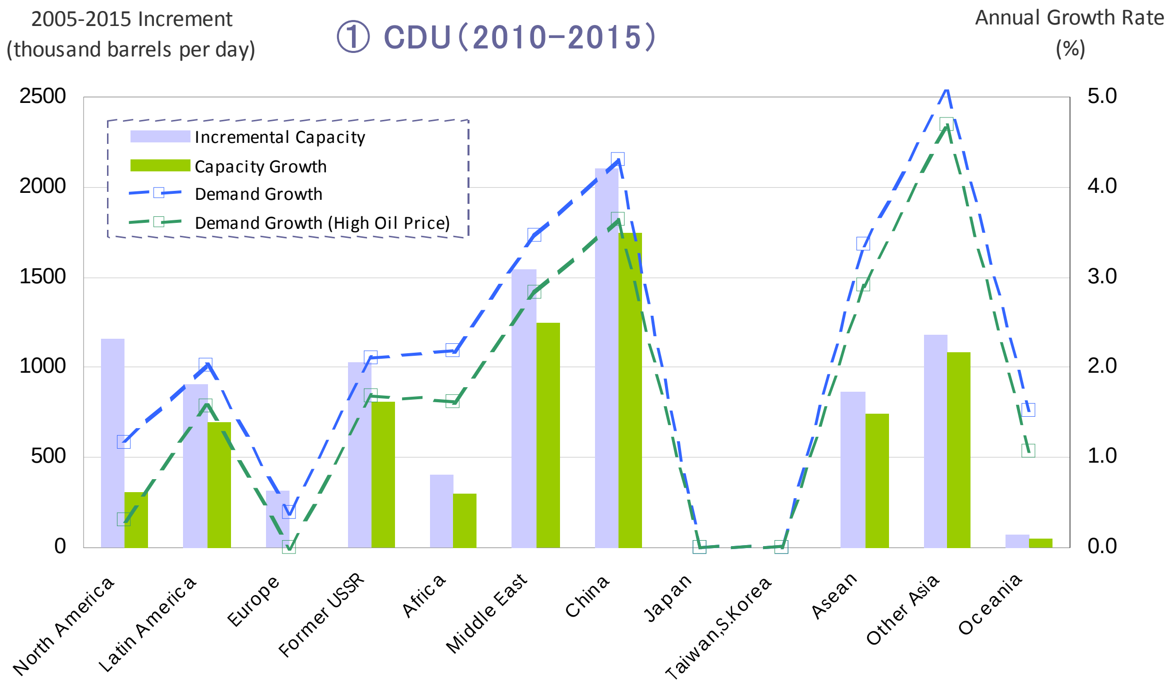
Table 3-14. Buildup of Installed Capacity by Main Unit and by Region
High Price Case (2010-2015)

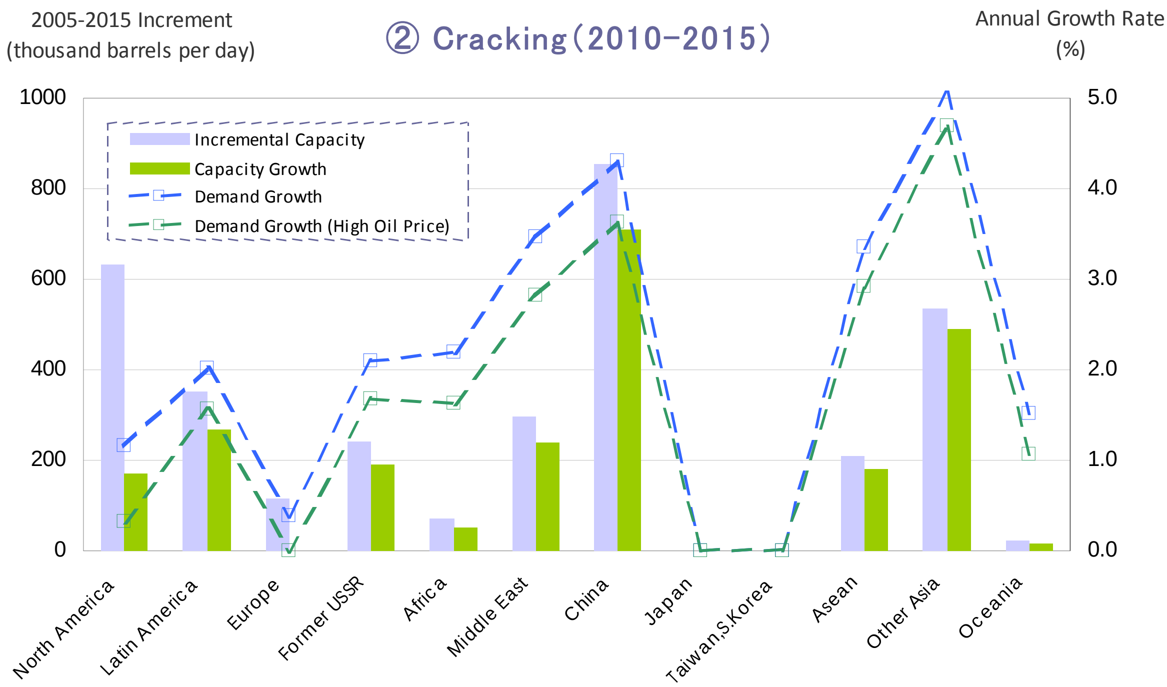
(thousand barrels per day)

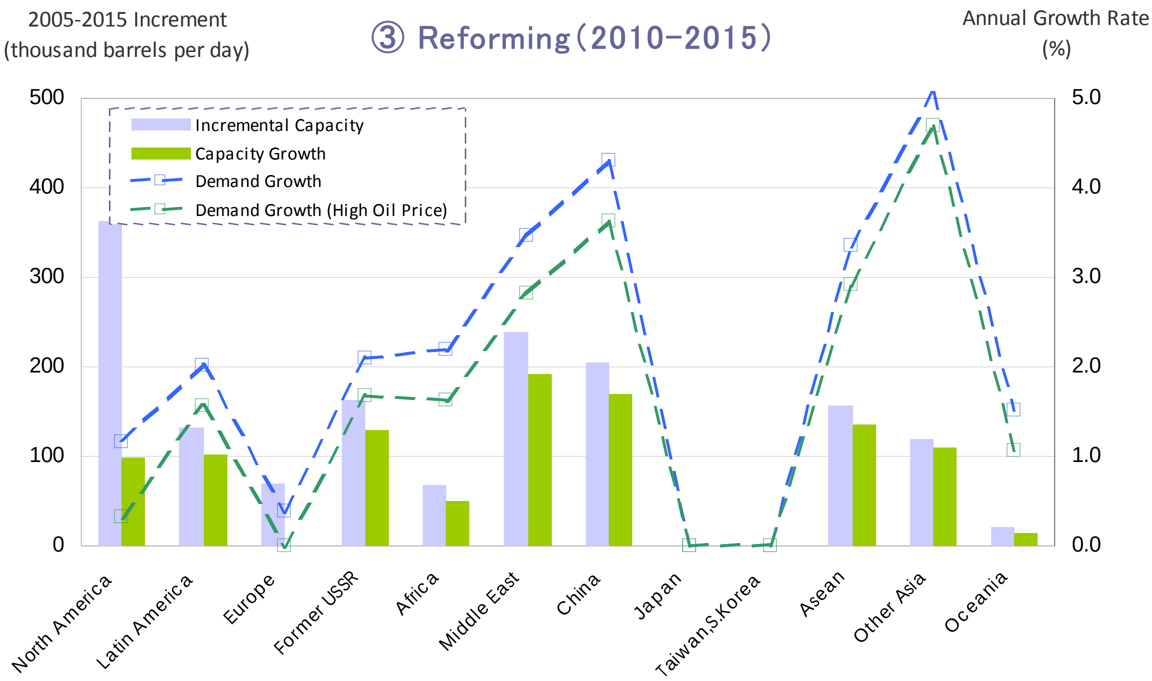
	Incremental Capacity (2005-2010)				Annual Growth Rate (%)			
	CDU	Cracking	Reforming	Desulfurization	CDU	Cracking	Reforming	Desulfurization
United States	310	173	98	332	0.4	0.4	0.4	0.4
Canada	0	0	0	0	0.0	0.0	0.0	0.0
Latin America	695	269	102	473	1.6	1.6	1.6	1.6
Europe	0	0	0	0	0.0	0.0	0.0	0.0
Former USSR	810	191	129	547	1.7	1.7	1.7	1.7
Africa	299	52	50	140	1.6	1.6	1.6	1.6
Middle East	1,246	239	192	817	2.8	2.8	2.8	2.8
China	1,750	710	170	1,033	3.6	3.6	3.6	3.6
Japan	0	0	0	0	0.0	0.0	0.0	0.0
Taiwan	0	0	0	0	0.0	0.0	0.0	0.0
South Korea	0	0	0	0	0.0	0.0	0.0	0.0
Asean	747	180	135	492	2.9	2.9	2.9	2.9
Other Asia	1,083	492	110	1,039	4.7	4.7	3.5	4.7
Oceania	49	15	15	49	1.1	1.1	1.1	1.1
World	6,990	2,321	1,000	4,922	1.5	1.4	1.1	1.2

