Changes in the flow of crude oil to the West and Asia and the issue of higher prices of eastbound Middle East crude[*1]

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Objectives of the Study

Since the 1990s, the pricing level for Middle East crude oil exported to Asia has been comparatively higher than crude oil prices earmarked for Europe and the United States. For example, the price of Arabian Light Crude Oil has constantly shifted at the higher end of the price spectrum. The primary objective of this study is to comparatively analyze and grasp the transitions in crude oil movement, the differences in the supply structure, crude price differential, and the factors underlying the price differential between Asia and Europe and the United States. Additionally, another objective is to pinpoint future issues pertaining to the problem of higher crude prices of eastbound Middle East crude.

Conclusion

1. The export of crude oil by the Middle East countries of UAE, Qatar, Oman, Yemen has shifted to Asia. Although Saudi Arabia, Iran, Iraq, and Kuwait have increased their export of crude oil to Asia, they export to all three largest oil consumption regions - the United States, Europe, and Asia. The exporter countries in the latter group are residual suppliers that fix the price to reflect the competitive conditions in each consumption region by using different benchmark crude.

2. The flow of crude oil west of the Suez Canal (the long position) and to the east of the Suez Canal (the short position) has continued to expand. The crude import volume of Asia rose from 5.77 million barrels per day in 1988 to 11.53 million barrels per day in 1997. The crude import volume from Africa grew from 2 percent in 1988 to 7 percent in 1997. The oil supply from Africa is also subject to stringent environmental regulations.

3. In a comparison of the formula price of Saudi Arabia's Arabian Light for Asia and Europe and the

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United States, the pricing level for Asia was a high USD 1.00/barrel from 1992 to 1995, which rose to about USD 1.50/barrel in 1997 and 1998.

4. The initial price differential of USD 1.00/barrel stemmed from an unavoidable structural problem that was due to the use of the Dubai crude price as benchmark for Asia. However, in order to ascertain whether the cause of the further difference of 50 cents/barrel was due to price manipulation of Dubai crude on the spot market or whether Dubai crude can carry out reliable price formation, requires further watching.

5. If the price differential from Arabian Light falls below USD 1.00/barrel, there is an advantage to shifting to African or North Sea crude oil. Korea does not have enough secondary facilities (desulfurization and cracking facilities), so it is advantageous to shift to other crude oils at a price differential of 1.00 to 2.00 dollars/barrel, but such an incentive does not exist for Japan and Singapore. Shifting to African or North Sea crude oil raises awkward transportation, quality and market issues.

6. Specific measures to counter the issue of higher prices of eastbound middle East crude are: 1) change the benchmark from Dubai crude, 2) develop crude oil sources other than the Middle East, and 3) set up an East Asian spot market for petroleum products. A further review of these three measures aimed at strengthening the bargaining power against oil-producing countries, is an important issue for the Asian market, which represents a consumption area equivalent in scope to the United States and Europe.

1. Crude oil distribution in the United States, Europe, and Asia

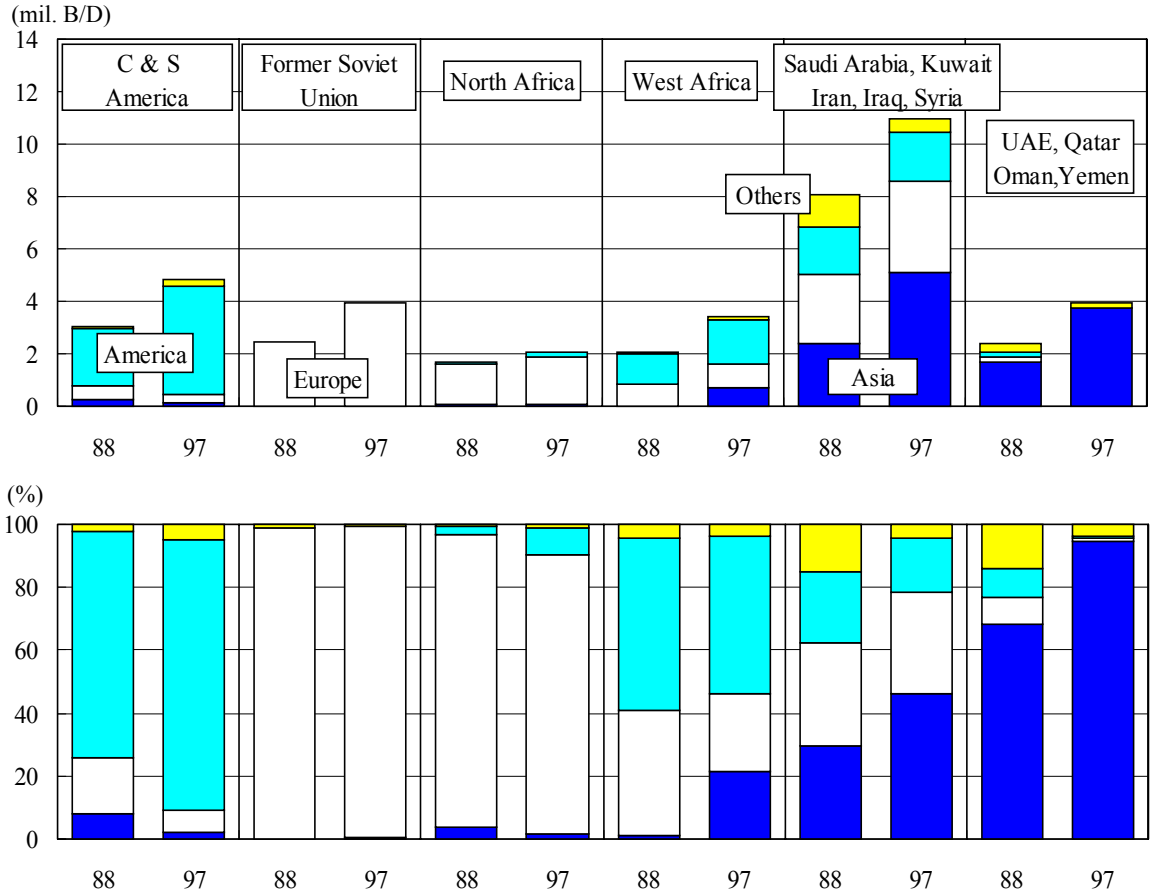
1.1 Transitions in crude oil flow in oil producing countries

Competitive oil prices in the United States, Europe and Asia have produced regional disparities in the three largest oil consumption areas. The analytical data on the underlying factors have been compiled in this research paper. But firstly, the transitions that have occurred in the flow of crude oil from the exporting countries to the consumption areas from 1988 to 1997 have been studied. The transitions in crude oil flow from the perspective of the oil exporting countries are shown in **Fig. 1-1**.

The Middle East is a focal region among the oil producing and exporting regions and it has the largest volume of oil resources, but other regions include Latin America, the former Soviet Union, and North and West Africa. Although the volume of crude oil exported from North Africa has shown only relatively moderate growth, the other regions experienced a rise in their export volume from 1988 to 1997. Latin America increased their crude oil export to North America, namely the United States; and the former Soviet Union and North Africa have increased their export to Western European countries.

More than half of the crude oil produced in West Africa is exported to the United States, but West Africa has been unable to increase its export volume to Europe due to the competition and diversity of the

Fig.1-1 Crude oil flow from the perspective of the oil exporting countries



(Source) Prepared by IEEJ based on the data in Blackwell Energy Research's 'World Oil Trade'.

region. Its remaining export volume has recently been exported to Asia; and its overall export ratio to Asia in 1997 was 20 percent. The Middle East oil exporters, UAE, Qatar, Oman, and Yemen, have shifted their entire export volume to Asia; and their export ratio to Asia was about 95 percent in 1997.

Although Syria mainly ships its entire export volume to Europe and the United States, the remaining Middle East exporters such as Saudi Arabia, Iran, Iraq, and Qatar have focused their oil export to the United States, Europe, and Asia, the three largest oil consumption regions. These four exporters are globally, the last residual suppliers. However, Iraq presently exports its oil to Europe and the United States under the supervision of the United Nations. In reviewing the transitions from 1988 to 1997, the export ratio to Asia has grown among these five oil exporters, reaching about 50 percent in 1997. These residual suppliers, mainly Saudi Arabia, have priced their crude oils according to the competitive conditions in the consumption region, using different benchmarks according to the region.

