Study of the Marketability of Oil Sands Products in Asian Countries

Prepared For:
Alberta Economic Development

Prepared By:
The Institute of Energy Economics, Japan（IEEJ）

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Executive Summary

Objectives

IEEJ (the Institute of Energy Economics, Japan) conducted this study "Study of the Marketability of Oil Sand in Asian Countries" in order to evaluate potential markets of Synthetic Crude Oil (SCO), SynSynBit, SynBit and DilBit by exploring and by comparing conventional crude oil-based markets in the Asian countries toward the year 2015. In addition, this study also focuses on the marketability of oil sand-derived products, particularly gasoline and diesel oil, in the Asian counties.

The study aims to develop the required activities to reduce the uncertainty and risks in the marketing of oil sand by evaluating oil sand quantity accepted in the Asian countries. The study also aims to understand the drivers such as price and quality of oil sand that affect the introduction of oil sand in the Asian countries. With this goal in mind, following major items are studied.

(1) Supply and demand situations of conventional crude oil in the Asian countries in the year 2015
(2) Pricing and qualitative differences between oil sand and conventional crude oil that are marketed in the Asian countries
(3) Acceptable price and quality of oil sand that are processed by the Asian refineries in the year 2015
(4) Evaluate the marketability of oil sand in the Asian counties
(5) Evaluate the marketability of oil sand-derived products especially gasoline and diesel fuel in the Asian counties

IEEJ has conducted above study through collection and analysis of related data and information, through interviews and discussions with experts in the related organizations and through applying the World Energy Demand-Supply Model (econometric model) and the Petroleum Refining and Trade Estimation Model (linear programming model) that are developed by IEEJ.

Model Outline

The World Energy Demand-Supply Model is applied to derive the level of world energy demand and supply and to estimate the demand for each petroleum product. The Petroleum Refining and Trade Estimation Model can identify the demand-supply balance for each country and analyze international trade flows by modeling petroleum refining and forming demand assumptions by petroleum products. Both models divide the world into 30 areas and individually analyze 18 major economies out of the 21 members of the Asia-Pacific Economic Cooperation (APEC).

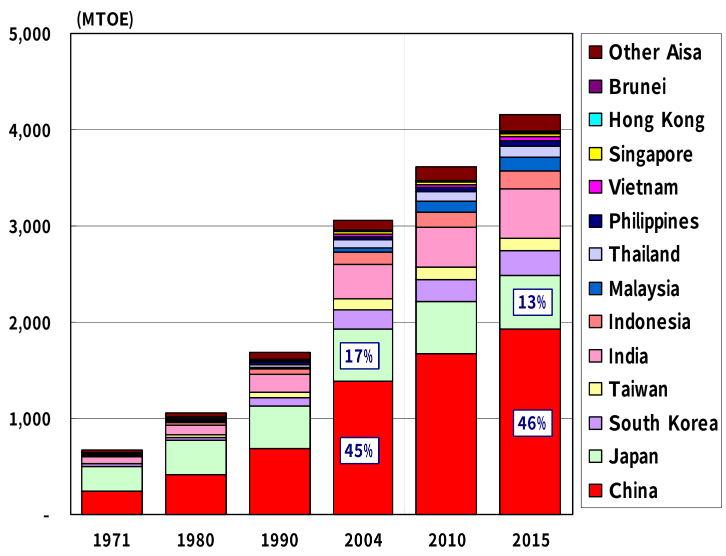
Major exogenous variables for the World Energy Demand-supply Model include GDP, energy (crude oil) prices and population, as well as primary energy variables. Final energy consumption is the central component of the model, covering the industry, transport, residential, commercial and agriculture sectors, and non-energy sectors.

The LP calculation for the Petroleum Refining and Trade Estimation Model begins with the selection of crude oil from 70 crude oil types and combines oil-refining costs and products trade to specify an optimal solution to minimize total energy system costs for the whole of the world. For the purpose of simplifying this model, each area is assumed to have integrated refineries into a single location. The model data was based on primary and secondary sources, including data provided by the different countries. Long term forecast data such as refinery capacity outlook in Asian countries are partly obtained by IEEJ interviews with selected Asian companies.

Asia / World Energy outlook

The world's primary energy consumption is expected to increase at an average annual growth rate of 1.4% from 10,246 Mtoe (million tons of oil equivalent) in 2004 to 11,974 Mtoe in 2015. Asian primary energy consumption is projected to expand at an average annual growth rate of 2.8% from 3,063 Mtoe to 4,152 Mtoe in 2015.

Asian Primary Energy Consumption Outlook



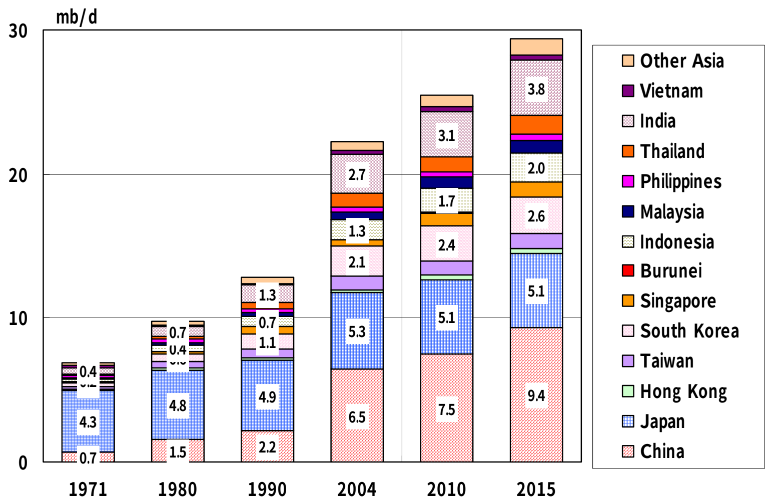
*Including combustible renewables

Asia's share of global primary energy consumption is forecast to increase from 29.9% in 2004 to 34.7% in 2015. China, in particular, is expected to boost primary energy consumption at an average annual growth rate of 3.0% from 1,389 Mtoe in 2004 to 1,927 Mtoe in 2015. Japan's primary energy consumption is expected to expand at an average annual growth rate of 0.3% from 533 Mtoe in 2004 to 552 Mtoe in 2015.

Asia / World Petroleum Outlook

World oil consumption is projected to increase by 12.9 million b/d from 80.2 million b/d in 2004 to 93.1 million b/d in 2015. Asian oil consumption is expected to expand by 7.1 million b/d from 22.3 million b/d in 2004 to 29.4 million b/d in 2015. China is projected to boost oil demand from 6.5 million b/d in 2004 to 9.4 million b/d in 2015. India's oil demand is also forecast to rise from 2.7 million b/d in 2004 to 3.8 million b/d in 2015.

Asian Oil Consumption Outlook



By 2015, world gasoline consumption is projected to increase to 23.0 million b/d, diesel oil consumption to 27.5 million b/d, and fuel oil consumption 11.7 million b/d. Asian gasoline consumption is projected to increase at an average annual growth rate of 2.9% to 4.6 million b/d, diesel oil consumption at a 3.0% rate to 9.0 million b/d, and fuel oil consumption at a 3.6% rate to 4.3 million b/d.

Asian net products import is projected to increase from 1.064 million b/d in 2004 to 2.536 million b/d in 2015. Asia's dependence on oil imports would rise steadily from 73% in 2004 to about 85% in 2015. Energy security may thus be positioned as a more important challenge.

The capacity utilization ratio for refineries in the whole of Asia is expected to rise from 93.9% in 2004 to 95.7% in 2015, indicating that Asian refineries would continue operating almost at full capacity on the strength of robust demand for petroleum products.

In China, demand for petroleum products is estimated to increase by an annual average of about 0.29 million b/d from 2004 to 2015, and refining capacity is projected to expand by a total of 3.035 million b/d (or an annual average of about 0.28 million b/d). Thus, the capacity utilization ratio is estimated to rise from 89.3% in 2004 to 92.0% in 2015.

Oil Sand Export Study

For the introduction of oil sand, following seven cases are analyzed.

(1) Exporting Sweet SCO oil sand (for only the United States as a reference case)

(2) Exporting Sweet SCO oil sand

(3) Exporting SynSynBit oil sand

(4) Exporting SynBit oil sand

(5) Exporting DilBit oil sand

(6) Selecting Sweet SCO, SynSynBit, SynBit or DilBit for exports through optimization

(7) Exporting gasoline or diesel oil refined from oil sand

Oil Sand Characteristics

Blend Ratio Vol%	Athabasca Bitumen	Dilbit (Cold Lake Blend)	SynBit	SynSynBit	Sweet SCO
Bitumen	100	72	52	36	-
SCO	-	-	48	64	100
Condensate	-	28	-	-	-
API	8.3	22.6	19.9	24.2	34.8
Sulfur	4.8	3.39	2.5	1.8	0.1
TAN (mgKOH/g)	4	2.9	2	1.4	0

For the price assumptions of oil sand, SCO price for 2015 is assumed to be close to Arab Extra Light price. SynBit and SynSynBit prices are envisaged to retain the same percentage price differentials with Dubai and Arab Extra Light prices between 2004 and 2015. DilBit price is assumed to follow the Dubai price trend.

Oil Sand Price Assumptions

	2004	2010	2015
WTI	49.0	61.3	75.9
Arab Extra Light	47.0	56.4	69.8
DilBit	37.6	45.5	56.4
Sweet SCO	47.3	57.2	70.9
SynSynBit	42.1	50.9	63.1
SynBit	40.4	48.8	60.6
Dubai	43.7	52.9	65.6

(1) Exporting Sweet SCO (reference case)

If Sweet SCO is exported only to the United States, exports quantity is 1.381 million b/d. If Sweet SCO price in 2015 is the same as in 2004, exports is 0.317 million b/d more at 1,698 million b/d.

(2) Exporting Sweet SCO

If Sweet SCO is exported, exports total is 0.958 million b/d for Asia and 1.381 million b/d for the United States. As a result, the total exports exhibit at 2.339 million b/d. Thailand, the Philippines and other countries that lack secondary processing systems such as reforming, cracking and de-sulfurization units introduce Sweet SCO.

(3) Exporting SynSynBit

If SynSynBit is exported, exports total is 1.207 million b/d for Asia and 1.444 million b/d for the United States. As a result, the total exports exhibit at 2.651 million b/d. SynSynBit exports and the number of countries importing SynSynBit is larger than for Sweet SCO. The greater number of countries importing SynSynBit means that it would be more favorable for Canada to export SynSynBit from the viewpoint of acquiring firm and stable demand. The average API gravity and the average sulfur content for total Asian crude oil imports are almost the same as in the reference case. Asia thus is able to accept SynSynBit without any major modification of oil refineries including secondary devices. In addition, sales value is maximized if only SynSynBit is selected for exports. Therefore, the above results indicate that SynSynBit export is most favorable option in terms of its exporting volume, diversification of sales destinations and sales value.

(4) Exporting SynBit

SynBit features a lower API gravity, a higher sulfur content, and a higher total acid number than Sweet SCO, indicating that measures should be taken against corrosion of refineries in processing SynBit. If SynBit is exported, exports total is 0.938

million b/d for China and 1.493 b/d for the United States. No exports are expected to Asian countries other than China that has established cracking and other secondary processing systems for heavy crude.

(5) Exporting DilBit

If DilBit is exported, exports total is 0.866 million b/d for China and 1.473 million b/d for the United States. As is the case with the SynBit, China, which has imported heavy crude oil, is expected to absorb the majority of DilBit oil sand exports.

(6) Selecting Sweet SCO, SynSynBit, SynBit or DilBit for exports through optimization

If Sweet SCO, SynSynBit, SynBit or DilBit is selected for exports from the viewpoint of optimum costs, exports total is 1.294 million b/d for Asia and 1.459 million b/d for the United States. In total, 2.753 million b/d is exported. Of the total, Sweet SCO accounts for 0.528 million b/d, SynSynBit for 0.378 million b/d, SynBit for 0.402 million b/d, and DilBit for 1.445 million b/d.

(6)' Selecting Sweet SCO, SynSynBit, SynBit or DilBit for exports through optimization (at 2004 price)

If Sweet SCO, SynSynBit, SynBit or DilBit is selected for exports at 2004 price, exports to the world and Asia are maximized. Exports total is 1.475 million b/d for Asia and 1.530 million b/d for the United States. In total, 3.005 million b/d is exported. Of the total, Sweet SCO accounts for 0.535 million b/d, SynSynBit for 0.440 million b/d, SynBit for 0.489 million b/d, and DilBit for 1.541 million b/d.

A comparison of oil sand export cases indicates that the case in which oil sand is exported in all of the four forms shows the largest quantity of exports to the United States and Asia. Additionally, exports in all types of oil sand at 2004 price ensure the largest number of importing countries (including eleven Asian countries or regions), enabling the exporter to diversify sales destination. Though Sweet SCO is the highest value added oil sand, export quantity to Asia is more limited than SynSynBit. SynBit or DilBit, though cheaper than the SynSynBit, may cost more than the SynSynBit in terms of refining. Therefore, exports of the SynBit or DilBit are more limited than SynSynBit.

Comparison of Oil Sand Export Cases

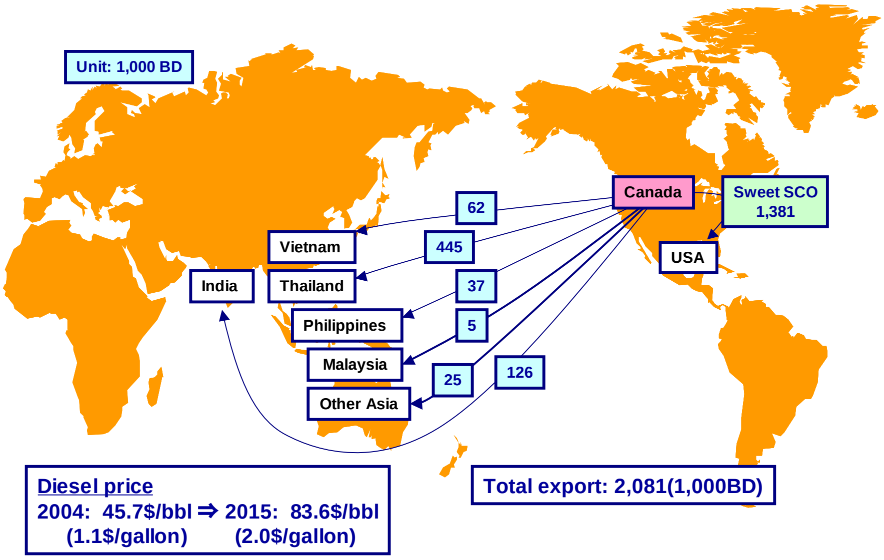
US$/BBL 1,000b/d	(1) SCO only to USA		(2) SCO	(3) SynSynbit	(4) Synbit	(5) Dilbit	(6) All Oil Sands Export Case	
	Reference	Low Price					Reference	Low Price
WTI	75.9	49.0	75.9	75.9	75.9	75.9	75.9	49.0
Arab Extra Light	69.8	47.0	69.8	69.8	69.8	69.8	69.8	47.0
Arab Light	67.7	44.9	67.7	67.7	67.7	67.7	67.7	44.9
Arab Medium	64.5	43.0	64.5	64.5	64.5	64.5	64.5	43.0
Arab Heavy	61.0	40.6	61.0	61.0	61.0	61.0	61.0	40.6
DilBit	56.4	37.6				56.4	56.4	37.6
Sweet SCO	70.9	47.3	70.9				70.9	47.3
SynSynBit	63.1	42.1		63.1			63.1	42.1
SynBit	60.6	40.4			60.6		60.6	40.4
Dubai	65.6	43.7	65.6	65.6	65.6	65.6	65.6	43.7
Sweet SCO	**1,381**	**1,698**	**2,339**				**528**	**535**
United States	1,381	1,698	1,381				528	535
Japan			212					
South Korea			105					
Philippines			71					
Thailand			569					
SynSynBit				**2,651**			**378**	**440**
United States				1,444				
Japan				157			157	181
Taiwan				21				
South Korea				42			51	71
Singapore				247				
Philippines				55				
Thailand				479			170	188
India				202				
Vietnam				4				
SynBit					**2,432**		**402**	**489**
United States					1,493			
China					938			
Singapore							214	247
Philippines							32	41
Taiwan								11
Thailand							152	158
India							4	16
Vietnam								11
Other Asia								5
DilBit						**2,339**	**1,445**	**1,541**
United States						1,473	931	995
China						866	514	546
Total	**1,381**	**1,698**	**2,339**	**2,651**	**2,432**	**2,339**	**2,753**	**3,005**
United States	1,381	1,698	1,381	1,444	1,493	1,473	1,459	1,530
Japan			212	157			157	181
China					938	866	514	546
Taiwan				21				11
South Korea			105	42			51	71
Singapore				247			214	247
Philippines			71	55			32	41
Thailand			569	479			322	346
India				202			4	16
Vietnam				4				11
Other Asia								5
World	1,381	1,698	2,339	2,651	2,432	2,339	2,753	3,005
Asia	**0**	**0**	**958**	**1,207**	**938**	**866**	**1,294**	**1,475**

(7) Exporting gasoline or diesel oil refined from oil sand

While oil sand is exported in the form of crude oil, Canada can be expected to refine oil sand and export petroleum products. If gasoline from oil sand is exported, export quantity is 1.185 million b/d only for the United States. If diesel oil from oil sand is exported, the United States imports 1.381 million b/d of oil sand in the form of

Sweet SCO. Though total 0.7 million b/d of diesel oil is exported, destinations are limited only to the Asian countries except China. If China's refinery expansion delays, China will import 0.17 million b/d of diesel fuel from Canada. However, because other Asian countries are obliged to raise utilization ratio of their refineries in order to compensate the loss of China's products production, total diesel fuel exports from Canada decreases to 0.6 million b/d.

Projected Exports of Diesel Oil from Oil Sand in 2015



Dependence on Middle East

East Asia depended on the Middle East for 52.6% of its oil (crude and products) imports in 2004. The dependence is expected to rise to 59.5% in 2015. East Asia's dependence on the Middle East for crude oil imports is projected to increase from 64.7% in 2004 to 66.1% in 2015. Given the estimation, Asia's dependence on the Middle East for its oil imports may come to 55.7%, 3.8 points lower than in the reference case if Canadian oil sand is exported in the form of SynSynBit.

Oil Traffic through the Malacca Straits

As Asia is expected to expand oil imports from Middle East, oil traffic will steadily increase through the Malacca Straits, a key chokepoint for sea-lanes between the Middle East and Asia, from 11.700 million b/d in 2004 to 14.667 million b/d in 2015. If SynSynBit, which is expected to be one of the most favorable options to maximize oil sand export, is exported to Asia in 2015, oil traffic through the Malacca Straits may total 13.786 million b/d. This indicates that oil sand exports to Asia could work to reduce oil traffic through the Malacca Straits, making a great contribution to energy security with regard to sea-lanes.

Conclusions

This study has been prepared to explore at a macro level the potential markets for Canadian oil sands (synthetic and bitumen blends) and oil sand-derived products (gasoline and diesel oil) in Asian countries. Each country's refineries was represented as a single refinery model including existing and proposed or planned new refineries. The model provides a realistic world crude oil balance for 70 crude types in the 30 areas.

The study identified large markets in the range of 1 million b/d of synthetic crude oil if marketed as a segregated crude stream, or between 1.0 and 1.3 million b/d of synthetic/bitumen blends. It also identified a large potential market for diesel fuel that could be imported into the region. The study also undertook a pricing analysis. Although imported volumes were sensitive to price fluctuations, there was no significant reduction in the amounts imported into the different regions. This confirms the strong demand and competitiveness of oil sands.

As future work, this macro-level analysis should be followed up with more rigorous analysis of the key regions. Such analyses can include price setting refineries that determine the value of specific crude oils relative to regional crude oil price benchmarks that better reflect how regional markets normally work. Such studies will require more detailed information that may be difficult to get and was beyond the scope of the current study. Any prospective marketer of oil sands related crude oils will require this information to identify the most promising regional markets.

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1. Introduction

1-1. Objectives

In April 2005, Purvin & Gertz, Inc. prepared the report "Oil Sands Products Analysis for Asian Markets" which evaluated oil sand price by netback pricing evaluation.

By reference to this report, IEEJ (the Institute of Energy Economics, Japan) conducted this study "Study of the Marketability of Oil Sand in Asian Countries" in order to evaluate potential markets of Oil Sand-Derived Crude Oil such as Synthetic Crude Oil (SCO), SynSynBit, SynBit and Cold Lake DilBit by exploring and by comparing conventional crude oil-based markets in the Asian countries toward the year 2015.

The goal of the study is to develop the required activities to reduce the uncertainty and risks in the marketing of oil sand by evaluating oil sand quantity accepted in the Asian countries and to understand the drivers such as its price and quality that affect the introduction of oil sand in the Asian countries

With this goal in mind, following major items are studied.

(1) Understand supply and demand situations of conventional crude oil in the Asian countries in the year 2015

(2) Understand pricing and qualitative differences between oil sand and conventional crude oil that are marketed in the Asian countries

(3) Understand acceptable price and quality of oil sand that are processed by the Asian refineries in the year 2015

(4) Evaluate the marketability of oil sand in the Asian counties by reviewing following items.

- ◆ Review current and future refinery situations in the Asian countries
- ◆ Review current and future market situations for conventional crude oil
- ◆ Review qualitative differences between oil sand and conventional crude oil
- ◆ Review price differentials between oil sand and conventional crude oil
- ◆ Review candidate refineries which may process oil sand, especially SCO in Japan

(5) Evaluate the marketability of oil sand-derived products especially gasoline and diesel oil in the Asian counties.

1-2. Methods

IEEJ has conducted above study by following methods.

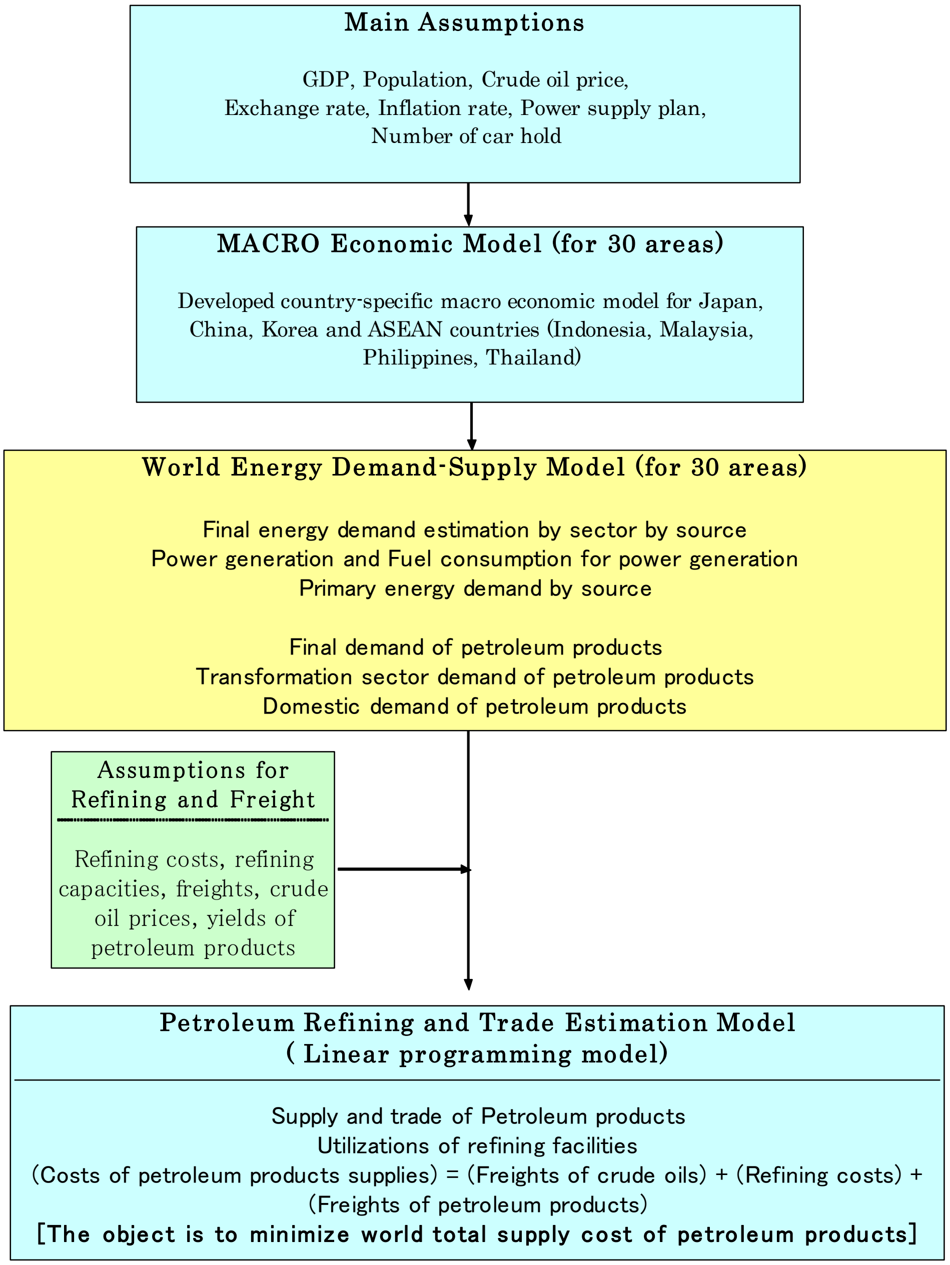
- ◆ Collection and analysis of related data and information
- ◆ Interviews and discussions with experts in the related organizations
- ◆ Apply the World Energy Demand-Supply Model (econometric model) and the Petroleum Refining and Trade Estimation Model (linear programming model) that are developed by IEEJ to determine acceptable quantity and most suitable quality of oil sand for the Asian market.

2. Model Outline

The model applied for the evaluation of the marketability of oil sand in the Study is a comprehensive one that consists of the World Energy Demand-Supply Model and the Petroleum Refining and Trade Estimation Model (see Figure 2-1-1).

1. World Energy Demand-Supply Model (econometric model)
2. Petroleum Refining and Trade Estimation Model (linear programming model)

Figure 2-1 Model Concept



The World Energy Demand-Supply Model is employed to identify the level of world energy demand and supply and to estimate the demand for each petroleum product. The Petroleum Refining and Trade Estimation Model is a comprehensive analysis tool that can identify the demand-supply balance for each country or region in a consistent manner and analyze international trade flows of crude oil and petroleum products by modeling petroleum refining and forming demand assumptions by petroleum products. Both models divide the world into 30 areas and are devised to individually analyze 18 major economies out of the 21 members of the Asia-Pacific Economic Cooperation forum (APEC).

Table 2-1 30 Areas

1. United States	12. FSU (Except Russia) & Non-OECD European Countries	23. Malaysia
2. Canada	13. Africa	24. Philippines
3. Mexico	14. Middle East	25. Thailand
4. Brazil	15. China	26. India
5. Other Central and South American countries	16. Japan	27. Vietnam
6. United Kingdom	17. Hong Kong	28. Other Asian countries
7. Germany	18. Taiwan	29. Australia
8. France	19. Korea	30. New Zealand
9. Italy	20. Singapore	
10. Other European OECD Countries	21. Brunei	
11. Russia	22. Indonesia	

Each model is outlined below:

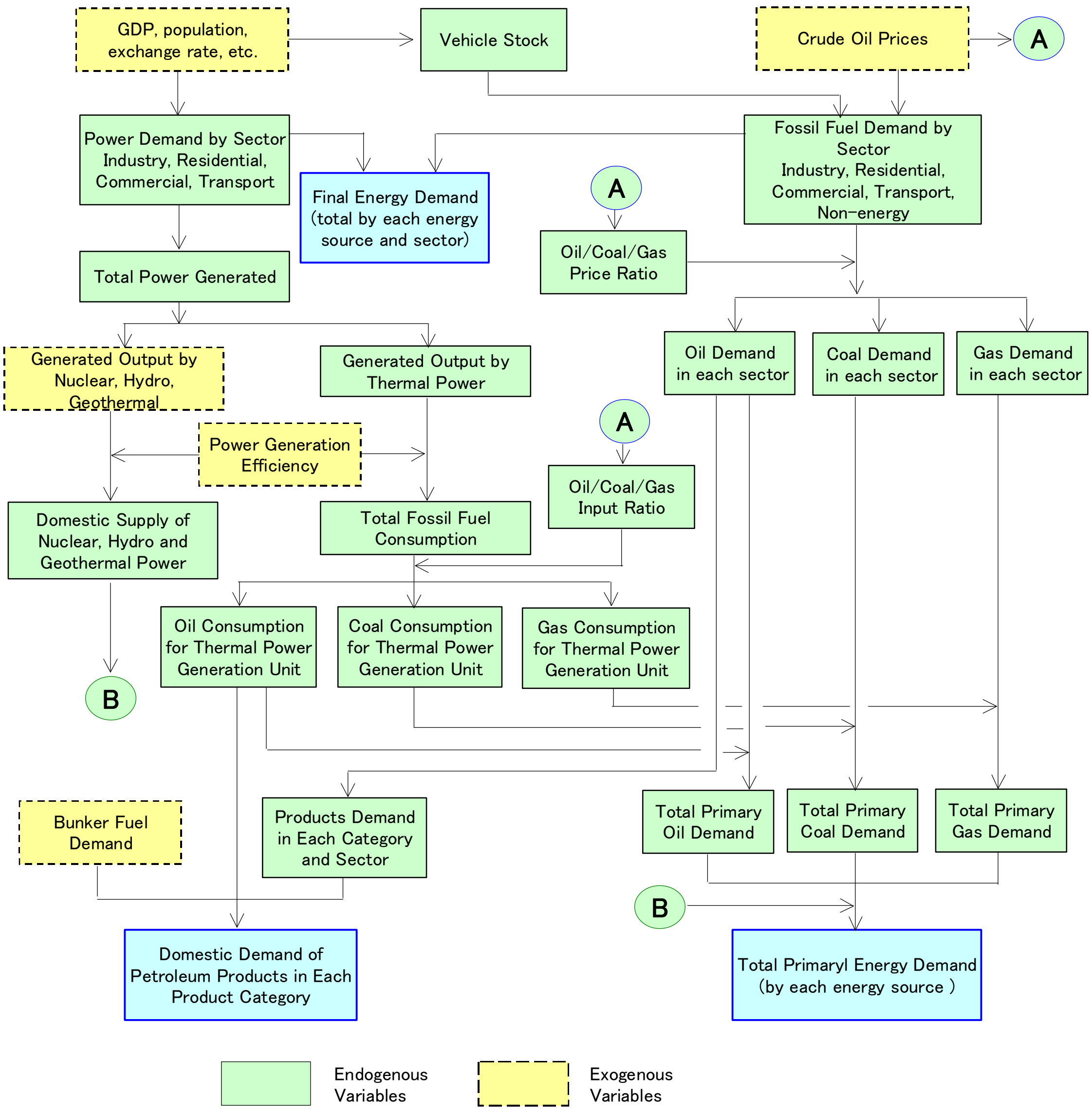
2-1. Outline of World Energy Demand-Supply Model

The World Energy Demand-Supply Model is a quantitative analysis tool that consists of energy source- and sector-based functions based on country-specific energy balance sheet data of the International Energy Agency (IEA). It is used to estimate demand for each petroleum product. The basic structure is indicated in Figure 2-2-1. But the model does not necessarily have the same structure for all 30 areas since estimation equations differ by individual country or region depending on energy demand/supply characteristics.

The model is devised to estimate energy demand for the final energy demand, energy conversion sectors and primary energy supply sectors on the energy balance sheet in a bottom-up manner to balance energy demand and supply.

Major exogenous variables include GDP, energy (crude oil) prices and population, as well as primary energy variables like nuclear, hydro, geothermal and renewable-energy power generation. Final energy consumption is the central component of the model, covering the industry, transport, residential, commercial and agriculture sectors, and non-energy use sectors. For the energy conversion sector, electricity output generated by utilities to meet electricity demand as estimated for final energy demand is estimated as a final electricity demand function.

Figure 2-1-1 World Energy Demand-Supply Model



Total power generation minus the exogenously-derived primary energy in the form of nuclear, hydro and geothermal output gives us the thermal power generation from fossil fuels. Fossil fuel input is estimated using the average thermal power generation efficiency. Input by fuel type is estimated with share functions, or with an estimated oil input share and an exogenously made natural gas input. Finally, primary demand for fossil fuel by energy source is estimated as a combination of input for electricity generation and demand for final consumption.

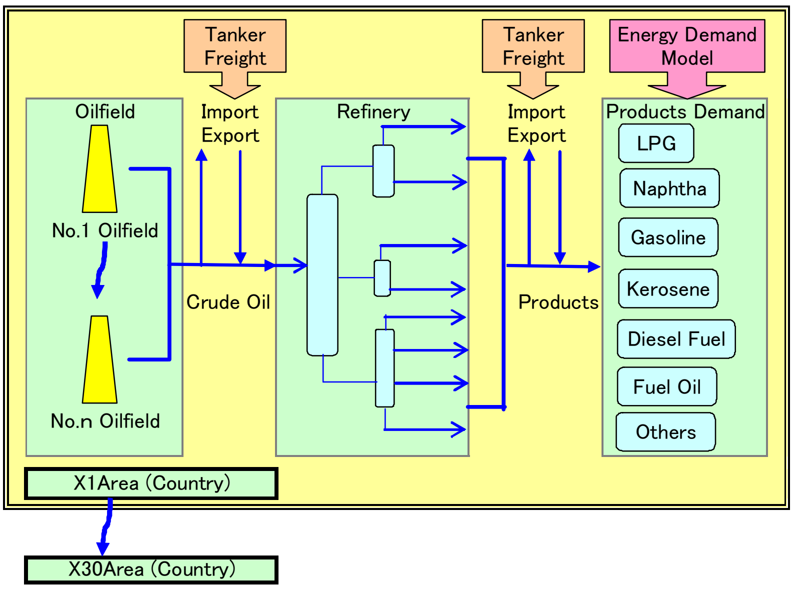
Among the major exogenous variables, crude oil price data is from the *Annual Energy Outlook 2006 Edition* by the U.S. Department of Energy. Population data is based on the estimation by the United Nations, by relevant countries and the IEA.

2-2. Outline of Petroleum Refining and Trade Estimation Model Structure

The Petroleum Refining and Trade Estimation Model is applied to the same 30 areas as those subjected to the above-mentioned World Energy Demand-Supply Model. The LP calculation specify an optimal solution of world oil production, trade and refinery operation etc. which minimize total energy system costs for the whole of the world as shown in Figure 2-2-2. Objective function consists of crude oil costs, crude oil and products trade costs, and oil-refining costs.

The model can be described for Country (or Area) X1 as follows: Country X1 produces crude oil at No. 1- No. n oilfields, and uses some of the crude oil output at its own refineries and exports the remainder to foreign countries. (If Country X1 is not an oil-producing country, it may unilaterally import crude oil.) Conversely, Country Xn sometimes imports crude oil from oil-producing countries such as Country X1 for domestic refining.

Figure 2-2-2 Concept of the Petroleum Refining and Trade Estimation Model



Refineries in Country Xn identify capacity utilization rates, product yields and other operational conditions to minimize refining costs. Petroleum products turned out at these refineries are used to meet domestic demand. Any surplus is exported to oil-consuming countries. If petroleum products production costs in Country Xn are higher than in other countries, Country Xn may minimize its own production and import these products in order to achieve the minimum possible cost on a global basis. This model targets trade of crude oil and petroleum products, other than intermediate goods.

Global refining and trade costs are a combination of crude oil trade, refinery operation and products trade costs in each country or area. Through the linear programming approach that permits variation in crude oil output and trade, refineries' capacity utilization rates and products transactions, the model estimates the mix of conditions to minimize global refining and trading costs.

2-2-1. Minimum cost vs Maximum profit LP modeling

In this model, oil refineries in the world are modeled as a "Linear Programming Problem" on a cost minimization basis. Due to the duality of the linear programming problem, a solution to the cost minimization problem can be replaced as that to the profit maximization problem. For the LP problem, it is guaranteed that the cost minimization solution is equal to the profit maximization solution. The solution is thus common to the cost minimization and profit maximization. However, it should be noted that these optimal solutions do not reflect the cost minimization or profit maximization of one specific country or area, but reflect that of world total. Consequently, these optimal solutions do not fully represent the profit maximization of one private company. On top of this, particularly in Japan, oil import diversification is a crucial issue in order to ensure its energy security. Therefore, these concerns would also influence exporters' and importers' decision in addition with the results derived from the model.

2-2-2. Major assumptions for LP

- There are 70 conventional crude oil types. The product yield and sulfur content are set for each crude oil type.
- CDU (crude distillation unit) and secondary processing unit capacity and operation costs for refineries are set for each of the 30 areas.
- VLCC, LR and MR freight is set between the 30 areas.

2-2-3. Assumptions for product standards

- An octane rating is set for each of the 30 areas.

- For diesel oil, demand for automobile use is separated from others. Sulfur content of diesel oil for automobiles and other uses are set by the relevant countries' standards for each of the 30 areas. The LP calculates an oil refining and trading volume that ensures the minimum costs as well as standard or lower sulfur content for a combination of oil refining (production) and products trading (imports).
- For fuel oil such as boiler fuel oil and bunker fuel oil, production and trade are set for two types – low-sulfur (0.2%) and high-sulfur (3%).

2-2-4. One refinery model for each country

For the purpose of simplifying this model, each area is assumed to have integrated refineries into a single location. The model data was based on primary and secondary sources, including data provided by the different countries. Long term forecast data are partly obtained by IEEJ interviews with selected companies. Refining capacity may be different from what companies presently planned.

These integrated refineries are also assumed to have crude distillation units and all representative secondary processing units for these areas' common energy flow for the integrated refinery model. Each model is assumed to freely select energy flows between various units of each refinery under the standard of minimum costs.

The reasons behind the assumption of integrated refineries include the following:

(i) No statistics exist to cover data (crude distillation unit capacity and secondary processing unit capacity) for all refineries in the world.

(ii) Even if models are developed for all refineries in the world, considerations may have to be given to oil flows between refineries, distribution from refineries to consumption points and other geographical flows. No data are available regarding downstream oil distribution in developing countries including China and India.

(iii) If a model were to be developed for every refinery in the world, a survey on crude oil brands at every refinery would have to be conducted. No such data exists

(iv) The linear programming approach can boost computation time exponentially by increasing parameters. Massive research and analysis time will be required.

(v) The purpose of this model analysis is to look into future oil flows between areas

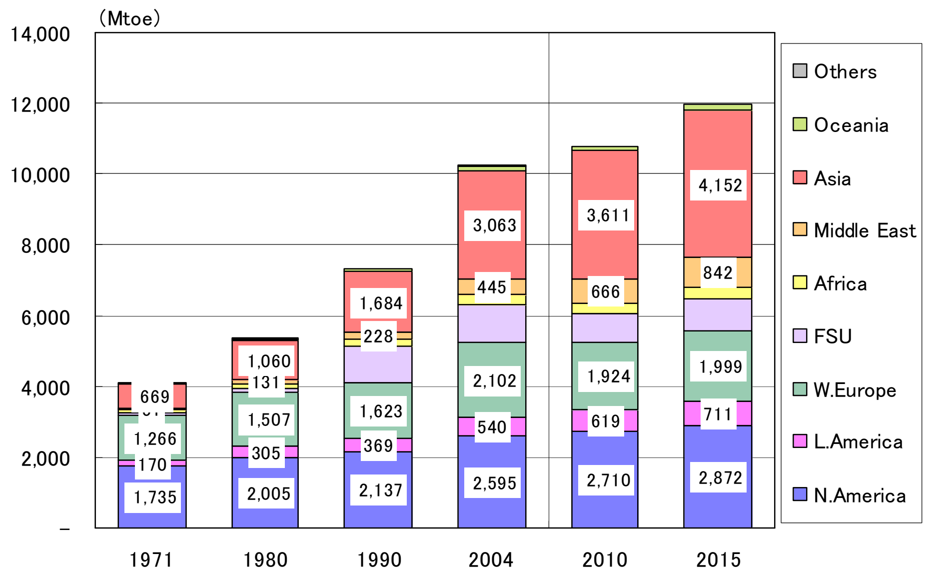
However, such model excludes regional market opportunities and may affect the import volumes for a particular country such as China where there is a big difference between inland and coastal areas.

3. Asia / World Energy outlook

3-1. World Primary Energy Consumption

The world's primary energy consumption is expected to increase at an average annual growth rate of 1.4% from 10,246 Mtoe in 2004 to 11,974 Mtoe in 2015. Asian primary energy consumption is projected to expand at an average annual growth rate of 2.8% from 3,063 Mtoe to 4,152 Mtoe in 2015. Since Asian consumption is thus estimated to rise faster than global consumption, Asia's share of global primary energy consumption is forecast to increase from 29.9% in 2004 to 34.7% in 2015.

Figure 3-1-1 World Primary Energy Consumption Outlook



*Including combustible renewables

Table 3-1-1 Average Annual Growth in World Primary Energy Consumption

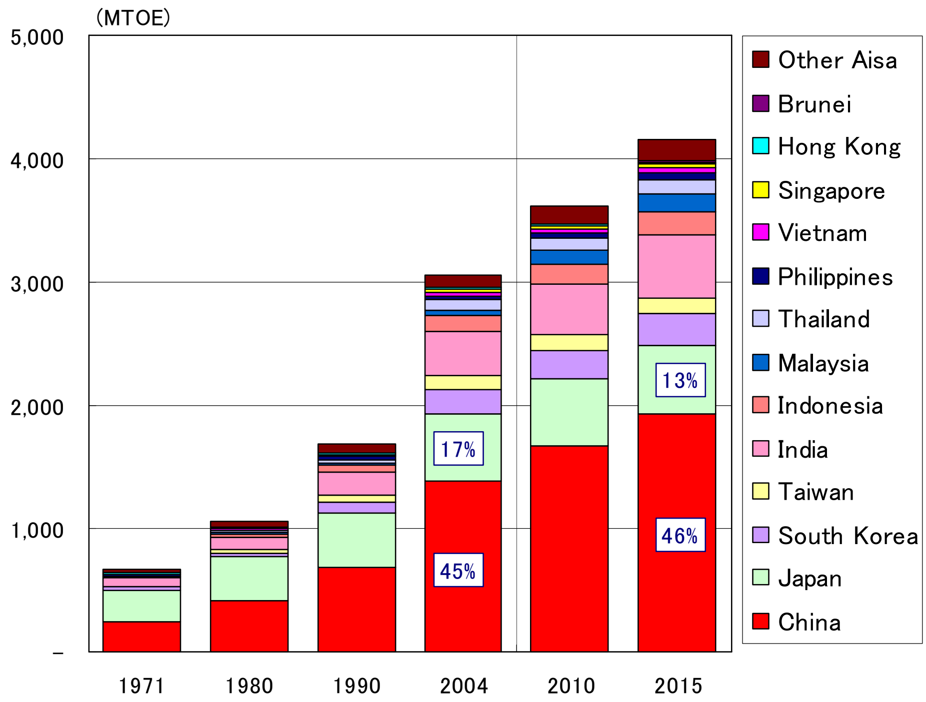
	1971-2004	2004-2015
N. America	1.2	0.9
L. America	3.6	2.5
W. Europe	1.5	-0.5
FSU	8.1	-1.6
Africa	4.1	1.5
Middle East	6.8	6.0
Asia	4.7	2.8
Oceania	2.5	1.6
Others	14.9	-11.7
World	2.8	1.4

Table 3-1-2 Primary Energy Consumption by Area

	1971	2004	2015
N. America	42.2	25.3	24.0
L. America	4.1	5.3	5.9
W. Europe	30.8	20.5	16.7
FSU	2.0	10.4	7.5
Africa	1.8	2.8	2.8
Middle East	1.2	4.3	7.0
Asia	16.3	29.9	34.7
Oceania	1.4	1.3	1.3
Others	0.0	0.2	0.0
World	100.0	100.0	100.0

3-2. Asian Primary Energy Consumption

Figure 3-2-1 Asian Primary Energy Consumption Outlook



*Including combustible renewables

Table 3-2-1 Average Annual Growth in Asian Primary Energy Consumption

	1971-2004	2004-2015
China	5.5	3.0
Japan	2.1	0.3
South Korea	8.0	2.0
Taiwan	7.2	2.2
India	5.5	3.3
Indonesia	8.4	3.5
Malaysia	7.6	8.8
Thailand	7.9	3.9
Philippines	4.2	4.6
Vietnam	4.0	3.0
Singapore	6.8	2.5
Hong Kong	5.0	1.3
Brunei	8.9	3.9
Other Asia	3.5	5.2
Total	4.7	2.8

Table 3-2-2 Asian Primary Energy Consumption by Area

	1971	2004	2015
China	35.5	45.3	46.4
Japan	40.3	17.4	13.3
South Korea	2.5	7.0	6.4
Taiwan	1.6	3.4	3.2
India	9.1	11.7	12.3
Indonesia	1.3	4.1	4.5
Malaysia	0.7	1.8	3.3
Thailand	1.0	2.7	3.0
Philippines	1.3	1.1	1.3
Vietnam	1.1	0.9	0.9
Singapore	0.4	0.8	0.8
Hong Kong	0.5	0.6	0.5
Brunei	0.0	0.1	0.1
Other Asia	4.7	3.2	4.1
Total	100.0	100.0	100.0

In particular, China is expected to boost primary energy consumption at an average annual growth rate of 3.0% from 1,389 Mtoe in 2004 to 1,927 Mtoe in 2015. China's share of Asian primary energy consumption is projected to rise from 45.3% in 2003 to 46.4% in 2015. Japan's primary energy consumption is expected to expand at an average annual growth rate of 0.3% from 533 Mtoe in 2004 to 552 Mtoe in 2015. Japan's share of Asian primary energy consumption is thus estimated to fall from 17.4% to 13.3% in 2015.

3-3. World/Asian Primary Energy Consumption (by Source)

A breakdown of world primary energy consumption by source shows that coal consumption is projected to increase at an average annual growth rate of 1.4% from 2004 to 2015, gas at 1.7% for the same period, oil at 1.3% and nuclear energy at 0.6%. Gas consumption are expected to expand fastest among fossil fuels, while nuclear energy consumption are predicted to grow at slowest pace among primary energies.

Oil's share of world primary energy consumption is forecast to drop from 37.6% in 2004 to 36.1% in 2015. Nuclear energy's share is also expected to fall from 7.2% to 6.4%, coal, from 27.4% in 2004 to 26.6% in 2015, while gas is forecast to grow moderately from 23.1% to 23.2%.