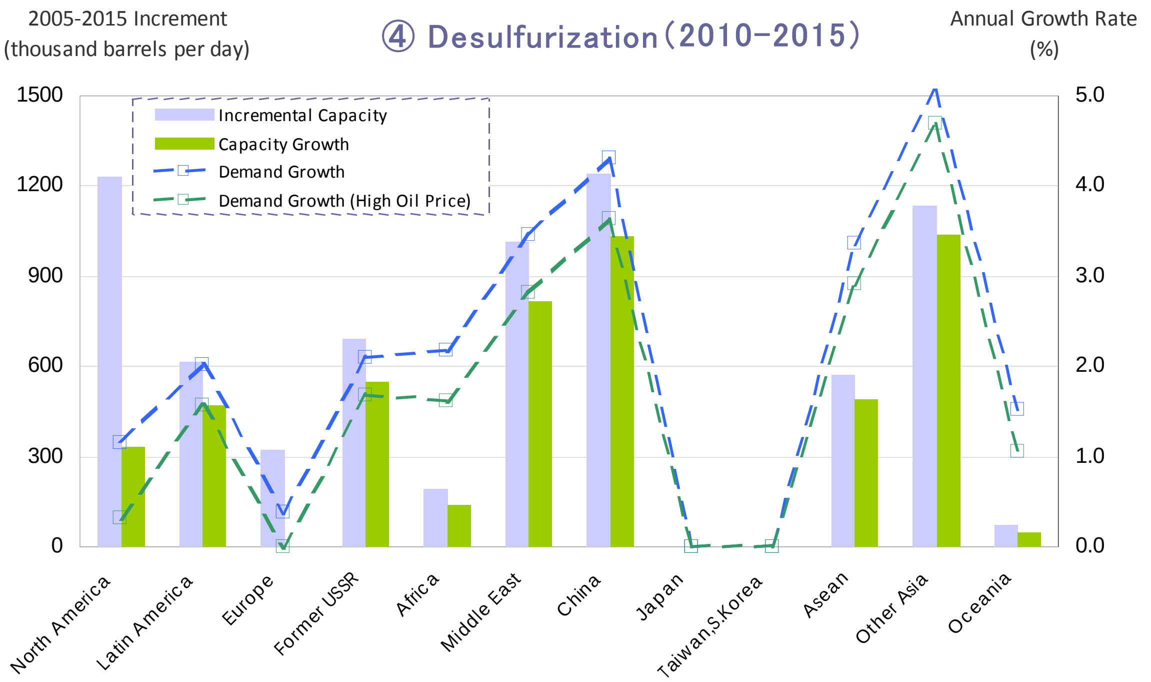
Figure 3-7 shows the unit capacity expansion and the rate of growth in product demand by region.

Figure 3-7. Changes in the Buildup of Installed Capacity by Region (2010-2015)






2005-2015 Increment
(thousand barrels per day)
③ Reforming(2010-2015)
Annual Growth Rate
(%)
Incremental Capacity
Capacity Growth
Demand Growth
Demand Growth (High Oil Price)
500
400
300
200
100
0
5.0
4.0
3.0
2.0
1.0
0.0
North America
Latin America
Europe
Former USSR
Africa
Middle East
China
Japan
Taiwan,S.Korea
Asean
Other Asia
Oceania


2005-2015 Increment
(thousand barrels per day)
④ Desulfurization(2010-2015)
Annual Growth Rate
(%)
Incremental Capacity
Capacity Growth
Demand Growth
Demand Growth (High Oil Price)
1500
1200
900
600
300
0
5.0
4.0
3.0
2.0
1.0
0.0
North America
Latin America
Europe
Former USSR
Africa
Middle East
China
Japan
Taiwan,S.Korea
Asean
Other Asia
Oceania

Chapter 4: Estimates by the LP Model

4.1 Reference Case and High Price Case

4.1.1 The Utilization Rate of CDU

(1) The Utilization Rate of CDU (Figures 4-1 and 4-2)

(a) Reference Case:

Demand is expected to grow steadily at the rates of 1.6% (for the period from 2005 to 2010) and 1.8% (for the period from 2010 to 2015). As a result, the capacity utilization rate of crude distillation units is projected to increase by 1.2% from 90.3% in 2005 to 91.6% in 2010 and further to 91.5% in 2015, thereby tightening supply and demand worldwide.

(b) High Price Case:

Demand is expected to grow at a lower rate of 0.7% (for the period from 2005 to 2010) and 1.2% (for the period from 2010 to 2015), so the capacity utilization rate is likely to drop by 3.4% from 90.3% in 2005 to 87.5% in 2010 (down 2.8% compared with the 2005 level) and further to 86.9% in 2015. In some regions, the capacity utilization rate will decline to generate a surplus capacity.

Figure 4-1. Changes in the Amount of Crude Oil Processed and the Utilization Rate of the CDU

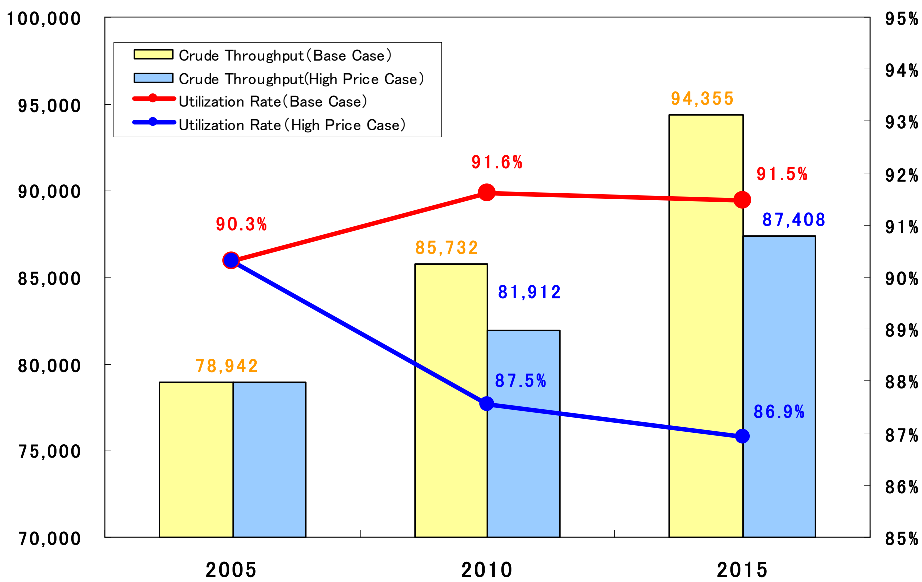
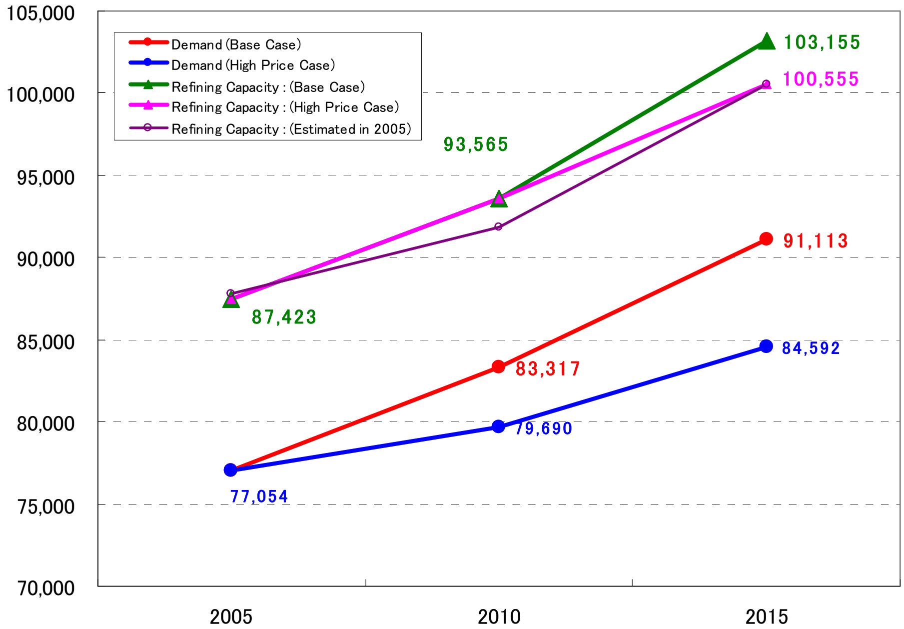


Figure 4-2. Estimates of CDU Capacity and Petroleum Product Demand



(2) The API Gravity of Processed Crude Oil and the Utilization Rate of Cracking Units

(a) API Gravity:

The API gravity of processed crude oil, as shown in Figure 4-3, is projected to rise from 33.6 in 2005 to 33.8 in 2010 and to 33.9 in 2015 in "Reference case", with oil becoming a little lighter. In "High price case", on the other hand, the API gravity is projected to reach 33.5 in 2010 and 2015, with oil becoming heavier, if only a little.

(b) The Capacity Utilization Rate of Cracking Units:

In "Reference case", the capacity utilization rate is projected to rise by 2.1% from 87.9% in 2005 to 89.2% in 2010 and to 90.0% in 2015. In "High price case", on the other hand, it is projected to rise by 0.5% to 90.1% in 2010 and to 90.4% in 2015.

Figure 4-3. Changes in the Utilization Rate of CDU and the API Gravity of Processed Crude Oil

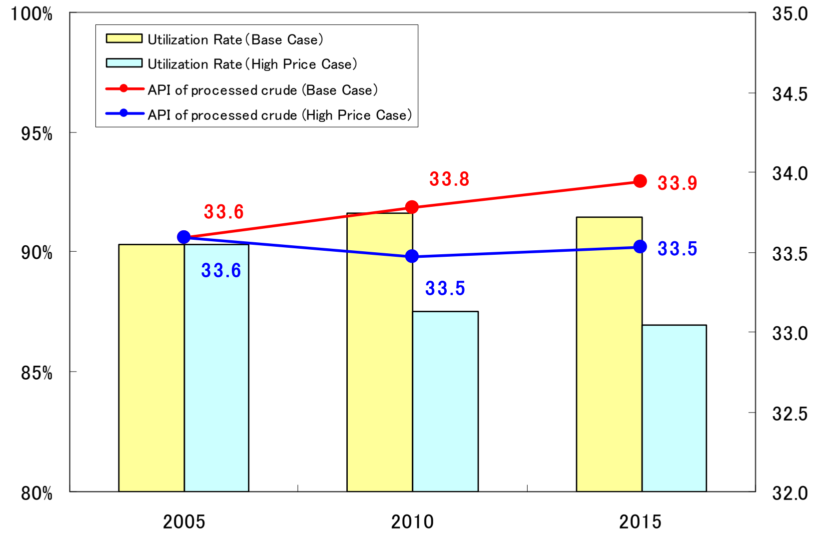
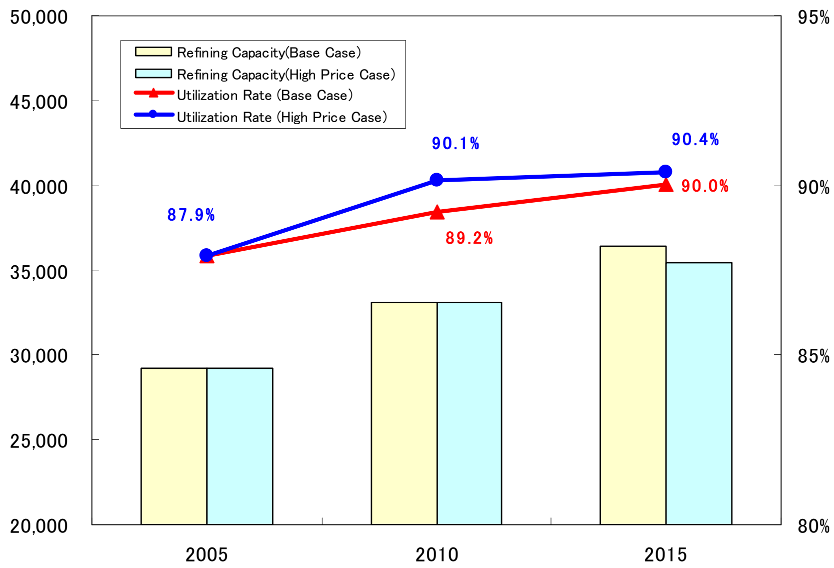