1.2 Transitions in crude oil flow from the perspective of oil consumption regions

The transitions in the import patterns of the three oil consumption regions, the United States, Europe, and Asia, are shown in **Fig. 1-2**. The foremost characteristic of the Asian region is the rapid increase in

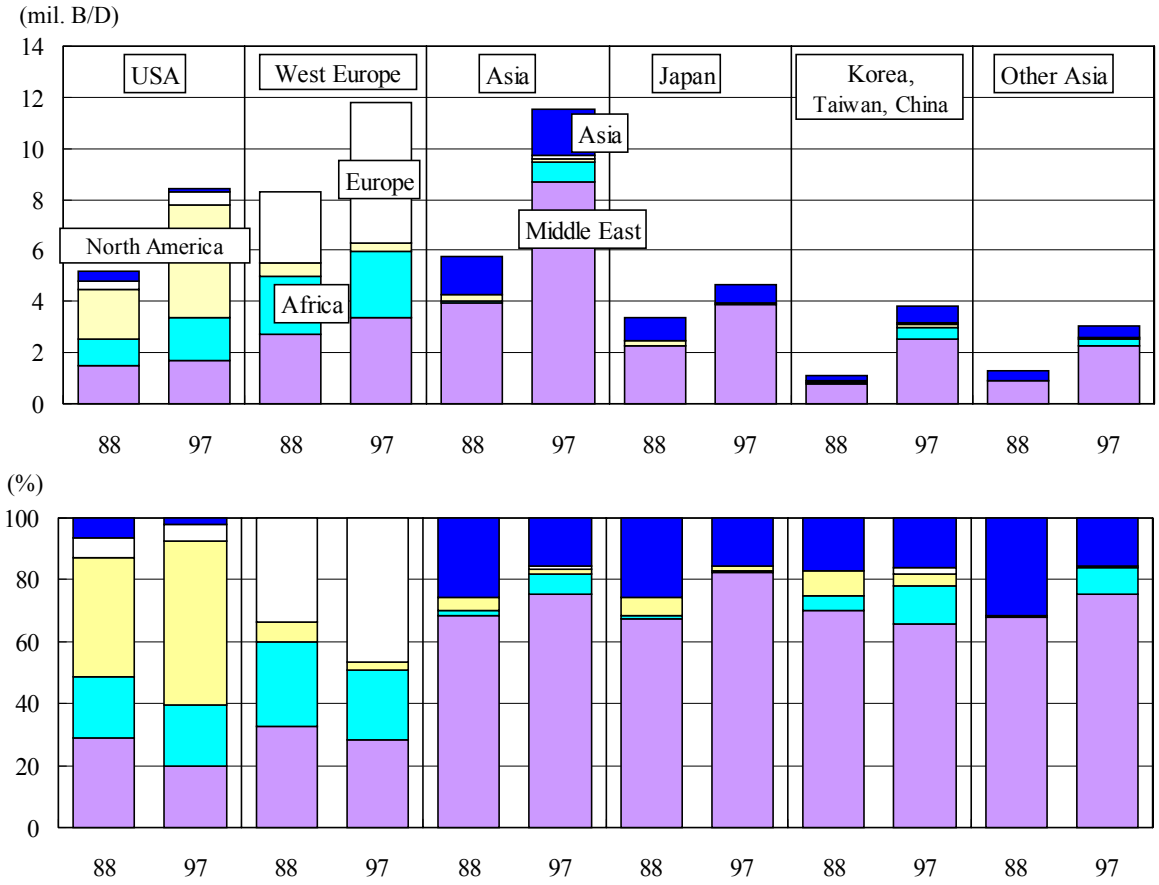
the volume of imported crude oil from 1988 to 1997 that occurred in tandem with very high economic growth.

In **Fig. 1-2**, Asia has been divided into three regions - Japan as a separate region, Korea, Taiwan, and China as one region, and others; and a comparison of the transitions in their crude import volume from 1988 to 1997 is shown.

Firstly, the crude oil import patterns of Western Europe and the United States, west of the Suez Canal, show that the volume of crude oil imported by the United States increased mainly from the neighboring countries of Canada and Mexico, and Venezuela. Secondly, there has been a notable increase in the import volume from West Africa. Subsequently, the volume of crude oil imported from the Middle East has not grown in the past nine years and the dependence ratio of the United States on imported Middle East crude oil fell from 25 percent in 1988 to 20 percent in 1997.

Due to the expanded trade in local crude in Western Europe from 1993, stemming from the spread of new oil production technology and the subsequent increase in the production of North Sea crude oil, there has been a notable increase in the supply of local crude oil in Europe and the former Soviet Union. The

Fig.1-2 Crude oil import patterns of the three oil consumption regions



(Source) Prepared by IEEJ based on the data in Blackwell Energy Research's 'World Oil Trade' and MITI 'Year book of production, supply and demand of Petroleum, coal and coke'.

rise in imported African crude oil has been reciprocally moderate and the volume of imported crude oil from the Middle East has been greater than African crude. However, the marked increase in imported local crude oil comprised half of the total imported crude volume in 1997. As a result, the ratio of Europe's dependence on imported Middle East crude oil declined slightly from 32 percent in 1988 to 28 percent in 1997.

In contrast, Asia's crude oil import volume rose rapidly and doubled from 5.77 million barrels/day in 1988 to 11.53 million barrels in 1997. Of this figure, the dependence ratio on imported Middle East crude oil increased from 68 percent in 1988 to 75 percent in 1997. Regional crude oil production was minuscule and the ratio of local crude oil dropped from 26 percent in 1998 to 16 percent in 1997. One notable characteristic was the rise in imported crude oil from Africa, which rose from 2 percent in 1988 to 7 percent in 1997, in addition to the increased dependence on imported crude oil from the Middle East.

The rise in the volume of imported crude oil in Japan has been relatively moderate in comparison to the developing countries in Asia, but its dependence ratio on Middle East crude oil rose rapidly from 68 percent in 1988 to 82 percent in 1997. An increase in the imported volume of African crude oil has been nil in Japan and despite a summary period of increased crude oil imported from Mexico, the volume from Latin America has since declined.

There has been a tremendous rise in the volume of imported crude oil among the three countries of Korea, Taiwan, and China. However, the dependence ratio on Middle East crude oil dropped slightly from 70 percent in 1988 to 66 percent in 1997. This is due to the rapid rise in the share of African crude oil in contrast to the unchanging ratio of Asian oil. In Korea and Taiwan, the demand for African crude, with relatively low sulfur content, has grown due to strict restrictions on the sulfur content of petroleum products such as gas oil and residual oil stemming from environmental concerns. In China, the government has imported crude oil similar in grade to its domestic crude oil from around the globe, due to the limitations of its refineries.

The volume of imported crude oil in other areas of Asia has also greatly increased and the dependence ratio on Middle East crude oil grew from 68 percent in 1988 to 75 percent in 1997. The region imported 32 percent of sweet local crude oil easy-to-refine in 1988, but this volume dropped to 16 percent in 1997. The volume of imported crude oil from Africa was not that large in this region, in comparison to Korea, Taiwan, and China, but the import volume of sweet crude oil easily refined has grown due to the low ratio of well-equipped refineries. In 1997, African crude oil comprised 8 percent of the total volume of imported crude oil.

1.3 Burgeoning oil movement from west to east of the Suez Canal

Based on the above, the west of the Suez Canal centering the United States and Europe takes a long position having a surplus supply potential with regard to petroleum supply and demand, while the east of the Suez Canal centering Asia with a rapidly growing petroleum demand stemming from high economic

growth, has a tight short position with regard to supply and demand. Presently, there is a global surplus in the supply of petroleum due to the Asian currency and economic crises, which began in the summer of 1997. But when the Asian economy achieves medium to long-term recovery, the regions west and east of the Suez Canal are expected to return to the long and short positions, respectively.