Figure 3-3-1 World Primary Energy Consumption Outlook (by Source)

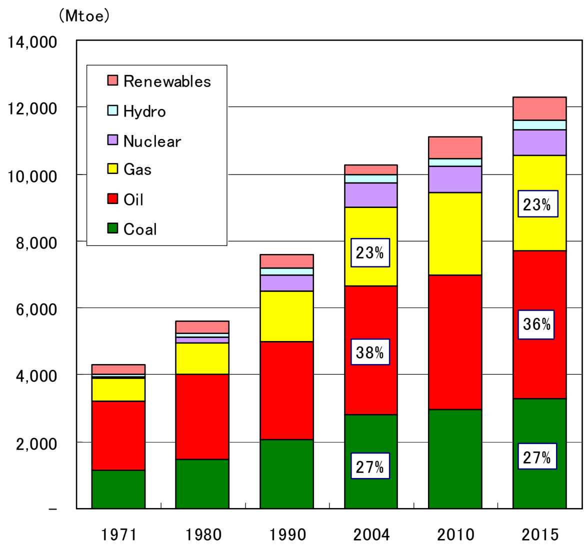


Figure 3-3-2 Asian Primary Energy Consumption Outlook (bySource)

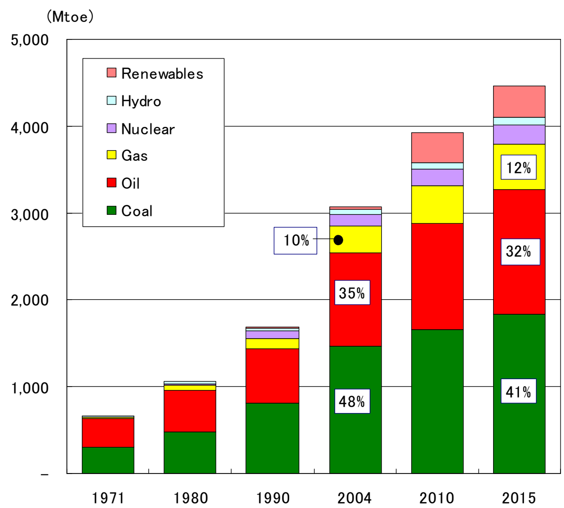


Table 3-3-1 Average Annual Growth in World Primary Energy Consumption (by Source)

%	1971-2004	2004-2015
Coal	2.8	1.4
Oil	1.9	1.3
Gas	3.7	1.7
Nuclear	10.5	0.6
Hydro	2.9	1.7
Renewables	-0.3	9.3
Total	2.7	1.7

Table 3-3-2 Average Annual Growth in Asian Primary Energy Consumption (by Source)

%	1971-2004	2004-2015
Coal	4.8	2.0
Oil	3.6	2.7
Gas	10.5	5.2
Nuclear	13.0	4.7
Hydro	4.1	3.7
Renewables	18.6	26.5
Total	4.7	3.5

Table 3-3-3 Breakdown of World Primary Energy Consumption by Source

%	1971	2004	2015
Coal	26.3	27.4	26.6
Oil	47.8	37.6	36.1
Gas	16.7	23.1	23.2
Nuclear	0.6	7.2	6.4
Hydro	2.1	2.3	2.4
Renewables	6.4	2.4	5.4
Total	100.0	100.0	100.0

Table 3-3-4 Breakdown of Asian Primary Energy Consumption by Source

%	1971	2004	2015
Coal	46.6	48.2	41.2
Oil	49.2	34.9	32.0
Gas	1.7	9.8	11.7
Nuclear	0.4	4.4	5.0
Hydro	2.2	1.8	1.8
Renewables	0.0	0.9	8.2
Total	100.0	100.0	100.0

4. Asia / World Petroleum Outlook

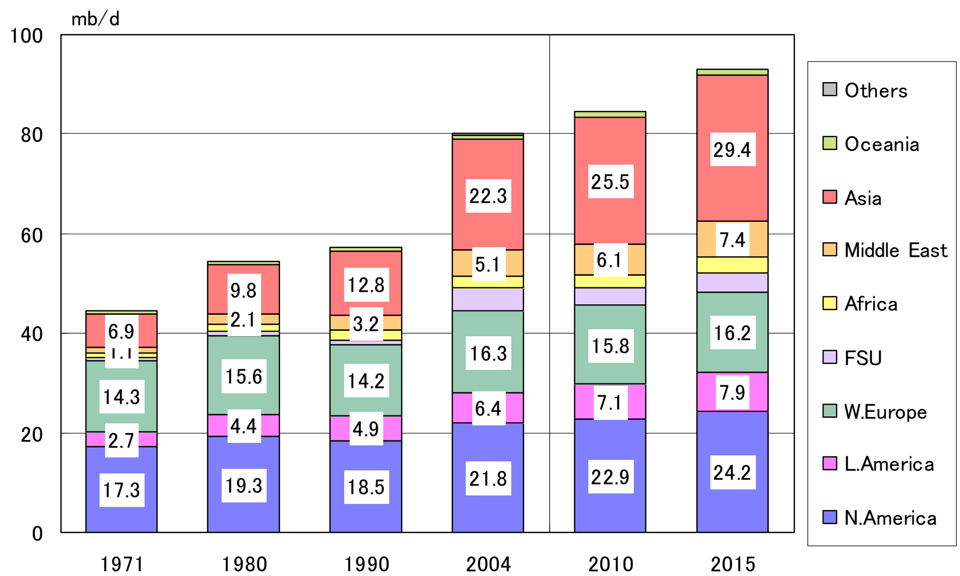
4-1. World Oil Consumption

World oil consumption is projected to increase by 12.9 million b/d from 80.2 million b/d in 2004 to 93.1 million b/d in 2015. Asian oil consumption is expected to expand by 7.1 million b/d from 22.3 million b/d in 2004 to 29.4 million b/d in 2015. The Asian share of world oil consumption is forecast to rise from 27.8% in 2004 to 31.5% in 2015. The Asian oil consumption increase between 2004 and 2015 is predicted to be at 7.1 million b/d, accounting for 55% of the expected global increase of 12.9 million b/d.

Table 4-1-1 World Oil Consumption Outlook

mb/d	1971	2004	2015	Incremental increase '04–'15	Share of incremental increase '04–'15
Asia	6.9	22.3	29.4	7.1	55%
N.America	17.3	21.8	24.2	2.4	19%
L.America	2.7	6.4	7.9	1.6	12%
W.Europe	14.3	16.3	16.2	−0.1	−1%
FSU	0.7	4.7	3.8	−0.9	−7%
Africa	0.9	2.4	3.0	0.6	5%
Middle East	1.1	5.1	7.4	2.2	17%
Oceania	0.6	0.9	1.2	0.3	2%
Others	0.0	0.3	0.0	−0.3	−2%
Total	44.6	80.2	93.1	12.9	100%

Figure 4-1-1 World Oil Consumption Outlook

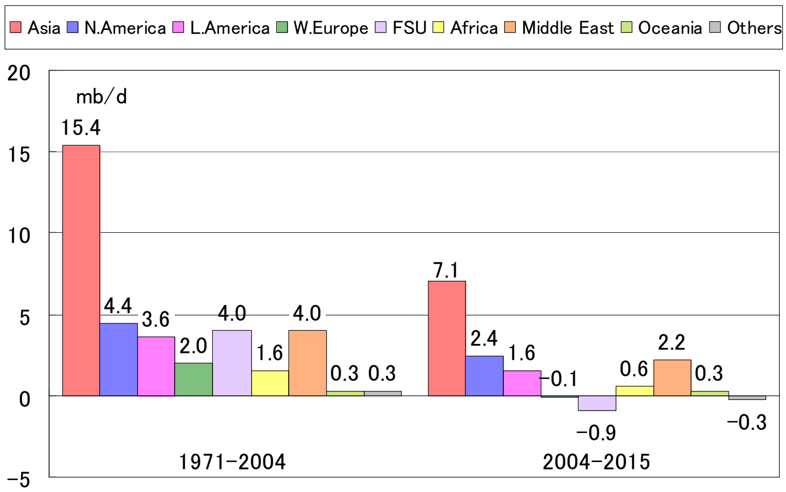


North America's oil consumption is projected to increase from 21.8 million b/d in 2004 to 24.2 million b/d in 2015, with its share of world oil consumption falling from 27.2% to 26.0%. The North American oil consumption increase between 2004 and 2015 is predicted to be at 2.4 million b/d, accounting for 19% of the expected global increase of 12.9 million b/d.

Table 4-1-2 Projected Share of World Oil Consumption by Region

	1971	2004	2015
Asia	15.4%	27.8%	31.5%
N.America	38.9%	27.2%	26.0%
L.America	6.2%	7.9%	8.5%
W.Europe	32.1%	20.3%	17.4%
FSU	1.5%	5.8%	4.0%
Africa	2.0%	3.0%	3.3%
Middle East	2.5%	6.4%	7.9%
Oceania	1.4%	1.1%	1.3%
Others	0.0%	0.4%	0.0%
Total	100.0%	100.0%	100.0%

Figure 4-1-2 Projected Growth in World Oil Consumption



4-2. Asian Oil Consumption

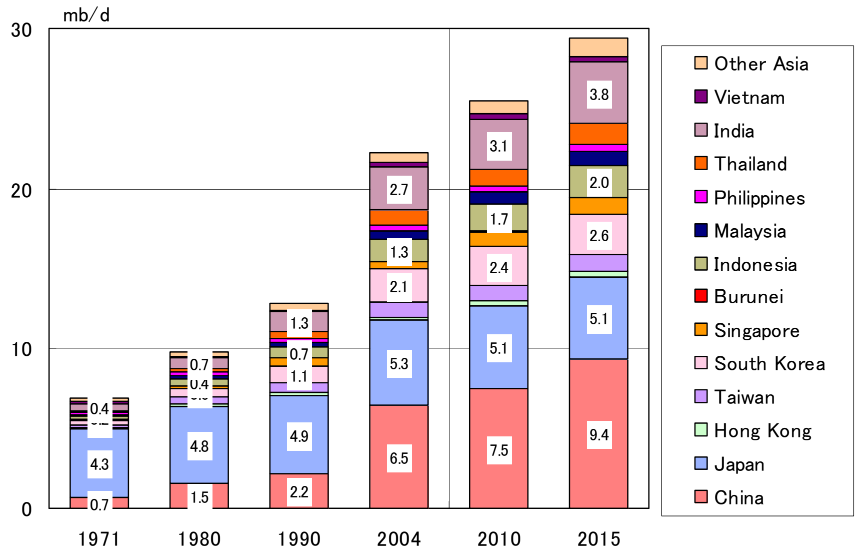
Within Asia, China is projected to boost oil demand by 2.9 million b/d from 6.5 million b/d in 2004 to 9.4 million b/d in 2015. As a result, China is predicted to capture 40.8% of Asian oil demand growth. India's oil demand is also forecast to rise by 1.1 million b/d from 2.7 million b/d in 2004 to 3.8 million b/d in 2015, accounting for 15.5%

of Asian oil demand growth.

Table 4-2-1 Asian Oil Consumption Outlook

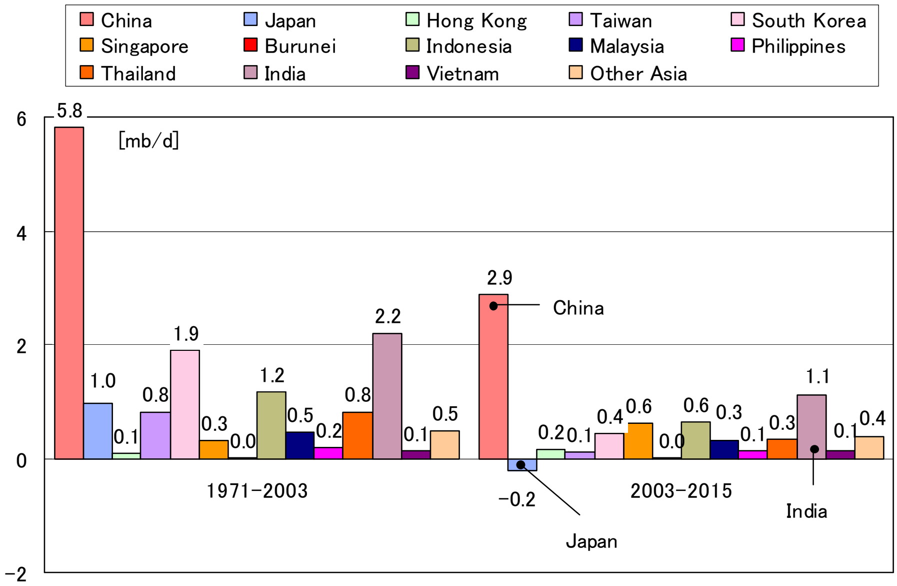
mb/d	1971	2004	2015	Incremental increase '04–'15	Share of incremental increase '04–'15
China	0.7	6.5	9.4	2.9	40.5%
Japan	4.3	5.3	5.1	−0.2	−3.1%
Hong Kong	0.1	0.2	0.3	0.2	2.4%
Taiwan	0.1	1.0	1.1	0.1	1.5%
South Korea	0.2	2.1	2.6	0.4	6.3%
Singapore	0.1	0.4	1.0	0.6	8.7%
Brunei	0.0	0.0	0.0	0.0	0.0%
Indonesia	0.2	1.3	2.0	0.6	8.9%
Malaysia	0.1	0.6	0.9	0.3	4.5%
Philippines	0.2	0.3	0.5	0.1	1.8%
Thailand	0.1	1.0	1.3	0.3	4.8%
India	0.4	2.7	3.8	1.1	16.0%
Vietnam	0.1	0.3	0.4	0.1	2.0%
Other Asia	0.2	0.7	1.1	0.4	5.7%
Total	6.9	22.3	29.4	7.1	100.0%

Figure 4-2-1 Asian Oil Consumption Outlook



In Asia, the transport sector expanded oil consumption by 6 million b/d between 1971 and 2004, the industry sector by 3 million b/d, and the residential and commercial sectors by 2.7 million b/d. The transport sector accounted for 52% of the total Asian oil consumption growth in the period, the industry sector for 24%, and the residential and commercial sectors for 22%.

Figure 4-2-2 Asian Oil Consumption Growth Outlook



The power generation sector posted an oil consumption increase of 0.3 million b/d, far smaller than other sectors. Between 2004 and 2015, the transport sector is projected to expand oil consumption by 3.9 million b/d, the industry sector by 1.6 million b/d, and the residential and commercial sectors by 1.0 million b/d. The transport sector is expected to account for 60% of the total Asian oil consumption growth in the period, the industry sector for 25%, and the residential and commercial sectors for 15%. Toward 2015, motorization is predicted to accelerate the transport sector to further expand oil consumption.

Figure 4-2-3 Asian Oil Consumption Growth

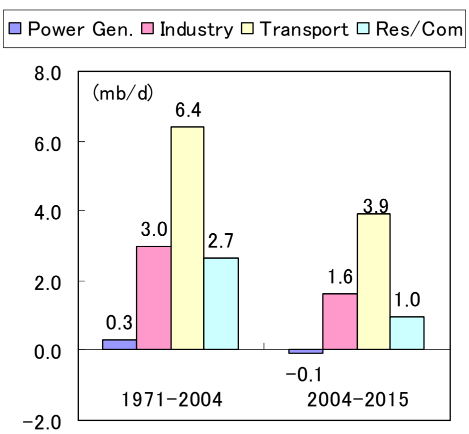
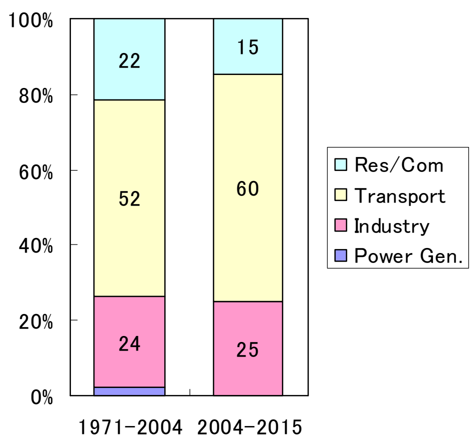


Figure 4-2-4 Share of Asian Oil Consumption Growth

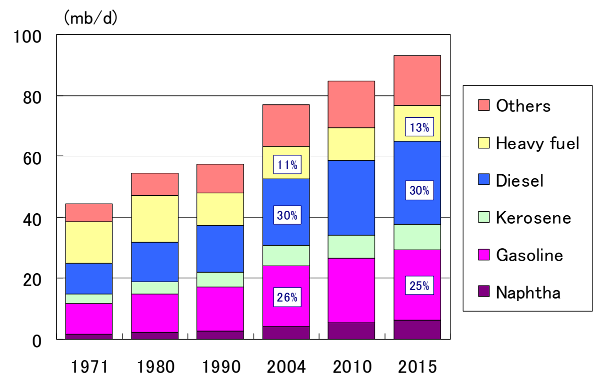


4-3. World/Asian Oil Supply/Demand

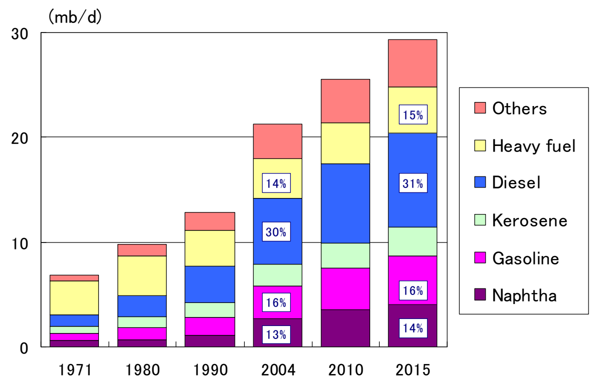
4-3-1. Petroleum Products Consumption

Figure 4-3-1 Regional Petroleum Products Consumption Outlook

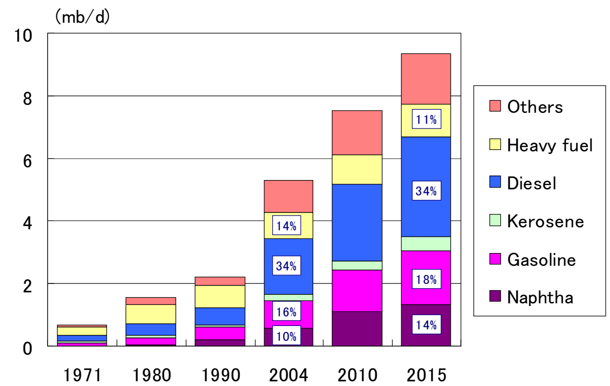
World



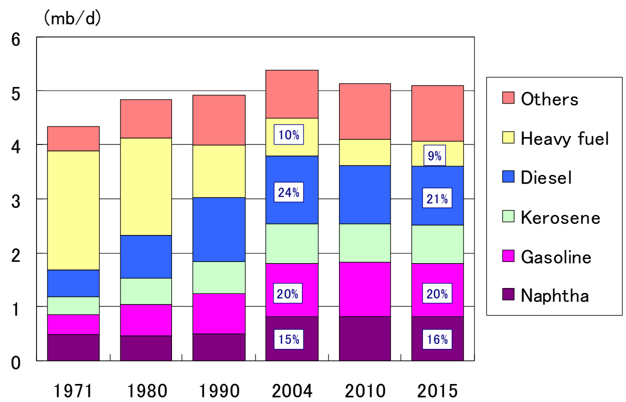
Asia



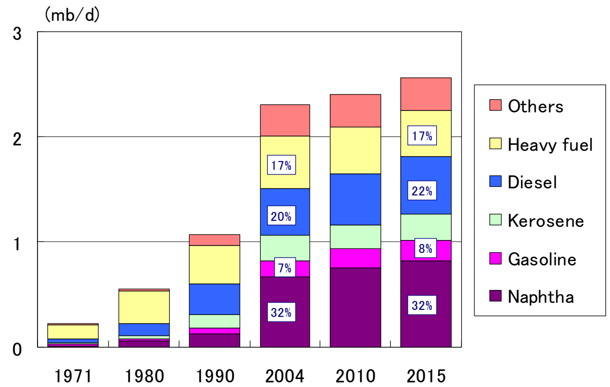
China



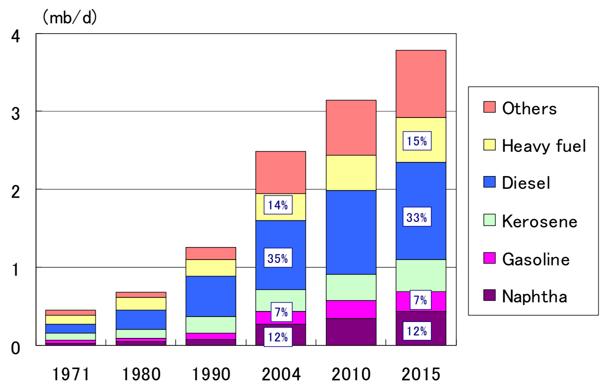
Japan



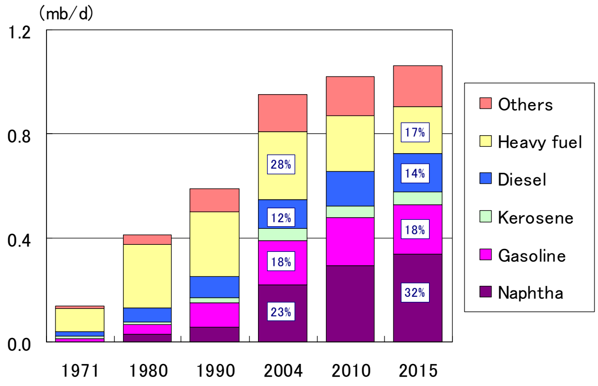
Korea



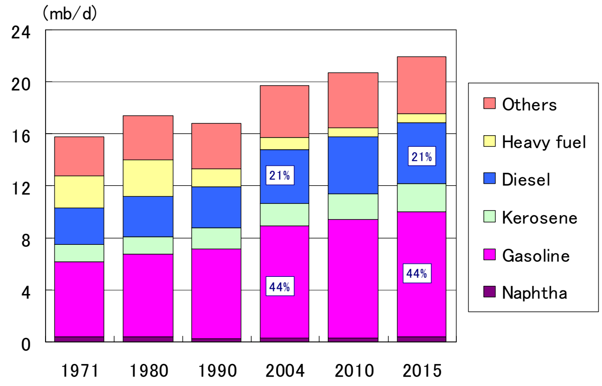
India



Taiwan



USA



World petroleum products consumption as of 2004 includes 19.8 million b/d in gasoline (25.5% of total oil consumption), 23.3 million b/d in diesel oil (29.9%), and 8.5 million b/d in fuel oil (10.9%). Between 2004 and 2015, gasoline consumption is projected to increase at an average annual growth rate of 1.4% to 23.0 million b/d, diesel oil consumption at a 1.5% rate to 27.5 million b/d, and fuel oil consumption at a 3.0% rate to 11.7 million b/d. The share of total petroleum consumption in 2015 is estimated to rise to 29.5% for diesel oil, level off at 24.7% for gasoline, and fall to 12.5% for fuel oil.

Asian petroleum products consumption in 2004 includes 3.3 million b/d of gasoline (15.7% of total oil consumption), 6.5 million b/d of diesel oil (30.4%), and 3.0 million b/d of fuel oil (13.9%). Between 2004 and 2015, gasoline consumption is projected to increase at an average annual growth rate of 2.9% to 4.6 million b/d, diesel oil consumption at a 3.0% rate to 9.0 million b/d, and fuel oil consumption at a 3.6% rate to 4.3 million b/d. The share of total oil consumption in 2015 is estimated to be 15.7% for gasoline and rise to 30.6% for diesel oil, and 14.8% for fuel oil.

Diesel oil is forecast to account for 31% of the total Asian oil consumption growth, gasoline for 16%, naphtha for 14%, heavy oil for 17%, and kerosene for 9%. Diesel demand will be derived from transport sector and private power generation sector, gasoline from transport sector, naphtha and heavy oil from industry sector.
Among petroleum demand growth in Asia, heavy fuel oil, mainly consumed for heating use in basic material production industry such as steel or cement, will post higher increasing rate in projection period than the past period from 1971 to 2004, as shown in Table 4-3-1. Toward 2015, industrialization in developing Asian countries is projected to promote the industry sector and thus further increase heavy oil demand.

Table 4-3-1 Regional Petroleum Products Consumption Outlook

World

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	1.8	4.9	6.2	3.1	2.3
Gasoline	10.0	19.8	23.0	2.1	1.4
Kerosene	3.1	6.6	8.3	2.3	2.0
Diesel	10.0	23.3	27.5	2.6	1.5
Heavy fuel	13.8	8.5	11.7	-1.5	3.0
Others	5.8	14.7	16.4	2.9	1.0
Total	44.6	77.8	93.1	1.7	1.6

Asia

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	0.5	2.8	4.0	5.2	3.2
Gasoline	0.7	3.3	4.6	4.9	2.9
Kerosene	0.7	2.1	2.8	3.5	2.6
Diesel	1.2	6.5	9.0	5.3	3.0
Heavy fuel	3.2	3.0	4.3	-0.2	3.6
Others	0.6	3.6	4.6	5.3	2.4
Total	6.9	21.3	29.4	3.5	3.0

China

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	0.0	0.6	1.3	-	7.0
Gasoline	0.1	1.0	1.7	7.3	4.8
Kerosene	0.1	0.3	0.4	4.9	3.1
Diesel	0.2	2.1	3.2	7.3	3.9
Heavy fuel	0.2	0.9	1.0	3.9	1.7
Others	0.1	1.3	1.6	9.5	2.1
Total	0.7	6.2	9.4	7.0	3.8

Japan

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	0.5	0.8	0.8	1.5	0.2
Gasoline	0.4	1.0	1.0	3.2	0.0
Kerosene	0.3	0.7	0.7	2.4	-0.1
Diesel	0.5	1.2	1.1	2.8	-1.2
Heavy fuel	2.2	0.5	0.5	-4.2	-1.4
Others	0.5	0.8	1.0	1.9	2.0
Total	4.3	5.1	5.1	0.5	0.0

South Korea

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	0.0	0.7	0.8	13.9	1.6
Gasoline	0.0	0.2	0.2	7.2	2.1
Kerosene	0.0	0.2	0.2	9.9	1.3
Diesel	0.0	0.4	0.6	7.3	2.4
Heavy fuel	0.1	0.4	0.4	3.0	1.8
Others	0.0	0.3	0.3	11.0	0.2
Total	0.2	2.1	2.6	7.2	1.6

India

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	0.0	0.3	0.4	7.5	3.1
Gasoline	0.0	0.2	0.3	5.2	3.1
Kerosene	0.1	0.3	0.4	3.2	4.0
Diesel	0.1	0.9	1.2	6.4	2.8
Heavy fuel	0.1	0.4	0.6	3.5	4.6
Others	0.1	0.6	0.9	7.1	4.0
Total	0.4	2.6	3.8	5.5	3.5

Taiwan

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	0.0	0.2	0.3	-	5.5
Gasoline	0.0	0.1	0.2	7.9	2.6
Kerosene	0.0	0.0	0.1	4.1	2.7
Diesel	0.0	0.1	0.1	5.4	4.1
Heavy fuel	0.1	0.2	0.2	2.8	-1.9
Others	0.0	0.1	0.2	7.1	2.6
Total	0.1	0.8	1.1	5.4	2.6

USA

mb/d	1971	2004	2015	AAGR, % 1971-2004	AAGR, % 2004-2015
Naphtha	0.4	0.3	0.4	-1.1	2.8
Gasoline	5.8	7.9	9.6	0.9	1.8
Kerosene	1.3	1.6	2.2	0.6	3.2
Diesel	2.8	3.8	4.7	1.0	1.8
Heavy fuel	2.5	0.8	0.7	-3.3	-2.3
Others	3.0	3.7	4.4	0.6	1.7
Total	15.8	18.0	21.9	0.4	1.8

*AAGR: Average Annual Growth Rate

** Oil consumption by petroleum product includes finial consumption and energy input for energy conversion sector.

China's petroleum products consumption in 2004 include 1.0 million b/d of gasoline (16.4% of total oil consumption), 2.1 million b/d of diesel oil (33.7%), and 0.9 million b/d of fuel oil (13.8%). Between 2004 and 2015, gasoline consumption is projected to increase at an average annual growth rate of 4.8% to 1.7 million b/d, diesel oil consumption at a 3.9% rate to 3.2 million b/d, and fuel oil consumption at a 1.7% rate to 1 million b/d. The share of total oil consumption in 2015 is estimated to rise to 18.3% for gasoline and to 34.3% for diesel oil, and fall to 11.0% for fuel oil.

Table 4-3-2 Share of Regional Oil Consumption by Product

World

	1971	2004	2015
Naphtha	3.9%	6.3%	6.7%
Gasoline	22.6%	25.5%	24.7%
Kerosene	7.0%	8.5%	8.9%
Diesel	22.5%	29.9%	29.5%
Heavy fuel	31.0%	10.9%	12.5%
Others	13.0%	18.9%	17.6%
Total	100.0%	100.0%	100.0%

Asia

	1971	2004	2015
Naphtha	7.7%	13.3%	13.6%
Gasoline	10.2%	15.7%	15.7%
Kerosene	10.1%	10.0%	9.6%
Diesel	16.9%	30.4%	30.6%
Heavy fuel	45.8%	13.9%	14.8%
Others	9.4%	16.7%	15.7%
Total	100.0%	100.0%	100.0%

China

	1971	2004	2015
Naphtha	0.0%	10.2%	14.3%
Gasoline	14.8%	16.4%	18.3%
Kerosene	9.7%	5.2%	4.8%
Diesel	30.2%	33.7%	34.3%
Heavy fuel	35.7%	13.8%	11.0%
Others	9.6%	20.8%	17.3%
Total	100.0%	100.0%	100.0%

Japan

	1971	2004	2015
Naphtha	11.2%	15.4%	15.8%
Gasoline	8.3%	19.7%	19.7%
Kerosene	7.7%	14.1%	14.0%
Diesel	11.4%	24.1%	21.2%
Heavy fuel	50.9%	10.4%	8.9%
Others	10.5%	16.4%	20.4%
Total	100.0%	100.0%	100.0%

South Korea

	1971	2004	2015
Naphtha	4.4%	32.3%	32.1%
Gasoline	7.0%	7.1%	7.5%
Kerosene	4.3%	9.9%	9.6%
Diesel	18.8%	19.7%	21.5%
Heavy fuel	61.0%	16.6%	17.0%
Others	4.5%	14.3%	12.3%
Total	100.0%	100.0%	100.0%

India

	1971	2004	2015
Naphtha	6.4%	12.1%	11.5%
Gasoline	7.6%	7.1%	6.8%
Kerosene	20.9%	10.3%	10.9%
Diesel	26.1%	35.1%	32.7%
Heavy fuel	25.7%	13.6%	15.3%
Others	13.1%	21.7%	22.8%
Total	100.0%	100.0%	100.0%

Taiwan

	1971	2004	2015
Naphtha	0.0%	23.3%	31.8%
Gasoline	8.3%	17.7%	17.8%
Kerosene	7.4%	4.9%	4.9%
Diesel	11.7%	11.5%	13.6%
Heavy fuel	63.7%	27.7%	17.0%
Others	8.8%	14.8%	14.9%
Total	100.0%	100.0%	100.0%

USA

	1971	2004	2015
Naphtha	2.6%	1.6%	1.7%
Gasoline	36.7%	43.5%	43.7%
Kerosene	8.1%	8.6%	10.0%
Diesel	17.8%	21.3%	21.4%
Heavy fuel	16.0%	4.7%	3.0%
Others	18.9%	20.4%	20.1%
Total	100.0%	100.0%	100.0%

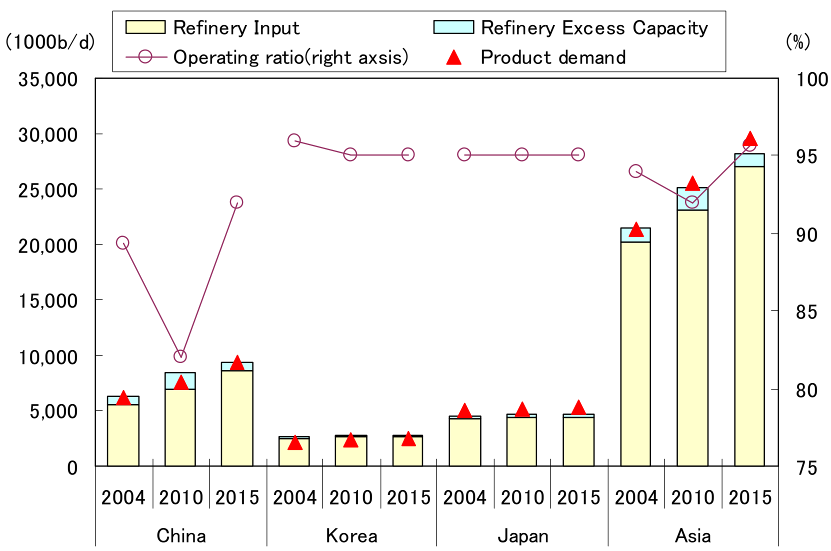
Japan's petroleum products consumption in 2004 include 1 million b/d of gasoline (19.7% of total oil consumption), 1.2 million b/d of diesel oil (24.1%), and 0.5 million b/d of fuel oil (10.4%). Between 2004 and 2015, gasoline consumption is projected to be almost unchanged to 1.0 million b/d, while diesel oil consumption is expected to decrease at an average annual growth rate of -1.2% to 1 million b/d, and fuel oil consumption is predicted to decrease at a rate of -1.4% to 0.5 million b/d. The share of total oil consumption in 2015 is estimated to be 19.7% for gasoline, fall to 21.2% for diesel oil, and fall to 8.9% for fuel oil.

India's petroleum products consumption in 2004 include 0.2 million b/d of gasoline (7.1% of total oil consumption), 0.9 million b/d of diesel oil (35.1%), and 0.4 million b/d of fuel oil (13.6%). Between 2004 and 2015, gasoline consumption is projected to increase at an average annual growth rate of 3.1% to 0.3 million b/d, diesel oil consumption at a 2.8% rate to 1.2 million b/d, and fuel oil consumption at a 4.6% rate to 0.6 million b/d. The share of total oil consumption in 2015 is estimated to fall to 6.8% for gasoline, 32.7% for diesel oil, and rise to 15.3% for fuel oil.

4-3-2. Petroleum Products Supply/Demand

Regarding petroleum products supply/demand in Asia, net product imports are projected to increase from 1.064 million b/d in 2004 to 2.536 million b/d in 2015. The capacity utilization ratio for refineries in the whole of Asia is expected to rise from 93.9% in 2004 to 95.7% in 2015, indicating that Asian refineries would continue operating almost at full capacity on the strength of robust demand for petroleum products.

Figure 4-3-2 Asian Petroleum Products Supply/Demand Outlook



In China, demand for petroleum products is estimated to increase by an annual average of about 0.29 million b/d from 2004 to 2015, and refining capacity is projected to expand by a total of 3.035 million b/d (or an annual average of about 0.28 million b/d). Since China's domestic supply/demand relationship is expected to remain tight toward 2015, the capacity utilization ratio is estimated to rise from 89.3% in 2004 to 92.0% in 2015.

In South Korea, domestic oil demand and exports to China are projected to firmly increase, while refining capacity is expected to increase slightly, from 2.60 million b/d in 2004 to 2.735 million b/d in 2015. The capacity utilization ratio is forecast to reach the theoretical ceiling of 95% by 2015. South Korea is expected to maintain net exports of petroleum products including fuel oil, diesel oil, kerosene and gasoline between 2004 and 2015.

Table 4-3-3 Asian Petroleum Products Supply/Demand Outlook

China	2004			2010			2015		
	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d
Total	6,214	5,618	-596	7,527	6,927	-599	9,355	8,579	-776
Gasoline	1,017	1,131	115	1,311	1,311	0	1,710	1,710	0
Naphtha	636	622	-14	1,103	784	-319	1,335	966	-369
Kerosene	53	33	-20	305	309	4	450	450	0
Diesel	2,096	2,085	-11	2,443	2,518	75	3,205	3,204	0
Heavy	855	423	-432	960	588	-373	1,033	766	-267
CDU (1,000b/d)	6,289	Operating ratio	89.3%	8,446	Operating ratio	82.0%	9,324	Operating ratio	92.0%
South Korea	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d
Total	2,143	2,493	350	2,399	2,598	200	2,560	2,598	38
Gasoline	152	197	45	184	208	24	192	208	16
Naphtha	693	443	-251	749	468	-281	822	468	-355
Kerosene	126	144	18	226	294	68	246	349	103
Diesel	422	626	204	493	728	235	551	728	177
Heavy	356	598	242	442	650	208	435	650	214
CDU (1,000b/d)	2,598	Operating ratio	96.0%	2,735	Operating ratio	95.0%	2,735	Operating ratio	95.0%
Japan	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d
Total	5,116	4,307	-809	5,136	4,438	-697	5,284	4,438	-846
Gasoline	1,006	951	-56	1,014	1,159	146	993	993	0
Naphtha	789	326	-463	805	244	-561	703	244	-459
Kerosene	496	479	-17	720	688	-32	720	688	-32
Diesel	1,231	1,230	0	1,086	1,154	68	1,240	1,110	-130
Heavy	532	620	88	482	444	-38	588	580	-8
CDU (1,000b/d)	4,531	Operating ratio	95.1%	4,672	Operating ratio	95.0%	4,672	Operating ratio	95.0%
Asia	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d	Consumption 1000b/d	Production 1000b/d	Net Export 1000b/d
Total	21,291	20,227	-1,064	25,507	23,118	-2,389	29,543	27,007	-2,536
Gasoline	3,345	3,389	44	3,952	4,013	61	4,593	4,576	-17
Naphtha	2,840	2,073	-767	3,519	2,562	-957	3,903	2,832	-1,072
Kerosene	1,150	1,086	-64	2,430	2,334	-96	2,822	2,729	-92
Diesel	6,467	6,524	57	7,532	7,761	228	9,154	8,980	-174
Heavy	2,954	3,065	111	3,971	2,879	-1,092	4,472	4,109	-363
CDU (1,000b/d)	21,536	Operating ratio	93.9%	25,126	Operating ratio	92.0%	28,225	Operating ratio	95.7%

In Japan, domestic oil demand is projected to decrease in the medium and long terms, while refining capacity is expected to fall slightly through consolidation of refineries. Therefore, the refinery capacity utilization ratio is expected to remain at 95% toward 2010 or 2015.

4-3-3. Oil Supply/Demand

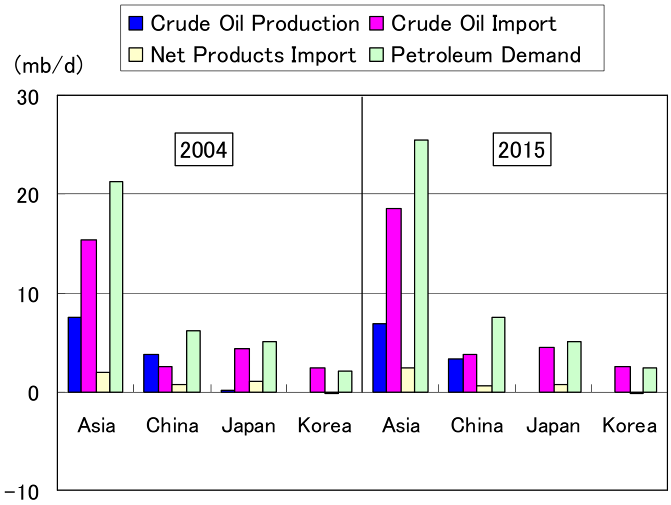
Asia depended on imports for about 72% of its oil supply in 2004. (The percentage represents the ratio of crude oil and petroleum products imports to total oil demand.) The crude oil and petroleum products supply/demand outlook for Asia indicates that the region's crude oil imports are estimated at about 23.2 million b/d or about 78% of the local oil supply in 2015, while its petroleum product imports are projected to be about 6.2 million b/d or about 21% of the local oil supply.

As a result, Asia's dependence on oil imports would rise steadily from 73% in 2004 to about 86% in 2015, due to increasing consumption and slackening local crude oil production. Energy security may thus be positioned as a more important challenge in Asia.

Table 4-3-4 Asian Oil Supply/Demand Outlook

	2004				2010				2015			
mb/d	Japan	Korea	China	Asia	Japan	Korea	China	Asia	Japan	Korea	China	Asia
Crude Oil Production	0.0	0.0	3.7	7.6	0.0	0.0	3.2	6.9	0.0	0.0	3.0	7.0
Domestic supply	0.0	0.0	3.6	5.8	0.0	0.0	3.2	4.7	0.0	0.0	2.6	4.3
Crude Oil Import	4.4	2.4	2.6	15.4	4.5	2.6	3.7	18.5	4.5	2.6	6.3	23.2
Middle East	4.0	1.9	1.2	10.9	4.2	2.2	2.0	14.2	4.2	2.3	2.5	15.3
Asia	0.2	0.2	0.2	1.7	0.3	0.1	0.1	1.4	0.2	0.0	0.0	2.0
Middle East Share %	91.6	78.1	47.2	70.8	92.1	85.0	55.2	77.0	92.3	90.0	39.7	66.1
Refining Capacity	4.5	2.6	6.3	21.5	4.7	2.7	8.4	25.1	4.7	2.7	9.3	28.2
Refinery Production	4.3	2.5	5.6	20.2	4.4	2.6	6.9	23.1	4.4	2.6	8.6	27.0
Operating Ratio %	95.1	96.0	89.3	93.9	95.0	95.0	82.0	92.0	95.0	95.0	92.0	95.7
Products Demand	5.1	2.1	6.2	21.3	5.1	2.4	7.5	25.5	5.3	2.6	9.4	29.5
Products Import	1.1	0.5	1.0	5.4	1.0	0.7	0.8	6.2	1.0	0.7	0.8	6.2
Middle East	0.5	0.3	0.2	1.8	0.6	0.3	0.2	1.6	0.6	0.3	0.3	2.1
Asia	0.2	0.1	0.6	2.3	0.2	0.1	0.3	3.0	0.1	0.0	0.4	3.1
Middle East Share %	45.4	66.2	21.9	33.9	57.5	41.3	26.7	26.4	58.7	38.5	33.6	34.5
Products Export	0.1	0.7	0.3	3.4	0.3	0.9	0.2	3.8	0.1	0.7	0.1	3.6
Asia	0.1	0.5	0.1	2.3	0.3	0.8	0.2	2.8	0.1	0.4	0.0	3.0
Net export	−1.0	0.2	−0.6	−2.0	−0.7	0.2	−0.6	−2.4	−0.8	0.0	−0.8	−2.5

Figure 4-3-3 Asian Oil Supply/Demand Outlook



5. Oil Sands Export Study

5-1. Feasibility of Oil Sand Introduction

Options for oil sand exports as crude oil include Sweet SCO with higher value added, or SynSynBit, SynBit, and DilBit, which are inferior to Sweet SCO in quality and thus prices. If oil sand is refined into petroleum products in Canada, gasoline or diesel oil may also be exported.

While various options for oil sand exports are conceivable, it may be important for Canada to estimate oil sand exports to the United States and Asia for each option in developing a medium-to-long-term oil sand production plan. In this respect, determinants of the oil sand volume for introduction into the international oil market include oil sand prices, national oil demand trends, oil demand mixes and refinery mixes. This analysis takes all these determinants into account in making the estimation.

The Petroleum Refining and Trade Estimation Model specifically takes into account crude oil prices, the national demand for each product and refineries. This model is employed to analyze oil sand introduction in the United States and Asia by oil sand category and by petroleum product.

This section deals with a category-by-category or product-by-product sensitivity analysis on the feasibility of oil sand introduction in the global oil market in 2015, to estimate oil sand exports to the United States and Asia and oil sand production.

In this section, we analyze the following six cases for the introduction of oil sand in the international oil market in 2015:

(1) Exporting Sweet SCO oil sand (for only the United States as a reference case)
(2) Exporting Sweet SCO oil sand
(3) Exporting SynSynBit oil sand
(4) Exporting SynBit oil sand
(5) Exporting DilBit oil sand
(6) Selecting Sweet SCO, SynSynBit, SynBit or DilBit for exports through optimization
(7) Exporting gasoline or diesel oil refined from oil sand

5-1-1. Oil Sand Characteristics

SynSynBit oil sand features an SCO content of 64% and a bitumen content of 36%. For SynBit, SCO content is 48% and the bitumen content 52%. DilBit, SynBit and SynSynBit feature high total acid number (TAN) and may cause corrosion of pipes etc. at refineries. However, conventional refineries may have limited problems in processing oil sand by mixing with other low TAN crude oils as long as the TAN in mixed crude is no more than 1.0.

Table 5-1-1 Oil Sand Characteristics

Blend Ratio Vol%	Athabasca Bitumen	Dilbit (Cold Lake Blend)	SynBit	SynSynBit	Sweet SCO
Bitumen	100	72	52	36	–
SCO	–	–	48	64	100
Condensate	–	28	–	–	–
API	8.3	22.6	19.9	24.2	34.8
Sulfur	4.8	3.39	2.5	1.8	0.1
TAN (mgKOH/g)	4	2.9	2	1.4	0

5-1-2. Oil Sand Price Assumptions

Price assumptions of oil sand for 2004 was based on estimated price differentials between net back prices for Japan and the WTI crude price in the study by Purvin & Gertz, Inc.. Sweet SCO price for 2015 is assumed to be close to Arab Extra Light price. SynBit and SynSynBit prices are envisaged to retain the same percentage price differentials with Dubai and Arab Extra Light prices between 2004 and 2015. DilBit price is assumed to follow Dubai price trend.

Table 5-1-2 Oil Sand Price Assumptions

	2004	2010	2015
WTI	49.0	61.3	75.9
Arab Extra Light	47.0	56.4	69.8
Arab Light	44.9	54.3	67.7
Arab Medium	43.0	52.0	64.5
Arab Heavy	40.6	49.1	61.0
DilBit	37.6	45.5	56.4
Sweet SCO	47.3	57.2	70.9
SynSynBit	42.1	50.9	63.1
SynBit	40.4	48.8	60.6
Dubai	43.7	52.9	65.6

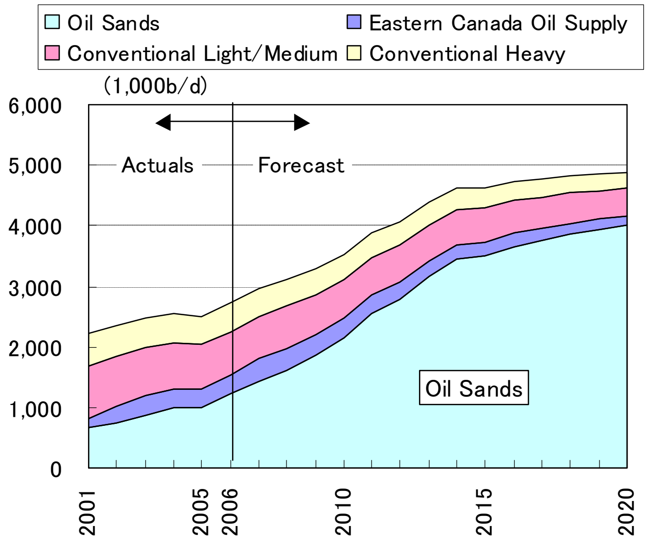
5-1-3. Canada's Oil Production Ceiling

The Canadian Association of Petroleum Producers (CAPP) has estimated in its Canadian Crude Oil Production Forecast 2006-2020 in May 2006, that Canada's oil production, including oil sand, to expand from 2.509 million b/d in 2005 to 4.617 million b/d in 2015, and to 4.878 million b/d in 2020.

Table 5-1-3 Canada's Oil Production Outlook (Source: CAPP)

1,000b/d	Actual	Forecast			
	2005	2006	2010	2015	2020
Eastern Canada Oil	306	315	320	230	161
Conventional	738	724	652	552	457
Conventional Heavy	475	467	412	340	263
Oil Sands	990	1,216	2,151	3,495	3,997
Total	2,509	2,722	3,535	4,617	4,878

Figure 5-1-1 Canada's Oil Production Outlook (Source: CAPP)



Since the CAPP estimates Canada's oil production at 5 million b/d over a medium to long term, the ceiling on Canada's oil production in 2015 is put at 5.2 million b/d, some 10% more than the CAPP estimate, for our following analysis.

5-1-4. Oil Sand Exports Analysis

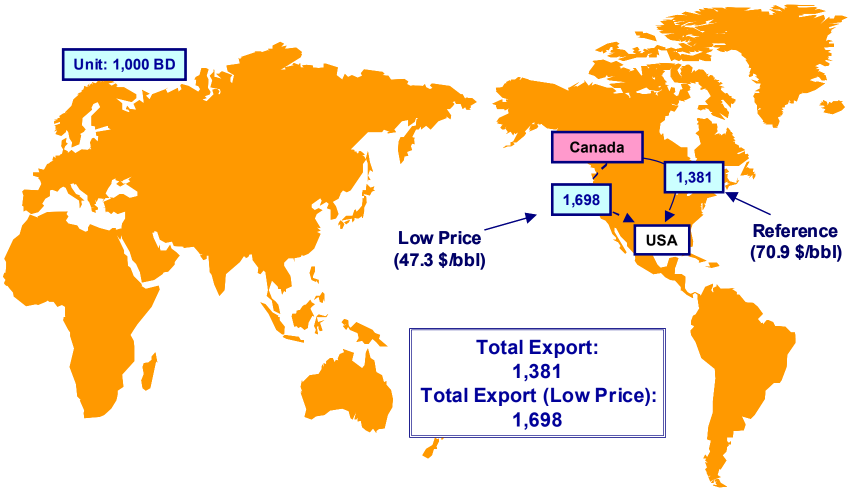
Table 5-1-4 Comparison of Oil Sand Export Cases (Summary)

US$/BBL 1,000b/d	(1) SCO only to USA		(2) SCO	(3) SynSynbit	(4) Synbit	(5) Dilbit	(6) All Oil Sands Export Case	
	Reference	Low Price					Reference	Low Price
WTI	75.9	49.0	75.9	75.9	75.9	75.9	75.9	49.0
Arab Extra Light	69.8	47.0	69.8	69.8	69.8	69.8	69.8	47.0
Arab Light	67.7	44.9	67.7	67.7	67.7	67.7	67.7	44.9
Arab Medium	64.5	43.0	64.5	64.5	64.5	64.5	64.5	43.0
Arab Heavy	61.0	40.6	61.0	61.0	61.0	61.0	61.0	40.6
DilBit	56.4	37.6				56.4	56.4	37.6
Sweet SCO	70.9	47.3	70.9				70.9	47.3
SynSynBit	63.1	42.1		63.1			63.1	42.1
SynBit	60.6	40.4			60.6		60.6	40.4
Dubai	65.6	43.7	65.6	65.6	65.6	65.6	65.6	43.7
Sweet SCO	**1,381**	**1,698**	**2,339**				**528**	**535**
United States	1,381	1,698	1,381				528	535
Japan			212					
South Korea			105					
Philippines			71					
Thailand			569					
SynSynBit				**2,651**			**378**	**440**
United States				1,444				
Japan				157			157	181
Taiwan				21				
South Korea				42			51	71
Singapore				247				
Philippines				55				
Thailand				479			170	188
India				202				
Vietnam				4				
SynBit					**2,432**		**402**	**489**
United States					1,493			
China					938			
Singapore							214	247
Philippines							32	41
Taiwan								11
Thailand							152	158
India							4	16
Vietnam								11
Other Asia								5
DilBit						**2,339**	**1,445**	**1,541**
United States						1,473	931	995
China						866	514	546
Total	**1,381**	**1,698**	**2,339**	**2,651**	**2,432**	**2,339**	**2,753**	**3,005**
United States	1,381	1,698	1,381	1,444	1,493	1,473	1,459	1,530
Japan			212	157			157	181
China					938	866	514	546
Taiwan				21				11
South Korea			105	42			51	71
Singapore				247			214	247
Philippines			71	55			32	41
Thailand			569	479			322	346
India				202			4	16
Vietnam				4				11
Other Asia								5
World	**1,381**	**1,698**	**2,339**	**2,651**	**2,432**	**2,339**	**2,753**	**3,005**
Asia	**0**	**0**	**958**	**1,207**	**938**	**866**	**1,294**	**1,475**
World								
Processed Volume	96,279	96,276	96,274	96,276	96,273	96,276	96,277	96,277
Average API	35.13	35.05	34.66	34.70	34.47	34.64	34.60	34.54
Average Sulfur	1.12	1.12	1.09	1.16	1.21	1.23	1.19	1.20
Asia								
Processed Volume	27,360	27,361	27,359	27,364	27,360	27,362	27,363	27,360
Average API	35.72	35.90	35.69	35.19	34.41	34.62	34.64	34.51
Average Sulfur	1.09	1.08	1.03	1.11	1.28	1.30	1.19	1.20

(1) Exporting Sweet SCO (for only to the United States)

This reference case limits Canada's oil sand production to Sweet SCO with no export to Asia taken into account. In this case, Sweet SCO exports are presumed only to the United States. If oil sand in the form of Sweet SCO is exported to the United States, exports quantity is 1.381 million b/d. If Sweet SCO prices in 2015 are the same as in 2004, exports is 0.317 million b/d more at 1.698 million b/d.