Figure 4-4. Changes in Cracking Capacity and the Utilization Rate



(3) Summary

(a) Reference Case:

The capacity utilization rate of crude distillation units stands at a very high level of 91% and that of cracking units is also projected to stay at a level as high as 90.0%, with the API gravity of processed crude oil becoming higher.

(b) High Price Case:

The capacity utilization rate of crude distillation units is projected to decline to 86%. On the other hand, the capacity utilization rate of cracking units is projected to rise to 90.4%, a level higher than in the reference case and the API gravity of processed crude oil is projected to become a little lower.

4.1.2 The Utilization Rate of CDU by Region (Figures 4-5 and 4-6)

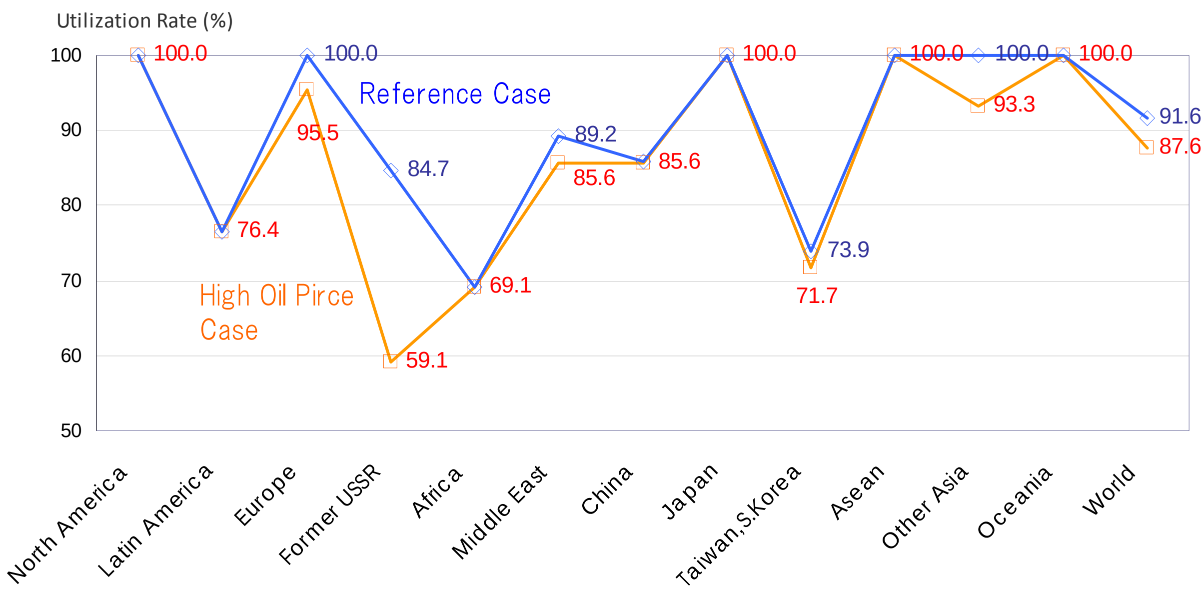
(a) Reference Case:

Units are projected to operate at nearly full capacity in North America (the United States and Canada), Europe, Japan, the ASEAN, South Asia, and Oceania.

(b) High Price Case:

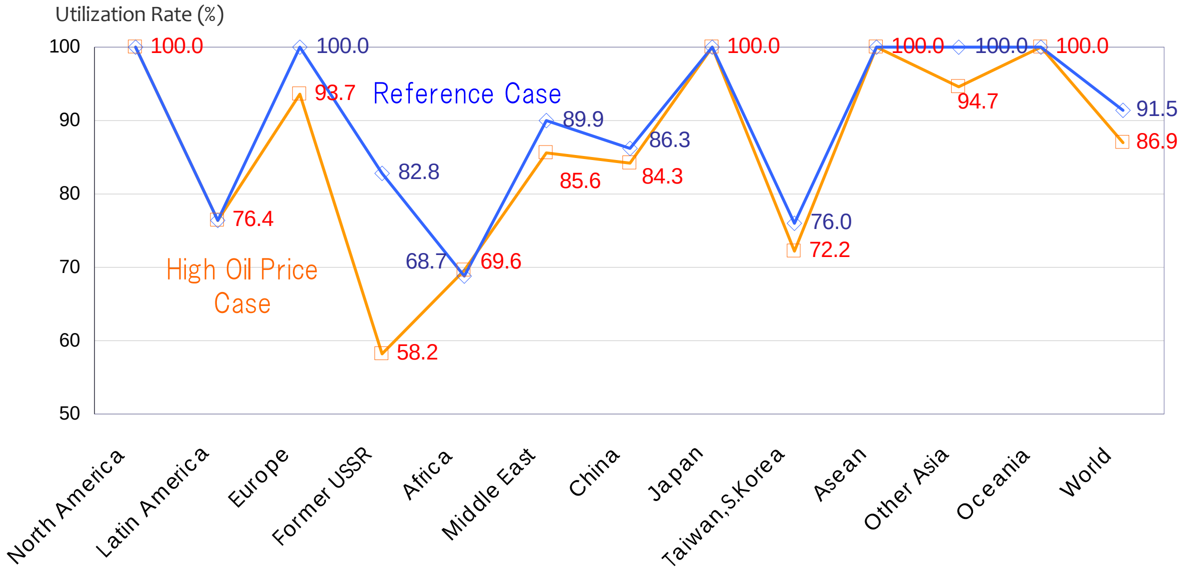
As in the reference case, units are projected to continue operating at nearly full capacity in North America (the United States and Canada), Japan[1], the ASEAN and Oceania, but the utilization rate is expected to decline, thus generating a surplus capacity in Europe, Russia, Middle East, China, Taiwan, South Korea and South Asia.

Figure 4-5. Comparison of the Utilization Rate of the CDU by Region (2010)



[1] Japan's gasoline and middle distillate exports are likely to decrease substantially and, instead, its fuel oil exports are expected to increase. If fuel oil exports are restricted, the capacity utilization rate will decline.

Figure 4-6. Comparison of the Utilization Rate of the CDU by Region (2015)



4.1.3 Product Supply-Demand Balance and Product Trade by Region

(1) Supply-Demand Balance by Region (Reference Case)

During the period from the 1990s to the first half of the 2000s, product trade was centered on intra-region: (a) in the Atlantic region where excesses and shortages were adjusted (traded) among North America, Europe and Russia; and (b) in the East Asian region where excesses and shortages in China and the ASEAN region were adjusted (traded) chiefly by the refining capacities of Japan, South Korea and Taiwan.

The results of supply-demand balance estimation with the LP model for 2005, 2010 and 2015 are shown in Figures 4-7, 4-8 and 4-9.[2] Based on this estimation, the intra-regional supply-demand balances for the Middle East and the South Asian region, in addition to the above two regions, are discussed below.

<u>Intra-Regional Supply-Demand Balances for the Three Main Regions</u>

(a) The Region (the numerical values given are for 2005[3], 2010, and 2015)

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[2] In the LP model, it should be noted, because regional excesses and shortages (exports and imports) are determined by verifying whether the refining capacity in which region can be operated at what levels and where excesses and shortages should be imported (or exported) at the minimum costs for the whole world to meet the demand in each region, these regional excesses and shortages do not always represent (potential) surpluses (exports) that can be made available when the refining capacity in the region in question is fully operational.

[3] Figure 4-7 shows the results of estimation with the LP model and the actual figures in 2005.