In order to cope with the supply and demand of petroleum with regard to these positions, the residual suppliers in the Middle East, i.e., UAE, Qatar, Oman, and Yemen, ship their entire export volume to Asia. The last global suppliers, Saudi Arabia, Iran, Kuwait, and Iraq, ship about 50 percent of their export volume to Asia. Likewise, West Africa, which has hitherto focused on exporting its crude oil to the United States, has begun to ship their crude oil to Asia due to the demand in quantity as well as quality, and the perception of crude oil surplus in Europe and the United States. This is the historical background on crude oil movement in the 1990s, which will assist in analyzing petroleum price disparities between Asia and Europe and the United States, as introduced below.

2. Oil prices in Western Europe and Asia and price differential

2.1 Crude oil pricing linked to the market

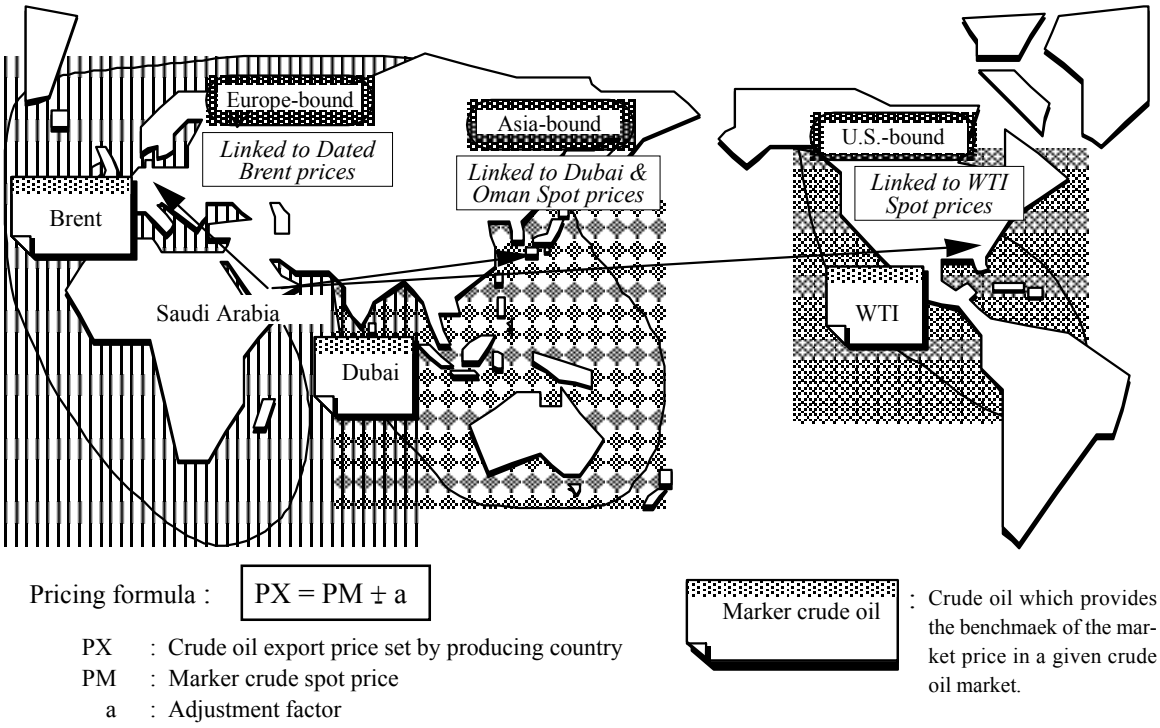
International transactions of crude oil and petroleum products entered the age of the market with the sudden drop in oil prices, due to the start of netback sales by Saudi Arabia in 1986. Although OPEC established a fixed pricing system of USD 18.00 per barrel at the end of 1986, the transitions in the oil market were continuously weak, due to a surplus production capacity exceeding 10 million barrels per day. In the fall of 1987, the formula method, which is based on spot benchmark crude oil prices, was applied to the long-term contract prices and therefore oil pricing became linked to the market.

As shown in **Fig. 2-1**, the three largest oil consumption regions, the United States, Western Europe, and Asia, select the benchmark crude oil price that is representative of the regional market, when crude oil prices are set using the formula method. In order to cope with spot price changes in benchmark crude, the oil-producing countries will add or subtract the adjustment factor according to the type of crude oil. The long-term contract price of the oil-producing countries is then established. Crude oil produced by West Texas Intermediate (WTI), which is representative of domestic crude oil in the United States, is the benchmark crude for this country, whereas the North Sea Brent is the representative local and benchmark crude for Europe. Since Asia did not have suitable local crude oil to serve as the benchmark crude for the region, Dubai crude oil was selected because of its comparatively active spot transactions.

Despite the Gulf crisis caused by Iraq's invasion of Kuwait in 1990 (which resulted in a drastic drop in oil supply, equivalent in scope to the first and second oil crises), the practice of market-linked oil prices has survived. The spot prices of Dubai oil have ranged between USD 15.00 to 20.00 per barrel for more than ten years, despite intensive daily price changes.

As mentioned earlier, there has been a surplus production capacity exceeding 10 million barrels a day

Fig.2-1 World's Marker Crudes and Arabian Light Pricing Formulas by Destination



(Source) 'Crude oil pricing in Asia and its future Issues' IEEJ's Energy in Japan No. 142, Novenber 1996

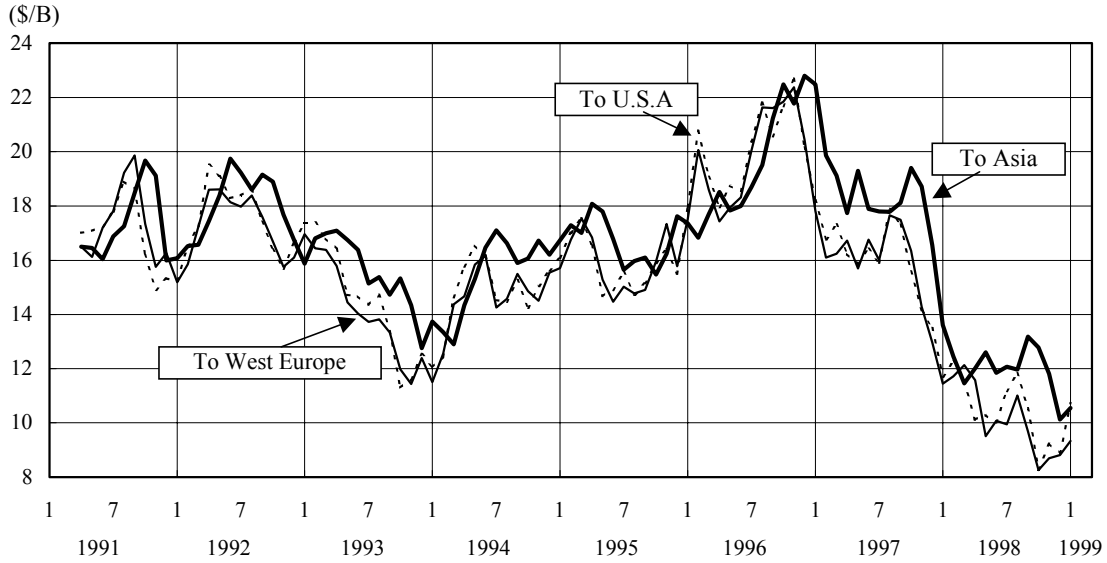
since 1986 and crude oil prices have moved weakly, falling below USD 10.00/barrel several times. In 1996, the oil inventory of Western petroleum companies dropping to low levels coincided with a mismatch in seasonal fluctuations in oil demand, and oil prices skyrocketed, surpassing USD 20.00/barrel.

Although OPEC no longer controls crude oil prices as it has in the past, it has been able to keep oil prices within the range of USD 15.00 to 20.00 a barrel for the past ten years through a combination of production adjustments based on a system of market-linked prices and a fixed production framework. What has controlled the daily oil price changes was spot crude oil prices that represented the consumption regions, namely WTI which was listed on NYMEX, and the North Sea Brent having active forward trading, listed on London's IPE.