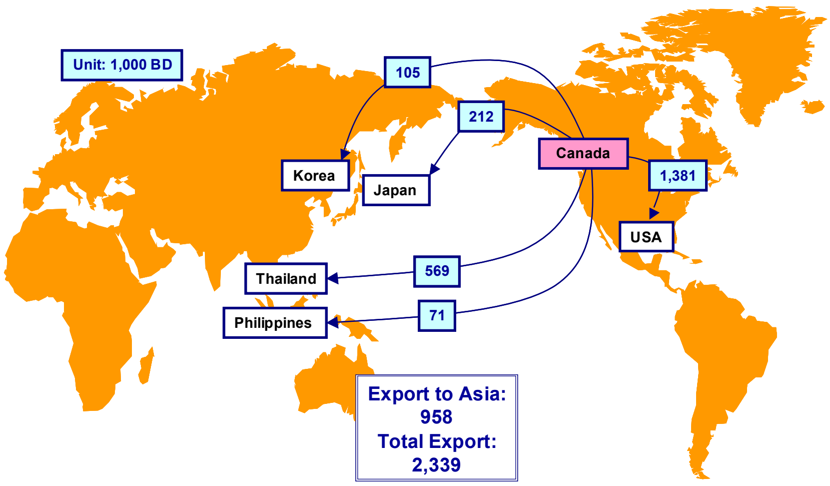
Figure 5-1-2 Projected Oil Sand Exports (for Sweet SCO) (Reference case)



(2) Exporting Sweet SCO

If Sweet SCO is exported, exports total is 0.958 million b/d for Asia and 1.381 million b/d for the United States. As a result, the total exports exhibit at 2.339 million b/d. Sweet SCO features a higher API gravity and lower sulfur content, and is easier to refine than SynBit.

Figure 5-1-3 Projected Oil Sand Exports (for Sweet SCO)

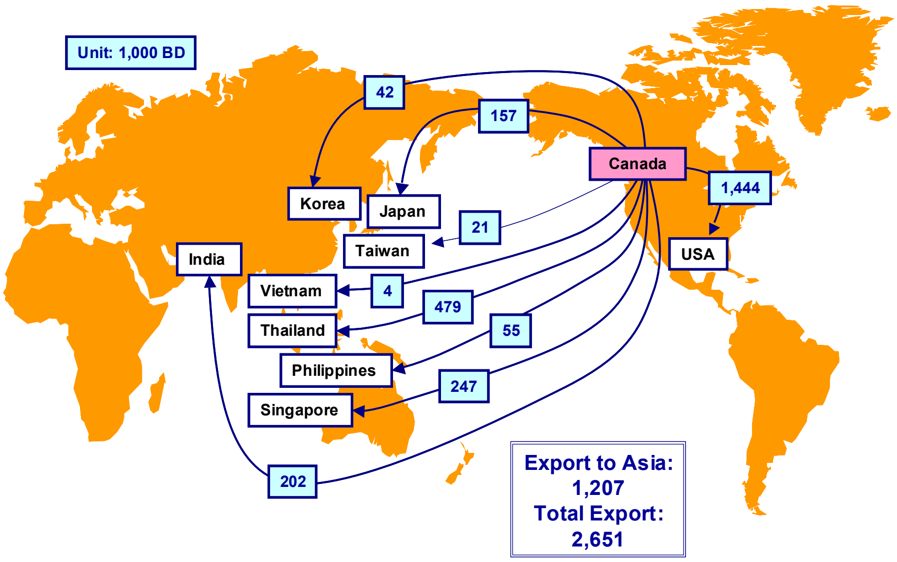


This means that Thailand, the Philippines and other countries that lack secondary processing systems for reforming and cracking introduce Sweet SCO.

(3) Exporting SynSynBit

If SynSynBit is exported, exports total is 1.20 million b/d for Asia and 1.444 million b/d for the United States. As a result, the total exports exhibit at 2.651 million b/d. SynSynBit features a lower API gravity and a higher sulfur content than Sweet SCO and must undergo cracking,reforming and de-sulfurization through secondary processing systems in order to produce lighter and lower sulfur products.

Figure 5-1-4 Projected Oil Sand Exports (for SynSynBit)



Since SynSynBit is cheaper than Sweet SCO, SynSynBit exports and the number of countries importing SynSynBit is larger than for Sweet SCO. The greater number of countries importing SynSynBit means that it would be more favorable for Canada to export SynSynBit rather than Sweet SCO from the viewpoint of acquiring firm and stable demand.

Even if SynSynBit exports are made to Asia, the average API gravity and the average sulfur content for total Asian crude oil imports are almost the same as in the case where oil sand exports are limited to the United States. Asia thus is able to accept SynSynBit without any major modification of oil refineries including secondary equipment.

(4) Exporting SynBit

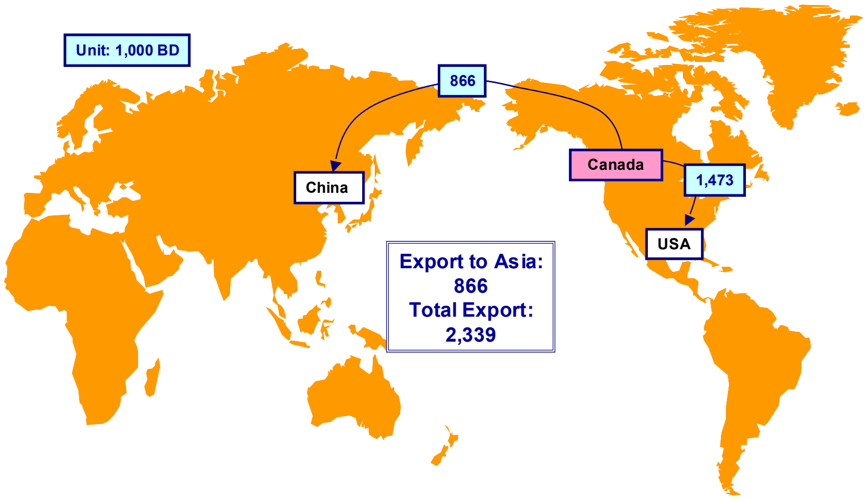
If SynBit is exported, exports total is 0.938 million b/d for China and 1.493 million b/d for the United States. No exports are expected to Asian countries other than China that has established cracking and other secondary systems for heavy crude and has been processing domestic low API crude oil like Daqing (API 32.0, Sulfur 0.10) and Shengli (API 25.7, Sulfur 0.86) and imported heavy crude oil from Venezuela (ex. Cero Negro API 16.0, Sulfur 3.34) and Brazil (ex. Marlim API 20.0, Sulfur 2.0). Therefore, China is expected to absorb the majority of SynBit oil sand exports. SynBit features a lower API gravity, a higher sulfur content, and a higher total acid number than Sweet SCO, indicating that measures should be taken against corrosion of refineries in processing SynBit. The development and expansion of secondary processing systems should be a precondition for introducing SynBit. As Asian importers are limited to China, exports may be unstable due to uncertain demand and the limited sales channels.

Figure 5-1-5 Projected Oil Sand Exports (for SynBit)

(5) Exporting DilBit

If DilBit is exported, exports total is 0.866 million b/d for China and 1.473 million b/d for the United States. As is the case with SynBit, China, which has imported heavy crude oil, is expected to absorb the majority of DilBit oil sand exports. DilBit features a lower API gravity, higher sulfur content, and higher total acid number than SynBit, indicating that more anti-corrosion measures for secondary processing systems are necessary. Since Asian importers are limited to China as is the case with the SynBit, DilBit exports may be vulnerable from the viewpoint of secure demand.

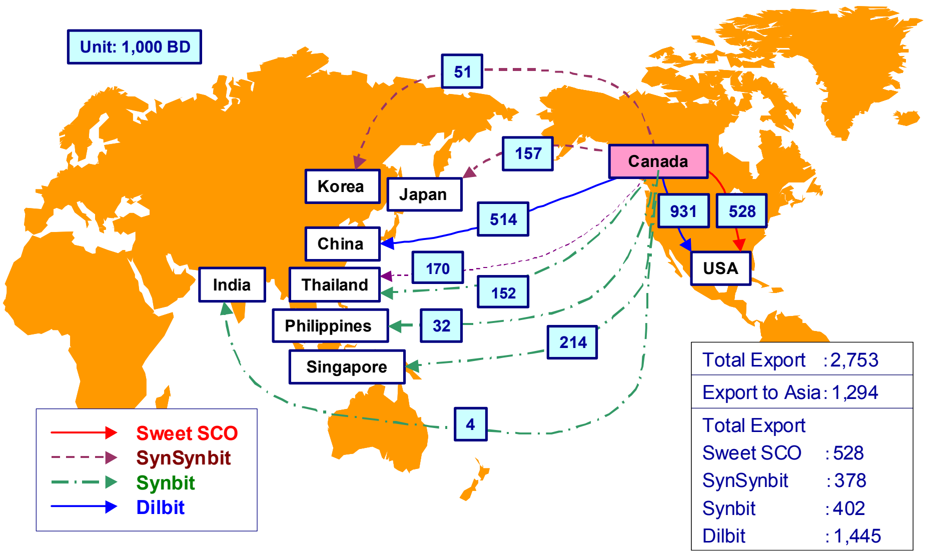
Figure 5-1-6 Projected Oil Sand Exports (for DilBit)



(6) Selecting Sweet SCO, SynSynBit, SynBit or DilBit for exports through optimization

The following includes a case for exports of all types of oil sands. In total, 2.753 million b/d is exported. Of the total, Sweet SCO accounts for 0.528 million b/d, SynSynBit for 0.378 million b/d, SynBit for 0.402 million b/d, and DilBit for 1.445 million b/d.

Figure 5-1-7 Projected Oil Sand Exports (Optimization Case)



Exports to the United States include 0.528 million b/d in Sweet SCO and

0.931 million b/d in DilBit. In total, 1.459 million b/d is exported to the United States. Exports to Japan and to South Korea do not change from the SynSynBit export case.

To China, export of DilBit is decreased by 0.055 million b/d from the Dibit export case to 0.514 million b/d. China decreases processing its domestic crude oil and exports to Asian countries. Instead, China increases importing Latin American crude oil that is heavier but lower sulfur content than DilBit.

In addition, 0.152 million b/d in SynBit and 0.170 million b/d in SynSynBit is exported to Thailand, 0.032 million b/d in SynBit is exported to the Philippines, and 0.214 million b/d in SynBit is exported to Singapore. Therefore, to Asia, 1.294 million b/d is exported.

Thailand imports SynBit in addition with SynSynBit but decreases imports of Asian crude oil with low sulfur content. Therefore, overall sulfur content of crude oil processed at the refinery increases but still lower than the SynSynBit export case. On the other hand, Singapore also imports large quantity of SynBit. However, Singapore increases imports of low sulfur Asian crude (Tapis, Bach Ho etc.) and stops importing Middle East crude (Arabian Light Crude) to keep overall sulfur content low at the refinery. The sulfur level at the refinery is slightly higher than the SynSynBit export case.

(6)' Selecting Sweet SCO, SynSynBit, SynBit or DilBit for exports through optimization (at 2004 price)

This case is analysis for exports of all types of oil sands at 2004 price. Exports to the world and Asia are maximized to 3.005 million b/d. Of the total, Sweet SCO accounts for 0.535 million b/d, SynSynBit for 0.440 million b/d, SynBit for 0.489 million b/d, and DilBit for 1.541 million b/d.

In total, 1.530 million b/d is exported to the United States. Exports to Japan and to South Korea also increase to 0.181 million b/d and 0.071 million b/d respectively. To China, export of DilBit is increased by 0.032 million b/d to 0.546 million b/d. China decreases processing its domestic crude oil and exports these to Asian countries. In addition, China increases importing Latin American crude oil.

0.158 million b/d in SynBit and 0.188 million b/d in SynSynBit is exported to Thailand, 0.041 million b/d in SynBit is exported to the Philippines, and 0.247 million b/d in SynBit is exported to Singapore. Furthermore in this case, the number of countries importing oil sands is larger than for the reference price. The newly added destinations are Taiwan, Vietnam and Other Asia. Exports in Synbit to Taiwan, Vietnam are 0.011 million b/d respectively. Therefore, to Asia, 1.475 million b/d is exported.

Figure 5-1-8 Projected Oil Sand Exports (Optimization Case at 2004 price)

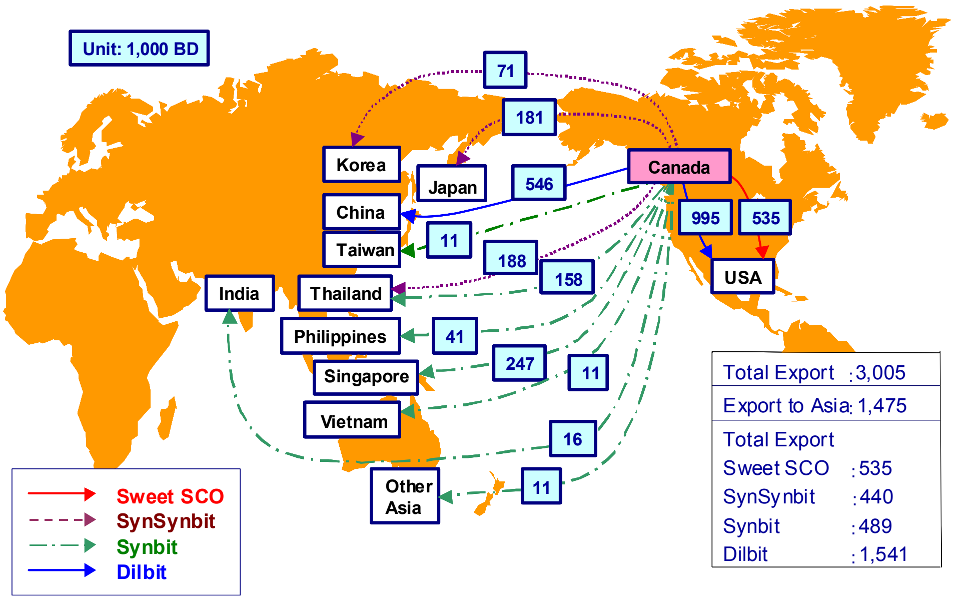


Table 5-1-5 China's Oil Sand Import

Export Case / Price	(1) SCO only to USA		(2) SCO	(3) SynSynBit	(4) SynBit	(5) Dilbit	(6) All Oilsands Export Case	
	Reference	2004 Price	70.9$/BBL	63.1$/BBL	60.6$/BBL	56.4$/BBL	Reference	2004 Price
China Crude Import								
Total (Thousand B/D)	6,255	6,204	6,255	6,249	5,983	6,025	6,345	6,359
Average API Degrees	39.2	39.4	39.2	39.3	34.0	34.8	36.3	36.1
Average Sulfur Content Wt%	1.01	0.99	1.01	1.01	1.67	1.74	1.34	1.37
Canadian Oilsand								
Import Volume	**0**	**0**	**0**	**0**	**938**	**866**	**514**	**546**
Share %	0.0	0.0	0.0	0.0	15.7	14.4	8.1	8.6
Middle East Crude								
Import Volume	2,486	2,486	2,486	2,486	2,487	2,486	2,487	2,486
Share %	39.7	40.1	39.7	39.8	41.6	41.3	39.2	39.1
Asian Crude								
Import Volume	20	0	20	0	0	0	0	0
Share %	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Russian Crude								
Import Volume	349	318	349	363	0	0	0	0
Share %	5.6	5.1	5.6	5.8	0.0	0.0	0.0	0.0
African Crude								
Import Volume	1,721	1,721	1,721	1,721	1,721	1,722	1,721	1,721
Share %	27.5	27.7	27.5	27.5	28.8	28.6	27.1	27.1
Latin American Crude								
Import Volume	1,679	1,679	1,679	1,679	837	951	1,623	1,606
Share %	26.8	27.1	26.8	26.9	14.0	15.8	25.6	25.3
Oceania Crude								
Import Volume	0	0	0	0	0	0	0	0
Share %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Crude Oil Processed	8,857	8,858	8,857	8,858	8,857	8,858	8,858	8,858
Domestic	2,602	2,654	2,602	2,609	2,874	2,833	2,514	2,499
Imported	6,255	6,204	6,255	6,249	5,983	6,025	6,345	6,359
Average API Degrees	36.4	36.5	36.4	36.4	32.7	33.3	34.4	34.3
Average Sulfur Content Wt%	0.84	0.82	0.84	0.84	1.26	1.31	1.09	1.11

Table 5-1-6 Thailand and Singapore Oil Sand Import

Export Case / Price	(1) SCO only to USA		(2) SCO	(3) SynSynBit	(4) SynBit	(5) Dilbit	(6) All Oilsands Export Case	
	Reference	2004 Price	70.9$/BBL	63.1$/BBL	60.6$/BBL	56.4$/BBL	Reference	2004 Price
Thailand Crude Import								
Total (Thousand B/D)	933	933	933	933	933	933	933	933
Average API Degrees	38.0	38.0	34.5	29.8	38.5	38.9	31.5	31.2
Average Sulfur Content Wt%	0.57	0.59	0.10	0.97	0.62	0.66	0.79	0.90
Canadian Oilsand								
Import Volume	**0**	**0**	**569**	**479**	**0**	**0**	**322**	**346**
SynSynBit				479			170	188
SynBit							152	158
SCO			569					
Share %	0.0	0.0	61.0	51.3	0.0	0.0	34.5	37.1
Middle East Crude								
Import Volume	250	262	0	16	277	288	0	0
Share %	26.8	28.1	0.0	1.7	29.7	30.9	0.0	0.0
Asian Crude								
Import Volume	682	670	364	438	655	628	612	533
Share %	73.2	71.9	39.0	46.9	70.3	67.3	65.5	57.1
Russian Crude								
Import Volume	0	0	0	0	0	17	0	54
Share %	0.0	0.0	0.0	0.0	0.0	1.8	0.0	5.8
Total Crude Oil Processed	932	932	933	933	932	933	934	933
Average API Degrees	38.0	38.0	34.5	29.8	38.5	38.9	31.5	31.2
Average Sulfur Content Wt%	0.57	0.59	0.10	0.97	0.62	0.66	0.79	0.90
Singapore Crude Import								
Total (Thousand B/D)	1,270	1,270	1,270	1,270	1,270	1,270	1,270	1,271
Average API Degrees	32.6	32.7	36.1	33.9	32.8	32.6	33.0	32.5
Average Sulfur Content Wt%	0.84	0.85	0.21	0.42	0.85	0.82	0.49	0.56
Canadian Oilsand								
Import Volume				**247**			**214**	**247**
SynSynBit				247				
SynBit							214	247
Share %	0.0	0.0	0.0	19.4	0.0	0.0	16.9	19.4
Middle East Crude								
Import Volume	574	584	0	0	583	558	0	0
Share %	45.2	46.0	0.0	0.0	45.9	43.9	0.0	0.0
Asian Crude								
Import Volume	696	686	1,121	1,024	687	712	1,056	1,024
Share %	54.8	54.0	88.3	80.6	54.1	56.1	83.1	80.6
Russian Crude								
Import Volume	0	0	149	0	0	0	0	0
Share %	0.0	0.0	11.7	0.0	0.0	0.0	0.0	0.0
Total Crude Oil Processed	1,270	1,270	1,270	1,271	1,270	1,270	1,270	1,271
Average API Degrees	32.6	32.7	36.1	33.9	32.8	32.6	33.0	32.5
Average Sulfur Content Wt%	0.84	0.85	0.21	0.42	0.85	0.82	0.49	0.56

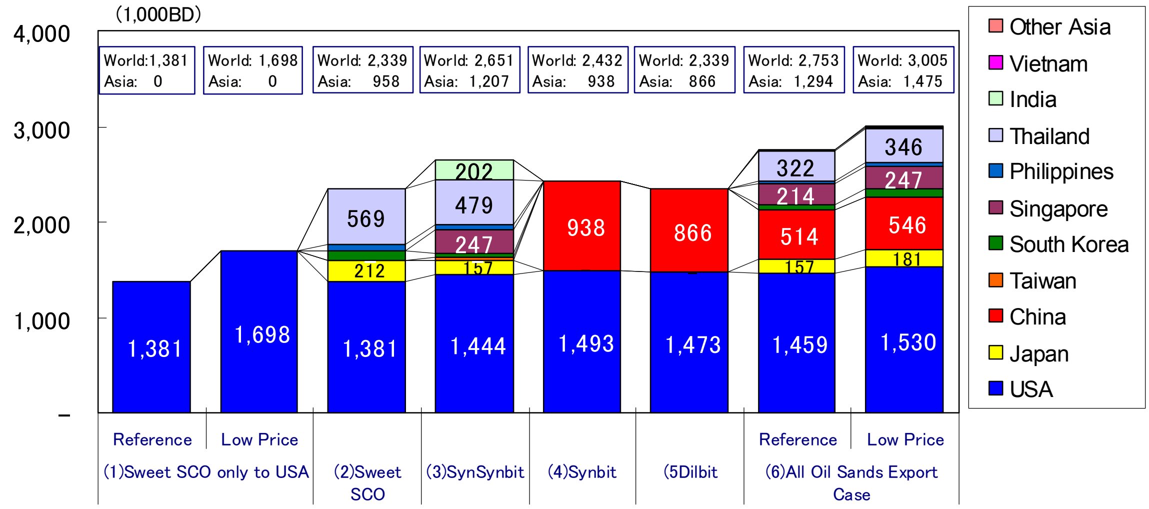
(8) Comparison of Oil Sand Export Cases

A comparison of oil sand export cases indicates that the case in which oil sand is exported in all of the four forms shows the largest quantity of exports to the United States and Asia. Additionally, exports in all types of oil sand at 2004 price ensure the largest number of importing countries (including eleven Asian countries or regions), enabling the exporter to diversify sales destinations.

Sweet SCO is the highest value added oil sand and relatively higher priced than Arabian Extra Light, the major crude oil for imports into Asia. In addition, economic growth based on industrialization particularly in developing Asian countries will consume large quantity of heavy fuel oil in industry sector which is not available from processing Sweet SCO. Therefore, Sweet SCO exports to Asia are more limited than the SynSynBit export case.

SynBit or DilBit, though cheaper than SynSynBit, may cost more than SynSynBit in terms of processing. Refineries must be upgraded to process SynBit or DilBit. Therefore, exports of SynBit or DilBit that features a lower API gravity and higher sulfur content, even though cheaper than SynSynBit, is more limited than SynSynBit exports.

Figure 5-1-9 Comparison of Oil Sand Export Cases



As a result, the SynSynBit export case secures the second largest number of importing countries (including eight Asian countries) after all types of oil sand export at 2004 price, allowing the exporter diversify sales channels in order to promote secure demand. SynBit and DilBit export destinations may be limited to China and the United States, making SynBit and DilBit exports vulnerable to demand insecurity. Therefore, exports of SynSynBit must be the most favorable option for the exporter.

5-1-5. Conclusions

Followings are the key points of this section's conclusion

- If Sweet SCO is exported only to the United States, 1.381 million b/d is exported.
- If oil sand is exported in the form of DilBit, export destinations are limited to the United States (1.473 million b/d) and China (0.866 million b/d).
- If oil sand is exported in the form of SynBit, export destinations are also limited to the United States (1.493 million b/d) and China (0.938 million b/d). SynBit exports exceed DilBit exports in volume.
- If oil sand is exported in the form of SynSynBit, exports to the United States fall

slightly to 1.444 million b/d with no exports made to China. However, exports to eight Asian destinations including Japan, Taiwan and South Korea are total 1.207 million b/d. Total oil sand exports come to 2.651 million b/d, the largest among the cases except for all types of oil sands export cases. Even if SynSynBit exports are made to Asia, the average API gravity and the average sulfur content for total Asian crude oil imports is almost the same as in the case where oil sand exports are limited to the United States. Asia may thus be able to accept SynSynBit without any major modification of oil refineries including secondary processing equipment.

- If oil sand is exported in the form of Sweet SCO, exports to the United States is 1.381 million b/d, the same as in the case where oil sand export destinations are limited to the United States. Asian export destinations are limited to Japan, South Korea, the Philippines and Thailand, with total exports to Asia being less at 0.958 million b/d. If Sweet SCO is priced as low as Arabian Medium (AM), exports to the world come to 2.677 million b/d (exports to Asia come to 1.034 million b/d) at the maximum. Asian Sweet SCO imports is more than Asian SynSynBit imports. But crude oil imports from the Middle East may not change due to the imports of Sweet SCO. Instead, declines are seen for such light crude oil imports as Russian and Malaysian Tapis crude oil that competes with Sweet SCO. The average API gravity and the average sulfur content for total Asian crude oil imports are almost the same as in the case where oil sand is exported only to the United States.
- If oil sand is exported in all of the four types, the United States imports 0.528 million b/d in Sweet SCO and 0.931 million in DilBit. China imports 0.514 million b/d in DilBit. On the other hand, three countries – Japan, South Korea, and Thailand – import 0.378 million b/d in SynSynBit. No country except the United States imports Sweet SCO. SynSynBit imports may be lower than in the case where only SynSynBit is exported. Total oil sand exports come to 2.753 million b/d, the number of which is the largest among the cases.

The above estimates indicate that oil sand exports is maximized if all of the four types of oil sands are exported. The numbers of importing countries are also maximized at low price (2004 price) case. Therefore, export in all types of oil sands seems to be a preferable option in terms of exports volume. However, in order to avoid cumbersome procedures for Canadian exporters in blending various kinds of oil sand and exporting through pipelines, exports in a single form of SynSynBit must be the most favorable option.

Table 5-1-7 Results of Estimation on Introduced Oil Sand

Export Case / Price	(1) SCO only to USA		(2) SCO	(3) SynSynBit	(4) SynBit	(5) Dilbit	(6) All Oilsands Export Case	
	Reference	2004 Price	70.9$/BBL	63.1$/BBL	60.6$/BBL	56.4$/BBL	Reference	2004 Price
WTI	75.9	49.0	75.9	75.9	75.9	75.9	75.9	49.0
Arab Extra Light	69.8	47.0	69.8	69.8	69.8	69.8	69.8	47.0
Arab Light	67.7	44.9	67.7	67.7	67.7	67.7	67.7	44.9
Arab Medium	64.5	43.0	64.5	64.5	64.5	64.5	64.5	43.0
Arab Heavy	61.0	40.6	61.0	61.0	61.0	61.0	61.0	40.6
DilBit	56.4	37.6				56.4	56.4	37.6
Sweet SCO	70.9	47.3	70.9				70.9	47.3
SynSynBit	63.1	42.1		63.1			63.1	42.1
SynBit	60.6	40.4			60.6		60.6	40.4
Dubai	65.6	43.7	65.6	65.6	65.6	65.6	65.6	43.7
Sweet SCO	**1,381**	**1,698**	**2,339**				**528**	**535**
United States	1,381	1,698	1,381				528	535
SynSynBit				**2,651**			**378**	**440**
United States				1,444			0	0
SynBit					**2,432**		**402**	**489**
United States					1,493		0	0
China					938		0	0
DilBit						**2,339**	**1,445**	**1,541**
United States						1,473	931	995
China						866	514	546
Total (Thousand B/D)	**1,381**	**1,698**	**2,339**	**2,651**	**2,432**	**2,339**	**2,753**	**3,005**
Amount of Sales (Million US$/Year)	**35,700**	**29,300**	**60,500**	**61,100**	**53,800**	**48,200**	**61,000**	**44,400**
Export Destination								
United States	1,381	1,698	1,381	1,444	1,493	1,473	1,459	1,530
China	0	0	0	0	938	866	514	546
Japan	0	0	212	157	0	0	157	181
Taiwan	0	0	0	21	0	0	0	11
Korea	0	0	105	42	0	0	51	71
Singapore	0	0	0	247	0	0	214	247
Malaysia	0	0	0	0	0	0	0	0
Philippines	0	0	71	55	0	0	32	41
Thailand	0	0	569	479	0	0	322	346
India	0	0	0	202	0	0	4	16
Vietnam	0	0	0	4	0	0	0	11
Other Asian Countries	0	0	0	0	0	0	0	5
Total (Thousand B/D)	**1,381**	**1,698**	**2,339**	**2,651**	**2,432**	**2,339**	**2,753**	**3,005**
Asian Countries Crude Import								
Total (Thousand B/D)	23,154	23,079	23,167	23,206	22,916	22,952	23,308	23,365
Average API Degrees	36.1	36.3	36.0	35.4	34.5	34.8	34.8	34.6
Average Sulfur Content Wt%	1.23	1.23	1.16	1.25	1.48	1.49	1.34	1.36
Canadian Oilsand								
Import Volume	**0**	**0**	**957**	**1,207**	**938**	**866**	**1,294**	**1,475**
Share %	0.0	0.0	4.1	5.2	4.1	3.8	5.6	6.3
Middle East Crude								
Import Volume	15,308	15,307	14,421	14,252	15,308	15,307	14,454	14,416
Share %	66.1	66.3	62.2	61.4	66.8	66.7	62.0	61.7
Asian Crude								
Import Volume	1,981	1,901	1,998	1,934	1,791	1,848	2,153	2,135
Share %	8.6	8.2	8.6	8.3	7.8	8.1	9.2	9.1
Russian Crude								
Import Volume	763	783	694	735	480	480	385	335
Share %	3.3	3.4	3.0	3.2	2.1	2.1	1.7	1.4
African Crude								
Import Volume	2,002	2,001	2,001	2,001	2,015	2,002	2,001	2,001
Share %	8.6	8.7	8.6	8.6	8.8	8.7	8.6	8.6
Latin American Crude								
Import Volume	3,015	2,864	3,012	2,992	2,212	2,306	2,936	2,919
Share %	13.0	12.4	13.0	12.9	9.7	10.0	12.6	12.5
Oceania Crude								
Import Volume	85	223	84	85	172	143	85	84
Share %	0.4	1.0	0.4	0.4	0.8	0.6	0.4	0.4
Total Crude Oil Processed	27,360	27,361	27,359	27,364	27,360	27,362	27,363	27,360
Average API Degrees	35.7	35.9	35.7	35.2	34.4	34.6	34.6	34.5
Average Sulfur Content Wt%	1.09	1.08	1.03	1.11	1.28	1.30	1.19	1.20
United States Crude Import								
Total (Thousand B/D)	12,475	12,475	12,475	12,475	12,748	12,706	12,691	12,717
Middle East Crude								
Import Volume	3,188	3,187	3,187	3,188	3,187	3,188	3,187	3,188
Share %	25.6	25.5	25.6	25.6	25.0	25.1	25.1	25.0
Canadian Oilsand								
Import Volume	**1,381**	**1,698**	**1,381**	**1,444**	**1,493**	**1,473**	**1,459**	**1,530**
Share %	11.1	13.6	11.1	11.6	11.7	11.6	11.5	12.0

5-2. Sweet SCO Price Sensitivity Analysis

Given the above, the price is expected to become the key to maximizing exports of Sweet SCO, the highest value added oil sand with a higher API gravity and lower sulfur content. In the next section, we would like to analyze demand sensitivity to prices and the relationship between Sweet SCO prices and exports.

Sweet SCO features a higher API gravity, lower sulfur content and a higher value added than other oil sand varieties. We conducted a Sweet SCO price sensitivity analysis to estimate the potential volume for the high-value-added oil sand brand to be introduced in the global oil market. The following cases are assumed for the Sweet SCO price sensitivity analysis:

(ⅰ) Reference (SCO exports go to the U.S. and Asian markets. Sweet SCO is priced at the same level as in the reference case)
(ⅱ) Linked to WTI (Sweet SCO is priced at the same level as WTI)
(ⅲ) Linked to WTI plus $10/bbl (Sweet SCO priced at WTI price plus $10/bbl)
(ⅳ) Linked to AL (Sweet SCO is priced at the same level as Arabian Light)
(ⅴ) Linked to AL-Dubai (Sweet SCO is priced at the average of Arabian Light and Dubai prices)
(ⅵ) Linked to Dubai (Sweet SCO is priced at the same level as Dubai)
(ⅶ) Linked to AM (Sweet SCO is priced at the same level as Arabian Medium)
(ⅷ) Lower-price case (2004 prices applied to 2015)

5-2-1. Export Volume of Sweet SCO

If Sweet SCO is linked to the WTI in pricing, exports to the world in 2015 decline to 2.249 million b/d from 2.339 million b/d. In the case where Sweet SCO is priced at the WTI level plus $10/bbl, exports become even lower at 1.667 million b/d. Exports to Asia fall from 0.958 million b/d in the reference case to 0.887 million b/d in the case linked to WTI, and 0.602 million barrels in the case where the price is $10/bbl above WTI level. Exports to the United States fall from 1.381 million b/d in the reference case to 1.362 million b/d in the case linked to WTI, and 1.076 million b/d in the case where the price is $10/bbl above WTI level. If Sweet SCO is linked to Arabian Light in pricing, exports increase by 0.154 billion b/d from the reference case to 2.493 million b/d. If Sweet SCO is linked to the average of Arabian Light and Dubai prices, exports increase by 0.227 million b/d from the reference case to 2.566 million b/d. If Sweet SCO is linked to Dubai, exports increase by 0.306 million b/d to 2.645 million b/d. If Sweet SCO is linked to Arabian Medium, exports increase by 0.338 million b/d to

2.677 million b/d.

Figure 5-2-1 Sweet SCO Price Sensitivity Analysis (in 2015)

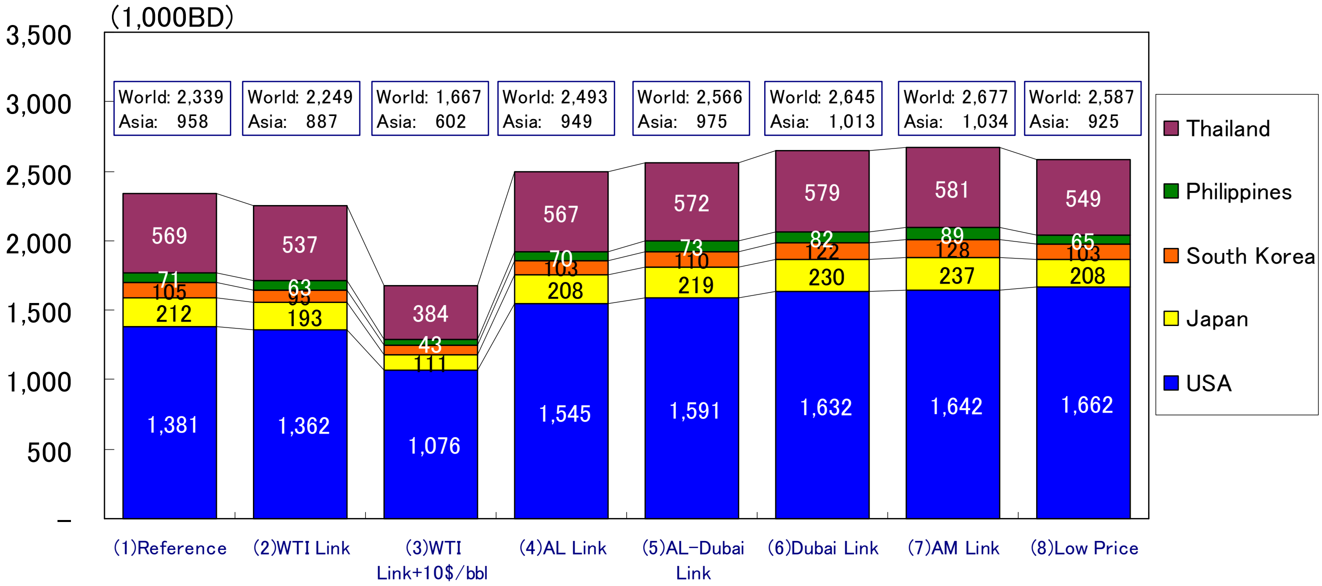


Table 5-2-1 Sweet SCO Price Sensitivity Analysis (in 2015)

1,000b/d	(1) Reference	(2) WTI Link	(3) WTI Link+10$/B	(4) AL Link	(5) AL-Dubai Link	(6) Dubai Link	(7) AM Link	(8) Low Price
USA	1,381	1,362	1,076	1,545	1,591	1,632	1,642	1,662
Japan	212	193	111	208	219	230	237	208
South Korea	105	95	64	103	110	122	128	103
Philippines	71	63	43	70	73	82	89	65
Thailand	569	537	384	567	572	579	581	549
World	2,339	2,249	1,677	2,493	2,566	2,645	2,677	2,587
Asia	958	887	602	949	975	1,013	1,034	925

5-2-2. Conclusions

Following are the key points of this section:

- Sweet SCO exports are estimated at each of three Sweet SCO prices – $70.9/bbl almost equal to Arabian Extra Light price ($69.8/bbl) for the reference case, $85.9/bbl (WTI price of $75.9/bbl plus $10/bbl) and $64.5/bbl equal to Arabian Medium price. The highest price is up $15/bbl from the reference case and the lowest is down $6.5/bbl from the reference case.
- As the price is raised by $15/bbl from the reference case, estimated Sweet SCO exports decrease by 0.662 million b/d from 2.339 million b/d in the reference case to 1.677 million b/d. As the price is lowered by $6.5/bbl from the reference case, however, estimated Sweet SCO exports increase by 0.338 million b/d to 2.677 million b/d. A price change of $21.5/bbl thus brings about a large export volume

change of 1 million b/d.

- Sweet SCO exports to Asia are estimated to increase as the price is lowered. But the number of Asian destinations do not change. Sweet SCO exports would not affect Asia's crude oil imports from the Middle East. Rather, Sweet SCO is expected to compete with Asian crude oil.
- If the 2004 price system is applied to 2015, exports are estimated to increase by 0.284 million b/d from the reference case to 2.587 million b/d. In this case, Sweet SCO price is almost equal to Arabian Extra Light price and close to the reference case. However, the increase is seen only in exports to the United States. Exports to Asia are estimated to decline.
- Given the refinery mix and product quality, Sweet SCO cannot be expected to compete with Middle East crude oil in Asia. This is the same case in the United States. Rather, Sweet SCO is expected to compete with Russian or Latin American crude oil.

Table 5-2-2 Results of Sweet SCO Price Sensitivity Analysis

Price Assumptions / Price	(1) Reference ≒AEXL 70.9$/BBL	(2) WTI Link 75.9$/BBL	(3) WTI +10.0 85.9$/BBL	(4) AL Price 67.7$/BBL	(5) AL-Dubai Ave. Price 66.7$/BBL	(6) Dubai Price 65.6$/BBL	(7) AM Price 64.5$/BBL	(8) 2004 Price 47.3$/BBL
WTI	75.9	75.9	75.9	75.9	75.9	75.9	75.9	49.0
Arab Extra Light (AEXL)	69.8	69.8	69.8	69.8	69.8	69.8	69.8	47.0
Arab Light	67.7	67.7	67.7	67.7	67.7	67.7	67.7	44.9
Arab Medium	64.5	64.5	64.5	64.5	64.5	64.5	64.5	43.0
Arab Heavy	61.0	61.0	61.0	61.0	61.0	61.0	61.0	40.6
Sweet SCO	70.9	75.9	85.9	67.7	66.7	65.6	64.5	47.3
Dubai	65.6	65.6	65.6	65.6	65.6	65.6	65.6	43.7
Export Destination								
United States	1,381	1,362	1,076	1,545	1,591	1,632	1,642	1,662
China	0	0	0	0	0	0	0	0
Japan	212	193	111	208	219	230	237	208
Taiwan	0	0	0	0	0	0	0	0
Korea	105	95	64	103	110	122	128	103
Singapore	0	0	0	0	0	0	0	0
Malaysia	0	0	0	0	0	0	0	0
Philippines	71	63	43	70	73	82	89	65
Thailand	569	537	384	567	572	579	581	549
India	0	0	0	0	0	0	0	0
Vietnam	0	0	0	0	0	0	0	0
Other Asian Countries	0	0	0	0	0	0	0	0
Total (Thousand B/D)	**2,339**	**2,249**	**1,677**	**2,493**	**2,566**	**2,645**	**2,677**	**2,587**
Asian Countries Crude Import								
Total (Thousand B/D)	23,167	23,151	23,345	23,150	23,150	23,135	23,121	23,091
Average API Degrees	36.0	36.1	36.0	36.0	36.0	36.1	36.1	36.3
Average Sulfur Content Wt%	1.16	1.16	1.18	1.16	1.16	1.15	1.15	1.15
Canadian Oilsand								
Import Volume	**957**	**888**	**602**	**948**	**974**	**1,012**	**1,034**	**925**
Share %	4.1	3.8	2.6	4.1	4.2	4.4	4.5	4.0
Middle East Crude								
Import Volume	14,421	14,454	14,600	14,423	14,423	14,424	14,419	14,447
Share %	62.2	62.4	62.5	62.3	62.3	62.3	62.4	62.6
Asian Crude								
Import Volume	1,998	2,013	2,231	1,998	1,971	1,930	1,899	1,938
Share %	8.6	8.7	9.6	8.6	8.5	8.3	8.2	8.4
Russian Crude								
Import Volume	694	698	814	704	704	691	692	704
Share %	3.0	3.0	3.5	3.0	3.0	3.0	3.0	3.0
African Crude								
Import Volume	2,001	2,001	2,001	2,001	2,002	2,002	2,001	2,001
Share %	8.6	8.6	8.6	8.6	8.6	8.7	8.7	8.7
Latin American Crude								
Import Volume	3,012	3,012	3,012	2,992	2,992	2,951	2,936	2,854
Share %	13.0	13.0	12.9	12.9	12.9	12.8	12.7	12.4
Oceania Crude								
Import Volume	84	85	85	84	84	125	140	222
Share %	0.4	0.4	0.4	0.4	0.4	0.5	0.6	1.0
Total Crude Oil Processed	27,359	27,364	27,360	27,363	27,363	27,364	27,363	27,360
Average API Degrees	35.7	35.8	35.7	35.7	35.7	35.8	35.8	35.9
Average Sulfur Content Wt%	1.03	1.03	1.05	1.03	1.03	1.02	1.02	1.02
United States Crude Import								
Total (Thousand B/D)	12,473	12,474	12,476	12,474	12,474	12,475	12,474	12,473
Middle East Crude								
Import Volume	3,187	3,187	3,188	3,187	3,187	3,187	3,187	3,188
Share %	25.6	25.5	25.6	25.5	25.5	25.5	25.5	25.6
Latin American Crude								
Import Volume	4,390	4,390	4,815	4,390	4,390	4,390	4,390	4,390
Share %	35.2	35.2	38.6	35.2	35.2	35.2	35.2	35.2
Russian Crude								
Import Volume	280	300	162	147	147	161	166	192
Share %	2.2	2.4	1.3	1.2	1.2	1.3	1.3	1.5
Canadian Oilsand								
Import Volume	**1,381**	**1,362**	**1,076**	**1,545**	**1,591**	**1,632**	**1,642**	**1,662**
Share %	11.1	10.9	8.6	12.4	12.8	13.1	13.2	13.3

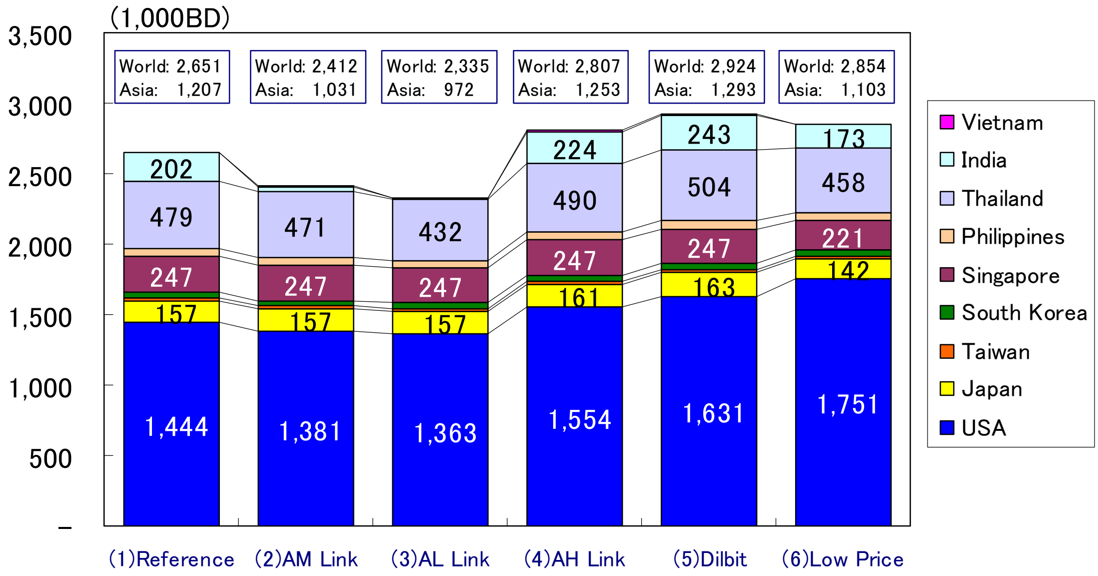
5-3. SynSynBit Price Sensitivity Analysis

Among oil sand varieties subjected to the export sensitivity analysis, the choice of SynSynBit is estimated to maximize oil sand exports. In this section, we conduct a price sensitivity analysis for SynSynBit, as is the case with Sweet SCO, to estimate the potential SynSynBit volume for introduction into the international oil market. Cases are set as follows:

(i) Reference (Standard SynSynBit price: SynSynBit is priced at the same level as in the reference case)
(ii) Linked to AM (SynSynBit is priced at the same level as Arabian Medium)
(iii) Linked to AL (SynSynBit is priced at the same level as Arabian Light)
(iv) Linked to AH (SynSynBit is priced at the same level as Arabian Heavy)
(v) DilBit (SynSynBit is priced at the same level as DilBit)
(vi) Lower price case (2004 price applied to 2015)

5-3-1. Export Volume of SynSynBit

Figure 5-3-1 SynSynBit Price Sensitivity Analysis (in 2015)



SynSynBit exports are estimated to decrease by 0.239 million b/d from the reference case to 2.412 million b/d if the price is linked to higher Arabian Medium price. If the price is linked to even higher Arabian Light price, exports are estimated to decline by 0.316 million b/d from the reference case to 2.335 million b/d. If the price is linked to the lower Arabian Heavy price, exports are estimated to increase by 0.156 million b/d from the reference case to 2.807 million b/d. If SynSynBit price is linked to the price of DilBit, another oil sand variety, exports are estimated to expand by 0.273 million b/d to 2.924 million b/d.

Table 5-3-1 SynSynBit Price Sensitivity Analysis (in 2015)

1,000b/d	(1) Reference	(2) AM Link	(3) AL Link	(4) AH Link	(5) Dilbit	(6) Low Price
USA	1,444	1,381	1,363	1,554	1,631	1,751
Japan	157	157	157	161	163	142
Taiwan	21	21	21	22	23	20
South Korea	42	42	41	42	43	40
Singapore	247	247	247	247	247	221
Philippines	55	55	55	60	64	45
Thailand	479	471	432	490	504	458
India	202	34	17	224	243	173
Vietnam	4	4	3	5	5	4
World	2,651	2,412	2,335	2,807	2,924	2,854
Asia	1,207	1,031	972	1,253	1,293	1,103

5-3-2. Conclusions

Following are the key points of this section:

- SynSynBit exports are estimated for the cases where the price is raised by $4.6/bbl from $63.1/bbl in the reference case to Arabian Light price of $67.7/bbl and lowered by $6.7/bbl to the DilBit price of $56.4/bbl.
- If the price is raised by $4.6/bbl, SynSynBit exports decrease by 0.316 million b/d from 2.651 million b/d in the reference case to 2.335 million b/d. If the price is lowered by $6.4/bbl, however, exports increase by 0.273 million b/d to 2.924 million b/d. A price change of $11.3/bbl may thus bring about an export volume change of 0.589 million b/d.
- Exports to the United States account for 0.268 million b/d of the change. SynSynBit exports may not affect crude oil imports from the Middle East but compete with Russian or Oceanian crude.
- SynSynBit exports to Japan, Taiwan, South Korea and Singapore do not change on a price reduction. The estimated exports to these destinations represent an effective ceiling under refinery mix or product quality constraints.
- SynSynBit imports into Thailand and India increase substantially on a price reduction. SynSynBit compete with Asian crude in Thailand and with Middle East crude in India.