- North America: Net gasoline imports (▲ 1.82 million B/D; ▲ 1.78 million B/D; ▲ 1.96 million B/D)
- Europe: Net gasoline exports (1.13 million B/D; 1.45 million B/D; 1.57 million B/D)
  Net middle distillate imports (▲ 1.03 million B/D; ▲ 0.42 million B/D; ▲ 0.6 million B/D)
- Russia: Net gasoline exports (0.23 million B/D; 0.45 million B/D; 0.45 million B/D)
  Net middle distillate exports (1.43 million B/D; 1.16 million B/D; 1.2 million B/D)

(b) The East Asian Region
- Japan: Net gasoline exports (0.17 million B/D; 0.14 million B/D; 0.12 million B/D)
  Net middle distillate exports (0.4 million B/D; 0.45 million B/D; 0.65 million B/D)
- South Korea and Taiwan: Net gasoline exports (0.04 million B/D; 0.03 million B/D; 0.04 million B/D)
  Net middle distillate exports (0.47 million B/D; 0.34 million B/D; 0.25 million B/D)
- China: Net gasoline exports (0.32 million B/D; 0.37 million B/D; 0.42 million B/D)
  Net middle distillate imports (▲0.28 million B/D; ▲ 0.45 million B/D; ▲ 0.55 million B/D)
- The ASEAN: From net gasoline exports to net imports (0.13 million B/D; ▲ 0.17 million B/D; ▲ 0.26 million B/D)
  From net middle distillate exports to net imports (0.16 million B/D; ▲ 0.16 million B/D; ▲-0.21 million B/D)

(c) The Middle East and the South Asian Region
- The Middle East: Net gasoline imports (▲0.17 million B/D; ▲0.16 million B/D; ▲0.21 million B/D)
  From net middle distillate imports to net exports (▲0.18 million B/D; 0.08

While gasoline exports and imports in the LP model include blending materials for gasoline, the actual figures include products only. A look at gasoline imports in the United States reveals that blending materials for gasoline are imported in the quantity almost equal to (or greater than) that of products.

million B/D; 0.11 million B/D)

- South Asia: Net gasoline export (0.17 million B/D; 0.25 million B/D; 0.32 million B/D)

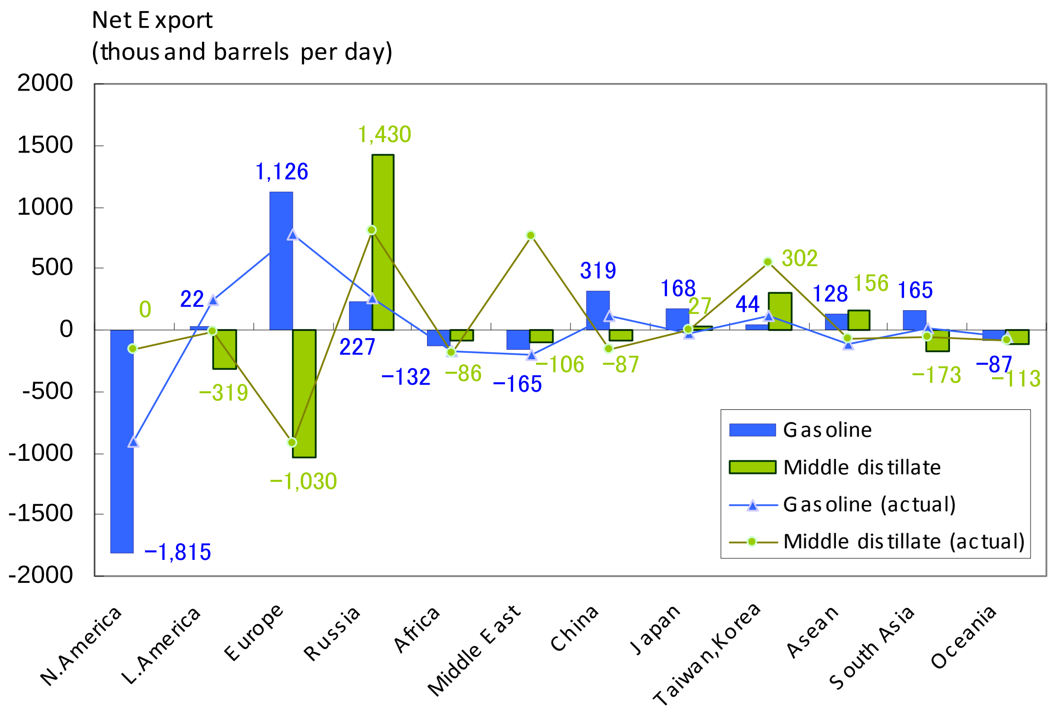
  From net middle distillate imports to net exports (▲0.10 million B/D; ▲ 0.01 million B/D; 0.16 million B/D)

Characteristically, while there will be no major change in the structure of intra-regional excesses and shortages in the Atlantic region, there will be a major change:

- in South Asia (India) and the Middle East region where intra-regional shortages will turn into surpluses; and
- in East Asia where an intra-regional surplus, mostly in Japan, will expand rapidly.

These product surpluses in the two regions will be exported to the Atlantic region (chiefly Europe and the United States) and the eastern part of the Pacific region (the west coast of the United States, Latin America, and Australia) and expand to inter-regional trade (world trade).

Figure 4-7. Comparison of the Product Supply-Demand Balance by Region (2005)



When the supply-demand balance for the whole world is optimized at minimum costs, Japan's optimum operation level will be full operation and exports will amount to 0.14 million B/D (gasoline) plus 0.45 million B/D (middle distillate), 0.59 million B/D in total in 2010, and 0.12 million B/D (gasoline) plus 0.65 million B/D (middle distillate), 0.77 million B/D in total in 2015. In crude oil equivalent, the exports will represent approximately 1 million B/D in 2015, accounting for approximately 20% of the present CDU capacity of approximately 4.8 million B/D.

Figure 4-8. Comparison of the Product Supply-Demand Balance by Region
Reference Case (2010)

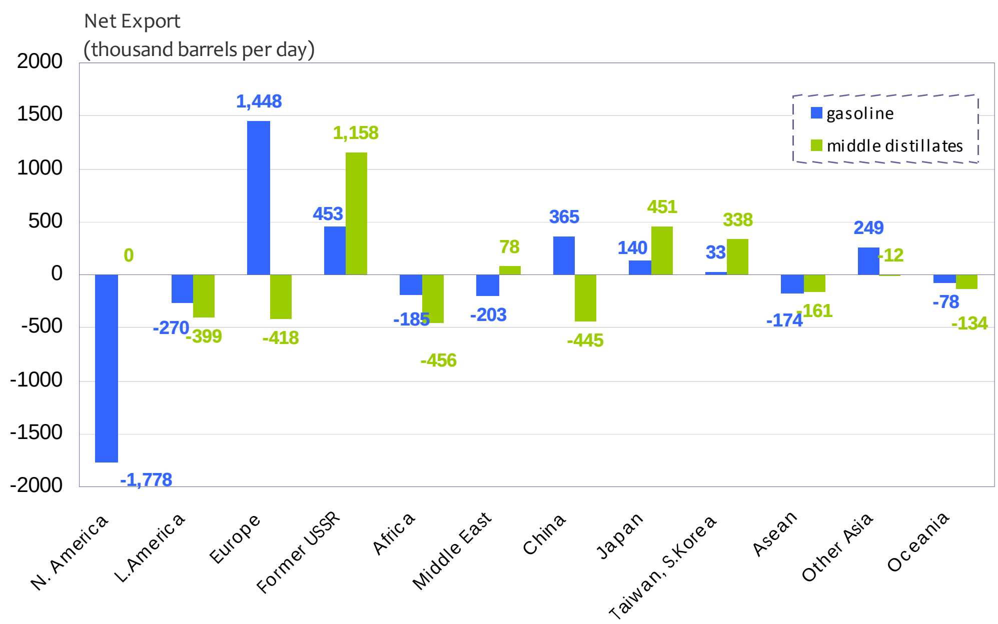
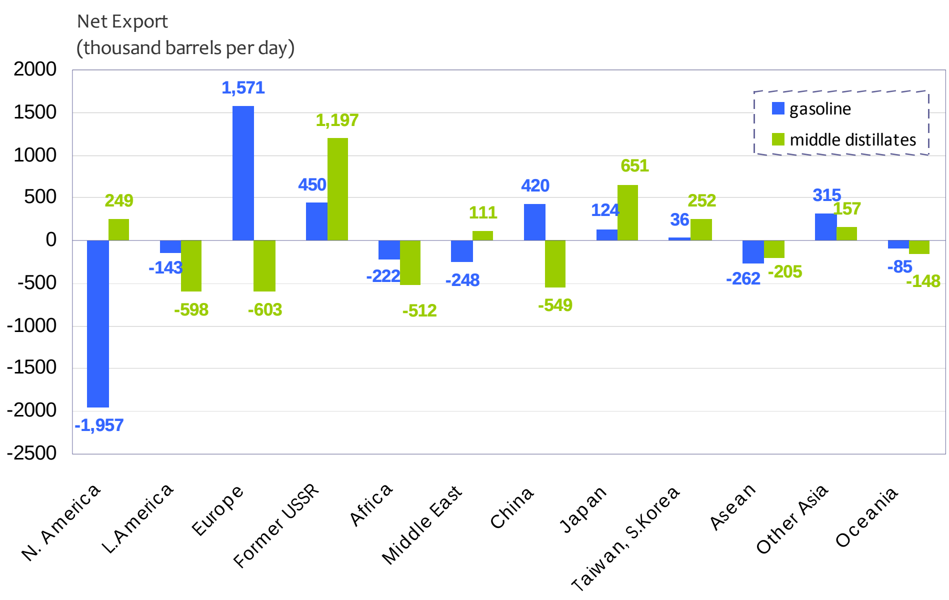


Figure 4-9. Comparison of the Product Supply-Demand Balance by Region
Reference Case (2015)



(2) Product Trade (Reference Case)

Trade flow diagram based on the results of estimation with the LP model are shown in Figures 4-10 (2005), 4-11 (2010) and 4-12 (2015).[4] Trade flow diagram is shown in terms of net exports (or net imports). However, for exports and imports from the South Asian region, exports (imports) are shown by dividing them into those from export-oriented oil refineries in India and other oil refineries for domestic supplies in order to look into the effects of export-oriented oil refineries in India. The results of optimization calculations indicate that although there will be no major structural changes in the trade flow in the Atlantic region, inter-regional trade from East Asia, the Middle East and South Asia will undergo the following changes.

(i) Gasoline

(a) Gasoline exports from East Asia (mostly from Japan) will be oriented to Oceania (Australia) and the United States (the west coast). Japan's exports to the United States[5] are projected to increase from 0.08 million B/D in 2005 to 0.11 million B/D in 2010 and 0.12 million B/D in 2015.

(b) The Middle East region's net gasoline imports are projected to continue from 2005 until 2015 and these imports will come chiefly from South Asia (India). India's exports will be expanded to 0.28 million B/D to the Middle East, Oceania, and Europe in 2010 and further to 0.32 million B/D in 2015.

(ii) Middle Distillate

(a) Exports from East Asia will be oriented to China, the ASEAN, and South Asia. Japan's exports are projected to increase from 0.40 million B/D in 2005 to 0.45 million B/D in 2010 and further to 0.65 million B/D in 2015.