2.2 Middle East Crude price changes and price disparities of oil exported to Asia, the United States and Europe

Formula price changes according to destination and the price differential between the markets for Saudi Arabia's long-term contract crude oil will be explained. The transitions in the formula price of Saudi Arabia's most representative crude oil, Arabian Light crude, exported to Western Europe, the United States, and Asia from 1991 to the present are shown in **Fig. 2-2**. The formula price was calculated to be the same at the shipping site, Ras Tanura, in Saudi Arabia based on the benchmark crude oil price and the adjustment factor, in accordance with the rules for confirmed base formula prices according to destination. The daily fixed base price at the shipping site was calculated and the monthly average was used.

Fig.2-2 Changes in Formula Price of Arbian Light Crude Oil (Monthly Average)
(Common Time Point Lifting at Ras Tanura, Finally Determined FOB Base)



(Source) Prepared by IEEJ based on the data in 'Platt's Oilgram Price Report'.

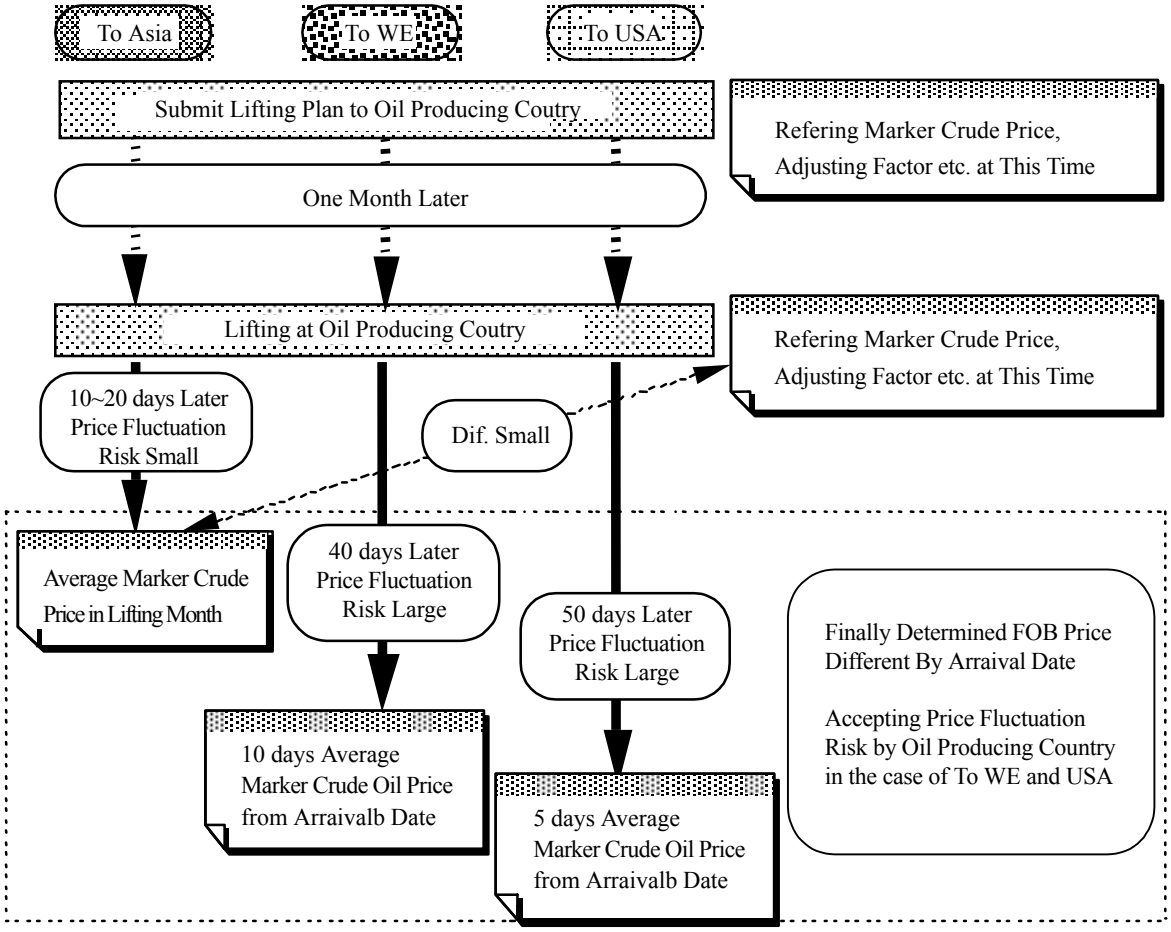
In reviewing the transitions in formula prices in **Fig. 2-2**, a clear time discrepancy between the formula price for Asia and the United States or Western Europe can be seen, as attested to by the fixed base. This time discrepancy does not exist in the formula price for the United States and Western Europe. One of the major reasons for the lack of a time discrepancy is that the benchmark oil price for Asia is fixed according to the monthly average of the shipment month, whereas the benchmark oil price for Western Europe is set at 40 days after the shipment date and 50 days after the shipment date for the United States.

The point-of-reference for the benchmark crude oil price appears to greatly effect the discrepancy, but if a comparison is made in terms of the shipping site, a large differential is observed between the formula price of Arabian Light crude oil earmarked for Asia and the formula price of Arabian Light crude oil slated for Western Europe or the United States. The formula price for Asia fluctuates at the higher end in comparison to the formula price for Europe and the United States.

2.3 Timing of market price reference

Fig. 2-3 chronologically shows the crude oil supply chain from the time the monthly oil shipment plan is submitted, the crude oil leaves the shipping site of the oil producer, to the time it arrives at the consumption site. Crude oil pricing, based on the most recent information on price differentials and the benchmark crude oil price of each destination, is carried out when the shipment plan is submitted. It can also be carried out, based on the latest information on differentials and benchmark prices, when the crude oil leaves the shipping site of the producer. However, it will differ according to destination by the time the crude oil arrives at the consumption site. As shown in **Fig. 2-3**, in the case of Europe and the United States, the crude oil shipment price, as the confirmed base, must refer back to the time of shipment, using the benchmark oil price at the time of arrival as a point-of-reference. In the case of oil shipped to Asia, the

Fig.2-3 Supply Chain of Crude Oil by Destinination and Timimg of Price Refer



(Source) Prepared by IEEJ based on various imformation.

price is based on the median benchmark price of the month the crude oil is shipped; and it is assumed that the benchmark crude oil price at the time of shipment will not greatly change.

For Europe and the United States, it takes 40 to 50 days for the crude oil to arrive at the consumption site; and it is highly possible for large differences in the crude oil price to occur during this period. Under these circumstances, there is a large risk of price fluctuation, but such price fluctuations are combined with the shipment price at the shipping site. Hence in actuality, the risk of price fluctuations is borne by the oil-producing country. An analysis of market differences at the time the crude oil is shipped from the producer's site will be carried out. However, in the case of Europe and the United States, the price fluctuations which have occurred during the period of shipment to arrival (point-of-reference price differential) will be reviewed separately.