- If the 2004 price system is applied to 2015, SynSynBit exports increase by 0.203 million b/d from the reference case to 2.854 million b/d. In this case, SynSynBit price is set at the middle between Arabian Heavy and Arabian Medium prices, and close to Arabian Heavy price rather than Arabian Light price. The increase center on exports to the United States. Rather, exports to Asia decrease, competing with Middle East, Russian and Asian crude.

Table 5-3-2 Results of SynSynBit Price Sensitivity Analysis

Price Assumptions / Price	(1) Reference 63.1$/BBL	(2) AM Price 64.5$/BBL	(3) AL Price 67.7$/BBL	(4) AH Price 61.0$/BBL	(5) Dilbit. Price 56.4$/BBL	(6) 2004 Price 42.1$/BBL
WTI	75.9	75.9	75.9	75.9	75.9	49.0
Arab Extra Light （AEXL）	69.8	69.8	69.8	69.8	69.8	47.0
Arab Light	67.7	67.7	67.7	67.7	67.7	44.9
Arab Medium	64.5	64.5	64.5	64.5	64.5	43.0
Arab Heavy	61.0	61.0	61.0	61.0	61.0	40.6
SynSynBit	63.1	64.5	67.7	61.0	56.4	42.1
Dubai	65.6	65.6	65.6	65.6	65.6	43.7
Export Destination						
United States	1,444	1,381	1,363	1,554	1,631	1,751
China	0	0	0	0	0	0
Japan	157	157	157	161	163	142
Taiwan	21	21	21	22	23	20
Korea	42	42	41	42	43	40
Singapore	247	247	247	247	247	221
Malaysia	0	0	0	0	0	0
Philippines	55	55	55	60	64	45
Thailand	479	471	432	490	504	458
India	202	34	17	224	243	173
Vietnam	4	4	3	5	5	4
Other Asian Countries	0	0	0	0	0	0
Total （Thousand B/D）	**2,651**	**2,412**	**2,335**	**2,807**	**2,924**	**2,854**
Asian Countries Crude Import						
Total (Thousand B/D)	23,206	23,230	23,214	23,208	23,187	23,147
Average API Degrees	35.4	35.5	35.6	35.4	35.4	35.8
Average Sulfur Content Wt%	1.25	1.26	1.25	1.25	1.25	1.26
Canadian Oilsand						
Import Volume	**1,207**	**1,031**	**973**	**1,251**	**1,292**	**1,103**
Share %	5.2	4.4	4.2	5.4	5.6	4.8
Middle East Crude						
Import Volume	14,252	14,405	14,419	14,203	14,176	14,296
Share %	61.4	62.0	62.1	61.2	61.1	61.8
Asian Crude						
Import Volume	1,934	1,963	1,998	1,929	1,907	1,982
Share %	8.3	8.5	8.6	8.3	8.2	8.6
Russian Crude						
Import Volume	735	733	725	748	735	765
Share %	3.2	3.2	3.1	3.2	3.2	3.3
African Crude						
Import Volume	2,001	2,001	2,001	2,001	2,001	2,001
Share %	8.6	8.6	8.6	8.6	8.6	8.6
Latin American Crude						
Import Volume	2,992	3,012	3,012	2,992	2,953	2,775
Share %	12.9	13.0	13.0	12.9	12.7	12.0
Oceania Crude						
Import Volume	85	85	86	84	123	225
Share %	0.4	0.4	0.4	0.4	0.5	1.0
Total Crude Oil Processed	27,364	27,363	27,362	27,359	27,361	27,364
Average API Degrees	35.2	35.2	35.3	35.2	35.2	35.5
Average Sulfur Content Wt%	1.11	1.12	1.11	1.11	1.11	1.11
United States Crude Import						
Total (Thousand B/D)	12,475	12,475	12,475	12,474	12,475	12,475
Canadian Oilsand						
Import Volume	**1,444**	**1,381**	**1,363**	**1,554**	**1,631**	**1,751**
Share %	11.6	11.1	10.9	12.5	13.1	14.0
Middle East Crude						
Import Volume	3,188	3,188	3,188	3,188	3,188	3,188
Share %	25.6	25.6	25.6	25.6	25.6	25.6
Latin American Crude						
Import Volume	4,390	4,390	4,390	4,390	4,390	4,390
Share %	35.2	35.2	35.2	35.2	35.2	35.2
Russian Crude						
Import Volume	248	281	299	147	160	141
Share %	2.0	2.3	2.4	1.2	1.3	1.1
Oceanian Crude						
Import Volume	140	170	170	140	101	0
Share %	1.1	1.4	1.4	1.1	0.8	0.0

5-4. Analyzing Possible Export of Petroleum Products Derived from Oil Sand

While oil sand is exported in the form of crude oil that are processed at the importers' refineries, Canada can be expected to refine oil sand and export petroleum products. We have made estimates for exports of ① gasoline and ② diesel oil produced through refining of oil sand. For the reference case, FOB price of gasoline is set at 82.2US$/BBL and diesel at 83.6US$/BBL.

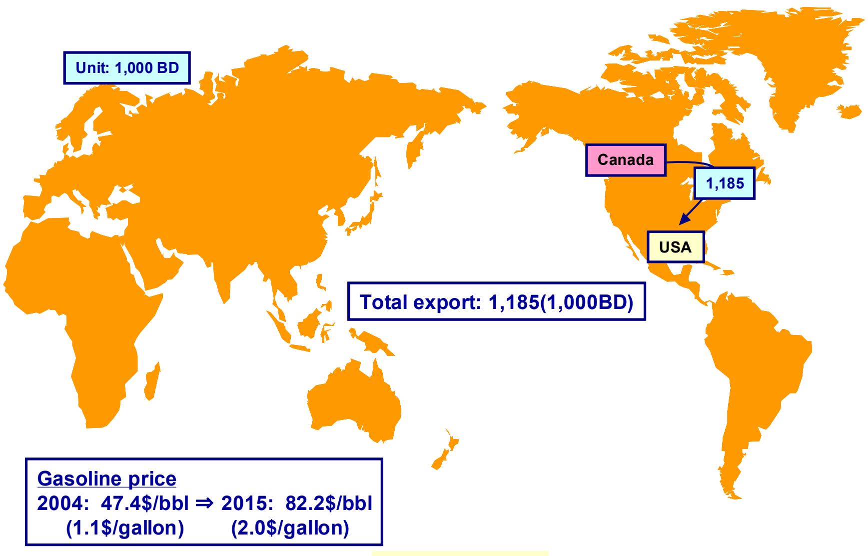
In developing mathematical modeling of gasoline or diesel export from Canada, we assumed that both the U.S. and Asian countries are able to select oil sand in the form of Sweet SCO or petroleum products on a global cost minimization basis.

5-4-1. Export Volumes of Gasoline and Diesel Oil

① Exporting Gasoline from Oil Sand

If gasoline from oil sand and Sweet SCO are exported, export destinations are limited only to the United States and quantity is 1.185 million b/d. In this case, oil sand is exported totally in the form of gasoline, not Sweet SCO.

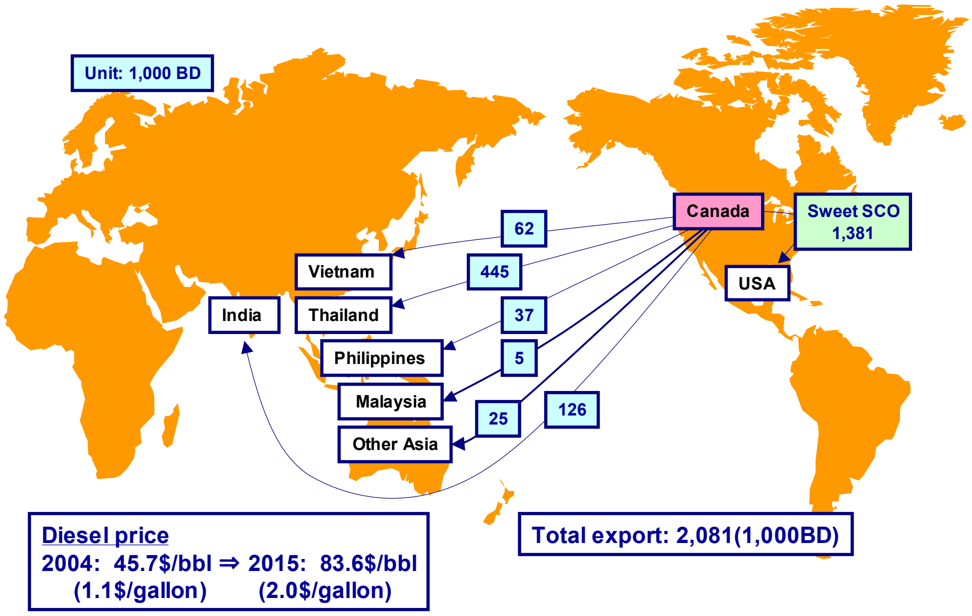
Figure 5-4-1 Projected Exports of Gasoline from Oil Sand in 2015



② Exporting Diesel Oil from Oil Sand

If diesel oil from oil sand and Sweet SCO are exported, the U.S. imports 1.381 million b/d of oil sand totally in the form of Sweet SCO. Diesel oil export destinations are limited only to the Asian countries. Exports is 0.062 million b/d for Vietnam, 0.445 million b/d for Thailand, 0.037 million b/d for Philippines, 0.005 million b/d for Malaysia, 0.126 million b/d for India, and 0.025 million b/d for the remaining Asian countries. In total, 0.7 million b/d is exported. This shows that there is a large diesel market for Alberta in Thailand and India because of their refinery capability. There may be a large potential market in China if the planned new refineries do not get built, which will be discussed later.

Figure 5-4-2 Projected Exports of Diesel Oil from Oil Sand in 2015



We have also analyzed the price sensitivity of exports of gasoline and diesel oil from oil sand. Prices are set at levels that are $10 per barrel lower and higher than the reference price as follows:

① Exporting gasoline from oil sand
High-price case: $92.2 per barrel (reference price plus $10 per barrel)
Low-price case: $72.2 per barrel (reference price minus $10 per barrel)

② Exporting diesel oil from oil sand
High-price case: $93.6 per barrel (reference price plus $10 per barrel)
Low-price case: $73.6 per barrel (reference price minus $10 per barrel)

In the low-price case for gasoline, exports may be 0.098 million b/d greater than in the reference-price case. In the high-price case, exports may be 0.165 million b/d less. In all cases, exports may be directed only for the United States. In the low-price case for diesel oil, exports may be 0.067 million b/d more than in the reference-price case. In the high-price case, exports may be 0.138 million b/d less. The

U.S. imports in the form of Sweet SCO does not change at 1.381 million b/d .

Figure 5-4-3 Gasoline Price Sensitivity Analysis (Export Volume of Gasoline: 2015)

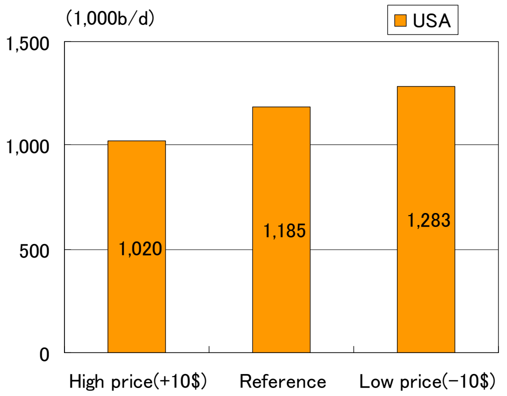


Figure 5-4-4 Diesel Oil Price Sensitivity Analysis (Export Volume of Diesel Oil: 2015)

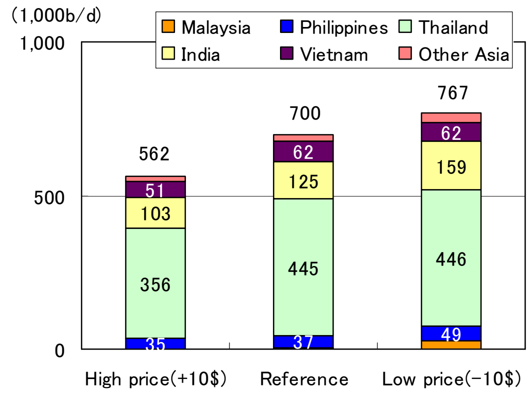


Table 5-4-1 Diesel Oil Price Sensitivity Analysis (Export Volume of Diesel Oil: 2015)

1000b/d	High price (+10$)	Reference	Low price (-10$)
Malaysia	0	5	25
Philippines	35	37	49
Thailand	356	445	446
India	103	125	159
Vietnam	51	62	62
Other Asia	16	25	27
Total	562	700	767

The Sinopec group accounts for 60% of China's oil refining capacity at present and CNPC for 40%. The Chinese government gave Sinopec 9.4 billion yuan (1.2 billion US dollars) in 2005 and 5 billion yuan (0.6 billion US dollars) in 2006 to help cover a loss at its oil refining division, indicating that the government was eager to expand oil refining capacity to meet fast-increasing oil consumption. In 2005, Sinopec reportedly incurred an estimated loss of 14 billion yuan.

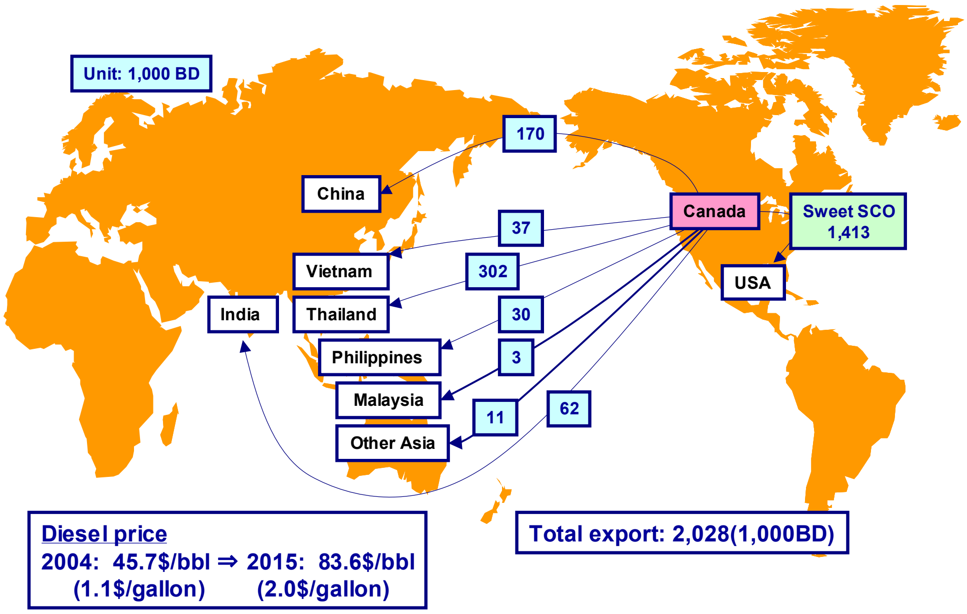
Sinopec's profit margin on refining is estimated at 1.5 dollars per barrel against an Asia-Pacific average of 9 dollars per barrel. The loss compensation is aimed to forestall a halt to Sinopec's oil products supply and provide Sinopec with an incentive to expand oil refining capacity. In August 2005, Sinopec had announced it would cut its refining capacity investment by 4 billion yuan due to cash flow problems. If losses at Sinopec's refining division widen, an annual capacity expansion may slow down from the target of 280,000 b/d to 200,000 b/d toward 2008.

On the other hand, CNPC does not incur any loss on refining operations because it refines its own crude oil including overseas output. At present, the price control system covers naphtha, gasoline, diesel oil and jet fuel. Given the present situation, any deterioration of Sinopec's refining operations can be expected to stall China's refining capacity expansion.

For these reasons, Canadian diesel oil exports to China are estimated for a case where China's oil refining capacity expansion is slower than in a reference case. China's oil refining capacity in 2015 is estimated at 9.32 million b/d excluding 0.83 million b/d of Asphalt- type refinery for the reference case. For the case where the expansion is delayed and limited to 50% of the planned level toward 2015, the capacity in the year may come to 7.89 million b/d.

In the case where China's oil refining capacity expansion is delayed, Canada's diesel oil exports to Asia may come to 615,000 b/d, some 85,000 b/d less than in the reference case where China will expand oil refining capacity as planned. China may cover all its diesel oil consumption on its own in the reference case but may have to import 170,000 b/d from Canada, 22,000 b/d from the Middle East and 13,000 b/d from Singapore in the delayed expansion case.

Figure 5-4-5 Estimated Oil Sand Exports for a delayed expansion case



Even in the reference case, utilization ratio of Asian refineries is very high at about 97%. If China's refinery expansion delays as shown on the above case, products trade in Asian market becomes tight. Some Asian countries meet difficulty when importing products including diesel oil from other countries to meet their domestic demand. Therefore, in the delayed expansion case, utilization ratio of Asian refineries exceeds 100% at 102%. In summary, China's stalled refining capacity expansion will increase its import of petroleum products, which eventually entails that other Asian countries are obliged to reduce products import or attempt to export products to China with enhancing operating ratio of refinery.

We have conducted the same approach as done in the case of selecting Sweet SCO, SynSynBit, SynBit or DilBit for exports from the viewpoint of optimum costs. In addition of these oil sand products, diesel oil from oil sand is listed for selection. However, diesel oil is not selected neither for China nor the rest of Asian countries. This indicates that Asian countries choose crude oil rather than products in order to utilize their refinery as much as possible for minimizing their overall costs.

5-4-2. Conclusions

Following are the key points of this section:

- We examined the case where gasoline and diesel oil from oil sand are exported. Gasoline export destinations are limited to the United States. Asian countries' gasoline demand is met by regional imports or domestic production.
- We examined gasoline exports sensitivity to a $10/bbl price rise or cut. Exports may fall by 0.165 million b/d on a $10/bbl hike and increase by 0.098 million b/d on a $10/bbl price cut. The price change of $20/bbl thus bring about an export change of 0.263 million b/d. Gasoline exports may be less sensitive to prices than oil sand exports.
- Even if diesel oil is exported, no exports go to the United States, which may purchase SCO. Traditional Asian diesel oil importers Thailand and India, as well as Vietnam, Malaysia and the Philippines, import diesel oil from Canada. If the diesel oil price is raised by $10/bbl, Malaysia no longer import diesel oil.
- We examined diesel oil exports price sensitivity. Diesel oil exports decline by 0.138 million b/d on a $10/bbl price hike and increase by 0.067 million b/d on a $10/bbl price cut. The change thus totals 0.205 million b/d, indicating diesel oil exports may be less sensitive to price changes than gasoline exports.
- If the diesel oil price is lowered, Thailand and India increase imports. Lower-priced diesel oil competes with Middle East and Asian crude oil in Thailand and with Middle East crude in India.
- China may cover all its diesel consumption on its own in the reference case but if

China's oil refining capacity expansion is delayed, China have to import 170,000 b/d from Canada.

Table 5-4-2 Results of Petroleum Product Export Sensitivity Analysis

Case Assumptions / Price	Gasoline Export Case			Diesel Fuel Export Case			
	High Price 92.2$/BBL	Reference 82.2$/BBL	Low Price 72.2$/BBL	High Price 93.6$/BBL	Reference 83.6$/BBL	Delayed Expansion 83.6$/BBL	Low Price 73.6$/BBL
Sweet SCO	70.9	70.9	70.9	70.9	70.9	70.9	70.9
Oilsand Gasoline	92.2	82.2	72.2				
Oilsand Diesel Fuel				93.6	83.6	83.6	73.6
Export Destination							
United States (Products)	1,020	1,185	1,283	**0**	**0**	**0**	**0**
United States (SCO)				**1,381**	**1,381**	**1,413**	**1,381**
China	0	0	0	0	0	170	0
Malaysia	0	0	0	0	5	3	25
Philippines	0	0	0	35	37	30	49
Thailand	0	0	0	356	445	302	446
India	0	0	0	103	125	62	159
Vietnam	0	0	0	51	62	37	62
Other Asian Countries	0	0	0	16	25	11	27
Total (Thousand B/D)	**1,020**	**1,185**	**1,283**	**1,943**	**2,081**	**2,028**	**2,148**
Canadian Oilsand Products							
Import Volume	**0**	**0**	**0**	**562**	**700**	**615**	**767**
Amount of Sales (Million US$/Year)	**34,300**	**35,600**	**33,800**	**54,900**	**57,100**	**55,300**	**56,400**
Asian Countries Crude Import							
Total (Thousand B/D)	22,713	22,713	22,718	22,639	22,523	23,045	22,469
Average API Degrees	36.2	36.2	36.1	36.0	36.0	36.1	36.0
Average Sulfur Content Wt%	1.27	1.27	1.28	1.22	1.22	1.27	1.22
Middle East Crude							
Import Volume	15,307	15,308	15,311	14,761	14,622	15,027	14,555
Share %	67.4	67.4	67.4	65.2	64.9	65.2	64.8
Asian Crude							
Import Volume	949	949	950	2,018	2,031	2,053	2,043
Share %	4.2	4.2	4.2	8.9	9.0	8.9	9.1
Russian Crude							
Import Volume	480	480	480	762	772	480	772
Share %	2.1	2.1	2.1	3.4	3.4	2.1	3.4
African Crude							
Import Volume	2,779	2,779	2,780	2,001	2,001	2,986	2,002
Share %	12.2	12.2	12.2	8.8	8.9	13.0	8.9
Latin American Crude							
Import Volume	2,992	2,963	2,963	3,012	3,012	2,146	3,012
Share %	13.2	13.0	13.0	13.3	13.4	9.3	13.4
Oceania Crude							
Import Volume	206	234	234	85	85	353	85
Share %	0.9	1.0	1.0	0.4	0.4	1.5	0.4
Total Crude Oil Processed	27,359	27,359	27,364	26,256	25,991	27,250	25,880
Average API Degrees	35.9	35.8	35.8	36.4	36.6	35.8	36.6
Average Sulfur Content Wt%	1.11	1.10	1.11	1.10	1.11	1.12	1.11
Refining Capacity	28,225	28,225	28,225	28,225	28,225	26,790	28,225
Utilization Ratio %	96.9	96.9	96.9	96.9	96.8	101.7	96.8

6. Dependence on Middle East

A future increase in Asian countries' oil imports is expected to shift to cost-competitive Middle East crude oil, increasing Asia's dependence on the Middle East for oil supply.

East Asia depended on the Middle East for 52.6% of its oil (crude and products) imports in 2004. The dependence is expected to rise to 59.5% in 2015. East Asia's dependence on the Middle East for crude oil imports is projected to increase from 64.7% in 2004 to 66.1% in 2015. Given the estimation, Asia's dependence on the Middle East for its oil (crude and products) imports may come to 55.7% if Canadian oil sand is exported in the form of SynSynBit. The percentage is 3.8 points lower than in the reference case where no oil sand exports to Asia are taken into account. If oil sand is exported in the form of Sweet SCO, Asia's dependence on the Middle East for oil imports may come to 56.3%, 3.2 points lower than in the reference case. Asia's dependence on the Middle East for crude imports may come to 61.4% in 2015 if Canada exports SynSynBit. The percentage is 4.7 points lower than in the reference case. If oil sand is exported in the form of Sweet SCO, Asia's dependence on the Middle East for crude imports may come to 62.2%, 3.9 points lower than in the reference case.

The above analysis indicates that oil sand exports to Asia may work to hold down any increase in the region's dependence on the Middle East. This apparently means that oil sand imports may make a great contribution to allowing oil-consuming countries to diversify oil import sources.

Figure 6-1 Dependence on Middle East (Oil imports)

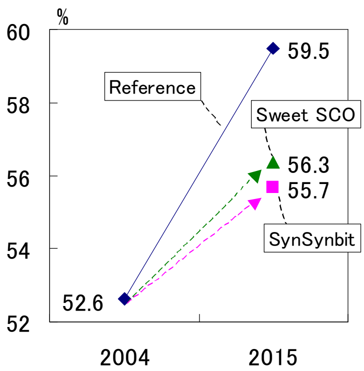


Figure 6-2 Dependence on Middle East (Crude oil imports)

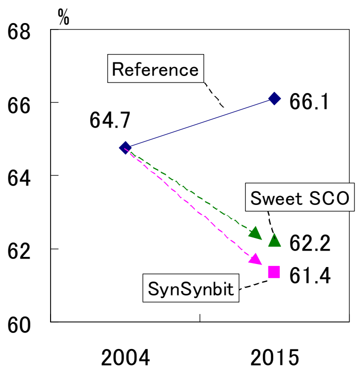
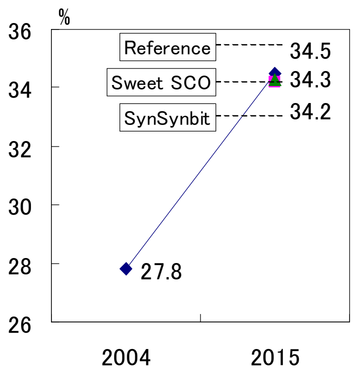


Figure 6-3 Dependence on Middle East (Petroleum product imports)



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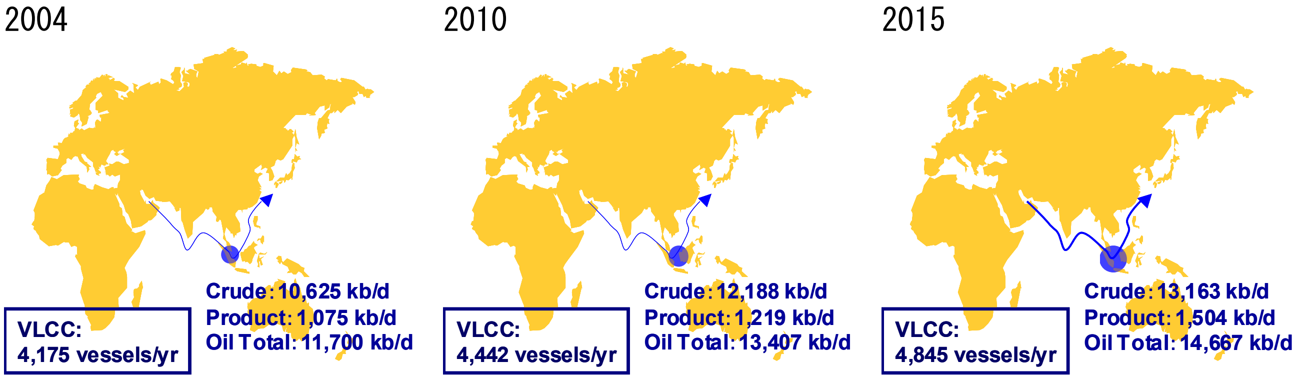
7. Oil Traffic through the Malacca Straits

Asian demand for oil has increased steadily due to industrialization, urbanization and motorization. But Asia has less oil resources and is failing to cover growing domestic demand with domestic resources. Asia is thus expected to expand oil imports including price-competitive Middle East crude oil. This means that oil traffic is expected to steadily increase through the Malacca Straits, a key chokepoint for sea lanes between the Middle East and Asia.

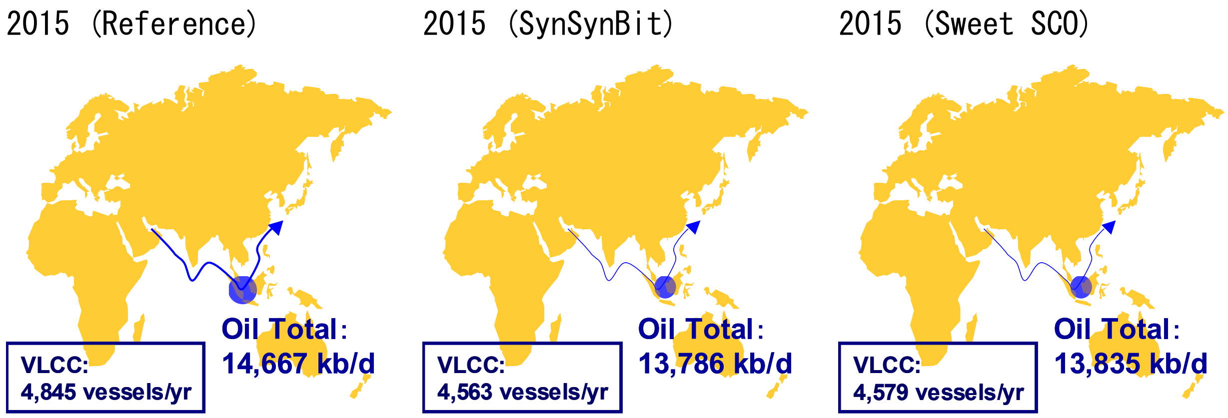
Figure 7-1 Projected Oil Traffic through Malacca Straits



Oil traffic through the Malacca Straits, which is here assumed to be equal to a combination of Asia's oil imports from the Middle East and Africa, may increase from 11.700 million b/d (10.625 million b/d in crude oil and 1.075 million b/d in petroleum products) in 2004 to 13.407 million b/d (12.188 million b/d in crude oil and 1.219 million b/d in petroleum products) in 2010, and to 14.667 million b/d (13.163 million b/d in crude oil and 1.54 million b/d in petroleum products) in 2015. The number of VLCC-class tankers sailing through the Malacca Straits may rise from 4,175 in 2004 to 4,442 in 2010 and to 4,845 in 2030. Congestion in the straits may thus grow more serious.

We have assessed the effect of oil sand exports to Asia on oil traffic through the Malacca Straits. Based on our estimates, if SynSynBit is exported to Asia in 2015, oil traffic through the Malacca Straits may total 13.786 million b/d, 0.881 million b/d less than for the case where oil sand exports to Asia are not taken into account. The number of VLCC-class tankers sailing through the straits may be 282 fewer at 4,563. If Sweet SCO is exported to Asia in 2015, oil traffic through the Malacca Straits may total 13.835 million b/d, 0.832 million b/d less than for the case where oil sand exports to Asia are not taken into account. The number of VLCC-class tankers sailing through the straits may number 266 less at 4,579.

Figure 7-2 Projected Oil Traffic through the Malacca Straits
(upon oil sand introduction)



The assessment indicates that oil sand exports to Asia could work to reduce oil traffic through the Malacca Straits, making a great contribution to energy security with regard to sea-lanes.

8. Conclusions

Oil Demand

Asian oil consumption is expected to expand from 22.3 million b/d in 2004 to 29.4 million b/d in 2015. Its share of world oil consumption is forecast to rise from 27.8% in 2004 to 31.5% in 2015. The Asian oil consumption increase between 2004 and 2015 is predicted to be at 7.1 million b/d, accounting for 55% of the expected global increase of 12.9 million b/d. Asia is thus expected to lead global oil demand expansion.

Oil Demand/Supply

Crude oil and petroleum products supply/demand outlook for Asia indicates that the region's dependence on imports for oil supply would rise steadily from 73% in 2004 to about 86% in 2015, due to increasing consumption and slackening local crude oil production. Energy security may thus be positioned as a more important challenge in Asia.

Feasibility of Oil Sand Exports to Asian Market

- If oil sand is exported in the form of DilBit, export destinations are limited to the United States (1.473 million b/d) and China (0.866 million b/d).
- If oil sand is exported in the form of SynBit, export destinations are also limited to the United States (1.493 million b/d) and China (0.938 million b/d).
- If oil sand is exported in the form of SynSynBit, total oil sand exports come to 2.651 million b/d, the largest among the cases except for all types of oil sands export cases. Exports to the United States fall to 1.444 million b/d with no exports made to China. However, exports to eight Asian destinations including Japan, Taiwan and South Korea are total 1.207 million b/d.
- If oil sand is exported in the form of Sweet SCO priced at a higher level than Arabian Extra Light which is the major crude oil for import into Asia, exports to the United States is 1.381 million b/d and Asian export destinations are limited to Japan, South Korea, the Philippines and Thailand (0.958 million b/d).
- If oil sand is exported in all of the four types, exports to the U.S and Asia come to 2.753 million b/d. Also, oil sands export in all of the four types at 2004 price serve to maximize the number of importing countries (including ten countries in Asia). From the viewpoint of securing demand, the four types exports may make the greatest contribution to diversifying export destinations out of all the oil sand

types.

- In the case where gasoline and diesel oil from oil sand are exported, gasoline export destinations are limited to the United States.
- Even if diesel oil is exported, no exports go to the United States, which imports 1.381 million b/d of Sweet SCO. Traditional Asian diesel oil importers Thailand and India, as well as Vietnam, Malaysia and the Philippines, import 0.70 million b/d diesel oil from Canada. China may cover all its diesel consumption on its own in the reference case but if China's oil refining capacity expansion is delayed, China has to import 170,000 b/d from Canada.

Table 8-1 Summary

Case		Export Volume ×1000 B/D					Number of Export Destinations (incl USA)
		USA	China	Japan	Other Asia	Total	
(1)	Reference	1,381			−	1,381	1
(2)	Sweet SCO	1,381		212	746	2,339	5
(3)	SynSynBit	1,444		157	1,050	2,651	9
(4)	SynBit	1,493	938			2,432	2
(5)	DilBit	1,473	866			2,339	2
(6)	Mix	1,459	514	157	623	2,753	8
(6-1)	Mix (Low Price)	1,530	546	181	748	3,005	11
(7)	Products Export						
(7-1)	Gasoline	1,185				1,185	1
(7-2)	Diesel Oil	1,381			700	2,081	7
(7-2)'	Diesel Oil (China Delayed)	1,413	170		445	2,028	8

The above estimates indicate that oil sand exports is maximized if all of the four types of oil sands are exported. The numbers of importing countries are also maximized at low price (2004 price) case. However, in order to avoid cumbersome procedures for Canadian oil sand exporters in blending various kinds of oil sand and exporting through pipelines, exports in a single form of SynSynBit must be the most favorable option. In addition, Asia is able to accept SynSynBit without any major modification of oil refineries including secondary equipments.

Oil Traffic through Malacca Straits

If oil sand is exported in the form of SynSynBit to Asia, oil traffic through the Malacca Straits may total 13.786 million b/d, 0.881 million b/d less than in the case where no oil sand exports to Asia are taken into account. The number of VLCC-class tankers sailing through the straits may number 282 less at 4,563. Oil sand exports to the Asian market are expected to work to hold down oil traffic through the Malacca Straits, making a great contribution to energy security with regard to sea-lanes.

Limiting Dependence on Middle East

Asia depended on the Middle East for 52.6% of its oil imports in 2004. This dependence is expected to rise to 59.5% in 2015. If SynSynBit is exported to Asia, Asia's dependence on Middle East oil imports may exhibit at 55.7%, 3.8 percentage points lower than for the reference case where no oil sand exports to Asia are taken into account. If Sweet SCO is exported, Asia's dependence on Asian oil imports may exhibit at 56.3%, 3.2 percentage points lower than for the reference case.

Oil sand exports to Asia may work to hold down any increase in the region's dependence on the Middle East. This means that oil sand imports may make a great contribution to enabling oil-consuming countries to diversify oil import sources.

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Appendices

1. Major Assumptions

1-1. Estimation Periods

Estimation has been carried out for 2010 and 2015.

1-2. Case for Analysis

In a case for the estimation, economic growth, crude oil prices and national refining capacity would follow their respective probable trends. Demand for petroleum products for the reference case is calculated with the World Energy Demand-Supply Model and oil sand exports are estimated with the Petroleum Refining and Trade Estimation Model. In the reference case, it is assumed that oil sand is exported only to the United States. Exports are estimated for each of the four types of oil sand.

For the sensitivity analysis purpose, oil sand exports are estimated for a case where oil sand is exported in all four types and another case where Sweet SCO (synthetic crude oil) price rises close to WTI (West Texas Intermediate) price. For a case where Canada exports products (gasoline and diesel oil) refined from oil sand, an estimate has been made with these products added to the list of crude oil choices.

1-3. GDP Growth

GDP growth assumptions are based on Asian Development Bank's estimates, national government plans and on-site survey data (see Tables 1-3-1 and 1-3-2).

Table 1-3-1 GDP Growth Rate Assumptions in Key Areas (average annual growth: %)

	80/71	90/80	03/90	10/03	15/10	20/15
East Asia (excl. Japan)	7.2	7.7	7.1	6.4	5.4	5.3
East Asia	4.9	4.7	3.1	3.7	3.2	3.4
Asia	4.8	4.6	3.5	4.1	3.6	3.9
North America	3.3	3.2	3.0	3.2	2.8	2.8
Latin America	5.6	1.1	2.5	3.5	3.3	3.3
Europe	3.0	2.4	2.0	2.2	2.2	2.2
West Europe	5.5	1.6	−1.4	6.4	6.6	3.7
Africa	3.8	1.6	2.4	4.2	4.0	3.9
Middle East	5.9	0.4	3.9	3.8	3.7	3.6
Oceania	2.7	2.9	3.5	2.9	2.9	2.8
World	3.8	3.0	2.7	3.3	3.1	3.1

Sources: *World Development Indicators* by World Bank, future estimates by IEEJ

Table 1-3-2 GDP Growth Assumptions in Key Countries (average annual growth: %)

	80/71	90/80	03/90	10/03	15/10	20/15
United States	3.2	3.2	3.0	3.2	2.8	2.8
Canada	4.0	2.8	2.8	3.0	2.8	2.8
Mexico	7.0	1.8	2.8	3.7	3.6	3.6
Brazil	8.1	1.5	2.3	3.6	3.1	3.1
United Kingdom	2.0	2.6	2.3	2.4	2.3	2.3
Germany	2.7	2.3	1.5	1.7	2.0	1.9
France	3.1	2.5	1.7	2.2	2.2	2.2
Italy	3.8	2.3	1.4	1.7	1.8	1.8
Russia	5.1	2.1	−1.8	6.7	7.0	3.8
China	6.1	9.3	9.7	8.2	6.6	6.6
Japan	4.4	3.9	1.3	1.7	1.1	1.1
Hong Kong	9.6	6.4	3.9	5.3	3.3	3.3
Taiwan	9.2	7.9	5.3	4.6	4.0	3.4
South Korea	7.1	8.7	5.7	4.5	3.7	3.3
Singapore	9.2	7.2	5.9	5.1	3.8	3.6
Brunei	8.0	0.0	1.7	2.6	5.9	2.4
Indonesia	8.0	6.4	6.9	5.2	4.5	4.5
Malaysia	8.1	6.0	8.1	5.4	5.0	5.0
Philippines	6.0	1.7	3.3	4.1	4.2	4.2
Thailand	7.1	7.8	4.5	5.5	5.0	5.0
India	3.1	5.8	5.6	5.8	5.5	5.5
Vietnam	1.3	5.2	7.4	7.2	6.8	6.3
Other Asia	4.6	2.5	6.6	6.4	6.1	6.1
Australia	2.9	3.0	3.5	2.9	2.9	2.8
New Zealand	1.5	1.9	3.0	3.0	2.7	2.6
World	3.8	3.0	2.7	3.3	3.1	3.1

Sources: *World Development Indicators* by World Bank, future estimates by IEEJ

1-4. Crude Oil and Products Prices

1-4-1. Benchmark Crude Oil Prices

Crude oil with relatively greater production output in the world have been selected as representative types. Each oil-producing country is represented by one or a few crude oil types. One natural gas liquid (NGL) brand name is designated to represent each of the major NGL-producing areas or countries – the United States, Canada, Mexico, Latin America (Venezuela), the Middle East, United Kingdom, other West European nations (Norway), Malaysia, Indonesia and Australia. The production volume of surrounding countries is also represented.

Crude oil price assumptions are based on the trends of the reference case in *Annual Energy Outlook 2006 (AEO2006)* conducted by the Energy Information Administration of the U.S. Department of Energy. Reflecting the international oil situation's growing vulnerability (attributed to such factors as slack upstream investment), AEO2006 has revised long-term crude oil price forecasts upward from levels in AEO2005 (the forecast real price for 2025 has been revised upward from $33 per barrel in AEO2005 to $54 per barrel in AEO2006).

Table 1-4-1 AEO2006 Forecast Crude Oil Prices

Unit：US$/BBL		2003	2004	2010	2020	2030	2004–30 Growth Rate (%) *
Real Price (2004 price)	Imported Light Crude	32	41	47	51	57	1.3
	Imported Crude	28	36	44	45	50	1.3
Nominal Price	Imported Light Crude		41	53	75	107	3.8
	Imported Crude		36	50	66	94	3.8
GDP Deflator			1.00	1.13	1.46	1.88	

＊ Annual Growth Rate %

The model adopts WTI crude price in the second half of 2004 as the standard. The nominal price hike in Table 1-4-1 is used for assuming WTI price for 2010 and 2015. Based on WTI price, prices are assumed for Saudi and Dubai crude. Saudi crude captures the largest share of crude imports in Asia and Dubai crude price serves as a price benchmark for Saudi crude. Assumed prices of individual crude oil types are based on their average FOB prices between October 2004 and March 2005, as well as the assumed WTI, Saudi and Dubai crude prices.

In 2004, Saudi Arabia exported 6.774 million barrels per day of crude oil, of which 46.1% were bound for the Far East (20.7% for the United States). It also exported 0.525 million b/d in petroleum products, of which 60.4% were bound for the Far East and 2.9% for the United States, and 0.749 million b/d in NGL, of which 56.8% were bound for the Far East and 3.4% for the United States. Saudi Arabia has equity stakes in some Asian oil refiners – a 9.96% stake in Japan's Showa Shell Sekiyu K.K. (with oil refining capacity at 0.515 million b/p), a 35% stake in South Korea's S-Oil Corp. (0.525 million b/p) and a 40% stake in the Philippines' Petron Corp. (0.18 million b/p).

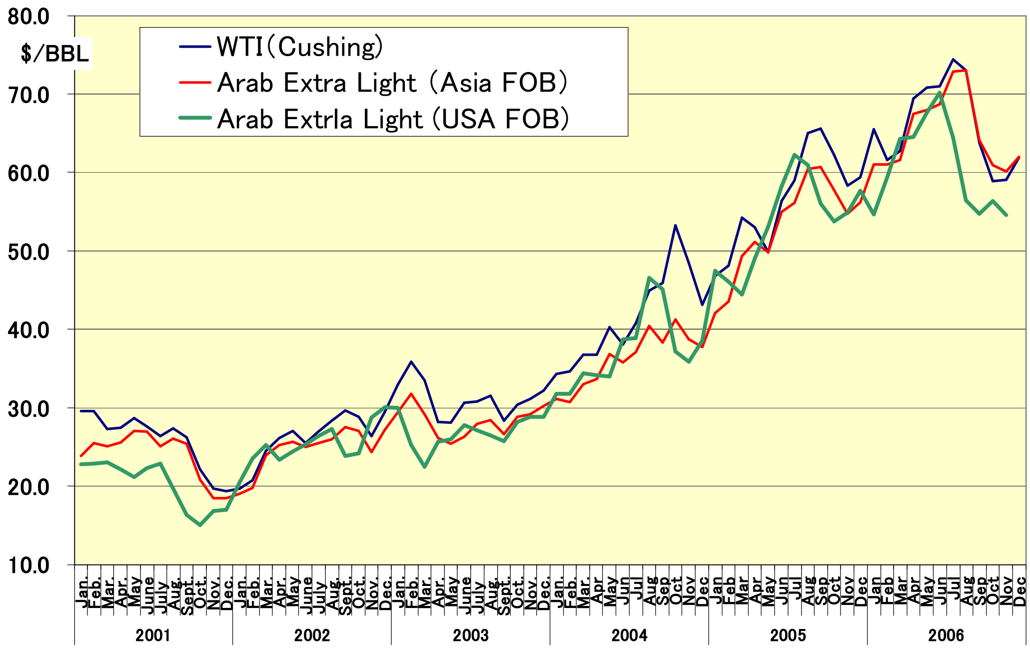
The prices of Saudi crude oil bound for Asia for a shipment month are based on their respective quality adjustment factors and the same month's average spot price for Dubai and Oman crude. Most other Middle East and Asian crude prices are set in accordance with Saudi crude prices.

Table 1-4-2 Profiles of the Latest Saudi Crude Oil Price Formulas

Destination	Point Of Sale	Current Market Link	Price Timing From Loading (in Days)	Adjustment Factors 2006											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
to EUROPE															
Saudi Arabia Ex. Lt.-37	f.o.b.	B-wave	40	-2.55	-2.95	-2.20	-2.70	-2.95	-2.80	-2.05	-1.75	-1.65	-1.65	-1.95	-2.55
Light-33	f.o.b.	B-wave	40	-5.30	-6.05	-5.35	-5.80	-6.40	-6.85	-6.25	-6.15	-5.75	-5.55	-5.05	-5.55
Medium-31	f.o.b.	B-wave	40	-7.45	-8.65	-7.65	-8.05	-8.65	-9.40	-8.90	-8.90	-8.20	-8.05	-6.95	-7.20
Heavy-27	f.o.b.	B-wave	40	-9.90	-11.30	-10.30	-10.55	-11.25	-12.30	-11.85	-12.05	-10.95	-10.50	-8.70	-8.70
to ASIA															
Saudi Arabia Ex. Lt.-37	f.o.b.	(Oman+Dubai)/2	0	2.10	2.95	3.10	2.65	2.30	3.00	3.20	3.65	3.70	4.00	3.10	2.95
Light-33	f.o.b.	(Oman+Dubai)/2	0	-0.10	0.25	0.40	0.05	-0.25	0.20	0.20	0.35	0.35	0.45	0.05	-0.10
Medium-31	f.o.b.	(Oman+Dubai)/2	0	-1.85	-1.95	-1.75	-1.80	-2.35	-2.80	-2.85	-2.85	-2.80	-3.10	-2.70	-2.70
Heavy-27	f.o.b.	(Oman+Dubai)/2	0	-4.05	-4.65	-4.40	-4.10	-4.85	-5.85	-5.95	-5.95	-5.85	-6.35	-5.50	-5.30
to the U.S.															
Saudi Arabia Ex. Lt.-37	f.o.b.	WTI	50	-4.50	-4.50	-5.25	-5.50	-4.00	-2.40	-2.70	-2.05	-2.05	-3.00	-3.65	-3.85
Light-33	f.o.b.	WTI	50	-7.95	-8.00	-8.35	-8.55	-7.25	-6.00	-6.35	-5.75	-5.75	-6.60	-7.00	-6.85
Medium-31	f.o.b.	WTI	50	-10.35	-10.05	-10.35	-10.75	-9.55	-8.55	-8.90	-8.90	-8.15	-9.00	-9.20	-8.55
Heavy-27	f.o.b.	WTI	50	-14.05	-13.10	-13.10	-13.35	-12.55	-11.80	-12.15	-12.15	-11.20	-11.70	-11.70	-10.80

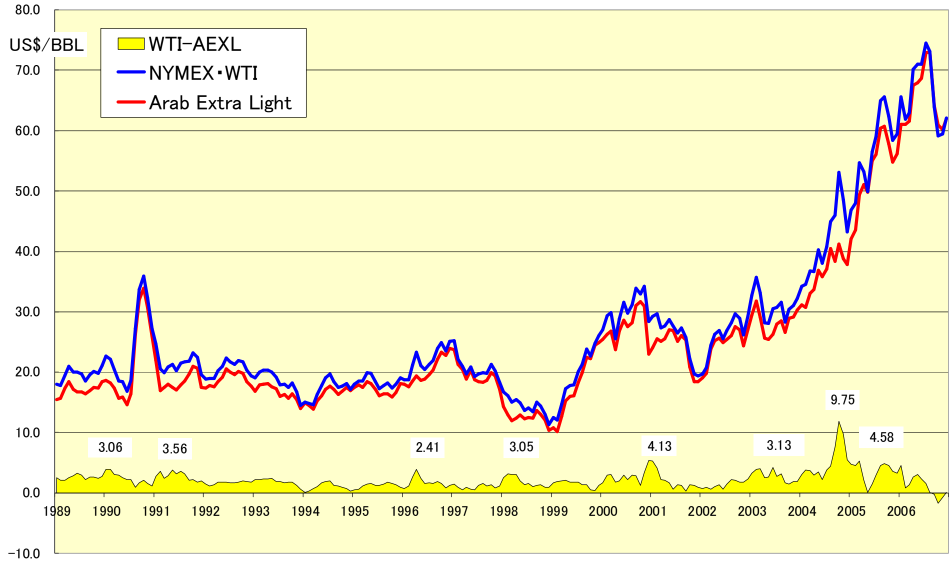
Saudi crude shipped to Asia in early April are based on April's Dubai and Oman crude prices. But prices of Saudi crude shipped to the United States in April are based on May's or June's WTI price. Because the prices of Saudi crude oil bound for the United States are based on WTI price for the period 10 days before and after the time a tanker arrives at the U.S. port that is about 50 days after loading. Therefore, a comparison of Arab Extra Light crude prices for the same month indicates that Arab Extra Light price for Asia is closely linked to the WTI price, while that for the United States deviates from the WTI price.