(b) While imports from outside the region will continue to meet intra-regional demand in South Asia, extra-regional exports far exceeding intra-regional-imports will occur. The destination of exports from India's export-oriented oil refineries will be expanded from the neighboring areas to Europe. Exports are projected to increase to 0.56 million B/D in 2010 (including 0.12 million B/D to Europe) and to 0.54 million B/D in 2015 (including 0.27 million B/D to Europe).

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[4] All trade flow is not counted but rather simplified (for details, refer to Annex 4). The numbers for 2005 are not results but are net exports based on the world's optimized operation level.

[5] In the LP model, gasoline quality standards are established chiefly on the octane number and the sulfur content. For the olefin content and vapor pressure, standard values that are as stringent as those set by the State of California are not taken into consideration.

Figure 4-10-1. Gasoline Product Trade by Region

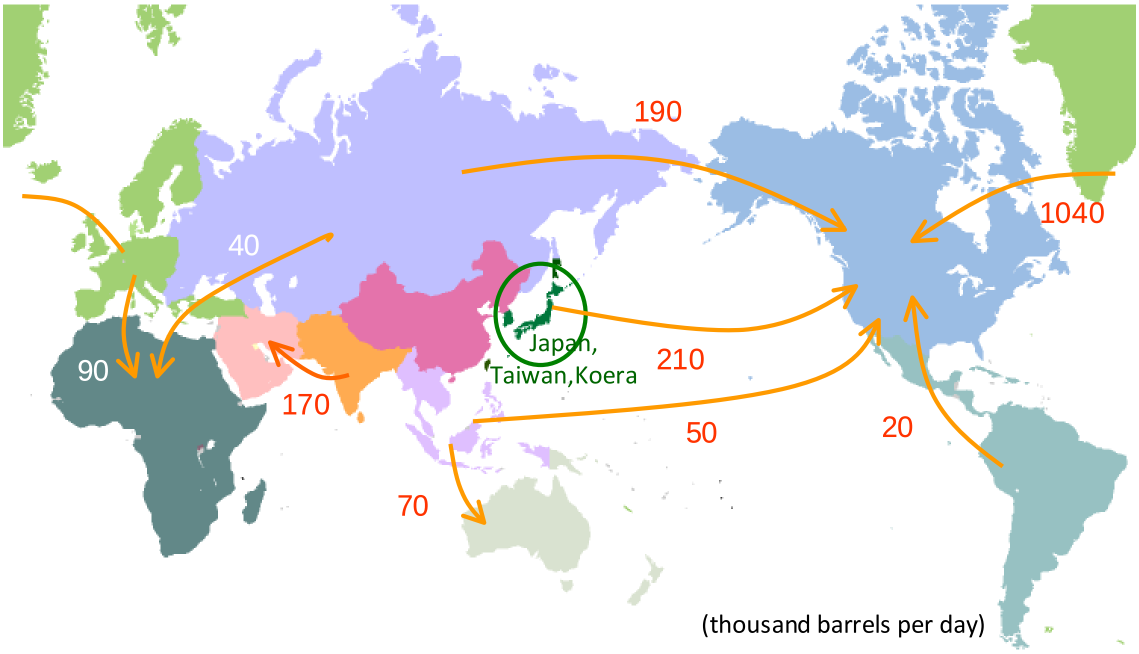


Figure 4-10-2. Middle Distillate Product Trade by Region

Reference Case (2005)

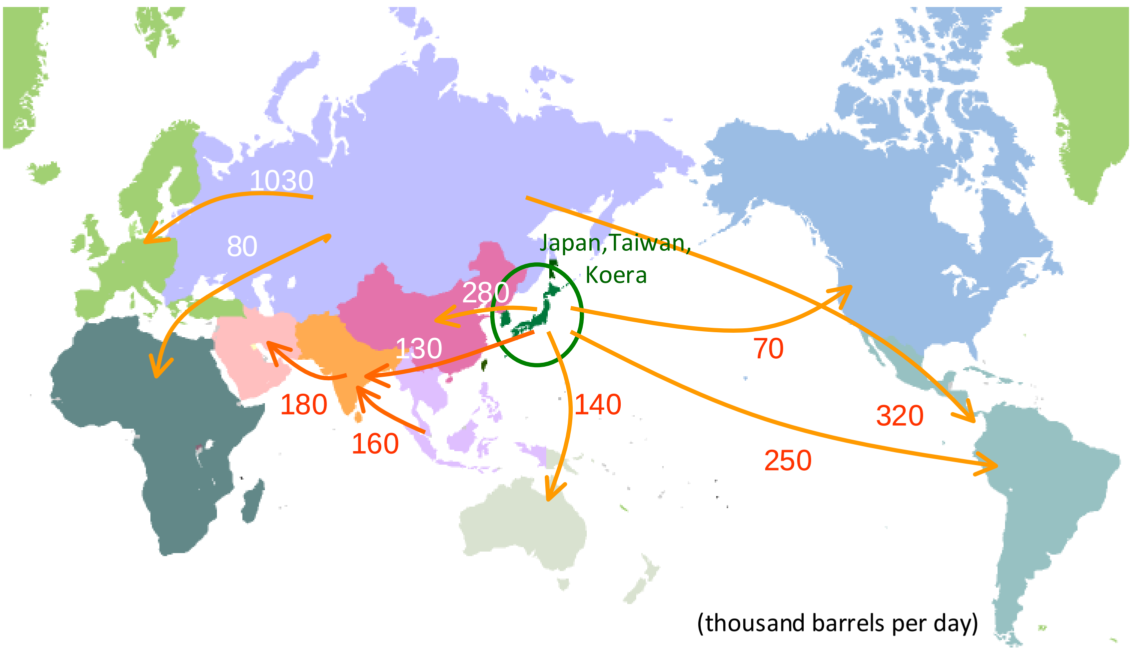


Figure 4-11-1. Gasoline Product Trade by Region
Reference Case (2010)

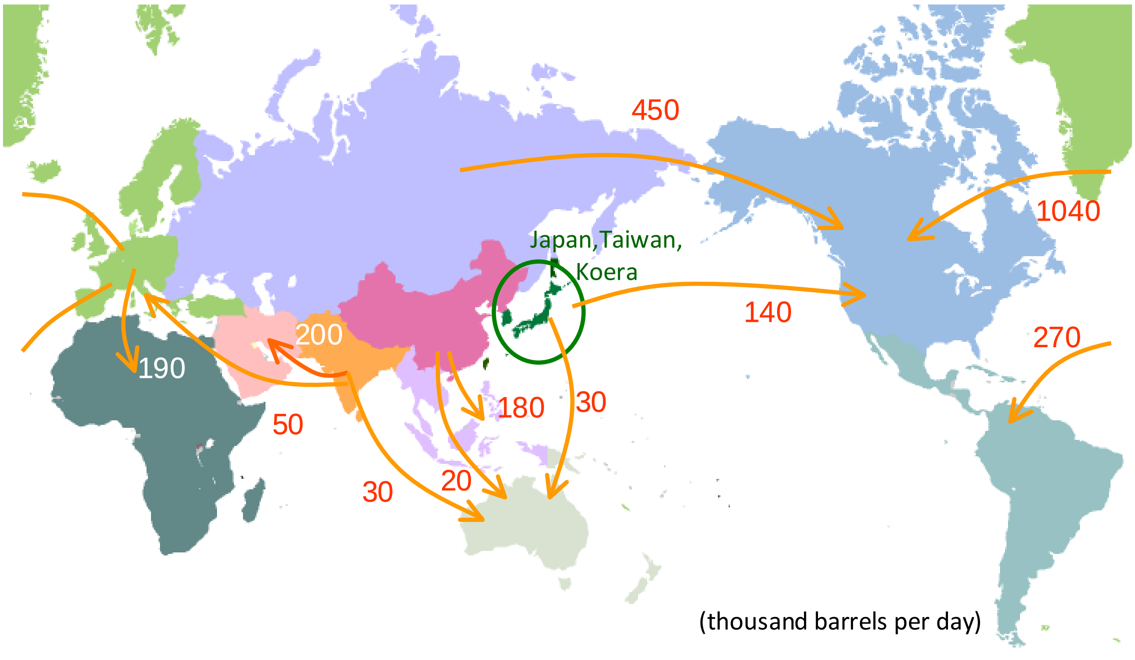


Figure 4-11-2. Middle Distillate Product Trade by Region
Reference Case (2010)

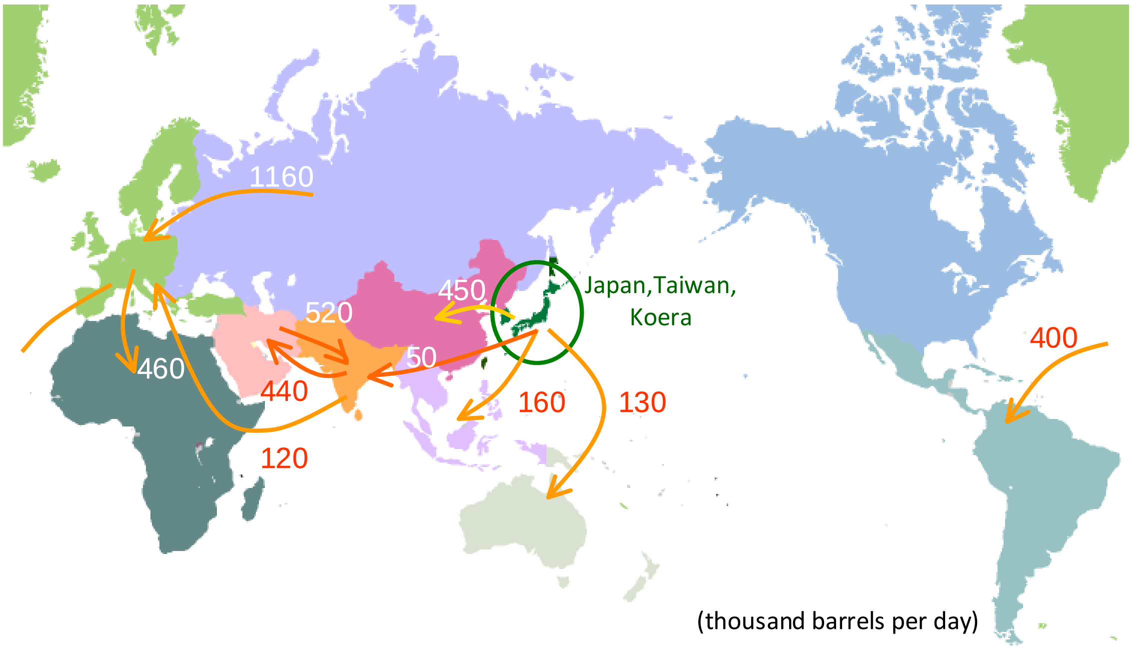


Figure 4-12-1. Gasoline Product Trade by Region

Reference Case (2015)