2.4 Factors affecting crude price differential between Asia, Europe and the United States

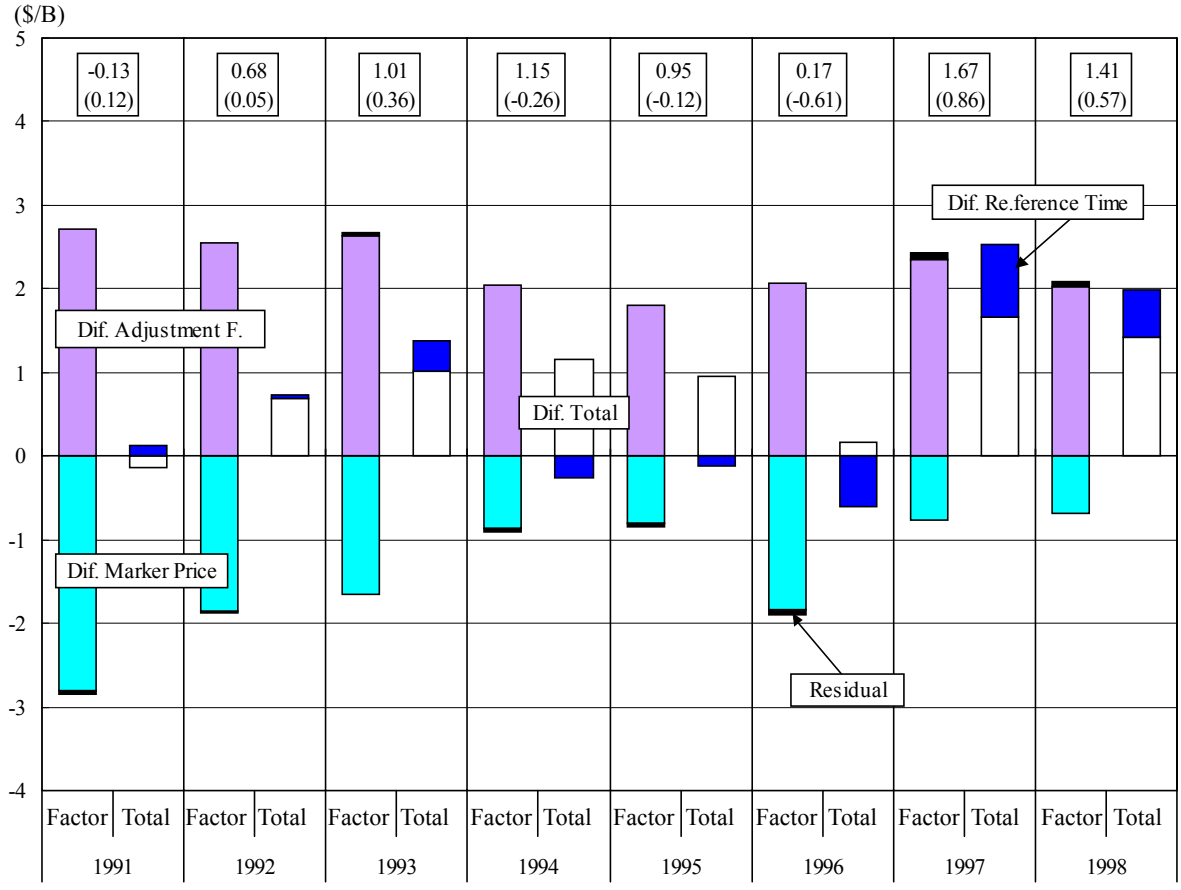
The transitions in the crude price differential between Asia and Western Europe from 1991 to the beginning of 1999, the degree of price differential that has developed, and the primary factors responsible

for the price differential were analyzed. **Fig. 2-4** shows an analysis of the primary factors that have determined the formula price at the shipping site of Arabian Light crude, the most representative grade of Saudi Arabian crude oils.

In a comparison of the formula prices shown in **Fig. 2.4**, there was a price differential of USD 1.00/ barrel for crude oil shipped to Asia and Western Europe from 1992 to 1995. The price differential rose to USD 1.50/barrel in 1997 to 1998; and the formula price was higher for Asia than for Western Europe. The different types of crude oil that were shipped did not affect formula price differential. Furthermore, in a review of the shipping price, where the time of arrival at the consumption site has been considered, there was a difference in the benchmark crude price between the time of shipment to the time of arrival in the formula price for Western Europe. Hence the unilateral rise or decline in crude price, as well as the price differential stemming from different points-of-reference, contribute to the price differential between Asia and Western Europe.

When the formula prices are compared at the shipping site, the differential in price between Asia and

Fig.2-4 Factors affecting Market Differential in Formula Price of Arabian Light Crude Oil (Asia vs Western Europe)



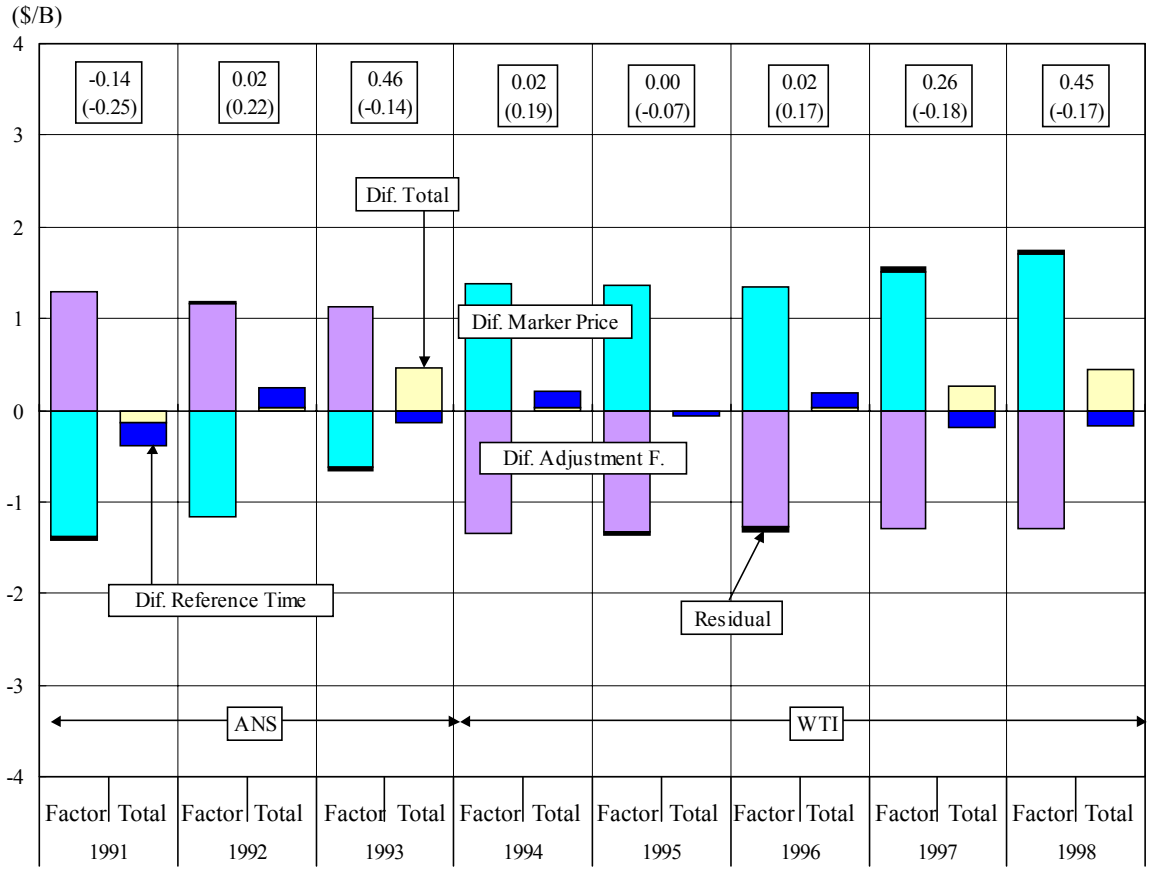
(Note) Upper figure in the above box is the total price diffrence, and lower figure is the price diffrence caused by the timing of reference.

(Source) Prepared by IEEJ from this survey results.

Western Europe becomes larger or even smaller. This is because the formula price for the United States or Western Europe is decided by the spot benchmark price at the time the crude oil arrives at its destination, due to the competitive oil prices there. Therefore, a price differential occurs due to the difference in point-of-reference, i.e., the time of arrival at the consumption site and the time of shipment at the shipping site. These price differentials fluctuate steeply on a daily basis and the expected value is zero unless definite projections can be made. The risks inherent in price fluctuations are borne by the producer, in view of the competition in the consumption region. In conclusion, although price differentials exist, the issues, which will be discussed further, completely differ in content.

The foremost primary factor for the higher formula price for Asian countries, as opposed to crude exported to Western Europe, is the rapidly diminishing gap between the spot price of Brent, which is the benchmark crude for Western Europe, and Dubai crude, which is the benchmark crude for Asia; and the inability of adjustment factors instituted by the oil producers to change this situation, as shown in **Fig. 2-4**. The formula price for the United States and Western Europe is clearly offset by the price differential in the benchmark spot oil price and in the adjustment factor, as shown in **Fig. 2-5**.

Fig.2-5 Factors affecting Market Differential in Formula Price of Arabian Light Crude Oil (USA vs West Europe)



(Note) Upper figure in the above box is the total price diffrence, and lower figure is the price diffrence caused by the timing of reference.