Figure 1-4-1 Changes in Arab Extra Light and WTI Crude Prices



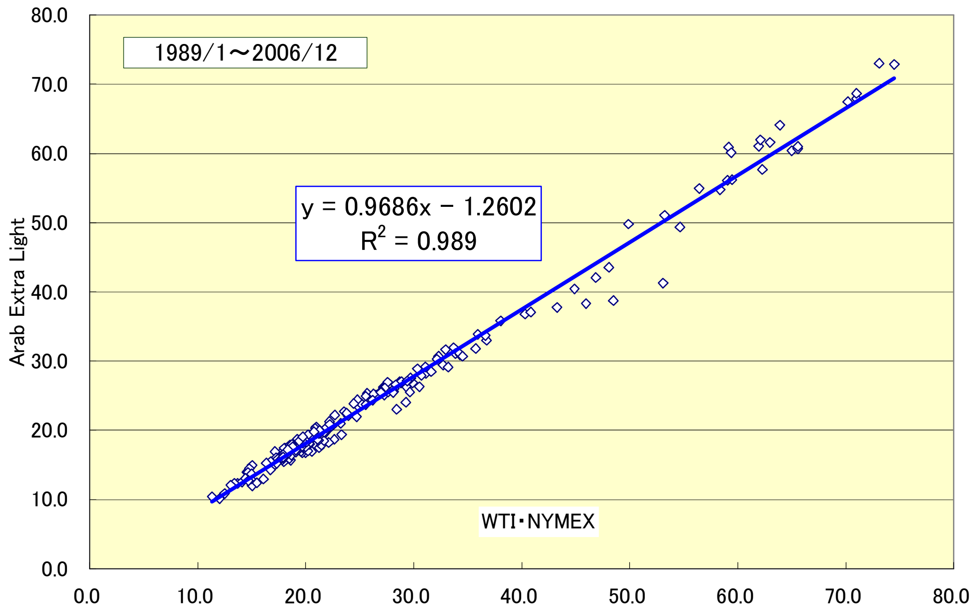
Arab Extra Light price for Asia has moved at a level around $3-4 per barrel lower than the WTI, indicating their strong correlation.

Figure 1-4-2 Changes in Arab Extra Light Price for Asia and WTI Price



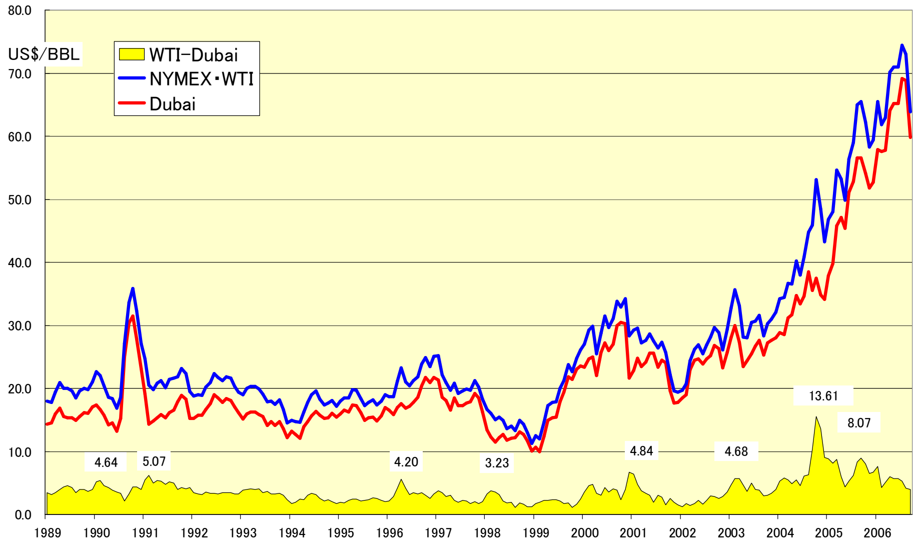
We then worked out a relationship between Arab Extra Light FOB price for Asia and the WTI price to form an assumption for future Arab Extra Light prices.

Figure 1-4-3 Correlation between Arab Extra Light Price for Asia and WTI Price



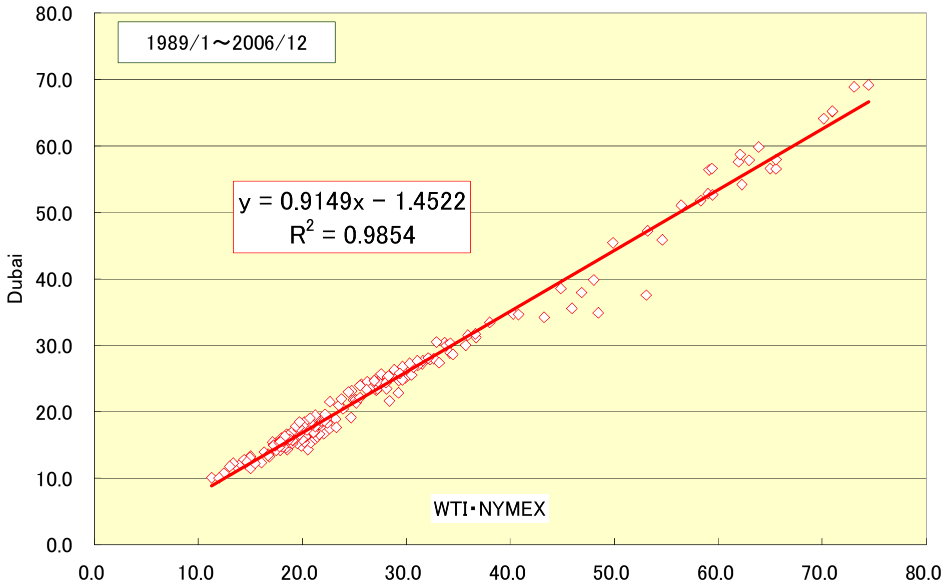
Similarly, the assumed price of Dubai crude as a Middle East crude price benchmark for Asia is based on the price's correlation with the WTI price. As indicated in Figure 1-4-4, Dubai price has moved at a level $4-6 per barrel lower than the WTI that is lighter and less sulfur content.

Figure 1-4-4 Changes in Dubai and WTI Crude Prices



We then worked out a relationship between Dubai and WTI crude prices to form an assumption for future Dubai crude prices.

Figure 1-4-5 Correlations between Dubai and WTI Crude Prices



1-4-2. Products Price Assumption

Prices of Gasoline and Diesel Oil in Asian market are based on the spot prices of these products in Singapore. As these data are available from U.S DOE/EIA database, the prices are considered to be more transparent than private information from such as Platts. As shown in Figures 1-4-6 and 1-4-7, prices are closely related with WTI price.

Figure 1-4-6 Changes in Gasoline and WTI Crude Prices

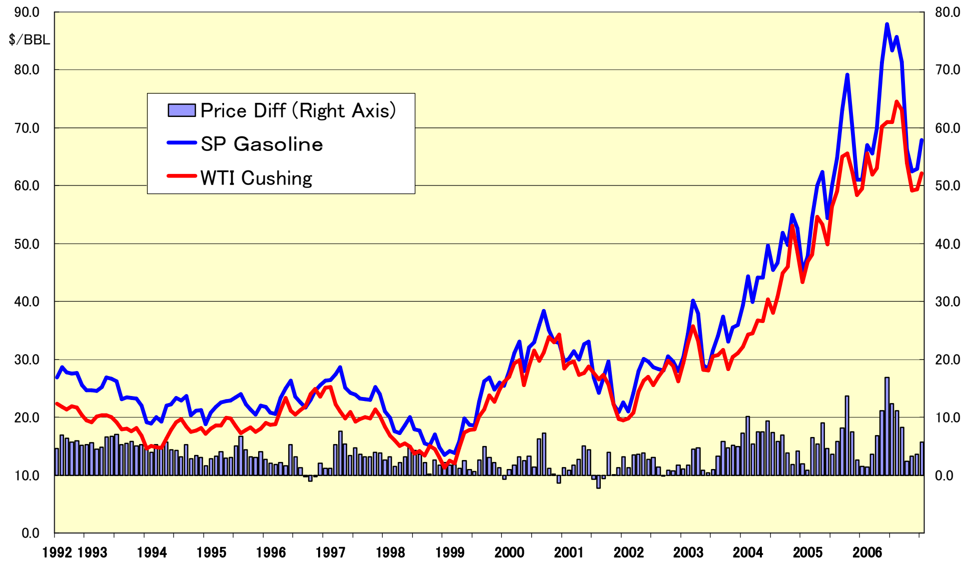
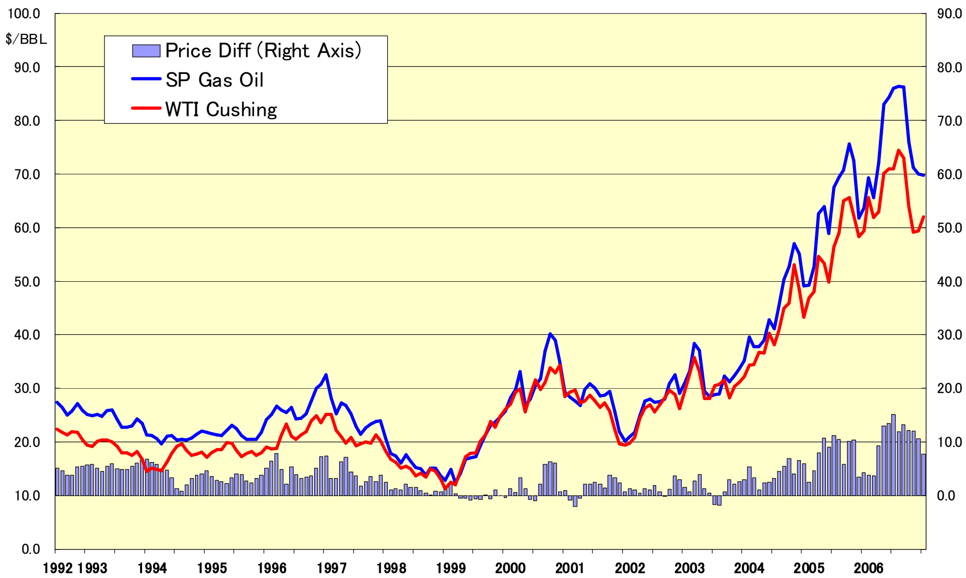
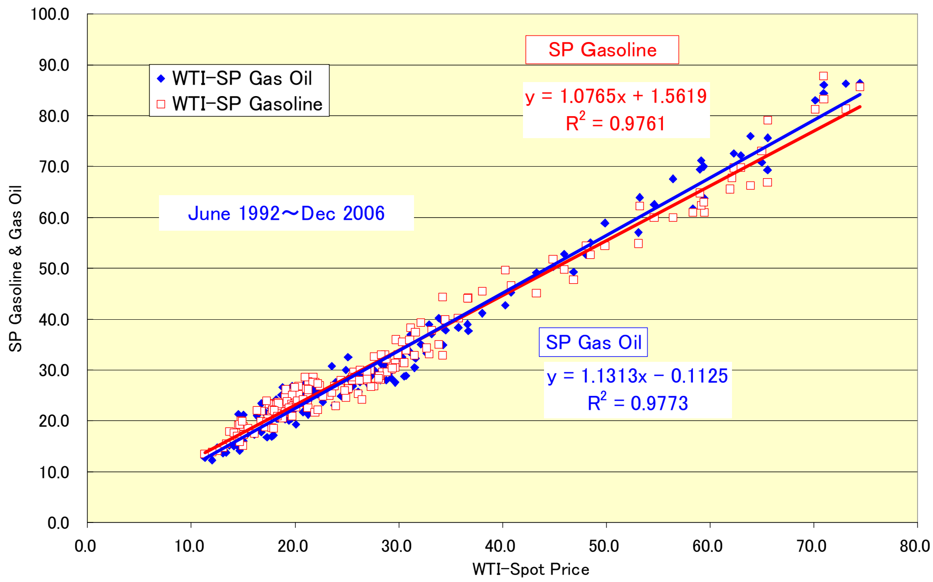


Figure 1-4-7 Changes in Diesel Oil and WTI Crude Prices



The assumed prices of Gasoline and Diesel Oil for Asia are based on the price's correlation with the WTI price as indicated in Figure 1-4-8.

Figure 1-4-8 Correlations between Products and WTI Crude Prices



1-4-3. Oil Sands Price Assumption

The oil sand subject to this study consists of four types – DilBit, SynBit, SynSynBit and Sweet SCO (SCO). SynSynBit features SCO content of 64% and bitumen content of 36%. For SynBit, SCO content is 48% and the bitumen content 52%. DilBit, SynBit, SynSynBit and Sweet SCO prices for Asia are difficult to form assumptions because these types of oil sand have never been exported to Asia except DilBit for Japan and Korea on a spot trading basis. Given Saudi crude oils' sulfur content and yield, Sweet SCO is expected to rank between the WTI and Arab Extra Light in quality. SynSynBit is close to Arab Light and SynBit to Arab Medium. DilBit is apparently heavier than Arab Heavy or Dubai crude.

DilBit, SynBit and SynSynBit feature high total acid number (TAN) and may cause corrosion of pipes etc. at refineries. Since total acid number is relatively low for Middle East crude oil imported into Japan and other Asian nations, refineries in these nations have not taken metallurgical counter-measures (including replacement of conventional pipes with anti-corrosive pipes). Reportedly, however, these conventional refineries may have limited problems in processing oil sand by mixing with other low TAN crude oils as long as the average TAN is no more than 1.0.

Table 1-4-3 Oil Sand Characteristics

Blend Ratio Vol%	Athabasca Bitumen	Dilbit (Cold Lake Blend)	SynBit	SynSynBit	Sweet SCO	WTI	Arab Extra Light	Arab Light	Arab Medium	Arab Heavy	Dubai
Bitumen	100	72	52	36	–						
SCO	–	–	48	64	100						
Condensate	–	28	–	–	–						
API	8.3	22.6	19.9	24.2	34.8	39.6	38.4	32.7	31.8	27.5	30.6
Sulfur	4.8	3.4	2.5	1.8	0.1	0.2	1.2	1.8	2.5	2.9	2.0
TAN (mgKOH/g)	4.0	2.9	2.0	1.4	0.0						
LPG Vol%	0.0	0.3	1.3	1.8	2.8	2.1	1.7	1.7	2.7	2.8	2.4
Naphtha	1.5	23.9	9.3	11.9	17.7	27.5	23.2	17.9	19.0	15.4	24.8
Jet	1.7	12.0	6.7	8.3	12.0	21.0	10.7	9.6	8.9	7.0	9.8
Diesel	13.9	7.3	23.4	26.6	33.8	13.6	22.5	24.1	23.2	22.2	20.5
VGO	31.9	17.6	32.6	32.9	33.4	23.5	41.9	46.7	46.2	52.6	25.7
Resid	50.8	38.9	26.4	18.3	0.0	10.3					16.7

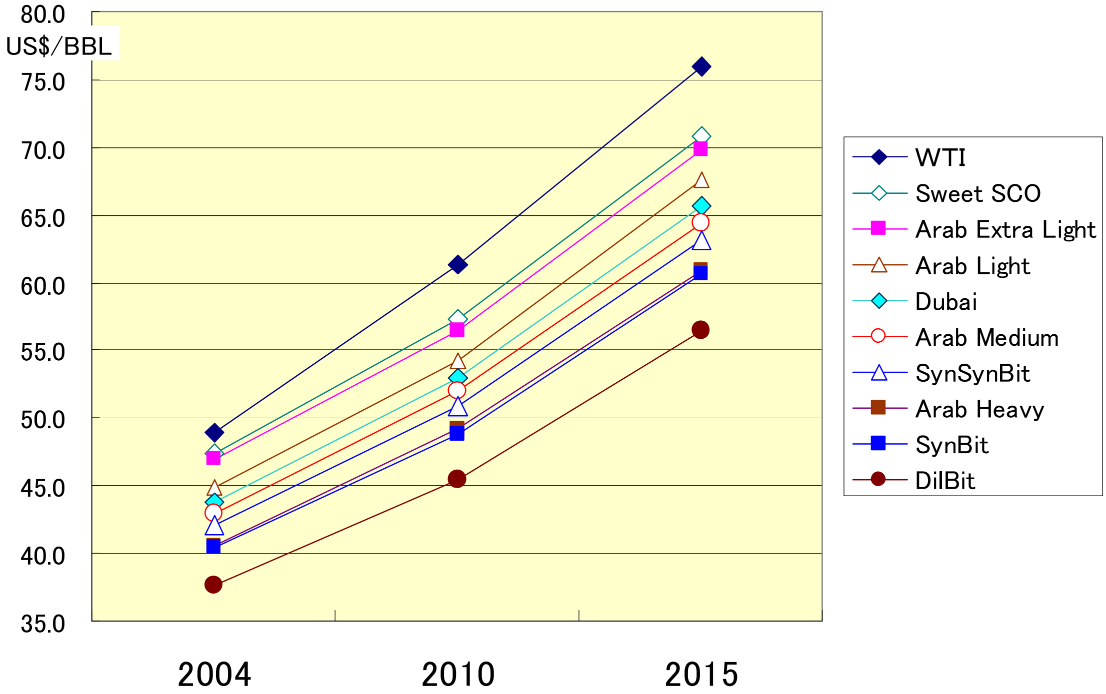
As the TAN is 2.9 for DilBit, DilBit alone cannot be processed at Japanese refineries. But it can be combined with crude oil with the TAN close to zero for processing. Oil refiners view 10-20% as an appropriate DilBit content for processing. SynBit (with the TAN at 2.0) and SynSynBit (1.4) are also difficult to process and should be mixed with crude oil for processing. Given their TANs, DilBit, SynBit and SynSynBit should be at discounted prices than Saudi crude prices.

Table 1-4-4 Oil Sand Price Assumptions

	2004	2010	2015
WTI	49.0	61.3	75.9
Arab Extra Light	47.0	56.4	69.8
Arab Light	44.9	54.3	67.7
Arab Medium	43.0	52.0	64.5
Arab Heavy	40.6	49.1	61.0
DilBit	37.6	45.5	56.4
Sweet SCO	47.3	57.2	70.9
SynSynBit	42.1	50.9	63.1
SynBit	40.4	48.8	60.6
Dubai	43.7	52.9	65.6

We based our oil sand price assumptions for 2004 on estimated price differentials between net back prices for Japan and the WTI crude price in *Oil Sands Products Analysis for Asian Markets* (April 15, 2005) by Purvin & Gertz, Inc.. SCO price for 2015 is envisaged to be close to arab Extra Light price, with the sensitivity analysis for the case where SCO price is equal to WTI price. SynBit and SynSynBit prices are envisaged to retain the same percentage price differentials with Dubai and Arab Extra Light prices between 2004 and 2015. DilBit price is assumed to follow Dubai price trend. However, netbacks for bitumen may be different for different bitumen products. Therefore, net back price to producers needs to be checked by producers.

Figure 1-4-9 Changes in Major Crude Oil and Oil Sand Prices



Other crude prices standing between WTI and Dubai prices in 2004 are assumed to retain their percentage price differentials with WTI and Dubai. Those that are lower than Dubai crude price are assumed to rise while maintaining the same differentials with Dubai crude.

Production of 70 representative crude oils includes production of other crude oil in the same area or country in this model and thus exceeds real production. To avoid this problem, the maximum output for a representative crude oil is taken to be about 30% higher than a standard level. The minimum is assumed to be about 30% less than the standard. Table 1-4-5 indicates prices of 70 crude oil types and Table 1-4-6 shows production limitations for the LP model and yields for petroleum products.

Table 1-4-5 Crude Oil Price Assumptions

No	Crude Oil	Country	Production (1000b/d)		Yield (%)					Sulfur Content (%)					Vacuum Distil. (NO)	Export (NO)
			2015		LPG	Gasoline	Kerosene	Diesel Fuel	Residue	Kerosene	Diesel Fuel	Residue	VGO	Vacuum Residue		
			Max.	Min.												
1	Arab Extra Light	Saudi Arabia	2,020	1,620	1.1	20.4	21.4	17.8	39.3	0.06	0.60	2.53	1.88	4.04		
2	Arab Light	Saudi Arabia	8,560	6,850	1.2	17.9	19.0	17.4	44.5	0.09	0.87	3.10	2.59	4.30		
3	Arab Medium	Saudi Arabia	1,620	1,300	2.7	19.0	8.9	23.2	46.2	0.12	1.23	4.14	3.19	4.99		
4	Arab Heavy	Saudi Arabia	2,320	1,860	2.0	14.8	15.2	14.3	53.7	0.14	1.42	4.35	3.78	5.67		
5	Kuwait	Kuwait	3,500	2,800	2.1	16.7	16.6	14.8	49.8	0.13	1.30	4.22	3.56	5.77		
6	Khafji	Neutral Zone	1,090	880	2.5	14.9	15.6	13.9	53.1	0.15	1.45	4.53	3.97	5.84		
7	Iran Light	Iran	1,820	1,460	2.8	18.9	18.6	16.4	43.3	0.07	0.73	2.51	2.10	3.46		
8	Iran Heavy	Iran	2,490	2,000	2.6	17.0	16.8	15.6	48.0	0.09	0.85	2.77	2.44	3.53		
9	Basrah Light	Iraq	2,680	2,150	2.4	18.2	17.9	15.6	45.9	0.10	1.00	3.56	2.94	5.01		
10	Kirkuk	Iraq	1,530	1,230	1.7	22.9	20.9	16.4	38.1	0.10	1.00	3.75	2.78	6.01		
11	Qatar	Qatar	470	380	5.0	21.9	20.0	16.6	36.5	0.06	0.60	2.88	2.43	3.94		
12	Qatar Marine	Qatar	240	200	2.2	20.2	20.7	18.3	38.6	0.07	0.74	2.85	2.34	4.03		
13	Murban	UAE	1,670	1,340	1.6	23.6	23.3	18.8	32.7	0.04	0.38	1.67	1.39	2.33		
14	Umm Shaif	UAE	560	450	2.1	21.9	20.1	17.3	38.6	0.07	0.70	2.84	2.48	3.67		
15	Lower Zakum	UAE	280	230	2.3	24.4	20.3	17.7	35.3	0.05	0.53	2.15	1.69	3.23		
16	Upper Zakum	UAE	740	600	3.3	19.1	19.0	15.8	42.8	0.10	0.97	3.30	2.87	4.30		
17	Dubai	UAE	100	80	3.2	18.0	18.1	17.0	43.7	0.10	1.00	2.96	2.51	4.01		
18	Sharjah Condensate	UAE	280	230	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
19	Oman	Oman	1,090	880	2.8	15.3	16.8	16.3	48.8	0.05	0.50	1.68	1.37	2.40		
20	Marib Light	Yemen	330	270	2.3	25.9	21.8	19.1	30.9	0.01	0.05	0.26	0.19	0.42		
21	Suez Blend	Egypt	1,280	1,030	2.5	17.1	16.7	15.5	48.2	0.07	0.69	2.40	2.10	3.09		
22	Belayim Blend	Egypt	430	350	1.9	12.9	13.3	15.1	56.8	0.11	1.10	3.49	2.84	5.00		
23	Es Sider	Libya	1,760	1,410	1.6	22.4	19.6	21.1	35.3	0.02	0.20	0.54	0.34	1.00		
24	Sirtica	Libya	440	360	2.8	27.7	22.1	19.0	28.4	0.02	0.21	0.99	0.56	2.00		
25	Forcados	Nigeria	1,400	1,120	0.7	14.4	20.4	26.4	38.1	0.01	0.12	0.34	0.26	0.52		
26	Bonny Light	Nigeria	1,600	1,280	1.5	25.2	9.8	19.0	44.5	0.01	0.08	0.26	0.20	0.40		
27	Zarzaitine	Algeria	100	80	2.8	19.0	21.1	18.1	39.0	0.00	0.04	0.13	0.01	0.40		
28	Saharan Blend	Algeria	1,000	800	2.0	40.0	12.0	15.0	31.0	0.00	0.04	0.37	0.27	0.60		
29	Argerian Condensate	Algeria	1,000	800	6.1	72.1	10.4	8.0	3.4	0.00	0.00	0.00	0.00	0.00		
30	Cabinda	Angola	3,400	2,720	1.1	15.7	8.4	24.1	50.7	0.01	0.08	0.28	0.23	0.40		
31	Minas (Sumatran Light)	Indonesia	350	280	0.5	9.5	13.8	17.5	58.7	0.00	0.04	0.11	0.08	0.17		
32	Cinta	Indonesia	50	40	0.9	7.6	10.4	14.2	66.9	0.01	0.06	0.13	0.10	0.19		
33	Duri	Indonesia	320	260	0.1	2.7	6.3	14.1	76.8	0.01	0.11	0.25	0.24	0.28		
34	Attaka	Indonesia	60	50	5.1	38.1	23.8	17.5	15.5	0.00	0.03	0.17	0.07	0.41		
35	Arun Condensate	Indonesia	20	20	7.3	70.8	14.9	7.0	0.0	0.00	0.01	0.18	0.26	0.00	1	
36	Seria Light	Brunei	110	90	2.5	21.7	24.3	26.6	24.9	0.01	0.05	0.17	0.09	0.35		
37	Champion	Brunei	110	90	0.3	6.0	23.2	37.5	33.0	0.01	0.07	0.25	0.14	0.50		
38	Miri Light	Malaysia	210	170	1.0	15.3	24.5	29.6	29.6	0.01	0.07	0.19	0.15	0.28		
39	Tapis	Malaysia	940	760	3.4	22.2	26.7	25.0	22.7	0.00	0.02	0.08	0.03	0.20		
40	Widuri & Others	Indonesia	740	600	0.9	7.6	10.4	14.2	66.9	0.01	0.06	0.13	0.10	0.19	1	
41	Daqing	China	2,370	1,900	0.4	7.6	10.4	13.2	68.4	0.01	0.05	0.16	0.14	0.20		
42	Shengli	China	1,140	1,000	0.7	5.0	7.8	12.5	74.0	0.04	0.43	1.10	0.71	2.00		
43	Bach Ho	Vietnam	420	340	0.3	12.7	16.8	17.7	52.5	0.00	0.03	0.08	0.06	0.13		
44	Bombay High	India	1,040	840	2.0	24.0	18.0	20.0	36.0	0.01	0.06	0.18	0.15	0.25		
45	Australian Condensate	Australia	170	140	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
46	Gippsland	Australia	740	600	1.8	35.5	13.6	27.6	21.5	0.00	0.05	0.23	0.16	0.40		
47	Merey	Venezuela	1,730	1,390	0.4	5.6	9.9	16.3	67.8	0.11	1.12	2.82	2.31	4.00		
48	Tia Juana Light	Venezuela	2,050	1,640	1.3	15.9	16.8	17.0	49.0	0.06	0.55	1.88	1.61	2.50		
49	Venezuela Condensate	Venezuela	330	270	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
50	Isthmus	Mexico	1,440	1,160	1.6	20.3	21.2	16.9	40.0	0.08	0.80	2.39	1.97	3.38		
51	Maya	Mexico	2,870	2,300	1.6	12.8	13.2	13.8	58.6	1.36	2.04	4.60	3.74	6.60		
52	Mexican Condensate	Mexico	310	250	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
53	West Texas Intermediate	U.S.	2,090	1,680	0.9	25.0	8.1	9.7	56.3	0.01	0.12	5.00	4.57	6.00		1
54	West Texas Sour	U.S.	2,400	1,920	0.7	24.0	7.1	8.7	59.5	0.08	0.75	5.00	4.57	6.00		1
55	Alaska North Slope	U.S.	3,550	2,840	1.8	12.8	13.9	17.0	54.5	0.05	0.52	1.10	0.84	1.70		
56	American Condensate	U.S.	1,670	1,340	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
57	Cold Lake	Canada	915	732	0.3	23.9	12.0	7.3	56.5	0.83	1.94	10.83	3.59	5.72		
58	Canadian Condensate	Canada	300	240	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00		
59	Syncrude Sweet Blend	Canada	1,271	1,017	2.8	17.7	12.0	33.8	33.7	0.01	0.01	0.00	0.43	0.44		
60	Urals	Russia	14,080	11,270	3.1	21.5	11.8	21.0	42.6	0.06	0.60	0.90	0.64	1.50		
61	Russian Condensate	Russia	630	510	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
62	Brent Blend	UK	1,800	1,440	3.6	22.3	18.4	17.3	38.4	0.01	0.13	0.73	0.50	1.27		
63	North Sea Condensate	UK	200	160	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
64	Ekofisk	Norway	3,300	2,640	1.1	33.6	20.4	15.8	29.1	0.01	0.07	0.40	0.29	0.65		
65	Norwegian Condensate	Norway	100	80	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
66	Sakhalin	Russia	600	480	3.1	21.5	11.8	21.0	42.6	0.06	0.60	0.90	0.64	1.50		
67	Oriente & Others	Other Latin America	3,000	2,400	0.7	5.0	7.8	12.5	74.0	0.04	0.43	1.10	0.71	2.00		
68	East Siberian Oil	Russia	400	320	2.8	27.7	22.1	19.0	28.4	0.02	0.21	0.99	0.56	2.00		
69	North Field･C	Iran & Qatar	600	480	4.0	76.5	14.7	4.0	0.8	0.00	0.02	0.35	0.50	0.00	1	
70	Marlim	Brazil	2,900	2,320	0.5	5.0	13.6	19.5	61.4	0.17	1.02	3.07	2.50	4.36		

Note） Crude Oil Marked 「１」 in Vacuum Distillation Column is not processed by Vacuum Distillation Unit

Crude Oil Marked 「１」 in Export Column is used domestically

1-5. Product Yields and Sulfur Contents of 70 Crude Oil Types

In the optimization calculation under the linear programming approach, assumptions are made for the upper and lower limits of productions, the sulfur content and product yields for each 70 crude oil along with the sulfur contents of intermediate products emerging from oil refineries. Each of the 70 types of crude oil has the sulfur content and data about yields for petroleum products like liquefied petroleum gas, gasoline, kerosene, diesel and atmospheric residues. Sulfur content data for atmospheric distillation and vacuum distillation residues serve as conditions for input for each refining unit and can affect such contents for products. Products from atmospheric distillation units are produced in accordance with product yields of each crude oil.

The model combines demand-supply balances for crude oil and for oil products in the 30 areas to calculate an optimum crude production volume that meets product-by-product sulfur content standards and minimizes overall costs in each area.

This means that a crude oil production volume is found for the case where the 30 areas' total costs are minimized including crude oil prices, crude and petroleum products transportation costs, and operation costs for such refining equipment as atmospheric and vacuum distillation and catalytic reforming units etc.

Table 1-5-1 Limitations of Crude Oil Production and Yield (2015)

No	Crude Oil	Country	API Degrees	Sulfur Wt%	2004 (2nd Half)	2010	2015
1	Arab Extra Light	Saudi Arabia	36.60	1.20	47.00	56.40	69.80
2	Arab Light	Saudi Arabia	33.00	1.73	44.85	54.26	67.66
3	Arab Medium	Saudi Arabia	31.80	2.45	42.95	51.97	64.45
4	Arab Heavy	Saudi Arabia	28.10	2.84	40.62	49.15	60.95
5	Kuwait	Kuwait	30.90	2.60	42.71	51.68	64.09
6	Khafji	Neutral Zone	27.90	2.90	40.62	49.15	60.95
7	Iran Light	Iran	33.70	1.45	44.94	58.09	69.10
8	Iran Heavy	Iran	31.10	1.70	42.83	51.82	64.26
9	Basrah Light	Iraq	34.10	2.00	42.90	51.90	64.37
10	Kirkuk	Iraq	35.40	2.00	38.31	46.35	57.49
11	Qatar	Qatar	42.00	1.19	46.99	60.75	72.26
12	Qatar Marine	Qatar	36.30	1.47	44.36	57.34	68.21
13	Murban	UAE	40.60	0.76	47.39	57.37	71.01
14	Umm Shaif	UAE	36.90	1.40	46.85	60.56	72.04
15	Lower Zakum	UAE	39.80	1.05	47.43	57.47	71.13
16	Upper Zakum	UAE	33.70	1.94	43.98	56.86	67.63
17	Dubai	UAE	30.70	2.00	43.74	52.92	65.64
18	Sharjah Condensate	UAE	55.30	0.04	51.92	67.12	79.84
19	Oman	Oman	34.90	1.00	44.62	57.67	68.61
20	Marib Light	Yemen	39.60	0.10	48.12	59.15	73.22
21	Suez Blend	Egypt	33.00	1.38	43.56	52.70	65.36
22	Belayim Blend	Egypt	27.50	2.20	41.83	50.61	62.76
23	Es Sider	Libya	39.10	0.40	46.24	59.77	71.11
24	Sirtica	Libya	41.10	0.42	46.53	60.15	71.55
25	Forcados	Nigeria	29.70	0.24	44.96	58.12	69.14
26	Bonny Light	Nigeria	36.70	0.15	47.04	56.51	69.94
27	Zarzaitine	Algeria	42.00	0.08	48.85	60.94	75.45
28	Saharan Blend	Algeria	45.70	0.08	49.49	63.97	76.10
29	Argerian Condensate	Algeria	62.40	0.00	54.93	71.01	84.47
30	Cabinda	Angola	32.90	0.16	46.18	59.70	71.02
31	Minas (Sumatran Light)	Indonesia	35.60	0.07	46.49	60.09	71.49
32	Cinta	Indonesia	33.00	0.11	44.63	57.69	68.63
33	Duri	Indonesia	21.20	0.21	40.60	49.13	60.93
34	Attaka	Indonesia	42.50	0.05	49.45	63.93	76.05
35	Arun Condensate	Indonesia	55.30	0.01	53.93	69.71	82.93
36	Seria Light	Brunei	34.40	0.10	47.10	56.65	70.11
37	Champion	Brunei	25.40	0.14	50.25	64.95	77.26
38	Miri Light	Malaysia	30.60	0.13	50.36	65.10	77.44
39	Tapis	Malaysia	46.30	0.03	50.36	65.10	77.44
40	Widuri & Others	Indonesia	34.00	0.10	44.66	57.72	68.67
41	Daqing	China	32.70	0.10	45.94	59.38	70.64
42	Shengli	China	25.70	0.86	42.47	51.39	63.73
43	Bach Ho	Vietnam	39.00	0.05	47.79	58.34	72.21
44	Bombay High	India	38.80	0.12	47.73	58.20	72.04
45	Australian Condensate	Australia	55.30	0.04	51.92	67.12	79.84
46	Gippsland	Australia	45.80	0.09	49.34	63.78	75.88
47	Merey	Venezuela	17.20	2.24	38.92	47.09	58.40
48	Tia Juana Light	Venezuela	31.30	1.10	43.48	52.60	65.24
49	Venezuela Condensate	Venezuela	55.30	0.04	51.92	67.12	79.84
50	Isthmus	Mexico	32.90	1.60	44.85	57.98	68.97
51	Maya	Mexico	21.80	3.40	36.99	44.75	55.50
52	Mexican Condensate	Mexico	55.30	0.04	51.92	67.12	79.84
53	West Texas Intermediate	U.S.A.	39.60	0.24	49.00	61.30	75.90
54	West Texas Sour	U.S.A.	35.00	1.50	43.85	56.69	67.43
55	Alaska North Slope	U.S.A.	26.80	1.04	43.73	52.91	65.62
56	American Condensate	U.S.A.	55.30	0.04	51.92	67.12	79.84
57	Cold Lake	Canada	22.60	3.39	37.60	45.49	56.42
58	Canadian Condensate	Canada	55.30	0.04	51.92	67.12	82.66
59	Syncrude Sweet Blend	Canada	34.80	0.10	47.34	57.25	70.85
60	SynSynBit	Canada	24.20	1.80	42.08	50.91	63.15
61	SynBit	Canada	19.90	2.50	40.37	48.85	60.58
60	Urals	Russia	33.40	1.19	38.48	46.56	57.74
61	Russian Condensate	Russia	55.30	0.04	51.92	67.12	79.84
62	Brent Blend	UK	38.20	0.26	46.08	59.57	70.86
63	North Sea Condensate	UK	55.30	0.04	51.92	67.12	79.84
64	Ekofisk	Norway	43.40	0.14	45.54	58.87	70.03
65	Norwegian Condensate	Norway	55.30	0.04	51.92	67.12	79.84
66	Sakhalin	Russia	33.40	1.19	43.82	56.64	67.38
67	Oriente & Others	Other Latin America	24.70	0.70	44.87	58.00	69.00
68	East Siberian Oil	Russia	41.10	0.42	47.29	57.12	70.70
69	North Field･C	Iran & Qatar	55.30	0.04	53.93	69.71	82.93
70	Marlim	Brazil	20.00	2.00	38.75	46.89	58.15

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2. Details of Petroleum-Refining Model

A refinery flow model is shown in Figure 2-1-1. The flow covers atmospheric distillation and all other secondary processing units. Since production of cleaner and lighter oil is expected to increase further, cracking units include hydro, catalytic and thermal cracking units. Catalytic cracking units cover both FCC (fluid catalytic cracking unit) and R-FCC (residual fluid catalytic cracking unit).

Assumptions are set for fuel, electricity, steam and hydrogen consumption by each refining materials processing unit along with chemical costs in order to estimate operation costs for each unit.

2-1-1. Atmospheric Distillation Units

Crude oil is first put into the atmospheric distillation unit and divided into fractions meeting boiling temperatures of products. The model assumes LPG, naphtha (gasoline), kerosene, diesel oil and atmospheric residues as crude oil fractions. Each fraction is obtained in accordance with a relevant yield.

① LPG and Naphtha Fractions

LPG and naphtha are treated as the same fraction and the LP model is assumed to separate LPG from naphtha at any rate out of the atmospheric distillation unit.

② Yield Changes

The atmospheric distillation unit can change yields of fractions by altering the inside temperature and pressure distribution. In a bid to model this function, we set up two virtual fractions – Swing 1 between naphtha and kerosene, and Swing 2 between kerosene and diesel oil – in the model flow to freely change yields of fractions within certain limits.

③ Sulfur Contents of Naphtha, Kerosene and Diesel Oil

The sulfur content of light fractions (straight-run kerosene and diesel oil) yielding from the atmospheric distillation unit is lower than that of crude oil. Conversely, the sulfur content of atmospheric residues is higher than that of crude oil. The rates of sulfur declines from crude oil are set for straight-run kerosene and diesel oil. The sulfur content of atmospheric residues is assumed for each crude oil.

2-1-2. Vacuum Distillation Units

The vacuum distillation unit uses atmospheric residues as a feedstock in a vacuum environment to distill vacuum gas oil (VGO). NGL is designed for not being processed with the vacuum distillation unit.

The sulfur content of vacuum residue is assumed for each crude oil. The sulfur content of VGO is calculated as the balance between the sulfur content of atmospheric residues upon feeding (sulfur put into the unit) and that of the yield (sulfur taken out from the unit). This means that the sulfur content of atmospheric residues is simply distributed to VGO and vacuum residues.

2-1-3. Naphtha, Kerosene and Diesel Oil De-sulfurization Units

These units de-sulfurize naphtha, kerosene and diesel oil yielded from the atmospheric distillation unit. The kerosene and diesel oil de-sulfurization unit can accept both kerosene and diesel oil. The model selects either for feeding to minimize costs. An assumption is made for the de-sulfurization rate in accordance with regional sulfur content standards for diesel oil.

2-1-4. Hydro-treating Units (for de-sulfurizing residues)

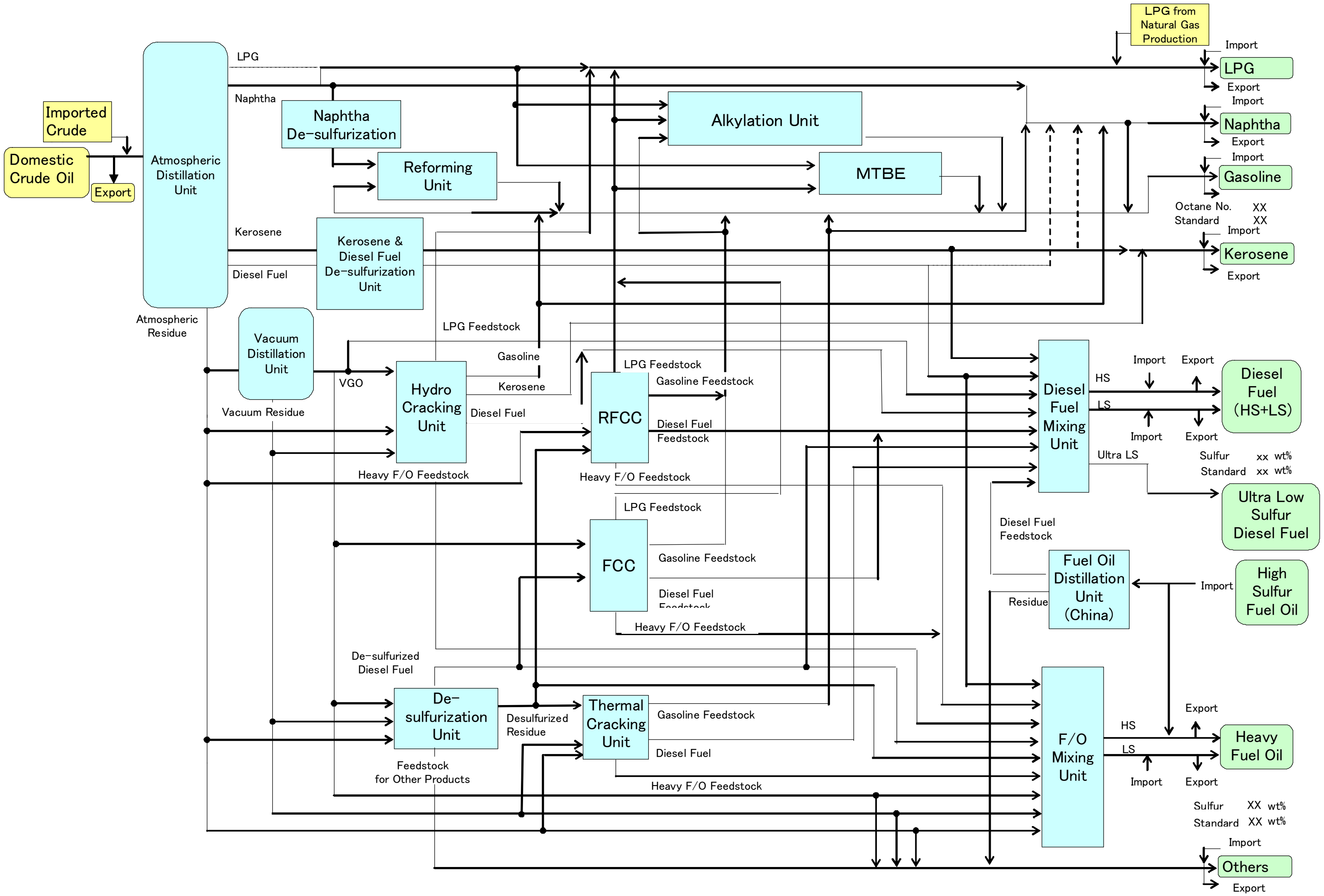
The hydro-treating units mean indirect and direct de-sulfurization units using VGO, atmospheric residues and vacuum residues as input materials. The de-sulfurization levels vary depending on crude oil types, catalysts and operating conditions. A condition-setting file is designed to change the levels.

2-1-5. Hydro Cracking Units

The hydro cracking unit cracks fractions and residues. The unit is designed to process VGO, atmospheric residues and vacuum residues.

The condition-setting file can change conditions in a single operation mode to process atmospheric residues and vacuum residues. The unit yields gasoline, kerosene, diesel and fuel oil as intermediate products. Swings are set up between these intermediate products to allow product yield assumptions to be set within a wide range. For diesel and fuel oil fractions, sulfur contents are taken into account. Three operation modes are assumed for processing VGO. In each mode, the condition-setting file can change product yields.

Figure 2-1-1Refinery Flow Model



2-1-6. Catalytic Cracking Units

The catalytic cracking units here include fluid catalytic cracking units and residual fluid catalytic cracking units. They process de-sulfurized diesel, VGO, vacuum residues and atmospheric residues. Atmospheric residues for use in these units are limited to those from crude oil with a low sulfur content of not more than 0.2 wt%.

Fractions from these units are LPG, gasoline feedstock, cracked diesel and fuel oil feedstock. LPG flows into the alkylation unit to produce high-octane gasoline blending components. These units have gasoline and diesel operation modes. Swings are set up between fractions to allow optimum yields to meet demand. Eventually, these units can freely shift from the gasoline operation mode to the diesel operation mode.

2-1-7. Thermal Cracking Units

Thermal cracking units include visbreakers as well as delayed cokers and Flexicokers that crack crude oil under severe conditions. They process atmospheric, vacuum and de-sulfurized residues.

2-1-8. Catalytic Reforming Units

The catalytic reforming unit for the model is assumed to process straight-run naphtha and hydro-cracked naphtha to produce highly aromatic gasoline blending component (reformate) with the octane value at 100.

2-1-9. Alkylation Units

The alkylation unit for the model includes an isomerization unit. The alkylation unit adds olefin to hydrocarbons for polymerization to produce side-chain hydrocarbons. The isomerization unit converts hydrocarbons into side-chain hydrocarbons without changing the chemical composition. Both the alkylation unit and the isomerization unit can produce high-octane gasoline blending components. The alkylation unit processes straight-run LPG from the atmospheric distillation unit and cracked LPG and gasoline from the catalytic cracking unit.

2-1-10. MTBE Units

In addition to the alkylation unit, the MTBE (methyl tertiary butyl ether) unit is set up for the model to improve octane numbers of gasoline based on regional standards. MTBE units may be installed at importing bases and petrochemical plants as well as refineries. Virtual MTBE units are assumed for areas that have no such units. Even for areas that have MTBE units, their capacity utilization rate can be set at levels above 100%. MTBE units process straight-run LPG from the atmospheric distillation unit and cracked LPG from the catalytic cracking unit.

2-2. Blending of Products

2-2-1. LPG

Since no standards are set for blending LPG, the model simply adds up LPG output from distillation unit and cracking units to meet domestic and overseas demand. If domestic demand is greater than production in one country (or area), imports from other countries (or areas) may emerge to satisfy domestic demand. If domestic demand is less than domestic production in one country, surplus LPG may be exported to other countries. If no country is short of LPG, however, domestic surplus LPG may be booked as surplus.

LPG for the model includes both dry gases like methane and ethane and wet gases such as propane and butane. Dry gases are mostly natural gases from gas fields and those emerging from refining are limited. Demand for dry gases from refining, as calculated for the model, is assumed to be met not by external trade but by domestic output alone.

2-2-2. Naphtha

Since no standards are set for blending naphtha, the model simply adds up naphtha output through distillation and cracking to meet domestic and overseas demand. China mixes kerosene fractions with naphtha for petrochemical production and ceiling assumptions can be set for kerosene and diesel contents of naphtha. For China alone, the model allows kerosene fractions to account for up to 50% of a kerosene-naphtha mix. The condition-setting file can change the percentage.

2-2-3. Gasoline

Export and import assumptions for gasoline are basically the same as those for LPG. Any domestic shortage may be covered by imports and any domestic surplus may be exported. If no country is short of gasoline, however, domestic surplus may be booked as surplus. As for MTBE to improve octane numbers of gasoline, ceilings on the MTBE content are set for each area (or country).

Since the octane number for a gasoline in each area (or country) is set, gasoline for domestic production must meet the domestic octane standard for each area. Gasoline can be exported from more stringent standard area to less stringent standard area. But the reverse case cannot be allowed.

2-2-4. Kerosene

Since no standards are set for blending kerosene, the model simply adds up kerosene output through distillation and cracking to meet domestic and overseas demand.

2-2-5. Diesel Oil

Export and import assumptions for diesel oil are basically the same as those for LPG. Any domestic shortage may be covered by imports and any domestic surplus may be exported. If no country is short of diesel oil, however, domestic surplus may be booked as surplus.

Low-sulfur diesel oil and high-sulfur diesel oil are separately produced and traded. In this case, sulfur contents of low- and high-sulfur diesel oil must meet international standards. Since international standards are adopted for low- and high-sulfur diesel oil for trade, these fuels can be traded freely between countries. After exports or imports, low- and high-sulfur diesel oil may be mixed to meet domestic sulfur content standards.

2-2-6. Fuel Oil

Each country exports or imports low-sulfur fuel oil and high-sulfur fuel oil meeting international standards and blends imported fuel oil with domestic output to meet domestic sulfur content standards. The excess of global output over demand may be booked as surplus.