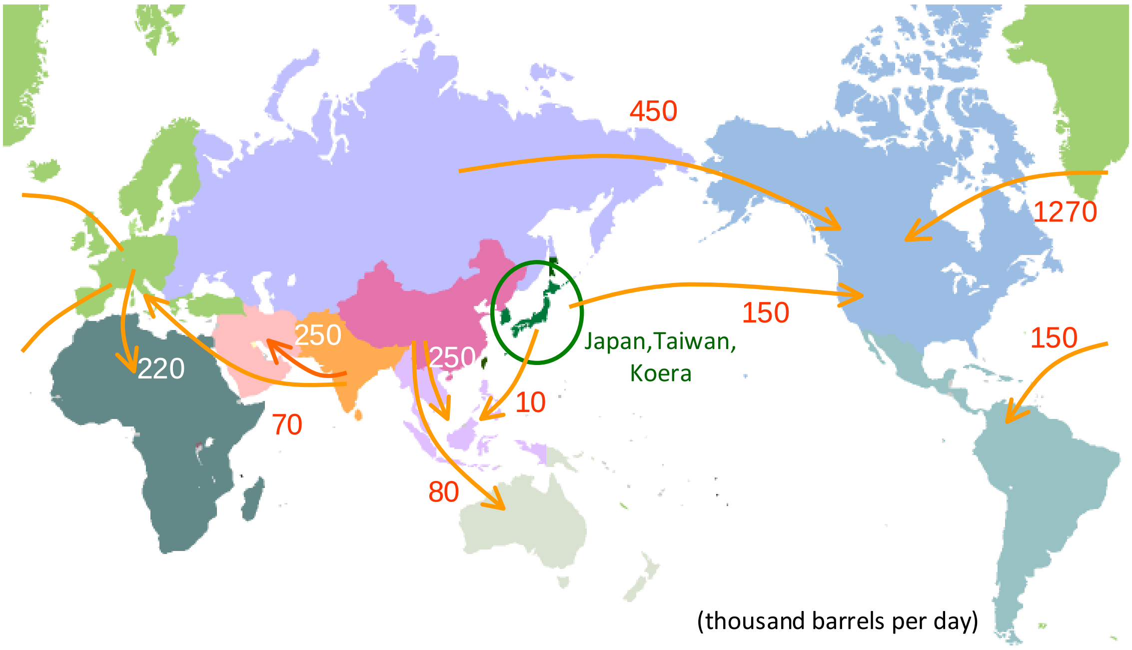
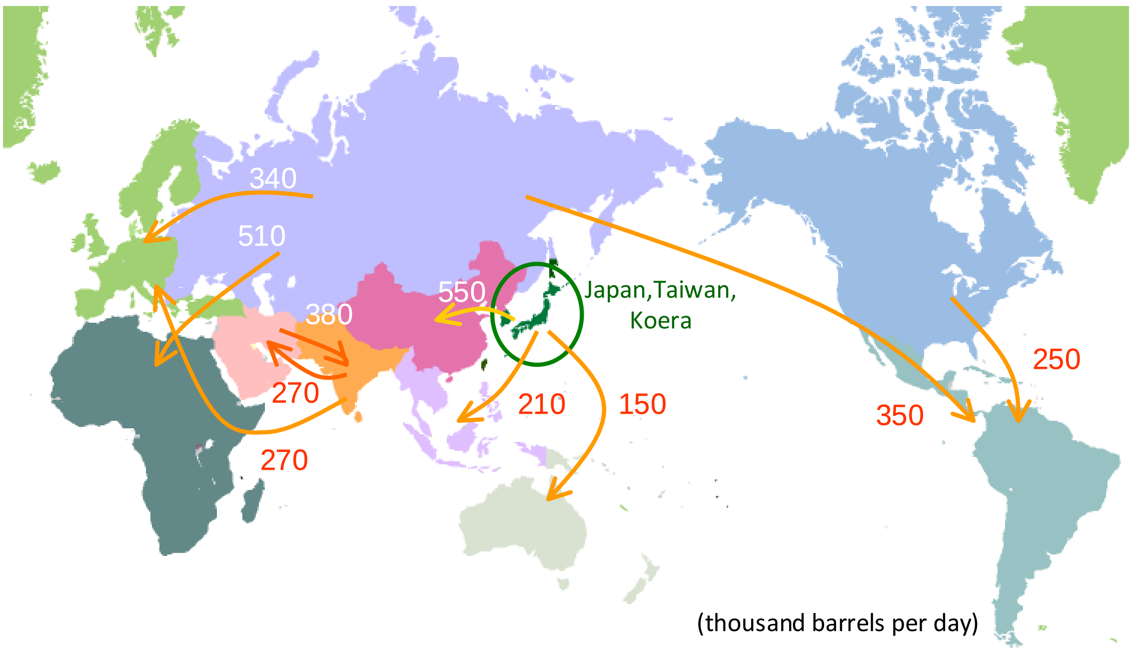


Figure 4-12-2. Middle Distillate Product Trade by Region

Reference Case (2015)



(3) Supply-Demand Balance by Region (High Price Case)

Figure 4-13 shows the results of estimation of the demand balance by region in 2010 and Figure 4-14 shows those in 2015. Since intra-regional demand is projected to drop to a level lower than that estimated in "Reference case", imports from outside the regions will decrease, thereby easing the strain on supply. In regions where there is a surplus refining capacity to export products to extra-regional markets, the utilization rate of the CDU(or the utilization rate of the secondary unit) will decline and exports will decrease, with the result that the amount of excesses and shortages in each region will decrease.

Figure 4-13. Comparison of the Product Supply-Demand Balance by Region High Price Case (2010)

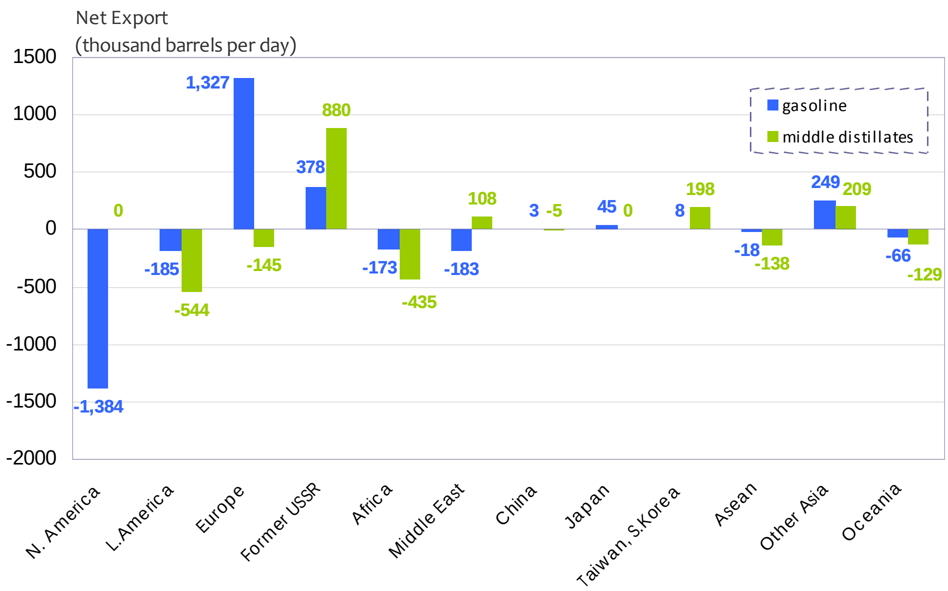
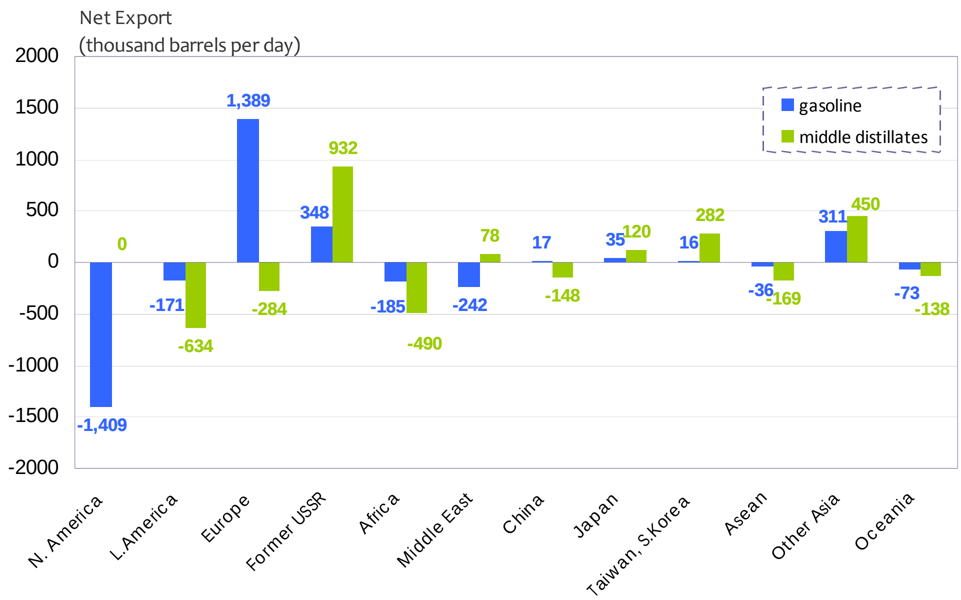


Figure 4-14. Comparison of the Product Supply-Demand Balance by Region High Price Case (2015)



(4) Product Trade (High Price Case)

(i) Gasoline

(a) The United States' gasoline imports will decrease to approximately 70% of those assumed in "Reference case", with the result that exports from East Asia (Japan, South Korea and Taiwan) will go mainly to the ASEAN and Oceania and exports to the United States will decrease sharply[6] (to become zero in the LP model).