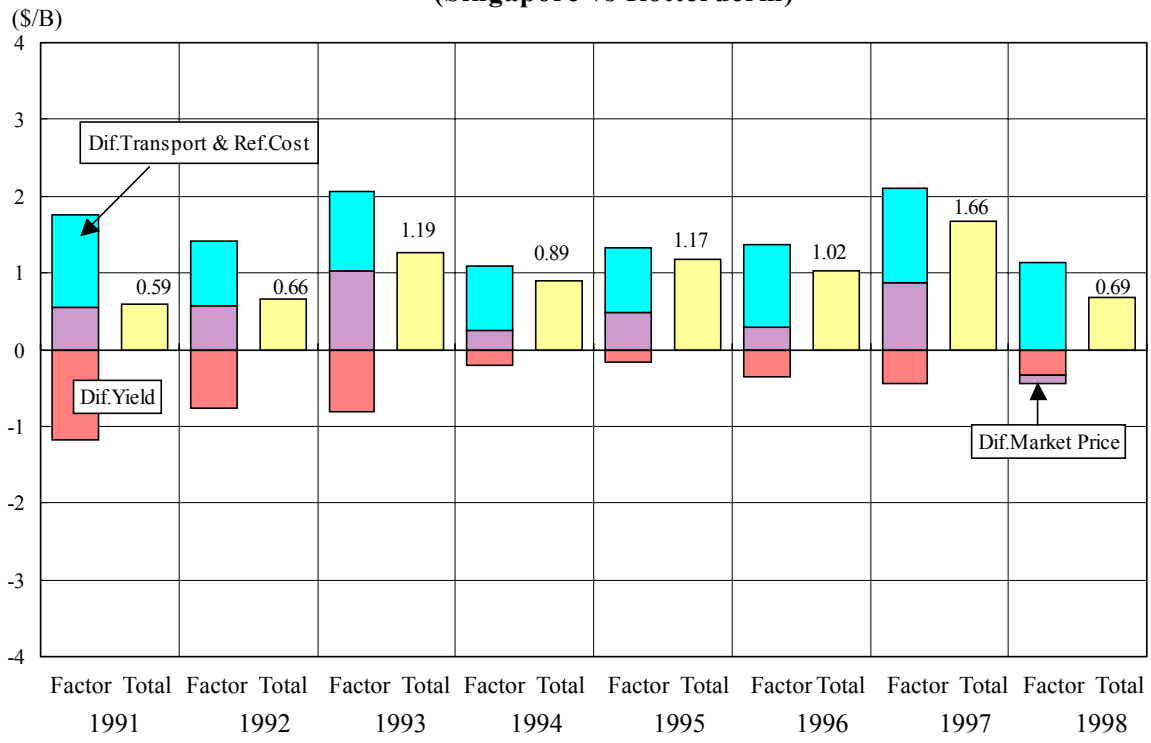
(Source) Prepared by IEEJ from this survey results.

2.5 Primary factors affecting crude oil price levels from the standpoint of product market conditions

A comparison of the netback values of Arabian Light crude in the Singapore and the Rotterdam markets is given in **Fig. 2-6**. There has been a value differential of USD 0.6 to USD 1.2 per barrel from 1991 to the present between the two markets, but the value in the Singapore market is higher. The netback value is an assessment of the crude oil value based on the spot prices of major petroleum products such as gasoline, jet fuel, kerosene, gas oil, residual oil, etc. When the spot price for petroleum products in the Singapore and Rotterdam markets was compared, it was USD 1.00/barrel higher in the Singapore market from 1992 to 1995, and 1996 (1997 depending on the product). However, although the period may slightly differ depending on the petroleum product, the price differential in both markets has narrowed in recent years and has disappeared when compared to the past.

As explained earlier, the difference in the netback value of Arabian Light crude between the Singapore and Rotterdam markets was higher for the Singapore market by USD 60 cents to USD 1.20/barrel. In analyzing the primary factors in the differential of netback value, the first factor component caused by yield difference was largely offset by the second factor component caused by oil product price difference between both markets. The foremost cause underlying the difference in netback value, as shown in **Fig. 2-6**, is the difference in transport costs from the Middle East gulf to the Singapore market and to the Rotterdam market via the Cape of Good Hope. The underlying cause of the difference in the netback value of the oil price between the Singapore and Rotterdam markets was the same for Dubai crude as well as for Arabian Light crude.

Fig.2-6 Factors affecting Netback Value of Arabian Light Crude Oil (Singapore vs Rotterderm)



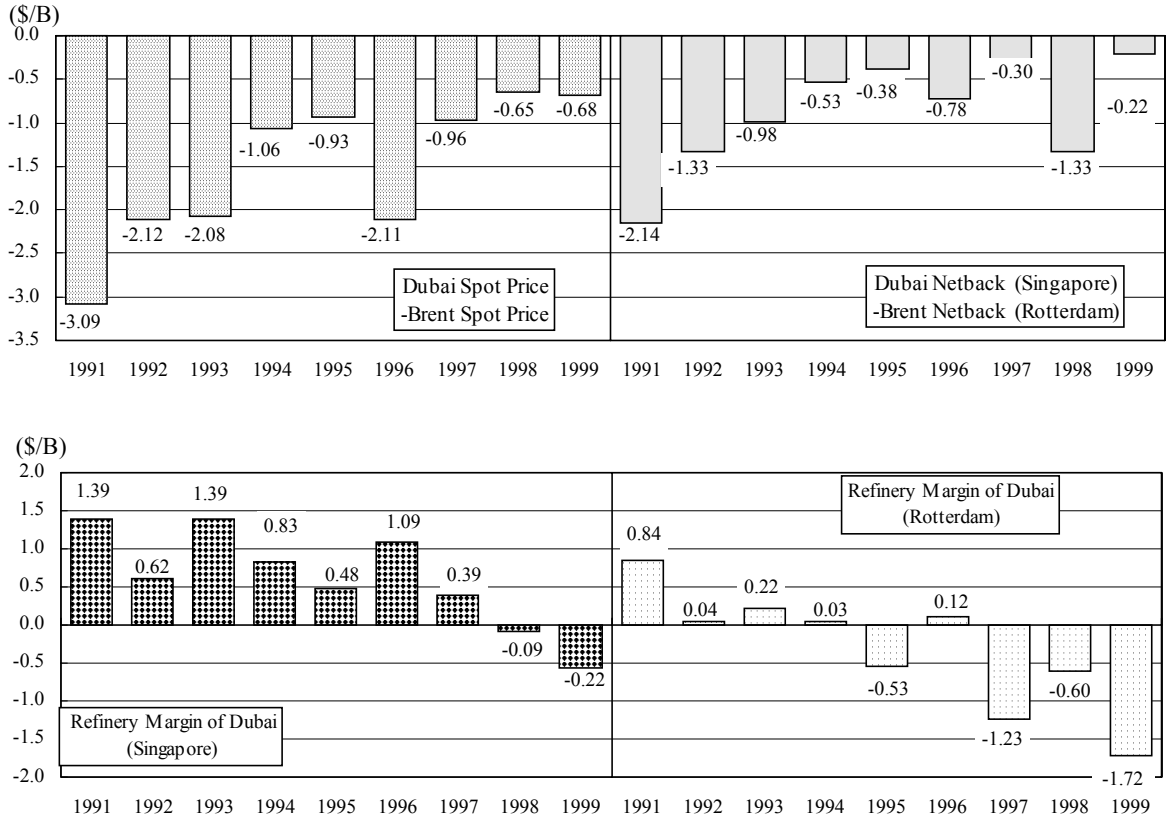
(Source) Prepared by IEEJ from this survey results.

2.6 Summarizing the primary cause of higher prices of eastbound Middle East crude

The rapid narrowing of the price differential between the spot prices of Brent and Dubai crude, the benchmark crude for Western Europe and Asia, respectively, is believed to be the major factor that has produced the differential of formula prices of Arabian Light exported to Asia and Western Europe. The spot prices of both crude oils, the difference in netback value, and the changes in the refining margin of Dubai crude oil in the Singapore and Rotterdam markets are shown in **Fig. 2-7**. The spot price differential of both crude oils was large, at USD 2.00 to 3.00 per barrel until 1993, due to the low price level of Dubai crude. But from 1994, the price differential rapidly narrowed to USD 1.00 to 1.50 per barrel; and there was a reversal in price in 1998, a clear indication of abnormal conditions in crude oil quality.