China has "bitumen refineries" that have no crude oil-importing rights. These refineries purchase foreign or domestic fuel oil for vacuum unit processing to produce low-quality diesel oil, asphalt and other petroleum products. For the linear programming model, these Chinese bitumen refineries' fuel oil processing capacity is set at about 400,000 barrels per day, with the production ratio of low-quality diesel oil to other petroleum products at 40:60.

2-2-7. Limitations on Product Yields

Under the model, a country (or area) may see output of some petroleum products at zero when producing petroleum products. In reality, output cannot be expected to be zero as long as production facilities exist. In order to avoid such problems for the model, limitations can be imposed on each product's share of overall petroleum products output. The model has set up such limitations to allow each product's share to remain within a certain range.

Each product's share in a country is expected to remain almost unchanged unless demand changes dramatically or refineries are modified substantially. But the model does not necessarily reflect real refineries strictly. Under the model, therefore, production may deviate far from real output. In order to avoid such deviation, we have set each product's share of overall petroleum products output in each area (or country).

2-2-8. Expanding Secondary Processing Units

Secondary equipment capacity is more difficult to assume than CDU (crude distillation unit) capacity. A growing shift to cleaner and lighter oil products may cause secondary equipment shortages. In this respect, the LP model is allowed to automatically expand secondary equipment capacity to meet regional demand and sulfur content standards and minimize export and import costs. But the expansion brings about additional costs. In the linear programming model, therefore, annual costs for long-existing refineries are compared with those after the expansion.

2-3. Processing Crude Oil

For crude oil imports into Japan for non-refining purposes (including burning at thermal power plants of electricity utilities), an exogenous value is input. In crude oil trade, oil-producing nations export such crude oil to Japan. But such crude oil imports are not processed at refineries in Japan. In the model, crude oil trade is implemented to minimize costs. In reality, however, oil-producing countries use some crude oil output for domestic consumption rather than exports. Such crude oil can be assumed to be for non-exporting purposes.

NGL may never be processed with vacuum distillation units in reality. But the model sets an assumption for atmospheric residues as a crude oil yield so that atmospheric residues may be processed with vacuum distillation units. To avoid such a result, NGL is designated as crude oil that may never be processed with vacuum distillation units.

2-4. Consideration for Crude Oil and General Price Hikes

Our estimation has explicitly taken crude oil price rises into account for not only the econometric World Energy Demand-Supply Model but also the Petroleum Refining and Trade Estimation (linear programming) Model. Because the crude oil price rises over the past few years have increased upward price pressure on materials, transportation and other costs for oil refiners, consideration may have to be given to such effects of crude oil price rises.

In this respect, we have considered the GDP deflator in AEO2006 to be a global price rise and explicitly included rises in costs (including those for operation and expansion of refining units, and transportation of crude oil and petroleum products) in the LP model.

3. Trading System

Major costs included in the objective function for this model analysis include crude oil prices, freights and refining costs. If oil sand is exported from Canada to U.S. and Asian markets, freights reflecting transportation distances between production and consumption points may become one of economic factors that determine the specific oil sand variety or products for exporting.

In the model, crude oil and petroleum products are transported by ship. Therefore, transportation through pipelines between the United States and Canada, and between European countries and between the Middle East and neighboring countries are not taken into account.

3-1. Port Assumptions

Each area is assumed to have a port that can accommodate a large VLCC-class tanker for exports and imports. Trading between the 30 areas (or countries) is set to use the assumed ports. Although one port is assumed to represent one area, the United States, Canada, Mexico, former Soviet republics and Africa are vast and surrounded by a number of oceans. If they have only one port, each may see trade flows being limited. Therefore, two ports are assumed for each of these areas (or countries). “Other Asian countries” cover Pakistan, Bangladesh, Myanmar and North Korea, but are represented by one port – Karachi in Pakistan in the LP model.

3-2. Freight Assumptions for Crude Oil and Petroleum Products

Different freights are assumed for crude oil and petroleum products. Freights for petroleum products are applied the same even if the quality of these products are different. VLCC-class (160,000-320,000 deadweight tons) tankers are assumed for transporting crude oil. MR-class tankers are assumed to carry petroleum products. But LR2-class (80,000 to 160,000 deadweight tons) tankers are assumed to be used for petroleum products transportation from the Middle East to Asia as such tankers actually used.

Different freight-setting approaches have been adopted for crude oil and petroleum products because their tanker sizes are different. Freights for areas that are not covered by the World Scale[1] have been estimated.

[1] The World Scale data mean the Worldwide Tanker Nominal Freight Scale as published by the World Scale Association in London and New York. The book lists freights for tanker routes in the world. Contracts for shipping companies to lease ships from owners may specify such percentages as 230%, 100% and 45% as multipliers of standard freights to calculate freights for specific routes. The book is published and distributed annually with considerations given to changes in bunker prices and port facility fees.

As mentioned above, this model explilcitly separates crude oil transportation from petroleum products transportation and sets different freights for crude oil and petroleum products. Different freight calculation formulas were used for setting freights for transportation between specific ports since crude oil tankers are different from petroleum product carriers. The World Scale data for 2015 have been estimated, based on hearings from experts. Freight calculation formulas for crude oil and petroleum products are as follows:

Crude Oil (2005 FLAT RATE)×(Crude Oil Density 0.855)×(Estimated WS 0.700)÷ 6.29 ＝ Freight (＄/bbl)

Petroleum Products (2005 FLAT RATE)×(Petroleum Products' Density 0.80)×(Estimated WS 2.000)÷6.29 ＝ Freight (＄/bbl)

For petroleum products transportation from the Middle East to Asia, the following formula is used:

Petroleum Products (2005 FLAT RATE)×(Petroleum Products' Density 0.80)×(Estimated WS 1.200)÷6.29 ＝ Freight (＄/bbl)

The flat rates employed in this model are given below along with crude oil and petroleum products freights as calculated according to the above formulas. Vancouver is assumed as a shipping port for Canada for setting the freights.

The following figures indicate freights for crude oil transportation from major oil-producing countries to Japan and China. The freight for oil sand transportation from Canada to Japan is $0.9/bbl, some $0.2/bbl lower than $1.1/bbl for Middle East crude oil that accounts for a major portion of Japan's crude imports. The freight for oil sand or crude oil transportation from Canada to Japan is $0.5/bbl higher than for Russian crude oil (costing $0.4/bbl for transportation to Japan) and $0.2-0.6/bbl higher than for Indonesian and other Asian crude oil. Canadian oil sand would cost far less than African crude oil in transportation to Japan as the freight for Canadian oil sand is $1.0/bbl lower than for African crude.

Figure 3-2-1 Freights for transportation from oil-producing countries to Japan (crude oil transportation with VLCC tankers in 2015)

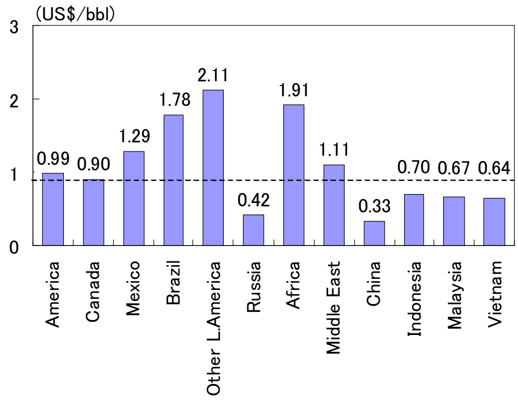
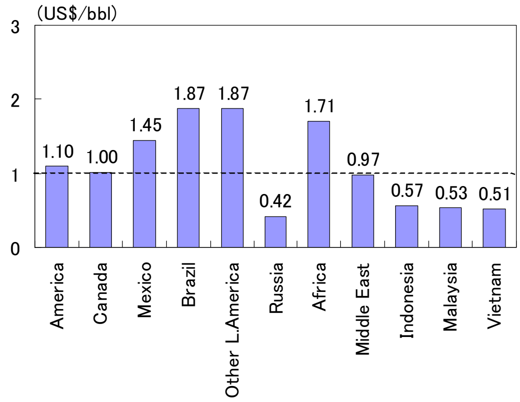


Figure 3-2-2 Freights for transportation from oil-producing countries to China (crude oil transportation with VLCC tankers in 2015)



The freight for oil sand transportation from Canada to China is $1.0/bbl, equal to the freight for Middle East crude oil. Canadian oil sand thus costs as much as Middle East crude oil in transportaiton to China. The freight for oil sand or crude oil transportation from Canada to China is $0.6/bbl higher than for Russian crude oil (costing $0.4/bbl for transportation to China) and $0.4-0.6/bbl higher than for Indonesian and other Asian crude oil. However, the freight for Canadian oil sand is $0.7/bbl lower than for African crude and $0.9/bbl lower than for Brazilian and other Latin American crude. In conclusion, Canadian oil sand would be more cost-competitive than African and Latin American crude in terms of transportation to China.

The following figure indicates freights for crude oil transportation with VLCC tankers from Vancouver to various export destinations. Freights are $0.4/bbl for the United States, $0.8-1.0/bbl for Latin America, $0.7-0.9/bbl for Europe, and $0.9-1.5/bbl for Asia.

3-3. Limitations on Crude Oil and Petroleum Products Trade

Under the model, crude oil or petroleum products exports from one country to another can be limited in volume. Volume limitations can be assumed for each crude oil type. For petroleum products such as LPG and gasoline, upper and lower export or import limits can be set for each product between an exporting country and an importing one.

Figure 3-2-3 Freights for crude oil transportation (with VLCC tankers in 2015) from Canada to export destinations

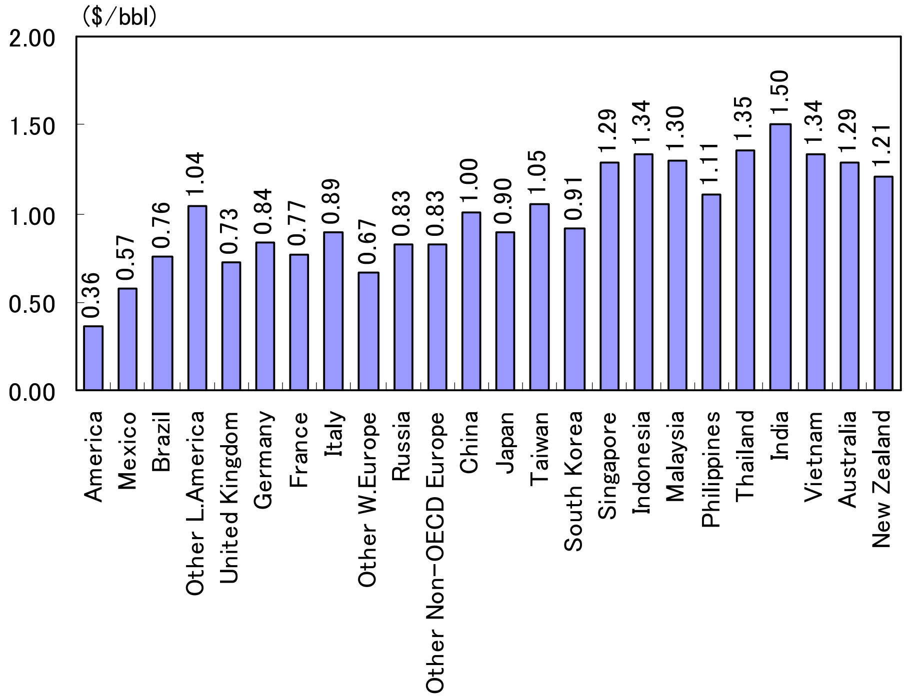


Table 3-2-1　Flat Rate（World Scale Ver.: 2005）

(FLATRATE)　→　Port of Destination　　(Unit:US$/MT)

Port of Embarkation ↓

	Region	America	Canada	Mexico	Brazil	Other L.America	United Kingdom	Germany	France	Italy	Other W.Europe	Russia	Other Non-OECD	Africa	Middle East	China	Japan	Hong Kong	Taiwan	South Korea	Singapore	Brunei	Indonesia	Malaysia	Philippines	Thailand	India	Vietnam	Other Asia	Australia	New Zealand	Region
1	America	*	5.00	2.77	11.00	11.09	11.13	11.56	10.53	12.06	10.40	11.67	13.32	10.46	20.09	11.53	10.37	12.62	12.04	10.31	14.49	13.66	14.99	14.83	12.60	15.15	19.43	14.83	18.75	13.86	11.57	America
2	Canada	3.75	*	6.00	8.00	10.98	7.63	8.78	8.07	9.33	7.04	8.71	8.71	8.57	15.10	10.54	9.42	11.67	11.00	9.60	13.54	13.00	14.04	13.71	11.67	14.20	15.75	14.04	15.85	13.54	12.71	Canada
3	Mexico	2.77	6.00	*	7.77	11.24	10.47	10.47	10.47	12.27	10.60	12.50	13.00	12.62	18.20	15.22	13.55	15.89	15.22	13.50	17.67	16.84	18.17	18.01	15.76	18.33	19.64	18.01	23.16	14.23	13.70	Mexico
4	Brazil	10.22	11.00	7.77	*	8.42	17.00	18.50	16.00	17.83	17.10	16.00	19.40	13.91	18.52	19.63	18.70	20.00	19.00	20.00	19.39	19.31	19.99	19.9	18.50	21.50	19.50	19.50	19.50	14.50	12.50	Brazil
5	Other L.America	11.09	10.98	11.24	8.42	*	11.04	12.18	11.04	11.35	10.92	14.32	14.35	7.92	14.97	19.63	22.16	14.98	19.75	12.67	16.85	17.97	16.93	17.19	14.96	17.51	16.86	17.19	15.63	11.44	9.44	Other L.America
6	United Kingdom	8.29	7.77	11.34	17.00	11.66	*	3.88	3.51	7.05	2.88	6.20	5.44	6.21	12.89	26.96	22.67	19.64	19.82	21.94	16.92	18.11	17.00	19.22	19.31	18.62	14.32	18.52	13.65	23.19	23.66	United Kingdom
7	Germany	8.57	8.37	11.76	18.50	12.10	3.88	*	3.79	7.49	3.07	5.75	4.98	6.65	13.34	21.70	23.13	20.10	20.28	22.39	17.37	18.57	17.45	19.67	19.77	19.08	14.77	18.97	14.10	23.64	24.11	Germany
8	France	8.44	8.07	11.49	16.00	11.81	4.25	4.54	*	7.20	3.52	6.87	6.10	6.36	13.04	20.62	22.05	19.02	19.20	20.70	17.06	18.26	17.14	19.37	19.46	18.77	14.47	18.66	13.80	23.33	23.80	France
9	Italy	9.45	9.22	12.27	16.00	11.24	7.05	7.49	6.45	*	6.32	9.69	8.89	3.95	9.64	18.62	19.34	15.17	15.35	16.85	13.64	14.84	13.71	15.96	16.04	15.36	11.06	15.23	10.40	24.27	23.29	Italy
10	Other W.Europe	7.56	7.04	10.60	15.77	10.92	2.88	3.07	2.78	6.32	*	5.40	4.63	4.75	12.16	21.19	21.92	18.89	19.07	20.57	16.18	17.37	16.25	22.5	18.55	17.88	13.58	17.87	12.91	22.44	22.91	Other W.Europe
11	Russia	11.67	9.60	12.50	16.00	14.32	6.20	5.75	6.87	9.69	5.40	*	4.44	10.59	12.85	4.43	4.42	5.59	5.06	3.20	7.46	6.65	7.96	7.62	5.65	8.11	12.50	7.35	12.85	11.42	12.39	Russia
12	Other Non-OECD Europe	12.51	9.32	13.16	18.33	13.48	5.44	4.98	5.35	7.41	4.63	4.44	*	8.27	14.78	23.20	24.00	17.52	17.70	19.20	14.81	16.00	14.88	22.5	17.18	16.51	12.21	16.50	11.54	21.07	21.54	OECD Europe
13	Africa	8.59	9.68	11.41	13.00	7.92	6.21	6.65	5.61	3.92	5.48	9.00	8.30	*	9.60	17.96	20.10	16.06	17.28	18.78	14.39	10.89	15.33	15.24	15.72	15.09	10.79	15.28	10.32	17.75	18.22	Africa
14	Middle East	20.09	15.10	18.20	18.52	14.97	12.89	13.34	13.04	9.64	12.16	12.16	14.78	9.60	*	10.23	11.62	8.78	8.96	10.33	6.34	7.31	6.13	5.95	8.47	7.86	3.29	8.12	2.49	12.35	13.56	Middle East
15	China	11.67	10.08	14.21	19.63	23.12	21.00	22.20	21.50	18.62	21.19	4.56	23.20	19.38	11.64	*	3.52	4.29	3.76	3.20	6.16	5.55	6.66	6.30	4.30	7.31	11.70	6.56	12.05	8.20	9.10	China
16	Japan	11.01	9.42	13.55	18.70	22.46	22.67	23.13	22.05	19.34	21.92	4.60	24.00	20.10	12.36	4.10	*	5.03	4.47	2.75	6.67	6.06	7.37	7.03	5.02	7.52	11.91	6.77	12.26	9.80	10.77	Japan
17	Hong Kong	12.62	11.67	14.65	20.00	20.75	19.63	19.46	19.89	15.17	18.89	5.59	17.52	16.06	9.39	3.63	4.84	*	2.17	3.70	3.94	3.50	4.43	4.10	2.60	4.59	8.95	3.74	9.29	10.03	10.63	Hong Kong
18	Taiwan	12.04	12.24	15.22	19.00	19.75	18.82	18.65	19.08	16.51	17.27	5.22	18.86	17.27	8.96	3.74	4.47	2.17	*	3.14	4.11	3.41	4.61	4.17	2.38	4.76	9.12	3.91	9.47	9.67	10.41	Taiwan
19	South Korea	10.31	6.32	13.50	20.00	20.34	22.13	21.96	22.39	16.85	20.58	3.21	19.20	17.61	11.04	3.21	2.75	2.03	3.17	*	5.57	4.80	6.06	5.73	3.76	6.22	10.59	5.45	10.94	9.55	10.66	South Korea
20	Singapore	14.49	13.54	17.67	19.39	16.85	16.92	17.37	17.78	12.48	16.18	7.46	14.81	14.39	6.73	5.49	6.67	3.94	4.11	5.57	*	2.47	1.81	1.48	3.61	2.97	6.30	2.97	6.64	9.57	10.68	Singapore
21	Brunei	13.66	13.00	16.68	19.31	17.97	18.11	18.57	18.26	13.70	17.37	6.65	16.00	10.89	7.90	4.79	6.06	3.50	3.41	4.80	2.47	*	2.96	2.61	2.65	3.34	7.46	2.92	7.80	9.23	10.41	Brunei
22	Indonesia	14.99	14.04	18.17	19.99	16.93	17.00	17.45	17.14	13.71	16.25	7.96	14.88	15.33	6.81	5.99	7.37	4.43	4.61	6.05	1.81	2.96	*	1.56	4.10	3.46	6.37	3.24	6.72	9.13	10.31	Indonesia
23	Malaysia	14.66	13.71	18.01	19.88	16.82	16.89	17.34	17.03	13.60	16.14	7.62	22.48	15.24	6.38	5.55	7.03	4.41	4.17	5.71	1.48	2.61	1.56	*	4.01	3.13	5.94	3.13	6.29	8.01	9.20	Malaysia
24	Philippines	12.60	11.67	15.76	18.50	14.96	19.31	19.77	19.46	13.84	18.55	5.65	17.18	15.72	9.06	3.70	5.02	2.60	2.38	3.76	3.61	2.65	4.10	4.08	*	4.26	8.61	3.49	8.96	10.00	9.92	Philippines
25	Thailand	15.15	14.20	18.33	21.50	17.51	18.62	19.08	18.77	12.30	17.88	8.11	16.51	15.09	8.41	6.14	7.52	4.59	4.76	6.21	2.97	3.34	3.46	3.13	4.26	*	7.96	3.57	8.31	10.80	12.05	Thailand
26	India	15.75	15.75	19.64	19.50	15.93	14.32	14.77	13.71	11.06	13.58	12.50	12.21	10.79	3.64	10.51	11.91	8.95	9.12	10.58	6.30	7.46	6.37	6.92	8.61	7.96	*	7.96	3.46	12.09	14.91	India
27	Vietnam	14.38	14.04	18.01	19.50	17.19	18.52	18.97	18.66	14.70	17.87	7.35	16.50	14.66	8.40	5.38	6.77	3.74	4.00	5.46	2.97	2.92	3.46	3.13	3.49	3.57	7.96	*	8.30	10.17	11.29	Vietnam
28	Other Asia	18.75	15.85	23.16	19.50	15.63	13.65	14.10	13.80	10.40	12.91	12.85	11.54	14.44	2.58	10.86	12.26	9.29	9.47	10.92	6.64	7.80	6.72	6.29	8.96	8.31	3.46	8.30	*	13.36	14.74	Other Asia
29	Australia	12.92	13.54	14.23	14.50	11.44	22.44	23.64	23.33	18.69	22.44	11.42	21.07	17.75	13.33	9.87	0.02	10.03	9.67	9.55	9.37	9.23	9.13	9.74	10.00	10.80	12.90	10.13	13.36	*	4.14	Australia
30	New Zealand	11.66	12.71	13.70	11.89	9.44	22.86	24.11	23.80	22.53	23.62	12.39	21.54	18.22	14.72	10.04	10.77	10.63	10.41	10.66	9.74	10.41	9.50	10.11	10.11	12.05	14.28	11.29	14.74	4.14	*	New Zealand

(Source) : 「New Worldwide Tanker Nominal Freight Scale " WORLDSCALE" (1st January 2005)」

Table 3-2-2 Crude Oil Tanker Freight（VLCC Scale Tanker: 2015）

WS値 70

(Crude Oil Freight 2005VL) → Port of Destination (FLAT RATE x Crude Oil Density 0.855 x WS 70)/ 6.29 = Freight US$/bbl (Unit:US$/bbl)

Port of Embarkation ↓

	Region	America	Canada	Mexico	Brazil	Other L.America	United Kingdom	Germany	France	Italy	Other W.Europe	Russia	Other Non-OECD	Africa	Middle East
1	America	*	0.48	0.26	1.05	1.06	1.06	1.10	1.00	1.15	0.99	1.11	1.27	1.00	1.91
2	Canada	0.36	*	0.57	0.76	1.04	0.73	0.84	0.77	0.89	0.67	0.83	0.83	0.82	1.44
3	Mexico	0.26	0.57	*	0.74	1.07	1.00	1.00	1.00	1.17	1.01	1.19	1.24	1.20	1.73
4	Brazil	0.97	1.05	0.74	*	0.80	1.62	1.76	1.52	1.70	1.63	1.52	1.85	1.32	1.76
5	Other L.America	1.06	1.04	1.07	0.80	*	1.05	1.16	1.05	1.08	1.04	1.36	1.37	0.75	1.42
6	United Kingdom	0.79	0.74	1.08	1.62	1.11	*	0.37	0.33	0.67	0.27	0.59	0.52	0.59	1.23
7	Germany	0.82	0.80	1.12	1.76	1.15	0.37	*	0.36	0.71	0.29	0.55	0.47	0.63	1.27
8	France	0.80	0.77	1.09	1.52	1.12	0.40	0.43	*	0.69	0.33	0.65	0.58	0.61	1.24
9	Italy	0.90	0.88	1.17	1.52	1.07	0.67	0.71	0.61	*	0.60	0.92	0.85	0.38	0.92
10	Other W.Europe	0.72	0.67	1.01	1.50	1.04	0.27	0.29	0.26	0.60	*	0.51	0.44	0.45	1.16
11	Russia	1.11	0.91	1.19	1.52	1.36	0.59	0.55	0.65	0.92	0.51	*	0.42	1.01	1.22
12	Other Non-OECD Europe	1.19	0.89	1.25	1.74	1.28	0.52	0.47	0.51	0.71	0.44	0.42	*	0.79	1.41
13	Africa	0.82	0.92	1.09	1.24	0.75	0.59	0.63	0.53	0.37	0.52	0.86	0.79	*	0.91
14	Middle East	1.91	1.44	1.73	1.76	1.42	1.23	1.27	1.24	0.92	1.16	1.16	1.41	0.91	*
15	China	1.11	0.96	1.35	1.87	2.20	2.00	2.11	2.05	1.77	2.02	0.43	2.21	1.84	1.11
16	Japan	1.05	0.90	1.29	1.78	2.14	2.16	2.20	2.10	1.84	2.09	0.44	2.28	1.91	1.18
17	Hong Kong	1.20	1.11	1.39	1.90	1.97	1.87	1.85	1.89	1.44	1.80	0.53	1.67	1.53	0.89
18	Taiwan	1.15	1.16	1.45	1.81	1.88	1.79	1.77	1.82	1.57	1.64	0.50	1.79	1.64	0.85
19	South Korea	0.98	0.60	1.28	1.90	1.94	2.11	2.09	2.13	1.60	1.96	0.31	1.83	1.68	1.05
20	Singapore	1.38	1.29	1.68	1.84	1.60	1.61	1.65	1.69	1.19	1.54	0.71	1.41	1.37	0.64
21	Brunei	1.30	1.24	1.59	1.84	1.71	1.72	1.77	1.74	1.30	1.65	0.63	1.52	1.04	0.75
22	Indonesia	1.43	1.34	1.73	1.90	1.61	1.62	1.66	1.63	1.30	1.55	0.76	1.42	1.46	0.65
23	Malaysia	1.39	1.30	1.71	1.89	1.60	1.61	1.65	1.62	1.29	1.54	0.73	2.14	1.45	0.61
24	Philippines	1.20	1.11	1.50	1.76	1.42	1.84	1.88	1.85	1.32	1.77	0.54	1.63	1.50	0.86
25	Thailand	1.44	1.35	1.74	2.05	1.67	1.77	1.82	1.79	1.17	1.70	0.77	1.57	1.44	0.80
26	India	1.50	1.50	1.87	1.86	1.52	1.36	1.41	1.30	1.05	1.29	1.19	1.16	1.03	0.35
27	Vietnam	1.37	1.34	1.71	1.86	1.64	1.76	1.81	1.78	1.40	1.70	0.70	1.57	1.39	0.80
28	Other Asia	1.78	1.51	2.20	1.86	1.49	1.30	1.34	1.31	0.99	1.23	1.22	1.10	1.37	0.25
29	Australia	1.23	1.29	1.35	1.38	1.09	2.14	2.25	2.22	1.78	2.14	1.09	2.00	1.69	1.27
30	New Zealand	1.11	1.21	1.30	1.13	0.90	2.18	2.29	2.26	2.14	2.25	1.18	2.05	1.73	1.40

	Region	China	Japan	Hong Kong	Taiwan	South Korea	Singapore	Brunei	Indonesia	Malaysia	Philippines	Thailand	India	Vietnam	Other Asia	Australia	New Zealand	Region
1	America	1.10	0.99	1.20	1.15	0.98	1.38	1.30	1.43	1.41	1.20	1.44	1.85	1.41	1.78	1.32	1.10	America
2	Canada	1.00	0.90	1.11	1.05	0.91	1.29	1.24	1.34	1.30	1.11	1.35	1.50	1.34	1.51	1.29	1.21	Canada
3	Mexico	1.45	1.29	1.51	1.45	1.28	1.68	1.60	1.73	1.71	1.50	1.74	1.87	1.71	2.20	1.35	1.30	Mexico
4	Brazil	1.87	1.78	1.90	1.81	1.90	1.84	1.84	1.90	1.89	1.76	2.05	1.86	1.86	1.86	1.38	1.19	Brazil
5	Other L.America	1.87	2.11	1.43	1.88	1.21	1.60	1.71	1.61	1.64	1.42	1.67	1.60	1.64	1.49	1.09	0.90	Other L.America
6	United Kingdom	2.57	2.16	1.87	1.89	2.09	1.61	1.72	1.62	1.83	1.84	1.77	1.36	1.76	1.30	2.21	2.25	United Kingdom
7	Germany	2.06	2.20	1.91	1.93	2.13	1.65	1.77	1.66	1.87	1.88	1.82	1.41	1.81	1.34	2.25	2.29	Germany
8	France	1.96	2.10	1.81	1.83	1.97	1.62	1.74	1.63	1.84	1.85	1.79	1.38	1.78	1.31	2.22	2.26	France
9	Italy	1.77	1.84	1.44	1.46	1.60	1.30	1.41	1.30	1.52	1.53	1.46	1.05	1.45	0.99	2.31	2.22	Italy
10	Other W.Europe	2.02	2.09	1.80	1.81	1.96	1.54	1.65	1.55	2.14	1.77	1.70	1.29	1.70	1.23	2.14	2.18	Other W.Europe
11	Russia	0.42	0.42	0.53	0.48	0.30	0.71	0.63	0.76	0.73	0.54	0.77	1.19	0.70	1.22	1.09	1.18	Russia
12	Other Non-OECD Europe	2.21	2.28	1.67	1.68	1.83	1.41	1.52	1.42	2.14	1.63	1.57	1.16	1.57	1.10	2.00	2.05	Other Non-OECD Europe
13	Africa	1.71	1.91	1.53	1.64	1.79	1.37	1.04	1.46	1.45	1.50	1.44	1.03	1.45	0.98	1.69	1.73	Africa
14	Middle East	0.97	1.11	0.84	0.85	0.98	0.60	0.70	0.58	0.57	0.81	0.75	0.31	0.77	0.24	1.18	1.29	Middle East
15	China	*	0.33	0.41	0.36	0.30	0.59	0.53	0.63	0.60	0.41	0.70	1.11	0.62	1.15	0.78	0.87	China
16	Japan	0.39	*	0.48	0.43	0.26	0.63	0.58	0.70	0.67	0.48	0.72	1.13	0.64	1.17	0.93	1.02	Japan
17	Hong Kong	0.35	0.46	*	0.21	0.35	0.37	0.33	0.42	0.39	0.25	0.44	0.85	0.36	0.88	0.95	1.01	Hong Kong
18	Taiwan	0.36	0.43	0.21	*	0.30	0.39	0.32	0.44	0.40	0.23	0.45	0.87	0.37	0.90	0.92	0.99	Taiwan
19	South Korea	0.31	0.26	0.19	0.30	*	0.53	0.46	0.58	0.55	0.36	0.59	1.01	0.52	1.04	0.91	1.01	South Korea
20	Singapore	0.52	0.63	0.37	0.39	0.53	*	0.24	0.17	0.14	0.34	0.28	0.60	0.28	0.63	0.91	1.02	Singapore
21	Brunei	0.46	0.58	0.33	0.32	0.46	0.24	*	0.28	0.25	0.25	0.32	0.71	0.28	0.74	0.88	0.99	Brunei
22	Indonesia	0.57	0.70	0.42	0.44	0.58	0.17	0.28	*	0.15	0.39	0.33	0.61	0.31	0.64	0.87	0.98	Indonesia
23	Malaysia	0.53	0.67	0.42	0.40	0.54	0.14	0.25	0.15	*	0.38	0.30	0.57	0.30	0.60	0.76	0.88	Malaysia
24	Philippines	0.35	0.48	0.25	0.23	0.36	0.34	0.25	0.39	0.39	*	0.41	0.82	0.33	0.85	0.95	0.94	Philippines
25	Thailand	0.58	0.72	0.44	0.45	0.59	0.28	0.32	0.33	0.30	0.41	*	0.76	0.34	0.79	1.03	1.15	Thailand
26	India	1.00	1.13	0.85	0.87	1.01	0.60	0.71	0.61	0.66	0.82	0.76	*	0.76	0.33	1.15	1.42	India
27	Vietnam	0.51	0.64	0.36	0.38	0.52	0.28	0.28	0.33	0.30	0.33	0.34	0.76	*	0.79	0.97	1.07	Vietnam
28	Other Asia	1.03	1.17	0.88	0.90	1.04	0.63	0.74	0.64	0.60	0.85	0.79	0.33	0.79	*	1.27	1.40	Other Asia
29	Australia	0.94	0.00	0.95	0.92	0.91	0.89	0.88	0.87	0.93	0.95	1.03	1.23	0.96	1.27	*	0.39	Australia
30	New Zealand	0.96	1.02	1.01	0.99	1.01	0.93	0.99	0.90	0.96	0.96	1.15	1.36	1.07	1.40	0.39	*	New Zealand

(Source) ： 「New Worldwide Tanker Nominal Freight Scale“ Worldscale”(1st January 2005)」

Table 3-2-3 Crude Oil Tanker Freight（LR2 Scale Tanker: 2015）

WS value 120

(Petroleum Products' Freight 2005) → Port of Destination (FLAT RATE x Crude Oil Density 0.855 x WS 120)/ 6.29 = Freight US$/bbl (Unit:US$/bbl)

Port of Embarkation ↓

	Region	America	Canada	Mexico	Brazil	Other L.America	United Kingdom	Germany	France	Italy	Other W.Europe	Russia	Other Non-OECD	Africa	Middle East	China	Japan	Hong Kong	Taiwan	South Korea	Singapore	Brunei	Indonesia	Malaysia	Philippines	Thailand	India	Vietnam	Other Asia	Australia	New Zealand	Region
1	America	*	0.82	0.45	1.79	1.81	1.82	1.89	1.72	1.97	1.70	1.90	2.17	1.71	3.28	1.88	1.69	2.06	1.96	1.68	2.36	2.23	2.45	2.42	2.06	2.47	3.17	2.42	3.06	2.26	1.89	America
2	Canada	0.61	*	0.98	1.30	1.79	1.24	1.43	1.32	1.52	1.15	1.42	1.42	1.40	2.46	1.72	1.54	1.90	1.79	1.57	2.21	2.12	2.29	2.24	1.90	2.32	2.57	2.29	2.59	2.21	2.07	Canada
3	Mexico	0.45	0.98	*	1.27	1.83	1.71	1.71	1.71	2.00	1.73	2.04	2.12	2.06	2.97	2.48	2.21	2.59	2.48	2.20	2.88	2.75	2.96	2.94	2.57	2.99	3.20	2.94	3.78	2.32	2.23	Mexico
4	Brazil	1.67	1.79	1.27	*	1.37	2.77	3.02	2.61	2.91	2.79	2.61	3.16	2.27	3.02	3.20	3.05	3.26	3.10	3.26	3.16	3.15	3.26	3.24	3.02	3.51	3.18	3.18	3.18	2.37	2.04	Brazil
5	Other L.America	1.81	1.79	1.83	1.37	*	1.80	1.99	1.80	1.85	1.78	2.34	2.34	1.29	2.44	3.20	3.61	2.44	3.22	2.07	2.75	2.93	2.76	2.80	2.44	2.86	2.75	2.80	2.55	1.87	1.54	Other L.America
6	United Kingdom	1.35	1.27	1.85	2.77	1.90	*	0.63	0.57	1.15	0.47	1.01	0.89	1.01	2.10	4.40	3.70	3.20	3.23	3.58	2.76	2.95	2.77	3.14	3.15	3.04	2.34	3.02	2.23	3.78	3.86	United Kingdom
7	Germany	1.40	1.37	1.92	3.02	1.97	0.63	*	0.62	1.22	0.50	0.94	0.81	1.08	2.18	3.54	3.77	3.28	3.31	3.65	2.83	3.03	2.85	3.21	3.22	3.11	2.41	3.09	2.30	3.86	3.93	Germany
8	France	1.38	1.32	1.87	2.61	1.93	0.69	0.74	*	1.17	0.57	1.12	1.00	1.04	2.13	3.36	3.60	3.10	3.13	3.38	2.78	2.98	2.80	3.16	3.17	3.06	2.36	3.04	2.25	3.81	3.88	France
9	Italy	1.54	1.50	2.00	2.61	1.83	1.15	1.22	1.05	*	1.03	1.58	1.45	0.64	1.57	3.04	3.15	2.47	2.50	2.75	2.22	2.42	2.24	2.60	2.62	2.51	1.80	2.48	1.70	3.96	3.80	Italy
10	Other W.Europe	1.23	1.15	1.73	2.57	1.78	0.47	0.50	0.45	1.03	*	0.88	0.76	0.77	1.98	3.46	3.58	3.08	3.11	3.36	2.64	2.83	2.65	3.67	3.03	2.92	2.22	2.91	2.11	3.66	3.74	Other W.Europe
11	Russia	1.90	1.57	2.04	2.61	2.34	1.01	0.94	1.12	1.58	0.88	*	0.72	1.73	2.10	0.72	0.72	0.91	0.83	0.52	1.22	1.08	1.30	1.24	0.92	1.32	2.04	1.20	2.10	1.86	2.02	Russia
12	Other Non-OECD Europe	2.04	1.52	2.15	2.99	2.20	0.89	0.81	0.87	1.21	0.76	0.72	*	1.35	2.41	3.78	3.91	2.86	2.89	3.13	2.42	2.61	2.43	3.67	2.80	2.69	1.99	2.69	1.88	3.44	3.51	Other Non-OECD Europe
13	Africa	1.40	1.58	1.86	2.12	1.29	1.01	1.08	0.92	0.64	0.89	1.47	1.35	*	1.57	2.93	3.28	2.62	2.82	3.06	2.35	1.78	2.50	2.49	2.56	2.46	1.76	2.49	1.68	2.90	2.97	Africa
14	Middle East	3.28	2.46	2.97	3.02	2.44	2.10	2.18	2.13	1.57	1.98	1.98	2.41	1.57	*	1.67	1.90	1.43	1.46	1.68	1.03	1.19	1.00	0.97	1.38	1.28	0.54	1.32	0.41	2.01	2.21	Middle East
15	China	1.90	1.64	2.32	3.20	3.77	3.43	3.62	3.51	3.04	3.46	0.74	3.78	3.16	1.90	*	0.57	0.70	0.61	0.52	1.00	0.91	1.09	1.03	0.70	1.19	1.91	1.07	1.97	1.34	1.48	China
16	Japan	1.80	1.54	2.21	3.05	3.66	3.70	3.77	3.60	3.15	3.58	0.75	3.91	3.28	2.02	0.67	*	0.82	0.73	0.45	1.09	0.99	1.20	1.15	0.82	1.23	1.94	1.10	2.00	1.60	1.76	Japan
17	Hong Kong	2.06	1.90	2.39	3.26	3.38	3.20	3.17	3.24	2.47	3.08	0.91	2.86	2.62	1.53	0.59	0.79	*	0.35	0.60	0.64	0.57	0.72	0.67	0.42	0.75	1.46	0.61	1.52	1.64	1.73	Hong Kong
18	Taiwan	1.96	2.00	2.48	3.10	3.22	3.07	3.04	3.11	2.69	2.82	0.85	3.08	2.82	1.46	0.61	0.73	0.35	*	0.51	0.67	0.56	0.75	0.68	0.39	0.78	1.49	0.64	1.54	1.58	1.70	Taiwan
19	South Korea	1.68	1.03	2.20	3.26	3.32	3.61	3.58	3.65	2.75	3.36	0.52	3.13	2.87	1.80	0.52	0.45	0.33	0.52	*	0.91	0.78	0.99	0.93	0.61	1.01	1.73	0.89	1.78	1.56	1.74	South Korea
20	Singapore	2.36	2.21	2.88	3.16	2.75	2.76	2.83	2.90	2.04	2.64	1.22	2.42	2.35	1.10	0.90	1.09	0.64	0.67	0.91	*	0.40	0.30	0.24	0.59	0.48	1.03	0.48	1.08	1.56	1.74	Singapore
21	Brunei	2.23	2.12	2.72	3.15	2.93	2.95	3.03	2.98	2.23	2.83	1.08	2.61	1.78	1.29	0.78	0.99	0.57	0.56	0.78	0.40	*	0.48	0.43	0.43	0.54	1.22	0.48	1.27	1.51	1.70	Brunei
22	Indonesia	2.45	2.29	2.96	3.26	2.76	2.77	2.85	2.80	2.24	2.65	1.30	2.43	2.50	1.11	0.98	1.20	0.72	0.75	0.99	0.30	0.48	*	0.25	0.67	0.56	1.04	0.53	1.10	1.49	1.68	Indonesia
23	Malaysia	2.39	2.24	2.94	3.24	2.74	2.76	2.83	2.78	2.22	2.63	1.24	3.67	2.49	1.04	0.91	1.15	0.72	0.68	0.93	0.24	0.43	0.25	*	0.65	0.51	0.97	0.51	1.03	1.31	1.50	Malaysia
24	Philippines	2.06	1.90	2.57	3.02	2.44	3.15	3.22	3.17	2.26	3.03	0.92	2.80	2.56	1.48	0.60	0.82	0.42	0.39	0.61	0.59	0.43	0.67	0.67	*	0.69	1.40	0.57	1.46	1.63	1.62	Philippines
25	Thailand	2.47	2.32	2.99	3.51	2.86	3.04	3.11	3.06	2.01	2.92	1.32	2.69	2.46	1.37	1.00	1.23	0.75	0.78	1.01	0.48	0.54	0.56	0.51	0.69	*	1.30	0.58	1.36	1.76	1.97	Thailand
26	India	2.57	2.57	3.20	3.18	2.60	2.34	2.41	2.24	1.80	2.22	2.04	1.99	1.76	0.59	1.71	1.94	1.46	1.49	1.73	1.03	1.22	1.04	1.13	1.40	1.30	*	1.30	0.56	1.97	2.43	India
27	Vietnam	2.35	2.29	2.94	3.18	2.80	3.02	3.09	3.04	2.40	2.91	1.20	2.69	2.39	1.37	0.88	1.10	0.61	0.65	0.89	0.48	0.48	0.56	0.51	0.57	0.58	1.30	*	1.35	1.66	1.84	Vietnam
28	Other Asia	3.06	2.59	3.78	3.18	2.55	2.23	2.30	2.25	1.70	2.11	2.10	1.88	2.36	0.42	1.77	2.00	1.52	1.54	1.78	1.08	1.27	1.10	1.03	1.46	1.36	0.56	1.35	*	2.18	2.40	Other Asia
29	Australia	2.11	2.21	2.32	2.37	1.87	3.66	3.86	3.81	3.05	3.66	1.86	3.44	2.90	2.17	1.61	0.00	1.64	1.58	1.56	1.53	1.51	1.49	1.59	1.63	1.76	2.10	1.65	2.18	*	0.68	Australia
30	New Zealand	1.90	2.07	2.23	1.94	1.54	3.73	3.93	3.88	3.68	3.85	2.02	3.51	2.97	2.40	1.64	1.76	1.73	1.70	1.74	1.59	1.70	1.55	1.65	1.65	1.97	2.33	1.84	2.40	0.68	*	New Zealand

（出所）：「New Worldwide Tanker Nominal Freight Scale“ Worldscale”(1st January 2005)」

Table 3-2-4 Petroleum Products Tanker Freight（MR Scale Tanker: 2015）

WS value	200

(Petroleum Products' Freight 2005) → Port of Destination (FLAT RATE x Products' Density 0.8 x WS 200)/ 6.29 = Freight US$/bbl

Port of Embarkation ↓

	Region	America	Canada	Mexico	Brazil	Other L.America	United Kingdom	Germany	France	Italy	Other W.Europe	Russia	Non-OECD Europe	Africa	Middle East	China	Japan	Hong Kong	Taiwan	South Korea	Singapore	Brunei	Indonesia	Malaysia	Philippines	Thailand	India	Vietnam	Other Asia	Australia	New Zealand	Region
1	America	*	1.27	0.70	2.80	2.82	2.83	2.94	2.68	3.07	2.65	2.97	3.39	2.66	5.11	2.93	2.64	3.21	3.06	2.62	3.69	3.47	3.81	3.77	3.21	3.85	4.94	3.77	4.77	3.53	2.94	America
2	Canada	0.95	*	1.53	2.03	2.79	1.94	2.23	2.05	2.37	1.79	2.22	2.22	2.18	3.84	2.68	2.40	2.97	2.80	2.44	3.44	3.31	3.57	3.49	2.97	3.61	4.01	3.57	4.03	3.44	3.23	Canada
3	Mexico	0.70	1.53	*	1.98	2.86	2.66	2.66	2.66	3.12	2.70	3.18	3.31	3.21	4.63	3.87	3.45	4.04	3.87	3.43	4.49	4.28	4.62	4.58	4.01	4.66	5.00	4.58	5.89	3.62	3.48	Mexico
4	Brazil	2.60	2.80	1.98	*	2.14	4.32	4.71	4.07	4.54	4.35	4.07	4.93	3.54	4.71	4.99	4.76	5.09	4.83	5.09	4.93	4.91	5.08	5.06	4.71	5.47	4.96	4.96	4.96	3.69	3.18	Brazil
5	Other L.America	2.82	2.79	2.86	2.14	*	2.81	3.10	2.81	2.89	2.78	3.64	3.65	2.01	3.81	4.99	5.64	3.81	5.02	3.22	4.29	4.57	4.31	4.37	3.81	4.45	4.29	4.37	3.98	2.91	2.40	Other L.America
6	United Kingdom	2.11	1.98	2.88	4.32	2.97	*	0.99	0.89	1.79	0.73	1.58	1.38	1.58	3.28	6.86	5.77	5.00	5.04	5.58	4.30	4.61	4.32	4.89	4.91	4.74	3.64	4.71	3.47	5.90	6.02	United Kingdom
7	Germany	2.18	2.13	2.99	4.71	3.08	0.99	*	0.96	1.91	0.78	1.46	1.27	1.69	3.39	5.52	5.88	5.11	5.16	5.70	4.42	4.72	4.44	5.00	5.03	4.85	3.76	4.83	3.59	6.01	6.13	Germany
8	France	2.15	2.05	2.92	4.07	3.00	1.08	1.15	*	1.83	0.90	1.75	1.55	1.62	3.32	5.25	5.61	4.84	4.88	5.27	4.34	4.64	4.36	4.93	4.95	4.77	3.68	4.75	3.51	5.93	6.05	France
9	Italy	2.40	2.35	3.12	4.07	2.86	1.79	1.91	1.64	*	1.61	2.46	2.26	1.00	2.45	4.74	4.92	3.86	3.90	4.29	3.47	3.77	3.49	4.06	4.08	3.91	2.81	3.87	2.65	6.17	5.92	Italy
10	Other W.Europe	1.92	1.79	2.70	4.01	2.78	0.73	0.78	0.71	1.61	*	1.37	1.18	1.21	3.09	5.39	5.58	4.81	4.85	5.23	4.12	4.42	4.13	5.72	4.72	4.55	3.45	4.55	3.28	5.71	5.83	Other W.Europe
11	Russia	2.97	2.44	3.18	4.07	3.64	1.58	1.46	1.75	2.46	1.37	*	1.13	2.69	3.27	1.13	1.12	1.42	1.29	0.81	1.90	1.69	2.02	1.94	1.44	2.06	3.18	1.87	3.27	2.90	3.15	Russia
12	Other Non-OECD Europe	3.18	2.37	3.35	4.66	3.43	1.38	1.27	1.36	1.88	1.18	1.13	*	2.10	3.76	5.90	6.10	4.46	4.50	4.88	3.77	4.07	3.79	5.72	4.37	4.20	3.11	4.20	2.94	5.36	5.48	Other Non-OECD Europe
13	Africa	2.19	2.46	2.90	3.31	2.01	1.58	1.69	1.43	1.00	1.39	2.29	2.11	*	2.44	4.57	5.11	4.09	4.40	4.78	3.66	2.77	3.90	3.88	4.00	3.84	2.74	3.89	2.63	4.52	4.63	Africa
14	Middle East	5.11	3.84	4.63	4.71	3.81	3.28	3.39	3.32	2.45	3.09	3.09	3.76	2.44	*	2.60	2.96	2.23	2.28	2.63	1.61	1.86	1.56	1.51	2.15	2.00	0.84	2.07	0.63	3.14	3.45	Middle East
15	China	2.97	2.56	3.61	4.99	5.88	5.34	5.65	5.47	4.74	5.39	1.16	5.90	4.93	2.96	*	0.90	1.09	0.96	0.81	1.57	1.41	1.69	1.60	1.09	1.86	2.98	1.67	3.07	2.09	2.31	China
16	Japan	2.80	2.40	3.45	4.76	5.71	5.77	5.88	5.61	4.92	5.58	1.17	6.10	5.11	3.14	1.04	*	1.28	1.14	0.70	1.70	1.54	1.87	1.79	1.28	1.91	3.03	1.72	3.12	2.49	2.74	Japan
17	Hong Kong	3.21	2.97	3.73	5.09	5.28	4.99	4.95	5.06	3.86	4.81	1.42	4.46	4.09	2.39	0.92	1.23	*	0.55	0.94	1.00	0.89	1.13	1.04	0.66	1.17	2.28	0.95	2.36	2.55	2.70	Hong Kong
18	Taiwan	3.06	3.11	3.87	4.83	5.02	4.79	4.74	4.85	4.20	4.39	1.33	4.80	4.39	2.28	0.95	1.14	0.55	*	0.80	1.05	0.87	1.17	1.06	0.61	1.21	2.32	0.99	2.41	2.46	2.65	Taiwan
19	South Korea	2.62	1.61	3.43	5.09	5.17	5.63	5.59	5.70	4.29	5.23	0.82	4.88	4.48	2.81	0.82	0.70	0.52	0.81	*	1.42	1.22	1.54	1.46	0.96	1.58	2.69	1.39	2.78	2.43	2.71	South Korea
20	Singapore	3.69	3.44	4.49	4.93	4.29	4.30	4.42	4.52	3.17	4.12	1.90	3.77	3.66	1.71	1.40	1.70	1.00	1.05	1.42	*	0.63	0.46	0.38	0.92	0.76	1.60	0.76	1.69	2.43	2.72	Singapore
21	Brunei	3.47	3.31	4.24	4.91	4.57	4.61	4.72	4.64	3.48	4.42	1.69	4.07	2.77	2.01	1.22	1.54	0.89	0.87	1.22	0.63	*	0.75	0.66	0.67	0.85	1.90	0.74	1.98	2.35	2.65	Brunei
22	Indonesia	3.81	3.57	4.62	5.08	4.31	4.32	4.44	4.36	3.49	4.13	2.02	3.79	3.90	1.73	1.52	1.87	1.13	1.17	1.54	0.46	0.75	*	0.40	1.04	0.88	1.62	0.82	1.71	2.32	2.62	Indonesia
23	Malaysia	3.73	3.49	4.58	5.06	4.28	4.30	4.41	4.33	3.46	4.11	1.94	5.72	3.88	1.62	1.41	1.79	1.12	1.06	1.45	0.38	0.66	0.40	*	1.02	0.80	1.51	0.80	1.60	2.04	2.34	Malaysia
24	Philippines	3.21	2.97	4.01	4.71	3.81	4.91	5.03	4.95	3.52	4.72	1.44	4.37	4.00	2.30	0.94	1.28	0.66	0.61	0.96	0.92	0.67	1.04	1.04	*	1.08	2.19	0.89	2.28	2.54	2.52	Philippines
25	Thailand	3.85	3.61	4.66	5.47	4.45	4.74	4.85	4.77	3.13	4.55	2.06	4.20	3.84	2.14	1.56	1.91	1.17	1.21	1.58	0.76	0.85	0.88	0.80	1.08	*	2.02	0.91	2.11	2.75	3.07	Thailand
26	India	4.01	4.01	5.00	4.96	4.05	3.64	3.76	3.49	2.81	3.45	3.18	3.11	2.74	0.93	2.67	3.03	2.28	2.32	2.69	1.60	1.90	1.62	1.76	2.19	2.02	*	2.02	0.88	3.08	3.79	India
27	Vietnam	3.66	3.57	4.58	4.96	4.37	4.71	4.83	4.75	3.74	4.55	1.87	4.20	3.73	2.14	1.37	1.72	0.95	1.02	1.39	0.76	0.74	0.88	0.80	0.89	0.91	2.02	*	2.11	2.59	2.87	Vietnam
28	Other Asia	4.77	4.03	5.89	4.96	3.98	3.47	3.59	3.51	2.65	3.28	3.27	2.94	3.67	0.66	2.76	3.12	2.36	2.41	2.78	1.69	1.98	1.71	1.60	2.28	2.11	0.88	2.11	*	3.40	3.75	Other Asia
29	Australia	3.29	3.44	3.62	3.69	2.91	5.71	6.01	5.93	4.75	5.71	2.90	5.36	4.52	3.39	2.51	0.01	2.55	2.46	2.43	2.38	2.35	2.32	2.48	2.54	2.75	3.28	2.58	3.40	*	1.05	Australia
30	New Zealand	2.97	3.23	3.48	3.02	2.40	5.81	6.13	6.05	5.73	6.01	3.15	5.48	4.63	3.74	2.55	2.74	2.70	2.65	2.71	2.48	2.65	2.42	2.57	2.57	3.07	3.63	2.87	3.75	1.05	*	New Zealand

(Source) : 「New Worldwide Tanker Nominal Freight Scale“ Worldscale”(1st January 2005)」

4. Japan's Oil Refining

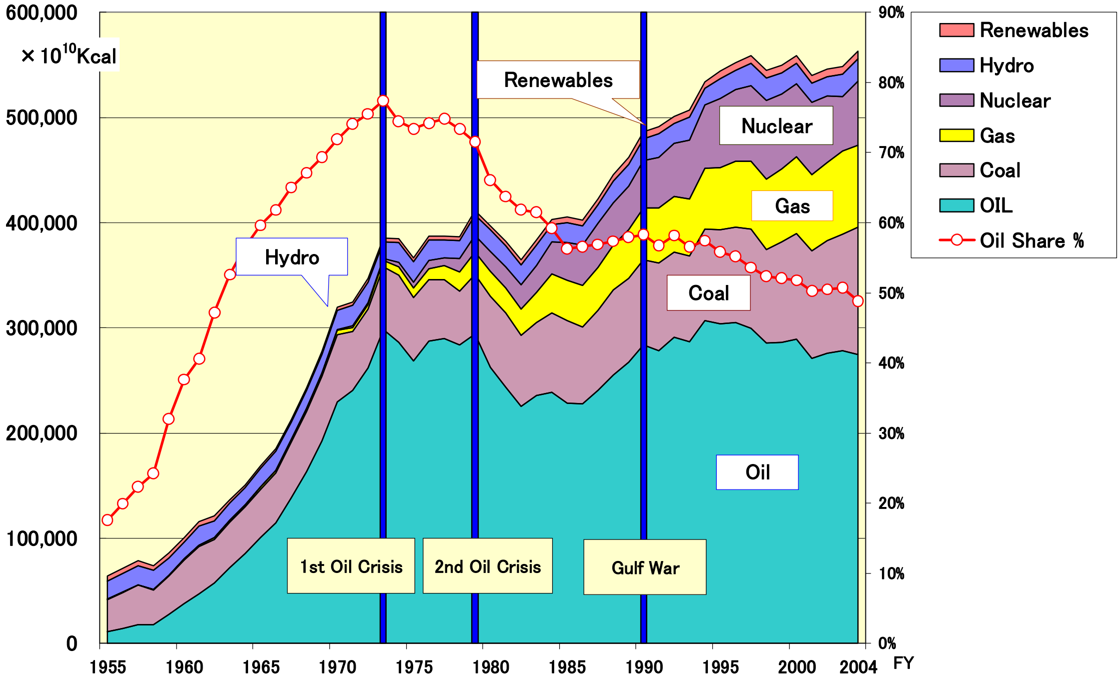
4-1. Japan's Energy Demand/Supply

4-1-1. Primary Energy Supply Trend

In fiscal 1955, a decade after the war, Japan's primary energy supply totaled 641 trillion kilocalories, equivalent to 64.1 million tons of oil equivalent (Mtoe). The largest energy source then was coal, accounting for 47.2% of total primary energy supply. Oil's share of the total supply was limited to 17.6%.