(b) Japan's exports to Oceania are projected to reach 0.04 million B/D in 2010 and to 0.08 million B/D in 2015.

(c) Gasoline exports from India's export-oriented oil refineries to Europe will decrease substantially compared with those assumed in the reference case and will compete with Japan in exports to Oceania.

(ii) Middle Distillate

(a) For middle distillate, projections similar to those for gasoline are possible. Since demand from China, the ASEAN, Oceania and the United States will decrease, exports by Japan, South Korea and Taiwan to these regions will be reduced.

[6] In the LP model, from which region, the B region or the C region, exports to a certain region (referred to as the "A region") will originate is determined depending on which region entails a smaller amount of the total cost of {Σ (the production cost of petroleum products) + Σ(the export cost of petroleum products)}. Accordingly, the size of the capacity utilization rate and the refining costs determined by a difference in the composition of secondary units in the respective regions will be added. It will not simply be determined solely by a difference in the export freight from both regions (the B or C region) to the A region.

Figure 4-15-1. Gasoline Product Trade by Region
High Price Case (2010)

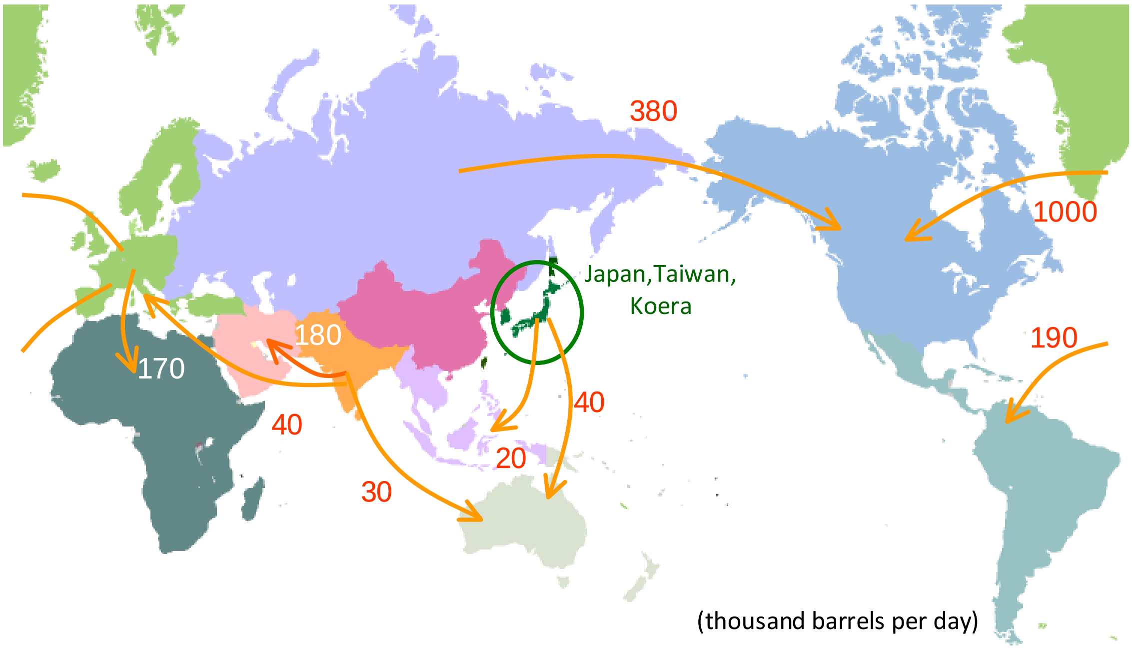


Figure 4-15-2. Middle Distillate Product Trade by Region
High Price Case (2010)

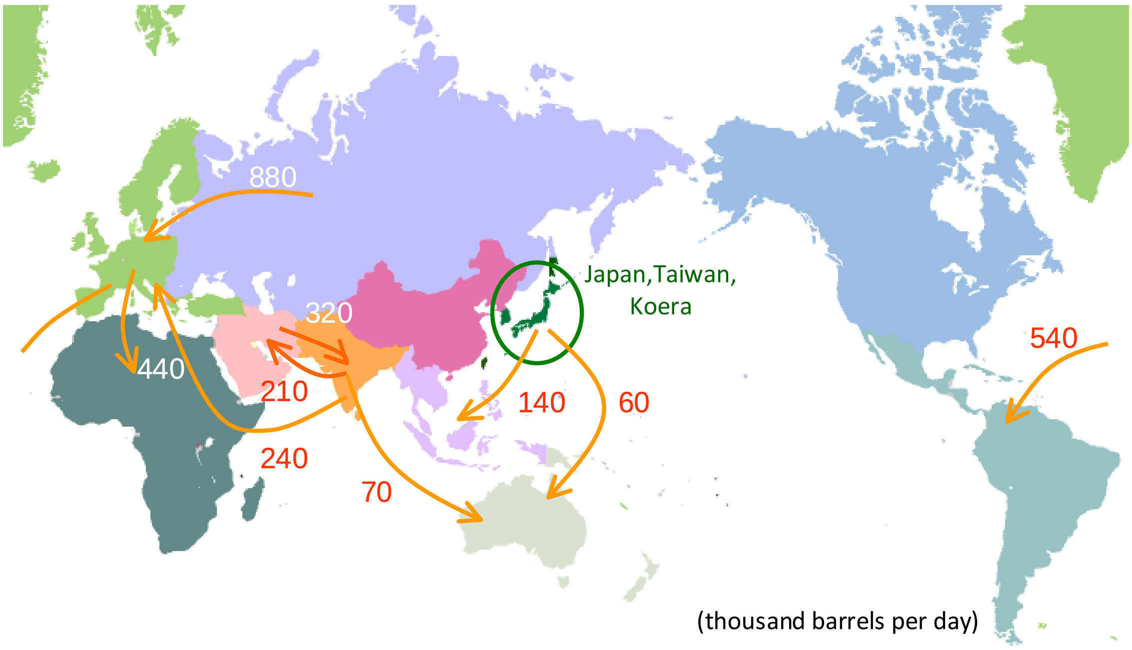


Figure 4-16-1. Gasoline Product Trade by Region
High Price Case (2015)

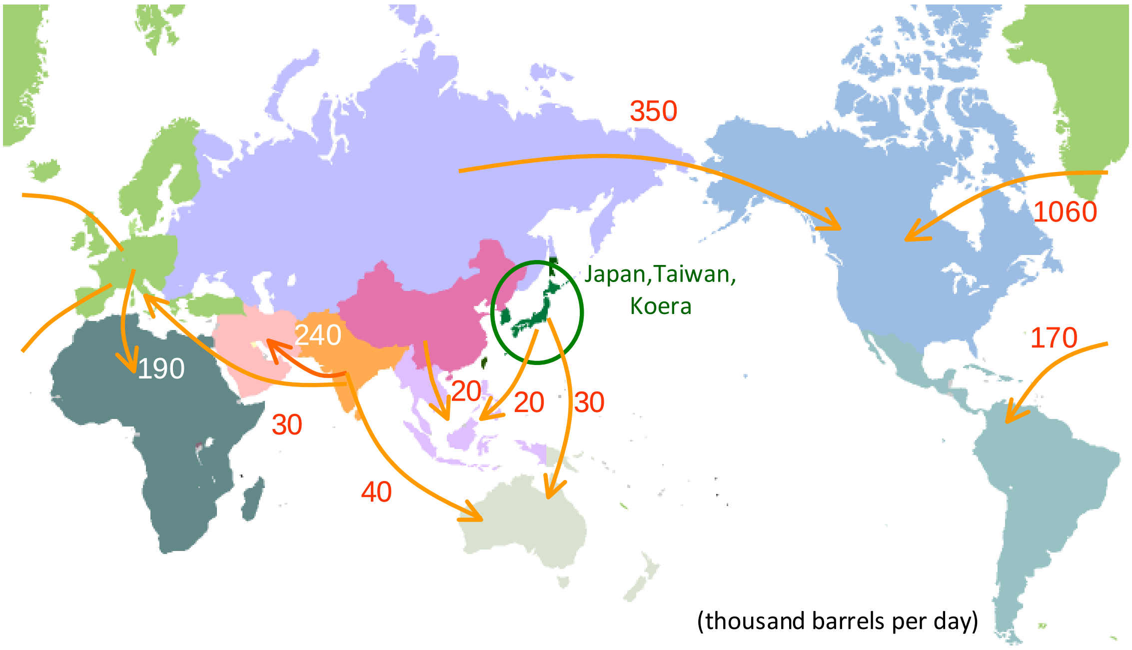
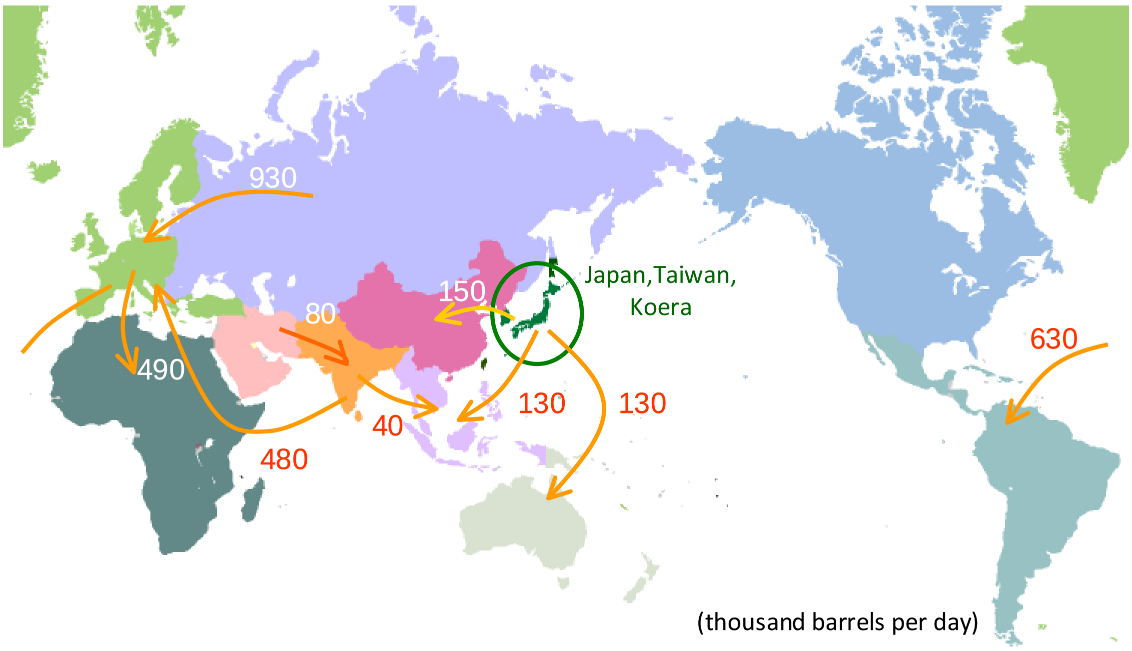