The spot transactions of Dubai crude, which is small in production scope, are limited to the Asian market in order to cope with the growing petroleum demand of the region. Therefore, a major component to determining the price level of Dubai crude is the netback value that remains after the transport cost, etc. to the market is subtracted and assessed by spot price conditions on the Singapore market, which represents Asia. As seen in the case of Arabian Light crude (**Fig. 2-7**), transport costs are also a major factor and the Singapore market has assessed a higher price differential of USD 1.00 per barrel over the Rotterdam market for Dubai crude. This means that Dubai crude can also be sold at a higher price differential of

Fig.2-7 Changes inPrice Differential between Dubai and Brent Appeared in Spot Price and Netback Value, and Refinery Margin of Dubai Crude in Singapore and Rotterdam



(Source) Prepared by IEEJ from this survey results.

USD 1.00 per barrel if the destination is restricted to Asia. This is believed to be the major cause for the oil price differential between Brent and Dubai, which narrowed to USD 1.00 per barrel from 1994. If the spot transactions of Dubai crude were large and conducted in the United States and Western Europe, this price differential would not develop since arbitration would occur between the three markets.

However, the price differential between Dubai and Brent narrowed even further in 1997 to 1998; and a reversal in the price differential was seen occasionally, although the reasons for this reversal are as yet unclear. According to on-site interview survey findings, the production volume of Dubai crude has dropped (presently, 210,000 barrels/day) and the scope of its transactions has continued to recede as well. As a result, the commonly held view is that Dubai crude is prone to price manipulation. However, there is no conclusive evidence that corroborates this view.

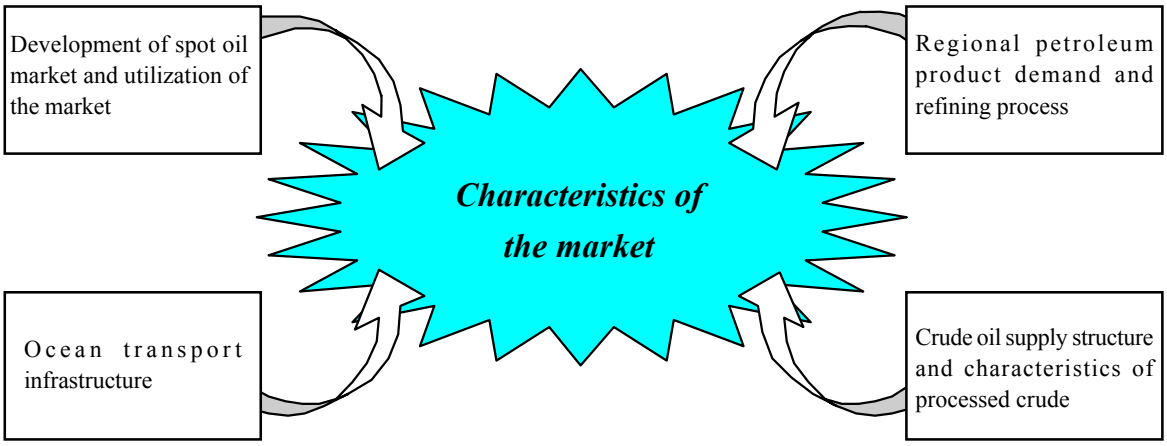
The price differential between the benchmark prices of Brent crude, exported to Western Europe, and Dubai crude is also incorporated into the formula price used in long-term contracts for Middle East crude oil. The oil-producing countries have not made adjustments to offset the changes in the quality and transport cost differences by the adjustment factor. As a result, a price differential of USD 1.00/barrel, which initially occurred between the formula price for Asia and Western Europe, rose recently to USD 1.50/barrel, as exemplified by the price differential of Arabian Light crude.

The initial price differential of USD 1.00/barrel was unavoidable and produced by structural problems that existed as long as the pricing method utilized the benchmark price for Dubai crude. Recently, this price differential has fallen to USD 50 cents/barrel and Dubai crude spot prices that differ from price levels demanded by market conditions for petroleum products through netback pricing has developed. Whether this is due to price manipulation of Dubai crude on the spot market or whether Dubai crude is able to carry out reliable price formation, are issues that require further watching and analysis. In addition, a price differential due to the discrepancy in the point-of-reference for the benchmark crude price of Western Europe can also develop. But this is a means of coping with price fluctuation risks and it is completely different in nature from the former two problems.

3. Characteristics of the crude oil supply in Western Europe and Asian countries

The characteristics of the crude oil supply structure in Western Europe and Asia has been discussed in the last chapter in terms of the physical distribution of crude oil and petroleum prices. In this chapter, the differences in the market environment that greatly affect the crude oil supply structure for both regions will be examined. As shown in **Fig. 3-1**, the characteristics that surround the market environment in both regions have been defined into the following four categories: 1) oil demand structure and refining process, 2) crude oil supply structure and oil processing properties, and petroleum product standards, 3) development and application of the crude oil spot market, 4) characteristics and issues in the infrastructure of ocean. The characteristics of both regions in each of these four categories will be presented and the differences in their environment will be analyzed. In addition, the differences in the market environment in Western Europe and the Asian countries according to each of these four categories are shown in **Table 3-1**.

Fig.3-1 Factors affecting the market environment in Western Europe and Asia



3.1 Characteristics of petroleum product demand

There is a high demand ratio for gas oil used mainly for transport and a low demand for residual oil and kerosene in Western Europe. Since crude oil processing is carried out on the premise of a maximized production volume of gas oil, a high cracking capacity is required in the refining process. In contrast, there is a low desulfurization capacity due to the reduced need to strengthen the refining process, since processed crude oil is low in sulfur content.

Conversely, in the Far East, there is a high demand ratio for kerosene for heating purposes and residual oil for general industry use in comparison to Western Europe. Recently, there has been a trend toward demand for gasoline and distillates, but due to a low cracking capacity, it is anticipated that the import demand will continue to grow for North Sea and West African crude with a high yield of gasoline and distillates. Additionally, the major processed crude oil is mainly Middle East crude oil with high sulfur content and the desulfurization processing capacity is high.

3.2 Characteristics of the crude oil supply structure

Crude oil supply in Asia has a low level of flexibility in comparison to Western Europe. In Western Europe, the oil production volume in the region is high and product demand and the refining yield of crude oil are extremely similar due to the geographical features of the region. Additionally, the supply process itself is short because there are numerous oil-producing areas in the adjacent countries. As a result, the region is in a more flexible position to cope with changes in product supply and demand and rapid changes in oil price trends through revised production plans and inventory and stock adjustments.

In contrast, Asia, due to its remote geographical location from oil producing areas, is highly dependent on imported crude from the Middle East and is unable to cope flexibly in formulating production plans and adjusting oil stock levels. The efficiency of its supply activities is lower than in Western Europe. If imported oil increases from the North Sea and African regions with longer transport distances than the Middle East, flexibility in coping with oil supply issues will decline even further.