Primary energy supply continued to increase in tandem with economic growth later. In fiscal 1973 when the first oil crisis occurred, Japan's primary energy supply was an aggregate 3,854 trillion kcal (385.4 Mtoe), indicating an annual increase of 10.5%. Oil replaced coal as the largest energy source. In fiscal 1973, coal's share of total primary energy supply was limited to 15.5% against 77.4% for oil.

Figure 4-1-1 Trends in Primary Energy Supply by Source in Japan



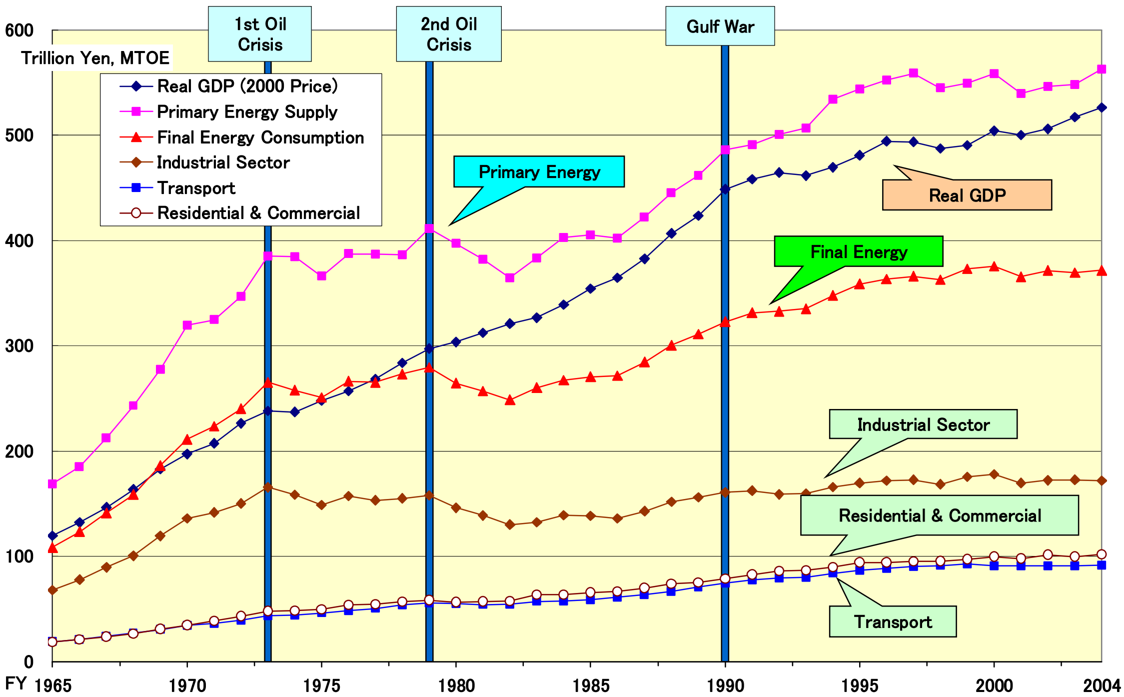
The first oil crisis in October 1973 and the second in February 1979 stimulated energy conservation and a shift to oil substitution including coal, natural gas and nuclear energy in Japan. Later, primary energy supply continued to expand, but growth slowed on an economic slump. In fiscal 1980 after the second oil crisis, Japan's primary energy supply became to 3,972 trillion kcal (397.2 Mtoe). The annual growth rate between fiscal 1973 and 1980 was limited to 0.4%. In fiscal 1991 following the August 1990 Gulf Crisis, primary energy supply totaled 4,910 trillion kcal (491.0 Mtoe). The annual increase between fiscal 1980 and 1991 stood at 1.9%. Primary energy supply in fiscal 2004 came to an aggregate 5,628 trillion kcal (562.8 Mtoe).

Oil's share of primary energy supply in Japan declined from 74.4% in fiscal 1974 to 66.1% in fiscal 1980 following the second oil crisis in February 1979 and to 56.7% in fiscal 1991 following the August 1990 Gulf Crisis. In fiscal 2004, oil's share of total primary energy supply stood at 48.8%.

4-1-2. Trends in Final Energy Consumption

Japan's final energy consumption declined at an average annual growth rate of 3.8% for the three years following the second oil crisis in fiscal 1979 and rebounded later. From fiscal 1982 to 2004, the average annual increase was 1.8%, below the average GDP growth rate of 2.3%. Since 1995, final energy consumption's average annual growth has slumped to 0.4%.

Figure 4-1-2 Trends of Final Energy Consumption



The industrial sector's energy consumption peaked at 165.7 Mtoe in fiscal 1973 and subsequently saw continued decreases. In fiscal 1982, the sector's consumption dropped to 130.1 Mtoe. In fiscal 2004, its energy consumption came to 172.0 Mtoe. From fiscal 1982 to 2004, the average annual growth rate was 1.3%, less than the 1.8% growth rate of total final energy consumption.

Within the industrial sector, manufacturers held down energy consumption through positive introduction of energy-saving technologies and a structural shift from materials to information technology products.

The transport sector's energy consumption has seen continued expansion from 43.4 Mtoe in fiscal 1973, reaching 91.8 Mtoe in fiscal 2004. From fiscal 1973 to 2004, the transport sector's annual energy consumption growth rate came to 2.4%, higher than the 1.2% for total final energy consumption. The transport sector is divided into the cargo and passenger transport. In particular, energy consumption growth has been conspicuous within the passenger transport.

Like the transport sector, the residential & commercial sector has scored notable growth in energy consumption. The residential & commercial sector's consumption has continued to expand from the level of 48.0 Mtoe in fiscal 1973, reaching 102.2 Mtoe in fiscal 2004. From fiscal 1973 to 2004, the average annual growth rate was 2.5%.

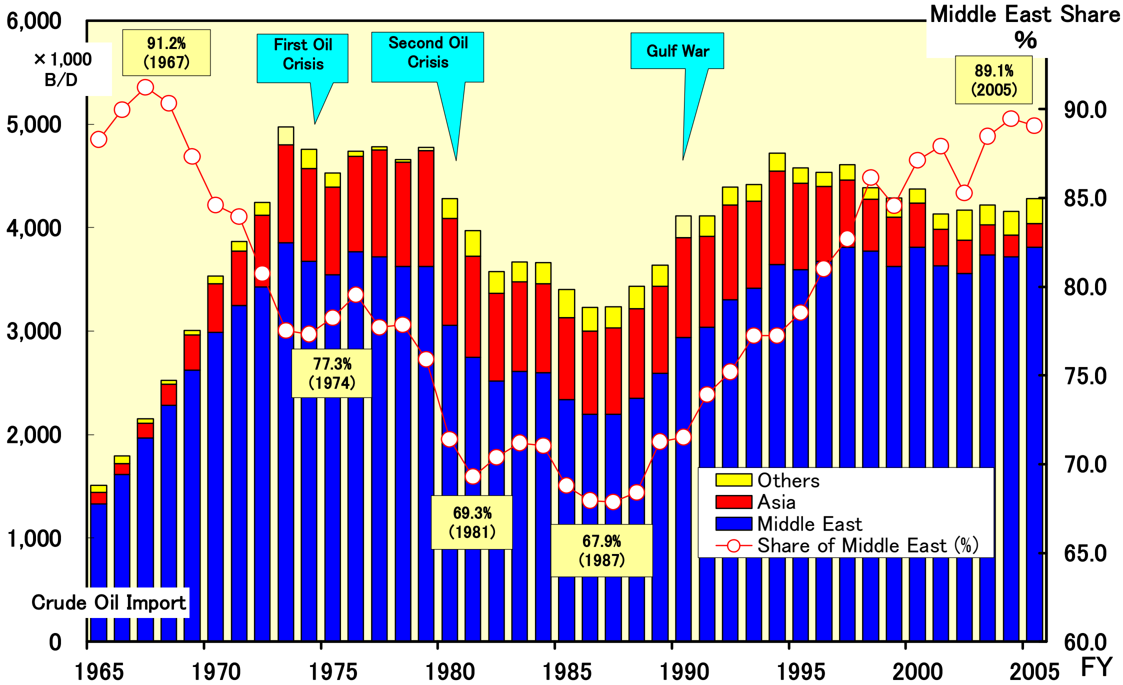
4-1-3. Energy Security Challenges

While Japan's final energy consumption continued expanding, imports' share of primary energy supply stood at 83.4% with oil's share at 48.8% in fiscal 2004. Both shares had continued a downward trend since the first oil crisis but have leveled off since fiscal 1987. Japan depended on the Middle East oil for 89.1% of its total oil imports in fiscal 2005. This percentage exceeded 76.2% in fiscal 1974 after the first oil crisis.

Japan's energy security has remained vulnerable as oil price hikes have coincided with energy demand growth in Asia including China and India as well as Japan. Therefore, an urgent challenge for Japan's energy security is to ensure stable energy supply, including oil supply and a shift to non-oil energy sources such as natural gas and coal. While nuclear energy is a promising substitute because it is considered as a domestic energy source and there are calls for its expansion, construction of new nuclear plants has made little progress due to plant troubles and other problems such as NIMBY (not in my backyard) issues.

In fiscal 2004, Saudi Arabia became the largest oil exporter to Japan for the first time in 18 years. Saudi Arabia accounts for 29.2% of Japan's total crude oil imports in fiscal 2005, followed by 24.5% for the United Arab Emirates and 13.0% for Iran. Japan's dependence on OPEC countries for crude oil imports hit bottom at 71.6% in fiscal 1985 and subsequently increased again, standing at 90.0% in fiscal 2005.

Figure 4-1-3 Changes in Japan's Middle East Dependence for Oil



In fiscal 2005, about 66% of Japan's total crude oil imports were based on long-term contracts. The remaining 34% were spot transactions. About 70% of crude oil imports from the Middle East were based on long-term contracts. Therefore, Middle East crude oil imports under long-term contracts accounted for 70% of total crude imports. Japan depends on spot transactions for most crude oil imports from Africa and low-sulfur crude from Western Europe and Latin America.

Table 4-1-1 Crude Oil Imports by Nation (Fiscal 2005)

	Import Volume			Contract ×1000 KL			Average API	Average Sulfur %
	×1000 KL	×1000 B/D	Share%	Term	Spot	Spot Share%		
East & Central Asia	961	17	0.4	87	874	90.9	31.3	0.10
China	961	17	0.4	87	874	90.9	31.3	0.10
South East Asia	12,139	209	4.9	6,491	5,608	46.2	33.9	0.09
Viet Nam	2,090	36	0.8	653	1,437	68.8	38.8	0.04
Thailand	22	0	0.0		22	100.0	25.8	0.31
Malaysia	1,110	19	0.4	845	265	23.9	34.6	0.07
Brunei	1,240	21	0.5	1,053	188	15.1	38.2	0.07
Indonesia	7,646	132	3.1	3,941	3,665	47.9	31.7	0.11
East Timor	32	1	0.0		32	100.0	56.4	0.02
Middle East	221,777	3,822	89.1	155,850	65,926	29.7	35.8	1.58
Iran	32,425	559	13.0	26,371	6,054	18.7	32.8	1.78
Iraq	1,742	30	0.7	1,584	158	9.1	30.7	2.82
Saudi Arabia	72,789	1,254	29.2	61,077	11,712	16.1	36.0	1.60
Kuwait	17,872	308	7.2	17,028	844	4.7	30.7	2.61
Neutral Zone	4,952	85	2.0	3,749	1,203	24.3	28.7	2.75
Qatar	23,511	405	9.4	9,477	14,034	59.7	38.4	1.44
Oman	6,462	111	2.6	2,444	4,019	62.2	33.2	1.12
UAE	61,089	1,053	24.5	33,507	27,582	45.2	38.3	1.15
Yemen	934	16	0.4	614	319	34.2	45.7	0.11
Europe	1,736	30	0.7	258	1,478	85.2	34.6	0.23
Russia	1,736	30	0.7	258	1,478	85.2	34.6	0.23
Africa	10,056	173	4.0	708	9,348	93.0	34.2	0.10
Sudan	6,398	110	2.6	708	5,689	88.9	34.0	0.05
Nigeria	2,079	36	0.8		2,079	100.0	38.2	0.09
Equatorial Guinea	767	13	0.3		767	100.0	28.6	0.27
Gabon	150	3	0.1		150	100.0	32.8	0.06
Angola	662	11	0.3		662	100.0	29.6	0.40
Oceania	2,341	40	0.9	757	1,584	67.6	45.0	0.30
Australia	2,341	40	0.9	757	1,584	67.6	45.0	0.30
Total	249,010	4,291	100.0	164,152	84,818	34.1	35.7	1.42
OPEC	224,105	3,862	90.0	156,733	67,332	30.0	35.7	1.54

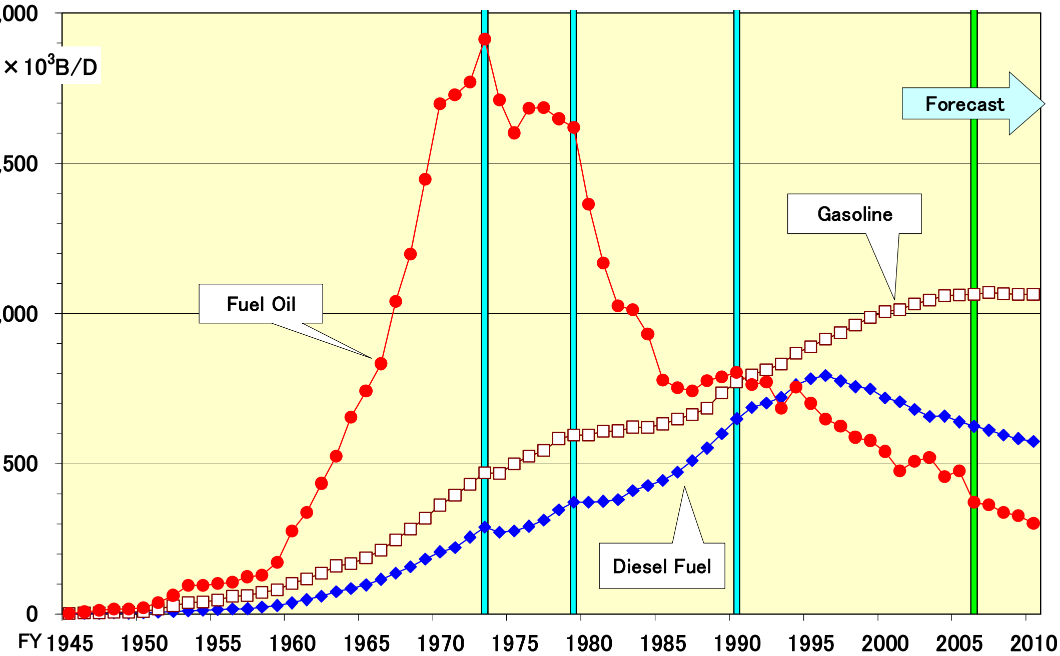
Note : Saudi Arabia does not export its crude oil under Spot Contract. However, Japan's refineries classify Saudi's crude purchased through trading firms as Spot Contract although that has Term Contract with Saudi's government.

4-2. Oil Demand/Supply

4-2-1. Petroleum Products Demand/Supply

Demand for petroleum products in Japan had increased rapidly until the first oil crisis in 1973. Since that year, however, demand for petroleum products has declined substantially as fuel oil for industrial consumption has been replaced by other energy sources and as electricity generators shifted from use of oil to nuclear energy, natural gas and coal. From 1980 to 2005, the ratio of gasoline and naphtha to total fuel products demand rose from 29.1% to 46.6%, while that of fuel oils B and C to the total demand dropped from 37.9% to 11.6%. Demand has thus shifted to lighter petroleum products. Demand for diesel oil for vehicles peaked in 1997 and has fallen back since then. Gasoline demand alone has continued an upward trend, but demand growth has been slowing.

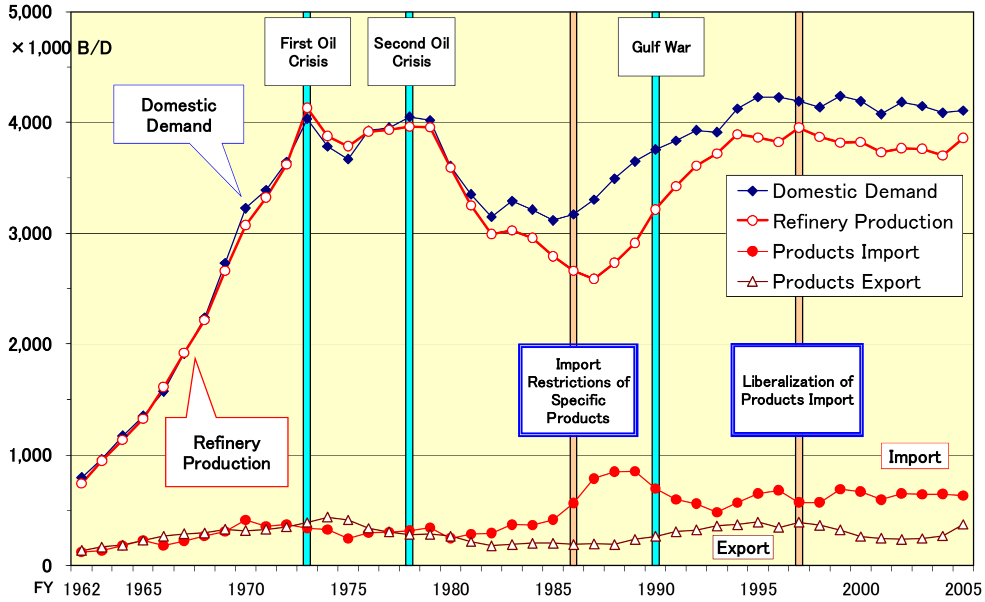
Figure 4-2-1 Real and Forecast Demand for Major Petroleum Products



Over the past few years, naphtha as a key petrochemical feedstock has accounted for about 80% of Japan's total petroleum products imports. Fuel product imports in fiscal 2005 decreased 2.2% from the previous year to 36.690 million kiloliters. Naphtha accounted for 76.2% (27.964 million kl) of the total imports, gasoline for 6.1%, kerosene for 3.1%, diesel oil for 1.4% and fuel oils B and C for 11.3%. Of the naphtha imports, 51.6% came from the Middle East and 15.1% from South Korea. Of gasoline imports, 61.0% were from Singapore and 22.8% from South Korea. Of kerosene imports, 77.3% came from South Korea. Diesel oil imports were almost all from South Korea (96.9%). Of fuel oil B and C imports, 75.7% came from Indonesia.

Fuel product imports' share of domestic demand stood at 15.5% in fiscal 2005, down 0.3 percentage points from 15.8% the previous year. Imports' share of domestic naphtha demand was as high as 56.6%, while imports' share of demand for domestic fuel products other than naphtha was limited to 4.7%. Imports of fuel products other than naphtha play only supplement role of domestic supply.

Figure 4-2-2 Trends in Petroleum Products Demand/Supply



According to a forecast (in March 2006) by the Petroleum Association of Japan, gasoline demand is projected to peak in 2007 and fall back subsequently. Total fuel products demand is forecast to decline at an annual pace of 1.9% from 238.47 million kl (or 4.11 million b/d) in 2005 to 216.45 million kl (or 3.73 million b/d) in 2010. Including NGL as a petrochemical feedstock and crude oil for direct burning at thermal power plants, petroleum products demand is projected to decrease at an annual pace of 2.4% from 247.25 million kl (4.26 million b/d) in 2005 to 219.44 million kl (3.78 million b/d) in 2010.

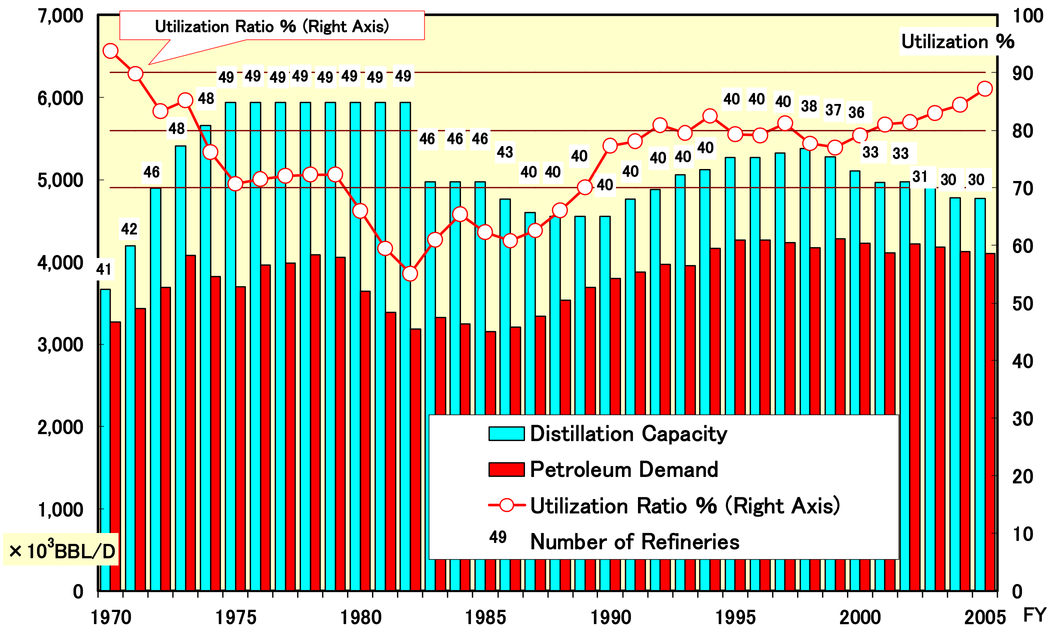
Table 4-2-1 Petroleum Products Demand Outlook

	2004	2005	2006	2007	2008	2009	2010	Growth Rate %	Share %	
	Actual		Forecast					2005/2010	2005	2010
Gasoline	61,469	61,624	61,773	62,074	61,844	61,775	61,704	0.0	25.8	28.5
Naphtha	48,992	49,513	48,886	48,454	48,503	48,279	48,300	▲ 0.5	20.8	22.3
Jet Fuel	4,906	4,983	4,942	4,938	4,929	4,971	5,054	0.3	2.1	2.3
Kerosene	27,977	29,366	28,091	27,803	27,365	26,924	26,487	▲ 2.0	12.3	12.2
Diesel Fuel	38,203	37,104	36,259	35,480	34,561	33,870	33,345	▲ 2.1	15.6	15.4
Fuel Oil A	29,100	28,217	26,993	26,278	25,457	24,750	24,090	▲ 3.1	11.8	11.1
Fuel Oil B & C	26,557	27,656	21,513	21,088	19,570	18,957	17,472	▲ 8.8	11.6	8.1
For Power Generation Use	9,362	12,325	7,059	7,349	6,551	6,573	5,672	▲ 14.4	5.2	2.6
Others	17,195	15,331	14,454	13,739	13,019	12,384	11,800	▲ 5.1	6.4	5.5
Fuel Oil Total	55,658	55,873	48,506	47,366	45,027	43,707	41,562	▲ 5.7	23.4	19.2
Total Products Demand	237,205	238,465	228,457	226,115	222,229	219,526	216,452	▲ 1.9	100.0	100.0
NGL for Petro Chemical	1,346	927	915	900	884	864	852	▲ 1.7		
Crude Oil for Power Generation	5,716	7,845	3,192	3,443	2,891	3,172	2,006	▲ 23.9		
NGL for Power Generation	34	14	34	34	34	34	34	19.4		
Total Petroleum Demand	244,400	247,251	232,698	230,592	226,139	223,696	219,444	▲ 2.4		

4-2-2. Oil Refining Capacity

As petroleum products demand has continued falling, Japanese oil refiners plagued with low capacity utilization ratios at their refineries have shut down refineries or reduced refinery capacity since 1997.

Figure 4-2-3 Changes in Number of Refineries, Capacity and Utilization Ratio



Japan's oil refining capacity decreased from 5.375 million b/d in fiscal 1998 to 4.767 million b/d in fiscal 2005, while the capacity utilization ratio rose from 77.7% to 87.2%. The number of refineries dropped from 38 to 30.

4-2-3. Secondary Processing Equipments Capacity

Japan introduced unleaded regular gasoline (accounting for some 80% of total gasoline consumption) in February 1975 and premium gasoline in December 1986. The benzene content in gasoline was reduced to not more than 1% in January 2000. The maximum summer gasoline vapor pressure was lowered from 78 kPa to 72 kPa in 2001 and to 65 kPa in 2005. The maximum sulfur content of gasoline was reduced from 0.01% to 0.005% (50 ppm) by the end of 2004. Sulfur-free gasoline (with a sulfur content of not more than 10 ppm) was introduced voluntarily in January 2005. Legally, gasoline will have to become completely free of sulfur in January 2008.

The maximum sulfur content of diesel oil was reduced from 0.05% to 0.005% (50 ppm) by the end of 2004. Diesel oil with sulfur content of 50ppm was introduced voluntarily in January 2003 and Sulfur-free diesel oil was introduced voluntarily in January 2005. Legally, diesel oil will have to become completely free of sulfur in January 2007.

Figure 4-2-4 Changes in Kerosene and Diesel De-sulfurization Capacity

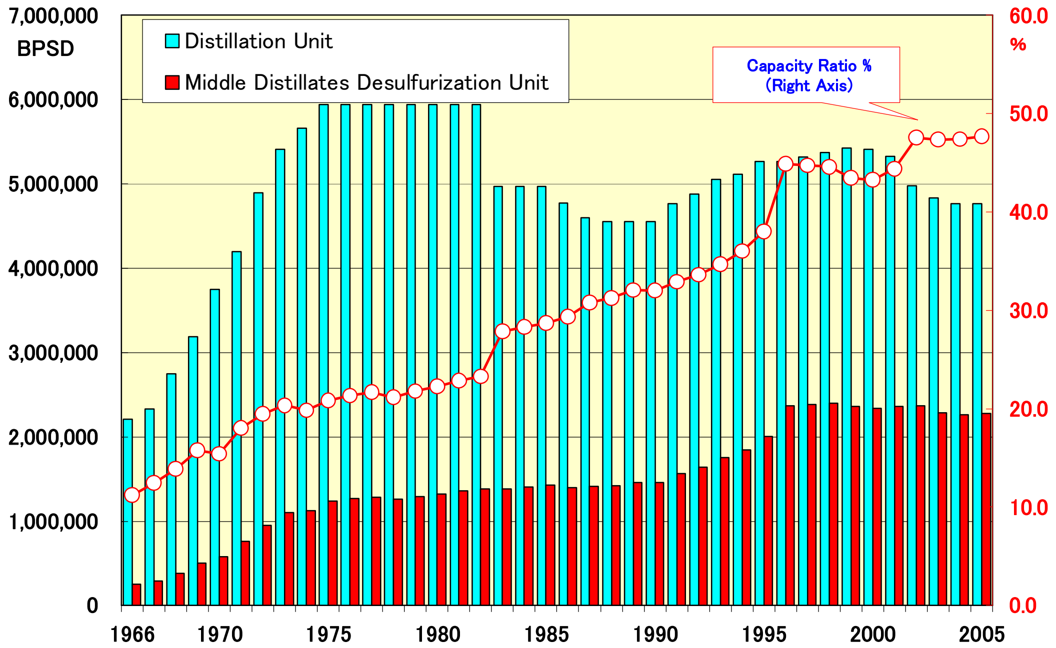
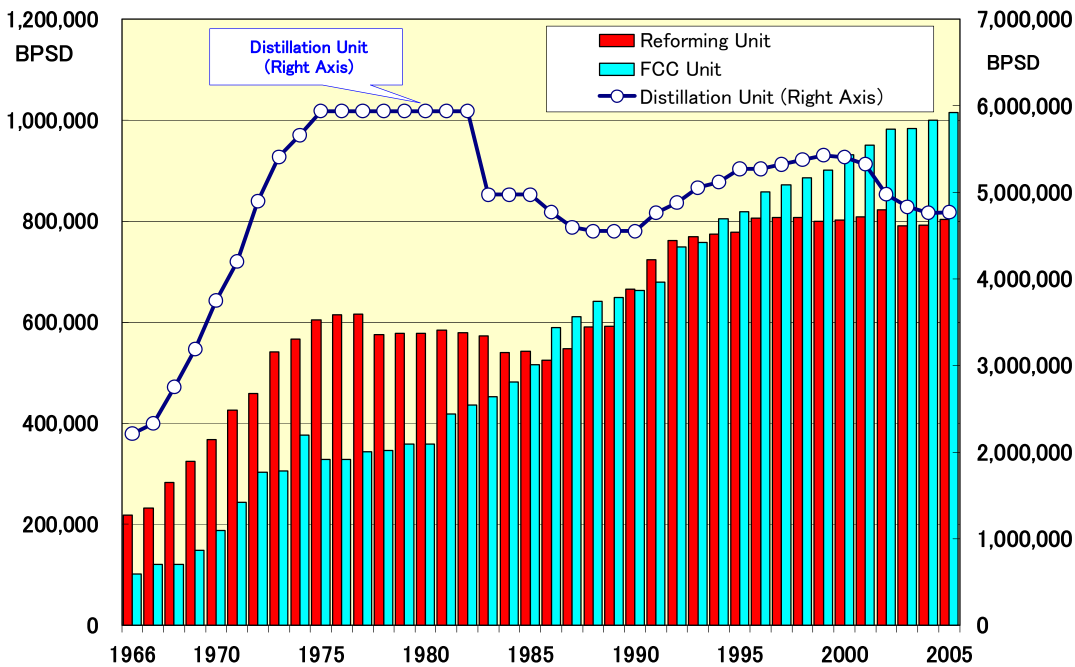


Figure 4-2-5 Changes in Reformer and FCC Capacity



In response to these requirements for lower sulfur content in gasoline and diesel oil, oil refiners have introduced, expanded and modified hydro de-sulfurization units. The Petroleum Association of Japan has estimated oil refiners' investment in hydro de-sulfurization units at about ¥500 billion, or ¥640 billion including investment in benzene reduction systems. They have also invested ¥550 billion in direct and indirect de-sulfurization systems to reduce the sulfur content of fuel oil.

Table 4-2-2 Heavy Oil Cracking Capacity

Company	Location	Unit	Capacity B/D
Japan Energy	Mizushima	Delayed Coker	26,000
Nippon Oil	Marifu	Delayed Coker	22,000
Fuji Oil	Sodegaura	Eureka Process	24,000
Toa Oil	Keihin	Fluid Coker	27,000
Tonen General	Kawasaki	H-Oil (Hydro Cracking)	28,000
Idemitsu Kosan	Hokaido	RFCC	33,000
Idemitsu Kosan	Aichi	RFCC	50,000
Kyokuto	Chiba	RFCC	34,000
Kyushu Sekiyu	Oita	RFCC	26,000
Nippon Oil	Sendai	RFCC	43,000
Nippon Oil	Negishi	RFCC	40,000
Showa Shell	Yokkaichi	RFCC	61,000

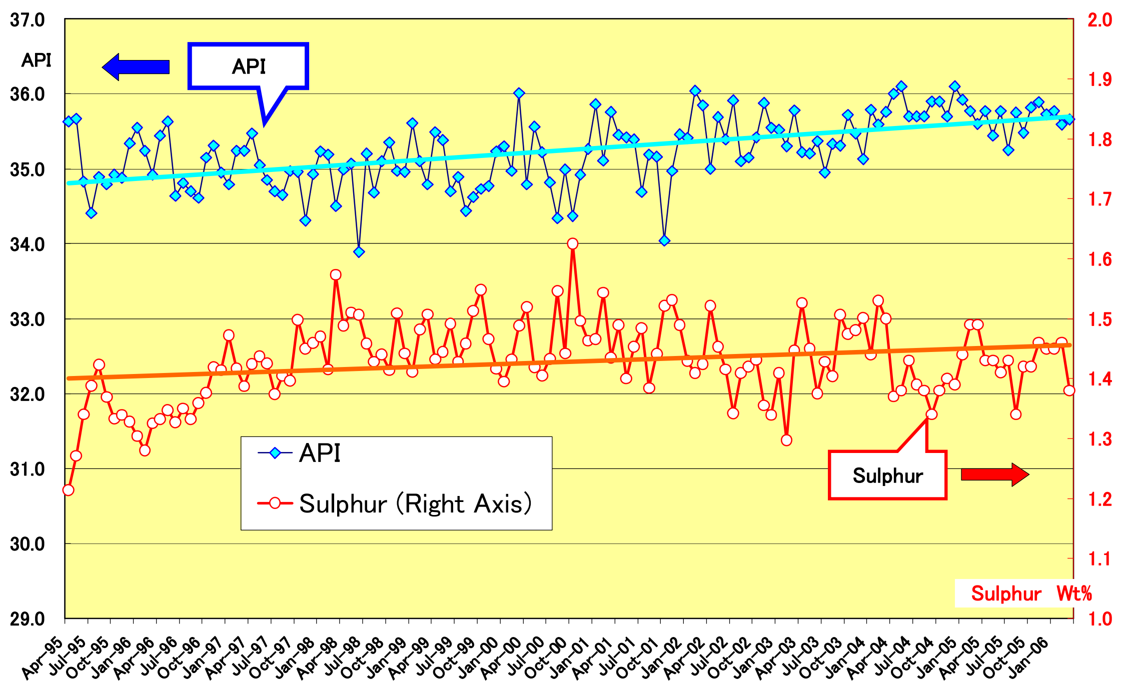
Table 4-2-3 Oil Refining Capacity by Company（As of April, 2006)

Company	Location	Atmospheric Crude Oil Distillation	Vacuum Crude Oil Distilltion	Catalytic Cracking	Hydro-Cracking	Alkylation	Catalytic Reforming		Naphtha De-sulfurizaton	Middle Distillate De-sulfurization	Heavy Oil Direct De-sulfurization	Heavy Oil Indirect De-sulfurization	Total Heavy Oil De-sulfurization Unit	Residual Oil Cracking
								for petro-chemical						
Showa Yokkaichi	Yokkaichi	210,000	105,000	61,000		17,000	70,800	10,200	69,000	21,000	103,500	45,000	40,000	
Seibu	Yamaguchi	120,000	44,000	28,000			24,700		32,000	13,000	56,000	50,000	—	
Toa	Keihin	185,000	88,000	42,000			39,100		52,000		83,000		62,000	27,000
Fuji	Sodegaura	192,000	55,000	18,000		4,000	29,900	9,000	43,000	13,000	63,500		47,000	24,000
Showa Shell Group Total		707,000	292,000	149,000	—	21,000	164,500	19,200	196,000	47,000	306,000	95,000	149,000	51,000
Japan Energy	Chita		40,000	17,000			23,500	19,500	39,000		75,000	—	30,000	
	Mizushima	205,200	109,000	52,000		9,000	44,000	17,200	34,000	35,000	125,400	31,000	70,000	26,000
Kashima	Kashima	190,000	42,000	34,500			22,000	8,500	23,000	26,000	90,000	30,000	25,000	
Japan Energy Group Total		395,200	191,000	103,500		9,000	89,500	45,200	96,000	61,000	290,400	61,000	125,000	26,000
Idemitsu	Hokkaido	140,000	24,000	33,000	16,500		18,000		27,000	10,000	58,300	42,000		
	Chiba	220,000	66,000	45,000			17,000		25,000	13,600	127,000	40,000	39,000	
	Aichi	160,000	16,000	50,000		10,000	20,000		30,000	15,800	83,000	60,000		
	Tokuyama	120,000	55,000	26,000		—	22,000	10,000	22,000		55,000		45,000	
Idemitsu Kosan Total		640,000	161,000	154,000	16,500	10,000	77,000	10,000	104,000	39,400	323,300	142,000	84,000	
Cosmo	Chiba	240,000	60,000	40,000			42,500		38,000	24,000	139,000	72,000	35,000	
	Yokkaichi	155,000	74,000	31,000			21,500		28,500	18,000	75,000		41,500	
	Sakai	80,000	34,000	24,000		8,000	8,000		11,000	14,000	54,000		20,000	
	Sakaide	120,000	41,500	20,000			14,000		14,000		64,000	30,000	17,200	
Cosmo Oil Total		595,000	209,500	115,000		8,000	86,000		91,500	56,000	332,000	102,000	113,700	
TonenGeneral	Sakai	156,000	70,000	46,000			34,000	25,000	50,000		90,200		44,000	
	Wakayama	170,000	74,000	39,000		3,600	23,000				89,600		32,000	
	Kawasaki	335,000	123,000	92,000		10,000	52,000		18,000		171,000		84,000	28,000
Kyokuto	Chiba	175,000	83,000	34,000	40,000		27,000		28,000		83,500			
Nansei	Nishihara	100,000					13,500		25,000		19,000			
Tonen General Group Total		936,000	350,000	211,000	40,000	13,600	149,500	25,000	121,000	—	453,300	—	160,000	28,000
Nippon Petroleum Ref.	Muroran	180,000	65,000	30,000	45,000		36,000		97,000		63,500	16,000		
	Sendai	145,000	60,000	43,000		9,000	18,000	2,000	18,000	31,000	34,000	52,000	40,000	
	Yokohama										7,300			
	Negishi	340,000	130,000	83,000		9,000	50,000	14,000	71,500	28,000	137,500	35,000	81,000	20,000
	Osaka	115,000	60,000	27,000		8,000	17,000		22,000		46,000		21,000	
	Mizushima	250,000	77,000	46,000	13,000	7,600	22,640	3,600	47,640	33,000	87,170	45,000	37,000	
	Marifu	127,000	75,000	28,000			24,000		34,000		48,000		48,000	22,000
Nihonkai	Toyama	60,000	11,000				7,000		11,000		24,500			
Nippon Oil Group Total		1,217,000	478,000	257,000	58,000	33,600	174,640	19,600	301,140	92,000	447,970	148,000	227,000	42,000
Kyushu	Oita	155,000	66,000	26,000	11,000		29,000	13,000	29,000	10,000	73,000		40,000	
Taiyo	Shikoku	120,000	27,000		19,000		33,000	19,000	37,000		48,000			
Teikoku	Kubiki	4,410												
Grand Total		4,769,610	1,774,500	1,015,500	144,500	95,200	803,140	151,000	975,640	305,400	2,273,970	548,000	898,700	147,000
Number of Plant		43	37	27	6	11	43	14	37	15	93	14	26	7

4-2-4. Characteristics of Imported Crude Oil

As demand has shifted to lighter, lower-sulfur petroleum products, refiners have been increasing their amount of gasoline production equipment, including catalytic reforming units (or reformers) for raising octane numbers of naphtha fractions, and fluid catalytic cracking units for improving gasoline yields. Over the recent years, they have also been constructing residual fluid catalytic cracking units. Globally, the quality of crude oil has become heavier. However, crude oil imports into Japan have become lighter with lower sulfur contents.

Figure 4-2-6 API Gravity and Sulfur Contents of Imported Crude Oils



Saudi crude oil imports, which accounted for 29.2% of Japan's total crude imports in fiscal 2005, had centered on arab Light with the API gravity at 32.7 degrees. In fiscal 2005, however, arab Extra Light with an API gravity of 38.4 degrees and a sulfur content of 1.16% accounted for 50.6% of total Saudi crude imports, with arab Light's share falling to 26.2%. Shares have also been declining for arab Medium and Arab Heavy. Such changes are attributable partly to Saudi Arabia's emphasis given to sales of light crude oil. Generally, however, Japanese refineries have tended to select lighter, lower-sulfur crude oil types.

Table 4-2-4 Trends in Saudi Crude Oil Imports into Japan (Unit: 1,000 kl)

FY	Arab Light	Arab Heavy	Arab Medium	Arab Extra Light	Others	Saudi Crude Total	AEXL Share %	Crude Oil Import Total	Saudi Crude Share %
1988	11,865	7,619	5,291	1,490	2,512	28,778	5.2%	199,756	14.4%
1989	13,548	4,736	3,238	3,370	3,336	28,227	11.9%	210,891	13.4%
1990	16,872	8,209	7,601	8,906	5,014	46,602	19.1%	238,480	19.5%
1991	18,991	10,877	7,374	13,428	5,100	55,770	24.1%	238,646	23.4%
1992	19,023	6,535	9,433	16,583	3,377	54,952	30.2%	255,668	21.5%
1993	22,271	7,716	8,201	14,848	2,187	55,223	26.9%	256,406	21.5%
1994	22,154	6,015	9,399	11,969	3,292	52,829	22.7%	273,777	19.3%
1995	19,993	4,835	9,617	13,110	3,521	51,075	25.7%	265,526	19.2%
1996	19,799	4,398	10,539	15,796	3,172	53,703	29.4%	263,792	20.4%
1997	20,639	6,380	10,127	18,395	3,446	58,988	31.2%	267,489	22.1%
1998	12,745	6,131	9,196	21,474	2,601	52,148	41.2%	254,279	20.5%
1999	10,280	5,359	8,754	21,413	2,553	48,359	44.3%	248,530	19.5%
2000	12,274	6,693	6,535	27,602	1,793	54,898	50.3%	254,604	21.6%
2001	12,257	4,362	4,549	30,476	1,720	53,365	57.1%	239,784	22.3%
2002	12,576	3,983	5,618	30,475	1,576	54,228	56.2%	241,898	22.4%
2003	14,335	5,065	4,454	29,014	2,837	55,704	52.1%	244,854	22.8%
2004	19,081	5,490	1,752	34,100	2,958	63,380	53.8%	241,805	26.2%
2005	19,087	10,000	4,092	36,832	2,778	72,789	50.6%	249,010	29.2%

A similar tendency is seen for the UAE, the second largest source of crude exports to Japan after Saudi Arabia. The share has been rising for the Murban crude oil with an API gravity of 39.9 degrees and a sulfur content of 0.78%. However, the share has been falling for the Upper Zakum with an API gravity of 33.7 degrees and a sulfur content of 2.0%.