Figure 4-16-2. Middle Distillate Product Trade by Region
High Price Case (2015)



Chapter 5: Conclusion

5.1 Summary

(1) Petroleum Product Demand

(a) Given economic growth in the Asian region, including China and India, in the reference case that assumes continued steady growth, petroleum product demand in the world is projected to grow by 1.6% during the 2005-2010 period and by 1.8% during the 2010-2015 period.

(b) In the "High price case" in which the present crude oil price level ($100) will continue and is assumed to remain unchanged from 2010 onward, the rate of growth in product demand in the world is projected to decline by 0.7% during the 2005-2010 period and by 1.3% during the 2010-2015 period.

(2) Refining Capacity

(a) A survey of projects designed to expand refining capacity as of the beginning of 2008 leads us to conclude that those projects, which are to be completed by around 2010, will be carried out as planned. CDU capacity will be expanded by approximately 6.10 million B/D, or by 1.4% annually.

(b) The supply-demand environment, at least from 2008 to 2010, will become a decisive factor in estimating refining capacity in 2015. In "Reference case", large projects will be carried out steadily to expand CDU capacity by around 9.60 million B/D, or by 2.0% annually, while in the high price case in which demand is assumed to decline, numerous capacity expansion projects will be deferred, so CDU capacity will be expanded by only about 7.00 million B/D, or by 1.5% annually.

(3) Supply and Demand for Petroleum Products

(i) Reference Case

While petroleum product demand will continue to growth steadily, the corresponding refining capacity expansion will generally be achieved, so that as in the present situation, the tightening supply situation for petroleum products will continue from 2010 onward. The utilization rate of refining capacity is projected to remain at high levels and increase from 90.3% in 2005 to 91.6% in 2010 and to 91.5% in 2015.

(ii) High Price Case

As growth in petroleum product demand will slow down, the tightening on supply that will occur from 2010 onward will be eased slightly. The utilization rate is projected to drop to 87.5% in 2010 and to 86.9% in 2015.

(4) Supply and Demand for Petroleum Products and Product Trade by Region

(i) During the period from the 1990s to the first half of the 2000s, product trade was intra-regional: (a) in the Atlantic region where excesses and shortages were adjusted (traded) among North America, Europe and Russia; and (b) in the East Asian region where excesses and shortages in China and the ASEAN region were adjusted (traded) chiefly by the refining capacities of Japan, South Korea and Taiwan.

(ii) From 2005 onwards, particularly during the period from 2010 to 2015, the world trade flow is such that while there will be no major changes in the structure of intra-regional excesses and shortages in the Atlantic region, there will be a major change,

(a) in South Asia (India) and the Middle East region where intra-regional shortages will turn to surpluses; and

(b) in East Asia where intra-regional surplus, mostly in Japan, will expand rapidly.

Product surpluses will be expanded in South Asia, the Middle East, and the East Asian region; exports to the Atlantic region (chiefly Europe and the United States) and the eastern part of the Pacific region (the west coast of the United States, Latin America and Australia) will increase and inter-regional trade (world trade) will become lively.

(iii) Points to be considered by region can be summarized as follows.

(a) China

Refining capacity expansion projects will be carried out almost as planned, with the result that refining capacity (Crude distillation units) will reach 9.00 million B/D in 2010 and 11.00 million B/D in 2015; this nation will become a net exporter of gasoline and slight net importer of middle distillates, thus maintaining the self-supply system generally.

(b) India

Refining capacity will reach 1.5 million B/D in the private companies, 2.5

million B/D at the state-owned companies, and 4.00 million B/D in total by 2010. India's export capacity (excluding exports to the South Asian region) will almost equal private companies' refining capacity and will amount to approximately 1.00 million B/D as equivalent to the amount of gasoline and middle distillate production.

(c) The Middle East
Refining capacity will reach approximately 8.30 million B/D in 2010 and approximately 10.40 million B/D in 2015. Intra-regional demand will grow at a high rate, Iran and Iraq will experience a shortage of refining capacity, and imports of petroleum products, mostly gasoline, from outside the region will continue. Making progress in Saudi Arabia's new oil refining construction project, which is delayed, holds the key to success in expanding intra-regional supplies and enhancing product export capacity.

(d) The United States
Petroleum product demand will continue to grow and there will be a shortage of refining capacity. In "Reference case", gasoline imports will reach approximately 1.90 million B/D (petroleum product imports will be about half of this amount) in 2010 and 2015.

(e) Europe
Between 2005 and 2015, gasoline demand will decrease and gas oil demand will increase a little, so the supply-demand balance consisting of gasoline exports and middle distillate imports will continue.

(f) East Asia (Excluding China) and South Asia
Exports from the East Asian region (excluding China) will go chiefly to China, Southeast Asia, Oceania, and North America (the west coast), while exports from South Asia and the Middle East will go primarily to Europe, Africa and the Oceania region, resulting in no competition, except for Oceania.

(g) East Asia (Excluding China) and the United States
Japan, South Korea and Taiwan will compete with one another because their export markets overlap each other. In regard to Japan's exports, it may be interesting to note that in the "Reference case" that assumes a steady

increase in the world demand and a strained supply, Japan will be able to export 0.59 million B/D of gasoline and middle distillates in 2010 and 0.77 million B/D in 2015. This represents approximately 16% of the present crude oil processing capacity (or 20% in crude oil equivalent).

(h) South Asia and the Middle East

South Asia, which is ahead of other regions in the buildup of refining capacity, will prevail in exports to the European and American markets during the period from 2010 to 2015. However, if from 2012 onward, export-oriented oil refineries come on line as planned in the Middle East region, there will be intensifying competition between South Asia and the Middle East for exports to the European and American markets.

5.2 Conclusions

The results of optimization calculation with the LP model can be summarized as follows, with emphasis placed on Japan

(1) Japan's Surplus Refining Capacity and Export Capacity

If steady growth in the product demand in the world results in a strained supply (Reference case), a look at Japan's refining capacity (approximately 4.80 million B/D) shows that approximately 20% of Japan's surplus refining capacity (or 16% on the gasoline and middle distillate basis) will be fully utilized – mainly for exports of high-quality (very low sulfur-content) petroleum products.

(2) Main Export Markets

Jet fuel, gas oil and other middle distillates will be exported mainly to the Asian region (China, the ASEAN nations and Australia), while gasoline will be exported mainly to the west coast of the United States and the Australian region.

(3) Inter-Regional and Intra-Regional Competition

Regarding inter-regional competition, there will be no competition between South Asia / Middle East, which export their products chiefly to the European and African markets, and East Asia, which targets the Pacific region (including Japan, South Korea and Taiwan but excluding China), with the exception of Australia.

However, analysis of the relations among three countries in the East Asian region – namely, Japan, South Korea and Taiwan – shows that because Japan's export market overlaps with those of South Korea and Taiwan with a slow growth in domestic demand and large surplus supply capacity, keener competition among these countries is most likely to occur in the years ahead.

5.3 Challenges Ahead

The above conclusions need to give full consideration to the following constraints and may have to be analyzed and assessed more elaborately and accurately.

(1) Exports of Gasoline and Gas Oil from Japan, South Korea and Taiwan into the United States

(a) East Asia's (excluding China) surplus capacity will be used effectively to provide exports to the United States (particularly to the west coast) that suffers from a supply shortage, resulting in a rise in the utilization rate. Because Japan must reduce the sulfur content of gasoline and gas oil to 10 ppm in 2005, South Korea in 2009, and Taiwan in 2011, products of generally uniform quality will be exported from the East Asian region to the regions, including the United States, Oceania and the ASEAN.

(b) Japan has a higher secondary unit composition ratio than South Korea and Taiwan. On the other hand, South Korea and Taiwan have established export units. In the LP model, however, refining capacity and quality standards alone are considered as conditions and the assessment of logistics is not taken into consideration. As a result, Japan's utilization rate will increase to a level higher than that of the actual level and its exports will tend to be overestimated.

(c) Because the United States is assumed to be a single market (uniform quality), standards (olefin content, vapor pressure, aroma content, etc.) for gasoline on the west coast of the United States, particularly gasoline in California (CARBOB), are not accounted for. Japan's standard gasoline, which comprises mainly FCC gasoline, is far from meeting the standards. In actuality, therefore, blending materials for gasoline such as Alkylate must be changed. Accordingly, the results of LP estimation tend to assume exports to be larger than actual levels.

(2) Treatment of Export-oriented Oil Refineries in South Asia and the Middle East region

(a) Export-oriented oil refineries in India in South Asia are assumed to be intended solely for exports, but the oil refineries to be constructed (in 2012) in the

Middle East region are not assumed to be export-oriented in the LP models.

(b) As a result, where exports to the European and American regions actually occur, intra-regional (to Iran and Iraq, etc.) supply is assumed to occur by priority. Exports to Europe and the United States from the Middle East region are underestimated as a result.

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