Table 4-2-5 Trends in Crude Oil Imports from UAE (Unit: 1,000 kl)

FY	Murban – 39.9	Umm Shaif – 37.2	Zakum – 39.79	Upper Zakum – 33.7	Others	UAE Crude Total	Murban Share %	Crude Oil Import Total	UAE Crude Share %
1988	11,759	6,833	4,854	8,046	8,479	39,971	29.4%	199,756	20.0%
1989	14,104	9,017	7,587	7,461	6,694	44,863	31.4%	210,891	21.3%
1990	18,248	9,223	9,319	7,174	7,021	50,985	35.8%	238,480	21.4%
1991	24,571	11,525	11,680	8,591	4,651	61,017	40.3%	238,646	25.6%
1992	25,048	10,286	13,142	7,716	5,976	62,168	40.3%	255,668	24.3%
1993	24,410	9,074	13,672	10,006	7,315	64,477	37.9%	256,406	25.1%
1994	28,559	9,667	13,076	13,277	7,228	71,807	39.8%	273,777	26.2%
1995	27,778	10,307	12,293	14,048	6,461	70,886	39.2%	265,526	26.7%
1996	27,042	10,523	12,494	13,646	8,317	72,021	37.5%	263,792	27.3%
1997	24,199	10,897	11,041	15,862	8,818	70,817	34.2%	267,489	26.5%
1998	25,213	10,530	10,704	16,554	8,090	71,091	35.5%	254,279	28.0%
1999	20,406	9,399	9,933	13,457	7,280	60,475	33.7%	248,530	24.3%
2000	25,891	9,574	10,556	13,764	5,327	65,112	39.8%	254,604	25.6%
2001	22,915	9,365	9,596	11,351	3,972	57,200	40.1%	239,784	23.9%
2002	21,924	7,982	9,690	10,880	5,019	55,496	39.5%	241,898	22.9%
2003	28,190	9,112	9,873	9,941	2,364	59,479	47.4%	244,854	24.3%
2004	26,897	9,124	10,519	11,481	2,434	60,456	44.5%	241,805	25.0%
2005	25,492	11,076	10,309	11,844	2,368	61,089	41.7%	249,010	24.5%

4-3. Oil Companies

4-3-1. Overview

Among oil companies in Japan, the Shell Group and ExxonMobil Group are owned by foreign firms. These two groups account for about 34% of total oil refining capacity in the country. In fiscal 2003, Nippon Oil Corp. accounted for about 25% of fuel product sales in Japan, followed by about 16% for Idemitsu Kosan Co. and about 14% for ExxonMobil. Of gasoline sales, Nippon Oil had the largest share at about 23%, followed by 19% for ExxonMobil and 14% for Showa Shell Sekiyu K.K. Foreign companies have relatively low shares for sales of industrial fuels like fuel oil C and naphtha but have been clearly active in the more profitable gasoline area. This is because some Japanese oil companies have refineries built for thermal power plants and petrochemical firms to supply of fuels and feedstocks.

Table 4-3-1 Fuel Product Sales in Japan by Company (FY 2003) (Unit: 1,000 kl)

	Gasoline		Naphtha		Jet Fuel		Kerosene		Diesel Fuel		Fuel Oil A		Fuel Oil C		Total	
		Share %		Share %		Share %		Share %		Share %		Share %		Share %		Share %
Nippon Oil	14,086	22.7	8,862	25.1	1,223	22.8	6,832	23.5	8,486	21.9	7,753	26.0	8,872	31.6	56,114	24.6
Fuji Kosan		0.0		0.0		0.0	260	0.9	157	0.4	762	2.6	73	0.3	1,251	0.5
ExxonMobil	11,874	19.2	2,947	8.3	776	14.5	4,062	14.0	5,563	14.4	3,866	13.0	2,799	10.0	31,886	14.0
Kyokuto Oil			623	1.8		0.0								0.0	623	0.3
Idemitsu Kosan	8,578	13.8	7,511	21.3	1,608	29.9	3,840	13.2	6,165	15.9	4,497	15.1	3,687	13.1	35,888	15.7
Toho Oil				0.0		0.0			33	0.1			108	0.4	141	0.1
Showa Shell	8,739	14.1	732	2.1	576	10.7	4,087	14.1	4,607	11.9	3,793	12.7	2,070	7.4	24,604	10.8
Seibu Oil	8	0.0	15	0.0		0.0	18	0.1	24	0.1	36	0.1	198	0.7	299	0.1
Cosmo Oil	6,843	11.0	6,946	19.7	381	7.1	3,556	12.3	4,788	12.4	3,799	12.7	3,903	13.9	30,216	13.2
Japan Energy	6,327	10.2	3,110	8.8	741	13.8	2,847	9.8	4,434	11.5	2,333	7.8	2,672	9.5	22,464	9.8
Fuji Oil			1,433	4.1		0.0							1,005	3.6	2,438	1.1
Kashima Oil			475	1.3		0.0							6	0.0	481	0.2
Kyushu Oil	1,200	1.9	543	1.5	34	0.6	891	3.1	968	2.5	842	2.8	775	2.8	5,252	2.3
Taiyo Oil	1,523	2.5	2,088	5.9		0.0	1,066	3.7	1,510	3.9	562	1.9	833	3.0	7,581	3.3
Kygnus Sekiyu	1,447	2.3		0.0		0.0	652	2.2	672	1.7	750	2.5	622	2.2	4,143	1.8
Mitsui Oil	1,331	2.1		0.0	31	0.6	891	3.1	1,296	3.3	768	2.6	409	1.5	4,725	2.1
Teikoku Oil	47	0.1	36	0.1		0.0	25	0.1	21	0.1	55	0.2	41	0.1	225	0.1
Others		0.0		0.0		0.0		0.0		0.0	25	0.1	1	0.0	26	0.0
Total	62,003	100.0	35,321	100.0	5,370	100.0	29,025	100.0	38,726	100.0	29,839	100.0	28,074	100.0	228,358	100.0

As petroleum products demand has declined, oil companies in Japan have shifted from a competitive to a cooperative stance and streamlined their refining and logistics operations. In October 1999, Nippon Oil formed an agreement with Cosmo Oil Co. on cooperation in refining and logistics operations, leading to the formation of the Nippon Oil-Cosmo Oil group. Nippon Oil also reached an agreement with Idemitsu Kosan in December 2002 and Japan Energy in July 2006 on cooperation in refining operations.

Japan Energy Corp. and Showa Shell Sekiyu agreed to cooperate in refining and logistics operations in December 1999, leading to formation of the Japan

Energy-Showa Shell group. But their cooperation was effectively terminated when Fuji Oil Co. severed its capital ties with Japan Energy in February 2005 and accepted Showa Shell Sekiyu's equity participation in October 2005.

ExxonMobil Yugen Kaisha emerged from a merger between Esso Sekiyu K.K. and Mobil Sekiyu K.K. in June 2002. Their subsidiaries – Tonen Corp. and General Sekiyu K.K. – merged into TonenGeneral Sekiyu K.K.. ExxonMobil Yugen Kaisha and TonenGeneral Sekiyu have thus formed the ExxonMobil Group. At present, TonenGeneral is owned 50.02% by ExxonMobil.

In September 2006, Brazilian Petrobras disclosed that the company is in discussions to buy TonenGeneral's majority stake in the Namsei Sekiyu 100,000 b/d Okinawa refinery. Okinawa is seen as a strategically important location for Petrobras' business expansion in Asia as it is close to Taiwan and China. Should Petrobras acquire Nansei Sekiyu, it is expected to upgrade the facility and add secondary units such as a delayed coker, to improve its current products mix, which is dominated by fuel oil. A new coker at the Okinawa refinery is estimated to cost around ¥ 100 billion.

Table 4-3-2 Relationships between Oil Companies in Japan (at End of April 2006)

		Refining Capacity B/D		Crude Oil (2004)		Major Shereholders
		Apr. 2000	Apr. 2005	API	Sulfur %	
Shell Group		757,000	707,000	34.30	1.69	
	Showa Shell	260,000	210,000	35.07	1.65	Shell Petroleum Company 35.04%, Saudi Aramco 14.96%
	Toa Oil	185,000	185,000			Showa Shell 37.42%
	Seibu Oil	120,000	120,000	33.55	1.88	Showa Shell 38.0%
	Fuji Oil	192,000	192,000	32.59	1.66	AOC HD 100.0% (Tokyo Electric 8.75%, Kuwait Petroleum Corp 7.43%, Saudi Arabia Gov. 7.43%, Showa Shell 6.58%)
ExxonMobil Group		917,000	936,000	38.31	0.95	
	Tonen General	657,000	661,000	38.29	1.00	ExxonMobil 50.02%
	Kyokuto Oil	160,000	175,000	38.10	0.84	ExxonMobil 50.0%, Mitsui Oil 50.0%
	Nansei Sekiyu	100,000	100,000	45.96	0.04	Tonen General 87.5%, Sumitomo Corp. 12.5%
Nippon Oil Group		1,348,000	1,217,000	34.83	1.60	
	Nippon Oil	1,288,000	1,157,000	34.71	1.62	
	Nihonkai Sekiyu	60,000	60,000	37.21	1.01	Nippon Oil 66.0%, Hokuriku Electric 28.0%
Idemitsu Group		865,000	640,000	36.05	1.56	
	Idemitsu Oil	720,000	640,000	36.05	1.56	
	Toho Sekiyu	35,000	0			Mothballed in 2004
	Okinawa Sekiyu	110,000	0			Mothballed in 2003
Cosmo Oil		645,000	595,000	35.36	1.65	
Japan Energy Group		480,200	390,200	34.01	1.62	
	Japan Energy	300,200	200,200	33.89	1.64	Shin Nikko HD 100.0%
	Kashima Oil	180,000	190,000	34.44	1.56	Japan Energy 70.7%, Mitsubishi Chemical 19.9%
Kyusyu Oil		155,000	155,000	35.99	1.43	Nippon Steel 36.01%, Nippon Oil 10.01%
Taiyo Oil		102,000	120,000	42.45	0.10	
Teikoku Oil		4,410	4,410			
Total		5,273,610	4,764,610	35.82	1.42	

As indicated in the table, the ExxonMobil Group, which focuses on gasoline sales, imports lighter, lower-sulfur crude oil with an average API gravity of 38.3 degrees and a sulfur content of 0.95%. Oil firms that must supply fuel oil to thermal power stations import heavier crude oil and have more de-sulfurization and residual oil cracking units at their refineries.

4-3-2. Moves by Oil Companies

The average API gravity of Japan's crude oil imports in fiscal 2004 stood at 35.8 degrees and in fiscal 2005 at 35.7. But crude oil imported by Nansei Sekiyu K.K. and Taiyo Oil Co. has been lighter and contained less sulfur than average levels. Nansei Sekiyu belongs to the ExxonMobil Group and has the only one refinery in Okinawa. Petroleum products demand in Okinawa centers on gasoline with little demand seen for industrial fuels, and this has prompted Nansei Sekiyu to select lighter crude oil. TonenGeneral Sekiyu and Kyokuto Petroleum Industries Ltd. also belong to the ExxonMobil Group and have tended to select lighter crude oil.

Taiyo Oil, which has focused on gasoline sales, acquired the styrene monomer division of Mitsui Chemicals Inc. in 2004 and might have been required to increase naphtha supply for petrochemical operations.

Nihonkai Oil Co. of the Nippon Oil group has selected lighter, lower-sulfur crude oil. It runs the only refinery on the Sea of Japan coast and supplies gasoline, kerosene and diesel oil to Nippon Oil and low-sulfur fuel oil to Hokuriku Electric Power Co. One apparent reason why Nihonkai Oil has selected lighter, lower-sulfur crude oil may have been that its refinery has little capacity to de-sulfurize heavy crude oil.

Figure 4-3-1 API Gravity of Crude Oil Imported by Each Company

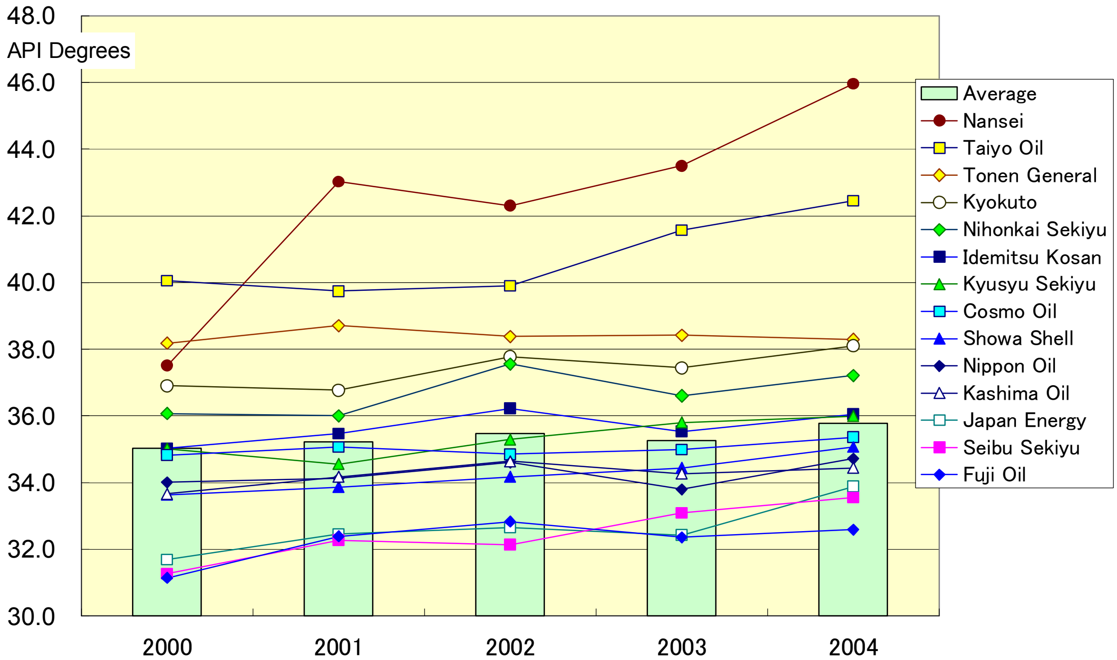
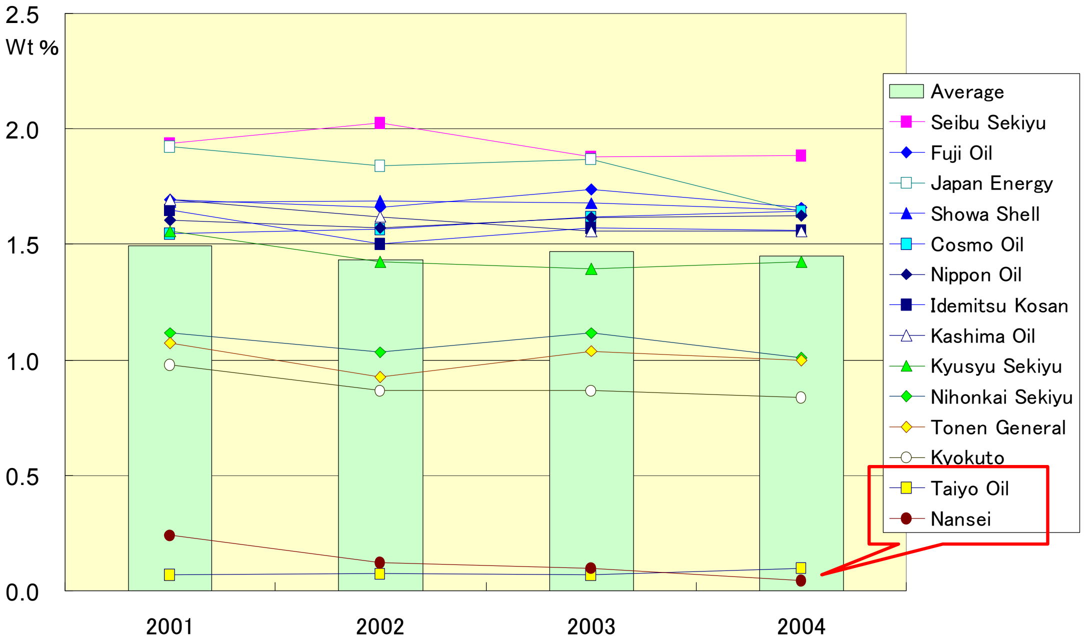


Figure 4-3-2 Sulfur Content of Crude Oil Imported by Each Company



The tendency is closely related to the de-sulfurization unit installation rate among oil refining systems. The figures indicate the ratio of hydro-treating capacity for naphtha, kerosene and diesel oil to atmospheric distillation capacity and that of de-sulfurization capacity to atmospheric distillation capacity.

Figure 4-3-3 De-sulfurization Capacity for Naphtha, Kerosene and Diesel Oil

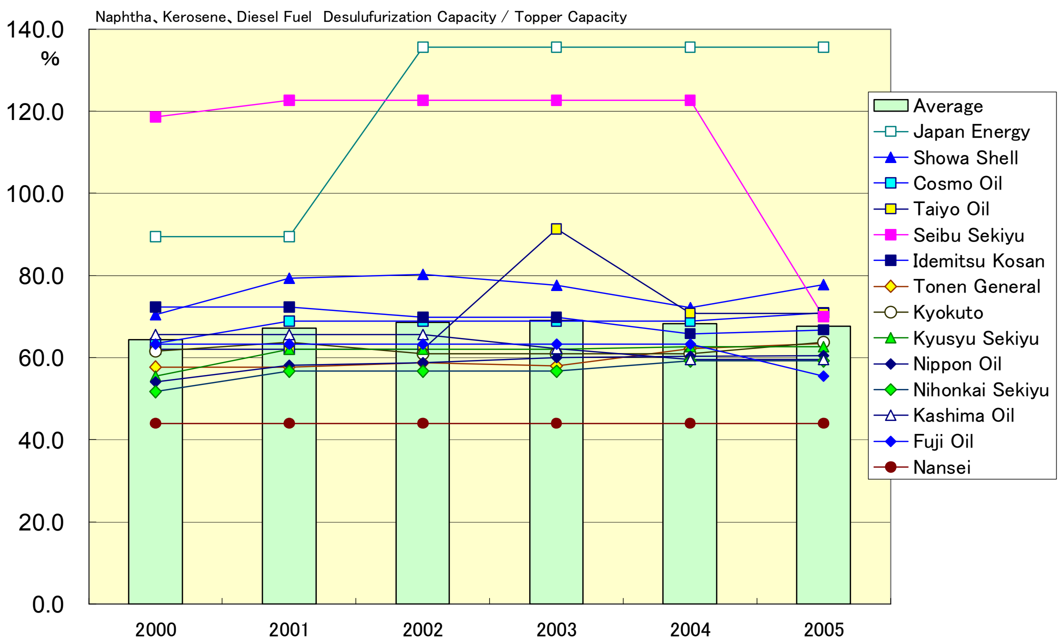
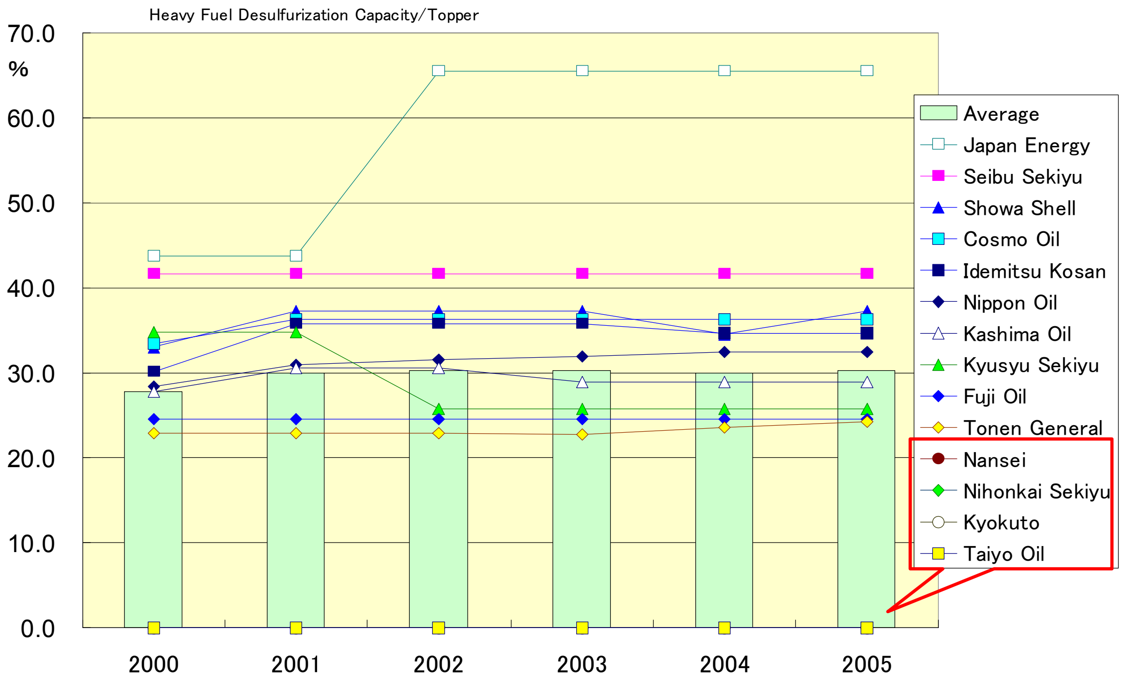


Figure 4-3-4 De-sulfurization Capacity for Fuel Oil

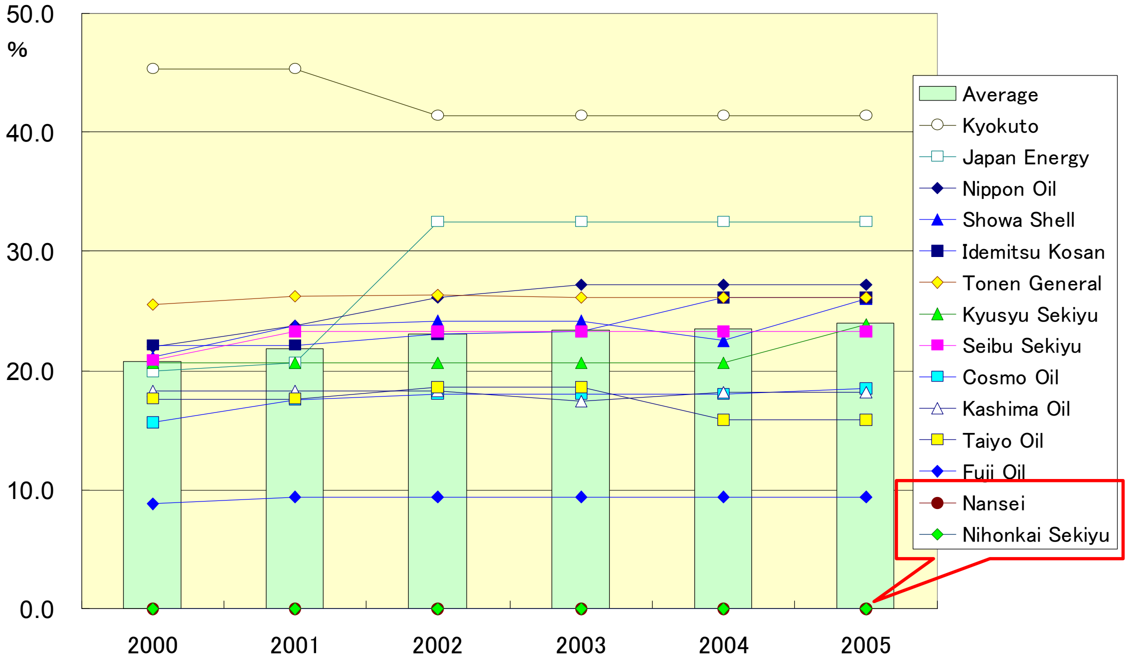


These figures show that Japan Energy and Seibu Oil Co. have a greater capacity to de-sulfurize lighter crude and tend to select crude oil with relatively high sulfur content.

Regarding production of more profitable lighter petroleum products such as gasoline, refineries that lack secondary processing unit such as hydro-cracking units tend to select lighter crude oil. Kyokuto Petroleum has medium-pressure hydro-cracking units to de-sulfurize heavy diesel oil from the atmospheric distillation units and VGO from the vacuum distillation units, as well as residual fluid catalytic cracking units to process vacuum residue. But the firm selects relatively light crude oil for refining. This may be because Kyokuto Petroleum is required to serve as a key base of the ExxonMobil Group for provision of petroleum products especially gasoline to customers in the Kanto region and to supply naphtha to neighboring Mitsui Chemicals.

In response to the growing dominance of heavier crude oil over the recent years, oil refiners have been considering the expansion of fluid catalytic cracking capacity. In March 2006, Fuji Oil released plans to spend some ¥30 billion on construction of its second FCC unit (with cracking capacity of 0.018 million b/d) and expansion in gasoline de-sulfurization capacity (from 0.013 million b/d to 0.021 million b/d). The plans will be completed by April 2008.

Figure 4-3-5 FCC and Hydrocracking Capacity



Heavy crude oil cracking units include delayed cokers at Japan Energy's Mizushima refinery and Nippon Oil's Marifu refinery, heavy oil gasification plant of Nippon Oil's Negishi refinery for 431MW power plant (IGCC, Integrated Gasification Combined Cycle Electric Power Plant), Flexicoker at the Kawasaki refinery of Toa Oil Co. owned by Showa Shell Sekiyu, a heavy crude hydrocracking unit (H-Oil process) at TonenGeneral Sekiyu's Kawasaki refinery, and the Eureka unit of Fuji Oil. Delayed coker construction plans are reportedly under consideration at Kashima Oil Co. of the Japan Energy group, Cosmo Oil (Sakai refinery) and Idemitsu Kosan (Chiba refinery).

Kashima Oil spent ¥500 million and increased its refining capacity to 200,000 b/d from 190,000 b/d in June 2006. Japan Energy Corp. plans to spend about ¥2 billion at its Mizushima Refinery to add more cracking capacity to 30,000 b/d from current 26,000 b/d. The work will take place in the first half of fiscal 2007, and the units are expected to be in operation by Jan 2008.

In November 21, 2006, Cosmo Oil announced that the company will spend ¥100 billion to newly install a set of Heavy Oil Cracking Unit (coker) in its Sakai Oil Refinery. The equipment uses the asphalt fraction as raw material to produce naphtha, jet fuels, and diesel oil. This allows a shift to profitable production, for example, from heavy oil made from crude to middle distillate.

Companies listed in Table 4-3-3 are planning to construct heavy oil cracking units. These companies consider that investment for cracking units is promising if recent hike of price differentials between heavy and light crude continues for some period in the future. Table 4-3-3 also shows plans of Korean petroleum companies for reference.

Figure 4-3-6 Heavy Crude Cracking Capacity

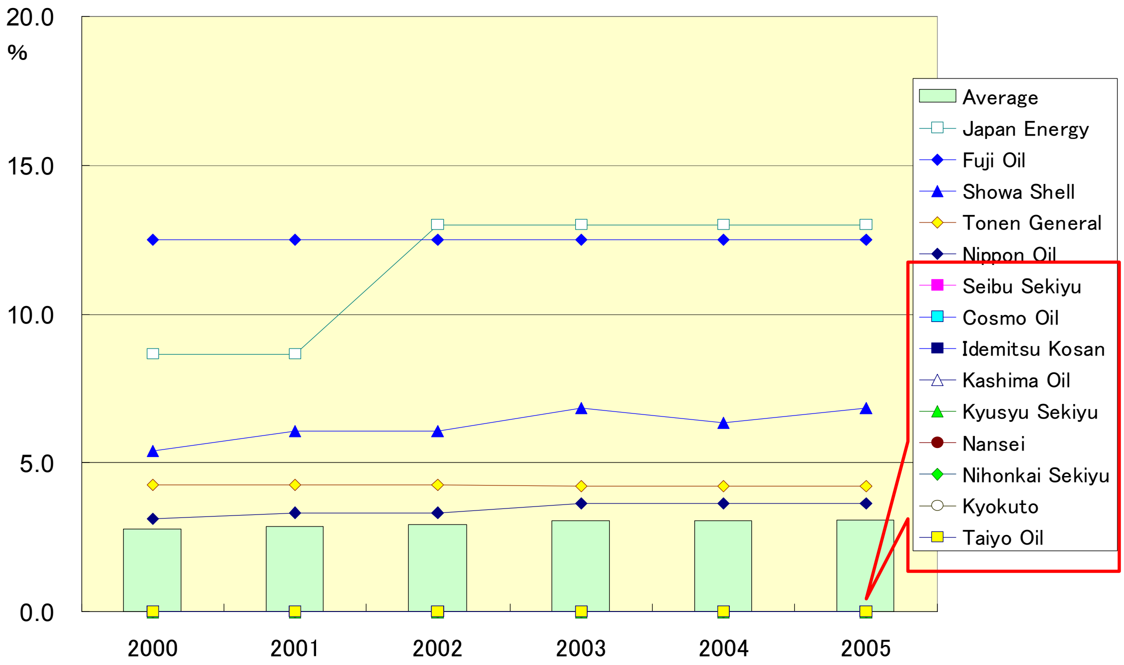


Table 4-3-3 Planned Newly Construction of Heavy Oil Cracking Units

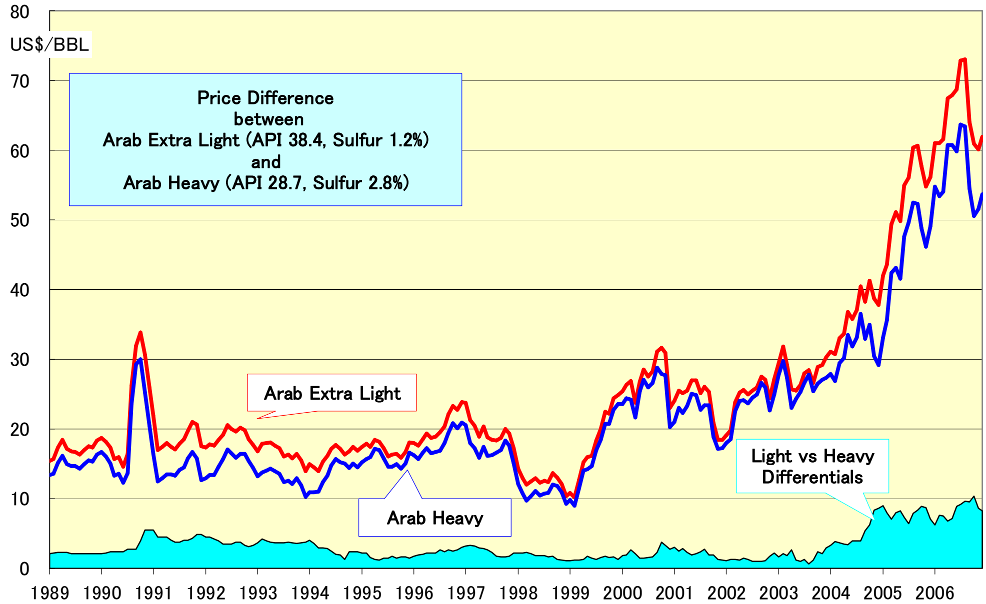
Company	Refinery	Process	Capacity 1,000 B/D	Operation
Japan Energy	Mizushima	Coker (expansion)	30.0	2007
Fuji Oil	Sodegaura	FCC	18.0	2008
		Eureka (expansion)	30.0	2009
Kashima Oil	Kashima	Coker	20.0	2009
Cosmo Oil	Sakai	Coker	25.0	2010
Taiyo Oil	Imabari	RFCC	25.0	2010
Total			118.0	
Korea (reference)				
GS Caltex	Yosu	Hydro Cracking	55.0	2007
Hyundai Oilbank	Seosan	RFCC	70.0	2010
SK Corp.	Inchon	CDU	75.0	2007
	Ulsan	RFCC	60.0	2008
S-Oil	Onsan	CDU	480.0	2010
		RFCC	75.0	2010
		Hydro Cracking	75.0	2010
Korea Cracking Capacity Tota			335.0	

Oil companies are thus divided over the selection of crude oil for their refining as demand increases for lighter, lower-sulfur petroleum products. Generally, the ExxonMobil Group procures lighter, lower-sulfur crude oil and cracks heavy fractions to maximize production of light fractions.

Other groups have refineries integrated with electricity utilities or petrochemical plants to ensure fuel oil and naphtha supply. In view of falling demand for gasoline and diesel oil, some groups are planning to export these products to other Asian countries such as China and to the U.S. in order to maintain capacity utilization ratios at their refineries. In November 21, 2006, Cosmo Oil declared that it would begin exporting 2.5 – 3.8 million BBL/Year of CARB diesel to the West Coast Area of the U.S. beginning in April 2007. As reported in December 2006, Nippon Oil aims to almost double oil product exports to 200,000 b/d by the end of March 2007.

It is thus difficult to predict whether Japanese oil refiners' crude oil procurement will shift to heavier or lighter crude.

Figure 4-3-7 Trends in Price Differentials between Heavy and Light Crude



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5. Refining Capacity

5-1. Global Refining Capacity

Capacity assumptions for refining units are based on unit-by-unit predictions by the Oil & Gas Journal and other data. For Asia, on-site survey results are also taken into account to improve the accuracy of the estimation. The refinery outlook for the world other than Asia is based on the Worldwide Construction Update (Oil & Gas Journal, Nov. 21, 2005).

The following are plans for construction of crude distillation and secondary processing units toward 2010, based on the Oil & Gas Journal (Asian crude distillation unit construction plans are based on hearings before modification).

Table 5-1-1 Plans for Construction of Crude Distillation and Secondary Processing Units toward 2010

Country	CDU	Vacuum Unit	Coking Unit	Themal Operations	FCC	RFCC	CCR	Hydrotreater	Catalytic Hydrocracking
United States	139,000	20,000	29,100	0	18,000	0	0	887,700	84,000
Canada	72,000	0	399,300	0	0	0	0	30,000	32,000
Mexico	0	0	0	0	0	0	0	0	0
Brazil	253,077	0	102,170	0	0	40,948	0	95,777	0
Other Latin America	865,000	36,000	40,000	40,600	50,000	0	27,200	218,000	0
England	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0
France	0	0	0	0	2,000	0	0	79,000	48,000
Italy	0	0	0	0	0	0	0	2,500	24,500
Other Europe	0	50,000	20,000	0	0	0	50,950	19,751	134,000
Russia	0	0	0	6,000	0	0	0	16,500	40,000
Non OECD Europe	376,900	30,200	0	8,600	20,000	0	0	85,900	89,000
Africa	321,000	35,000	0	0	0	0	0	4,000	0
Middle East	986,400	16,800	0	0	0	75,260	96,000	454,707	180,000
China	893,905	0	36,000	0	0	0	0	0	182,000
Japan	0	0	0	0	0	0	0	14,000	0
Hong Kong	0	0	0	0	0	0	0	0	0
Taiwan	600,000	0	0	0	0	73,000	40,000	114,000	0
Korea	0	0	0	0	0	0	0	185,000	0
Singapore	0	0	0	0	0	0	0	0	0
Brunei	0	0	0	0	0	0	0	0	0
Indonesia	100,000	0	0	0	0	0	0	73,500	
Malaysia	0	0	0	0	0	0	0	0	0
Phillippines	0	0	0	0	0	0	0	0	0
Thailand	58,000	0	0	0	0	0	0	0	0
India	905,000	0	41,000	0	52,000	0	33,200	41,900	0
Vietnam	148,000	0		0	0	69,700		29,000	0
Other Asia	0	0	5,600	0	0	0	10,700	30,800	8,500
Australia	0	0	0	0	0	0	0	0	0
New Zealand	0	0	0	0	0	0	0	0	0
Total	5,718,282	188,000	673,170	55,200	142,000	258,908	258,050	2,382,035	822,000

Table 5-1-2 indicates the world's refining capacity projected through 2015. The projected capacity is not the result of calculations using the petroleum products trade estimation model, but an exogenous condition based on oil companies' refinery construction plans and on-site surveys.

As of 2003, Asia had refining capacity of 20.79 million barrels per day, outdoing North America. Asia's capacity is expected to see an increase of 8.27 million b/d between 2003 and 2015, accounting for 49% of the global expansion estimated at 16.84 million b/d.

Table 5-1-2 Global Refining Capacity

Unit : 1,000b/d		Atomospheric Distillation			Increment Value	
		2003	2010	2015	03～10	10～15
North America		18,686	19,354	20,714	668	1,360
	U.S.A.	16,698	17,265	18,519	567	1,254
	Canada	1,988	2,089	2,195	101	106
Latin America		8,403	9,413	10,268	1,010	856
	Mexico	1,684	1,684	1,874	0	190
	Brazil	1,914	2,161	2,568	247	407
	Other Latin America	4,805	5,567	5,826	762	259
OECD Europe		14,920	15,350	15,785	430	435
	United Kingdom	1,817	1,877	1,940	60	63
	Germany	2,289	2,428	2,427	139	-1
	France	1,951	1,979	2,018	28	39
	Italy	2,313	2,324	2,299	11	-25
	Other European Countries	6,548	6,741	7,101	193	360
Non OECD Europe		10,323	10,247	10,607	-76	360
	Russia	5,435	5,341	5,636	-95	295
	Other Non OECD Countries	4,887	4,906	4,971	19	65
Africa		3,224	3,551	3,848	328	297
Middle East		6,462	8,020	9,331	1,559	1,311
Asia		20,794	25,126	29,059	4,332	3,933
	Japan	4,703	4,672	4,672	-31	0
	China	5,619	8,446	10,158	2,827	1,712
	Taiwan	1,220	1,220	1,820	0	600
	Korea	2,750	2,735	2,735	-15	0
	Singapore	1,337	1,337	1,337	0	0
	Brunei	9	9	9	0	0
	Indonesia	993	1,093	1,360	100	267
	Malaysia	516	545	695	29	151
	Philippines	333	333	333	0	0
	Thailand	703	761	982	58	221
	Vietnam	0	148	242	148	94
	India	2,135	3,316	3,972	1,181	656
	Other Asian Countries	477	512	744	35	232
Oceania		859	805	900	-53	95
	Australia	755	702	782	-53	81
	New Zealand	104	104	118	0	14
Total World		83,670	91,867	100,514	8,197	8,647

Note : China's refining capacity includes 834,000 B/D of Asphalt-type refineries in 2015

Source: IEEJ

5-2. Asian Refining Capacity

Table 5-2-1 shows Asian refining capacity projected through 2015.

Table 5-2-1 Asian Refining Capacity Outlook

Unit: 1,000b/d	Atomospheric Distillation			Increment Value	
	2003	2010	2015	03～10	10～15
China	5,619	8,446	10,158	2,827	1,712
Taiwan	1,220	1,220	1,820	0	600
Korea	2,750	2,735	2,735	-15	0
Singapore	1,337	1,337	1,337	0	0
Brunei	9	9	9	0	0
Indonesia	993	1,093	1,360	100	267
Malaysia	516	545	695	29	151
Philippines	333	333	333	0	0
Thailand	703	761	982	58	221
Vietnam	0	148	242	148	94
East Asia (excl. Japan)	13,479	16,626	19,671	3,146	3,045
Japan	4,703	4,672	4,672	-31	0
India	2,135	3,316	3,972	1,181	656
Other Asian Countries	477	512	744	35	232
Total Asia	20,794	25,126	29,059	4,332	3,933

Source: IEEJ

Note 1: Asian refining capacity projected for 2010 is based on various data and information from local oil companies. The Euro 3 standard is planned to be fully introduced in China in or after 2007 and in India in or after 2010. These countries and their neighbors are thus projected to have secondary processing capacity (particularly, de-sulfurization capacity) close to the present European level.

Note 2: Capacity in China and India in 2015 is based on their present plans. Other Asian countries are assumed to expand refining capacity in accordance with their oil demand growth. But the Philippines, Singapore and Brunei are projected to implement no capacity expansion.

East Asia's refining capacity is projected to increase by 3.92 million b/d from 2003 to 2010, according to present national plans in the region. An increase from 2010 to 2015 is predicted at 3.93 million b/d. Since refinery construction plans through 2015 are not necessarily certain, we have prepared the projection by collecting local information to specify feasible plans and by assuming capacity to expand in accordance with local demand growth. Secondary processing units are assumed to increase according to local quality regulation plans for fuels.

Chinese and Indian oil refining device construction plans are set as follows, based on hearings and other local information:

5-3. China's Refining Capacity

5-3-1. CNPC's Refining Capacity

According to local surveys and various documents, CNPC is expected to expand refining capacity by 30.5 million tons per year (or 610,000 b/d) by 2010. Dalian Petrochemical Company and Liaoyang Petrochemical Fiber Co.'s Liaoyang refinery are expected to expand capacity to refine Russian crude. Dushanzi Petrochemical Co. is projected to increase capacity to process Kazakh crude.

Table 5-3-1 CNPC's Refining Capacity Expansion Plan

CNPC：China National Petroleum Corporation	Additional / New Capacity		Year of Completion
	×1000 Ton	× 1000b/d	
Dalian Petrochemical	10,000	200	2005
West Pacific Petrochemical Co.	2,000	40	2005
Jinxi Petrochemical	4,500	90	2005
Dushanzi Petrochemical	10,000	200	2008
Liaoyang Petrochemical	3,000	60	2006
Jilin Petrochemical	1,000	20	2010
Total	30,500	610	

Source: IEEJ

5-3-2. SINOPEC's Refining Capacity

According to various surveys, SINOPEC is expected to expand refining capacity by 69.8 million tons per year (or 1.396 million b/d) by 2010.

Table 5-3-2 SINOPEC's Refining Capacity Expansion Plan

SINOPEC：China Petroleum & Chemical Corporation	Additional / New Capacity		Year of Completion
	×1000 Ton	× 1000b/d	
Maoming Petrochemical	5,000	100	2006
Tianjin Petrochemical	9,000	180	2010
Jinling Petrochemical	2,500	50	2005
Zhenhai Petrochemical	6,000	120	2005
Sinopec/ExxonMobil/Aramco Joint Venture	8,000	160	2008
Qingdao Petrochemical	10,000	200	2008
Luoyang Petrochemical	2,000	40	2006
Wuhan Petrochemical	4,000	80	2006
Changling Petrochemical	5,000	100	2006
Guangzhou Petrochemical	10,300	206	2008
Sinopec Corp/Guangxi Autonomous Region	8,000	160	2008
Total	69,800	1,396	

Source: IEEJ

5-3-3. CNOOC's Refining Capacity

CNOOC is expected to expand refining capacity by 12 million tons per year (or 240,000 b/d) by 2010.

Table 5-3-3 CNOOC's Refining Capacity Expansion Plan

CNOOC: China National Offshore Oil Corporation		Additional / New Capacity		Year of Completion
		×1000 Ton	× 1000b/d	
	CNOOC /Shell (Huizhou, Guangdong Province)	12,000	240	2007
	Total	12,000	240	

Source: IEEJ

5-3-4. China's Refining Capacity (Conclusion)

Based on hearings from Chinese oil companies, major refiners' definite plans to expand existing refineries and construct new ones indicate that their refining capacity may expand from the present 5.6 million b/d to 7.85 million b/d by 2010. We conducted hearings with independent oil refiners with rights to import crude oil in the current fiscal year as well, and have estimated their refining capacity at 600,000 b/d for 2010. Bitumen refineries that have no crude-importing rights and import fuel oil for the production of diesel oil and asphalt are estimated to process 400,000 b/d in fuel oil in 2010.

China's total refining capacity in 2010 is thus projected at 8.45 million b/d including 7.85 million b/d for major oil refiners and 600,000 b/d for independent refiners. Refining capacity is assumed to increase at the same pace with demand (expected to rise 4.3% on an annual average basis during the 2010-2015 period) between 2010 and 2015.

Table 5-3-4 China's Refining Capacity Expansion Plan

	Existing Capacity		Add / New Capacity		Total	
	×1000 Ton	× 1000b/d	×1000 Ton	× 1000b/d	×1000 Ton	× 1000b/d
CNPC	116,800	2,336	30,500	610	152,300	3,046
SINOPEC	163,200	3,264	69,800	1,396	259,500	5,190
CNOOC	0	0	12,000	240	12,000	240
Sub Total	280,000	5,600	112,300	2,246	392,300	7,846
Independent Refineries	28,800	600	0	0	28,800	600
Total	308,800	6,200	112,300	2,246	421,100	8,446

Source: IEEJ

5-4. India's Refining Capacity

In India, national oil companies are expected to boost their refining capacity by 305,000 b/d by 2010. Among private sector companies, Reliance is projected to increase such capacity by 600,000 b/d, and Essar by 156,000 b/d. India's total refining capacity is thus estimated to increase by 1.061 million b/d from 2.255 million b/d in 2004 to 3.316 million b/d in 2010. Refining capacity is assumed to increase at the same pace with demand (expected to rise 3.8% on an annual average basis during the 2010-2015 period) between 2010 and 2015.

Table 5-4-1 India's Refining Capacity Expansion Plan toward 2010

Company	Location	Additional Capacity		Year of Completion
		×1000 Ton	× 1000b/d	
NOC's		15,250	305	
BPCL	Bina	6,250	125	2007
HPCL	Bhatinda	9,000	180	2009
Public Companies		40,800	756	
Reliance	Jamnagar	33,000	600	2008
Essar		7,800	156	2006
Total		56,050	1,061	

Source: IEEJ

Table 5-4-2 India's Projected Refining Capacity in 2010

2004	Additional Capacity	2010
2,255	1,061	3,316

6. Estimating Net Back Prices

We estimated a gap between prices of the same oil sand shipments from Canada's Alberta Province to the U.S. Gulf Coast and Japan. Shipments to the United States may be based on West Texas Intermediate (WTI) crude price, while those to Japan may be linked to Dubai and Oman crude prices. We attempted to see how the difference in benchmark crude brands would affect prices of the oil sand shipments to Japan and the USGC.

Since oil sand shipments have never been made to Asia, however, we adopted WTI crude price for shipments to the United States and Saudi Arabian crude price for those to Asia. The Saudi Arabian crude price is based on Dubai and Oman benchmarks. Crude oil brands adopted for the estimation are Arab Extra Light close to SCO and arabian Heavy similar to DilBit (diluted bitumen). Our estimates are based on FOB prices of the two crude brands shipped from Ras Tanua between 1999 and 2005. Tanker freights for transportation to Japan and the USGC were added to these prices to compute C&F prices in Japan and the USGC. For Japan, Edmonton-Vancouver pipeline and Vancouver-Japan tanker transportation costs are subtracted from the total costs to compute a net back price at Edmonton.

For the USGC, pipeline transportation costs alone were subtracted to determine a net back price. Pipeline costs as provided by the CAPP (Canadian Association of Petroleum Producers) for January 2006 were considered to be those for 2005. The U.S. GDP deflator was employed to eliminate the effects of inflation on costs in and before 2004.

Table 6-1 Estimated Net Back Prices of Arab Extra Light Crude

Year	1999		2000		2001		2002		2003		2004		2005	
Market	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC
(1) FOB Ras Tanura	17.76	18.85	27.50	26.77	24.03	20.17	24.69	25.25	28.30	26.86	36.23	37.23	53.06	53.66
(2) Freight Ras Tanura → Japan or USGC	0.70	1.04	1.61	2.07	1.11	1.70	0.83	1.17	1.50	2.17	2.62	3.43	1.84	2.60
(3) C&F Japan or USGC (3) = (1) + (2)	18.46	19.89	29.11	28.84	25.14	21.87	25.52	26.42	29.80	29.03	38.85	40.66	54.90	56.26
WTI @ Cushing (for Reference)	(19.26)		(30.30)		(25.94)		(26.12)		(31.13)		(41.45)		(56.50)	
(4) Freight Canada (Pacific) → Japan	0.50		1.17		0.80		0.60		1.14		1.88		1.33	
(5) PL Tariff Edmonton → Pacific or USGC	1.34	3.01	1.36	3.07	1.39	3.14	1.42	3.19	1.44	3.25	1.46	3.29	1.48	3.33
(6) Netback Value @ Edmonton (6) = (3) −((4) + (5))	15.92	15.84	24.97	23.71	21.84	17.03	22.67	22.06	25.71	23.61	32.88	33.94	50.25	50.33
(7) Differential between 2 markets	0.08		1.26		4.80		0.61		2.10		−1.06		−0.08	

Estimates indicate that the price of shipments to Japan for Arab Extra Light remained higher than that of shipments to the USGC until 2003, and turned lower in 2004 due to WTI crude's spike.

However, the price of Arabian Heavy shipments to Japan remained higher until 2005. This may be because Arabian Heavy in the United States might have been discounted with fierce competition from other heavy crude oils.

Given these estimates and the possible future stabilization of WTI price, we can conclude that it may be favorable for Canadian oil sand producers to sell output to Asia rather than to the United States.

Table 6-2 Estimated Net Back Prices of Arab Heavy Crude

Year	1999		2000		2001		2002		2003		2004		2005	
Market	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC	JAPAN	USGC
(1) FOB Ras Tanura	16.35	16.58	25.30	23.25	21.85	15.89	23.41	22.87	26.56	23.63	31.39	31.35	45.15	44.62
(2) Freight Ras Tanura → Japan or USGC	0.70	1.04	1.61	2.07	1.11	1.70	0.83	1.17	1.50	2.17	2.62	3.43	1.84	2.60
(3) C&F Japan or USGC (3) = (1) + (2)	17.05	17.62	26.91	25.32	22.96	17.59	24.24	24.04	28.06	25.80	34.01	34.78	46.99	47.22
WTI @ Cushing (for Reference)	(19.26)		(30.30)		(25.94)		(26.12)		(31.13)		(41.45)		(56.50)	
(4) Freight Canada (Pacific) → Japan	0.50		1.17		0.80		0.60		1.14		1.88		1.33	
(5) PL Tariff Edmonton → Pacific or USGC	1.60	3.61	1.64	3.68	1.67	3.77	1.70	3.83	1.73	3.90	1.75	3.95	1.78	4.00
(6) Netback Value @ Edmonton (6) = (3) −((4) + (5))	14.25	12.97	22.49	19.57	19.37	12.13	21.10	19.04	23.69	19.74	27.76	27.41	42.05	40.63
(7) Differential between 2 markets	1.28		2.92		7.24		2.07		3.95		0.35		1.42	

Contact:report@tky.ieej.or.jp