Table 3-1 Differences in the market environment in Western Europe and Asia that affect the crude oil supply structure for both regions

Item	Western Europe characteristics	Asia characteristics	Notes and issues when considering increasing imports of African crude
Regional petroleum product demand and refining process			
Regional product demand	High ratio of gas oil, low ratio of kerosene, residual oil	High ratio of kerosene High ratio of residual oil	Due to high gasoline and distillates yield of North Sea, West African crude oil, advantageous for coping with greater regional demand for these components
Production ratio	High ratio of gas oil	Declining ratio of residual oil	
Refining process capabilities	Cracking capacity: High Desulfurization capacity: Low	Cracking capacity: Low Desulfurization capacity: High	Due to high desulfurization capacity, no L/S merit by importing low sulfur crude oil
Crude oil supply structure and characteristics of processed crude			
Regional oil production	High regional production volume,	Regional consumption volume has peaked out	Crude oil supply process is short and flexible in Western Europe in comparison to Asia
Distance from other oil producing regions	Many proximate oil-producing sites	Dependent on import from distant areas	
Processing plan formulation	Flexible planning/changes	Early stage formulation needed	Low flexibility of supply process due to high import volume from Middle East and long distance ocean transport Even less flexibility if import of African oil increases due to long distance ocean transport
Term/spot ratio	High spot ratio	High term ratio	
Crude oil stock level	Volatile fluctuation (response to oil price trends)	Low fluctuation (awareness of guaranteed safety high)	
Characteristics of processed crude oil	Maximized regional oil processing Other crude oils centered on low sulfur content	Processed Middle East crude oil is norm High demand for crude oil with low sulfur content	Restricted processing volume due to restriction in distillate ratio and product standards
Development of spot oil market and Utilization of the market			
Reliability of benchmark oil prices	Meet conditions as benchmark oil	Increased doubt about reliability	Hedge activities are needed to standardize purchase price to purchase Brent crude oil which has different price calculation standards
Creating a futures market	Extremely large market formation	Undeveloped futures market	
Market characteristics	Hedge activities flourish due to use of market	Focus on hedge activities in swap market	
Need to utilize the market	Hedge activities in the market become vital due to the advent of a liberalized market		
Ocean transport infrastructure			
Transport route	Decentralization progresses	Nearly 80% from Middle East	Transport route between West Africa and the Far East is not common, but tanker owners are willing to transport cargo
Type of shipping vessel	Differs according to transport route	Mainly VLCC	
Direction of chartered ship	Use of depreciated shipping vessels	Japan/Korea: Strong preference for modernized tankers Others: Cost-oriented	Transport routes differ according to the policy of tanker owner, New tankers transport to the Far East
Restricted vessel type	Use of large ships (ULCC)	Effective maximum intake is 260,000 tons Straits of Malacca passage issues	Restricted use of large tankers due to restrictions of Malacca Straits and domestic port facilities

(Source) Prepared by IEEJ from overseas survey results and other information.

Full-scale, large volume import of African crude oil to Japan is anticipated to be difficult due to physical restrictions on processing because of issues such as kerosene smoke and the cetane number of gas oil that are related to product quality standards but that cannot be inferred from the distillate yield.

3.3 Development of Spot Crude Oil Market

A large discrepancy has developed between the markets of the two regions. In Western Europe, both the spot and futures markets, where Brent crude oil is an maker, are adequately developed and the oil industry effectively uses both markets to actively fix the margin. In contrast, the futures market in Asia is extremely young; and trading is relatively polarized which has resulted in very low-key activity on the market. However, if the domestic market moves toward liberalization due to deregulation, a spot market with a fixed refining margin becomes essential. Hence there is a high possibility that the domestic petroleum market will improve in stages.

The demand for increased hedge price activities will rise using the spot crude oil or swap markets when the purchase price of West African crude oil is equalized to expand its import.

3.4 Characteristics of Ocean Transport Infrastructure

Although the type of oil tankers that are used to transport crude oil to Western Europe and Asia differs, this factor does not appear to be a disadvantage. Presently, there is an excess number of tankers; and stringency measures that will impede transport activities and the balance in the supply and demand of VLCC headed for Asia are not anticipated. As depreciated tankers are retired and the excess number of vessels declines slightly, it is expected that domestic oil companies with their more modern tankers will not be greatly affected.

An increased import volume of oil to the Far East from West Africa would signify an increased number of VLCC utilizing the shipping route between these two regions. In many cases, tanker owners do not adhere to specific shipping routes and are flexible in selecting routes according to the balance in the supply and demand of a transport route and the expected value of profit to be made. Hence the likelihood of skyrocketing transport costs due to cutbacks in the number of tankers is low.

As for restrictions in domestic port facilities, almost of main refineries are able to accommodate at maximum, tankers of 260,000 DWT and can not accommodate larger tankers of more than 300,000 DWT. This restriction is also related to the capacity of the Straits of Malacca, which is a major shipping route to the Far East; and therefore, it is difficult to improve the current situation.

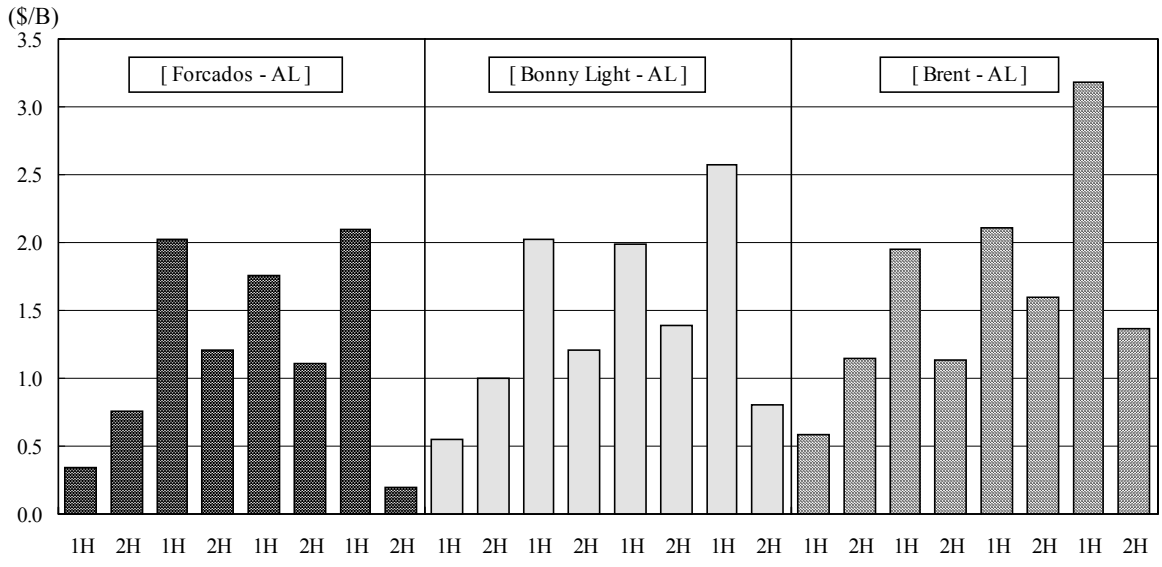
4. Western Europe and Asia's Assessment of West African and North Sea Crude Oil and the Impact of Increased Environmental Controls

4.1 Price Differential in C&F Prices in the East Asian Market

Firstly, the price differential in the C&F (arrival) price of crude oil at the consumption site for potentially competitive substitute oil for Middle East crude oil in Asia was analyzed. Arabian Light (medium crude; API 32.7, sulfur content 1.80%) which has hitherto been examined in terms of price differential from various perspectives, was selected as the representative crude oil of the region for the analysis. Bonny Light (light crude; API 35.4, sulfur content 0.14%) and Forcados (medium crude; API 28.5, sulfur content 0.19%), West African crude oil from Nigeria and Brent crude oil from Great Britain (light crude; API 38.3, sulfur content 0.37%), a North Sea crude oil, were selected from the long-position petroleum market, west of the Suez Canal as substitute crude oils in the price differential analysis.

The C&F price of these crude oils, arriving simultaneously at the consumption site was calculated. In studying the transitions in the price differential for the first and second six-month periods, as shown in **Fig. 4-1**, a price differential of under USD 1.00 per barrel occurred periodically between Arabian Light crude and the medium light crude oil of Forcados, dropping to an extreme average price differential of around USD 20 cents per barrel for six months. Conversely, this price differential also rose to USD 1.50 to 2.00 per barrel. In the case of Bonny Light and Forcados, the price differential has ranged at a high level of USD 20 to 30 cents per barrel. This is due to the difference of the pricing adjustment factors set by the oil-producing country.

Fig.4-1 Arrival Price Diferential Between West Africa / North Sea and Middle East Crude (Half Year Average)



(Source) Prepared by IEEJ from this survey results.

In the case of Brent crude oil, the price differential narrowed to USD 50 cents/barrel, but generally it has ranged at USD 1.00 to 2.00/barrel. It rose to a maximum of USD 3.00/barrel during the first six-month period of 1998. The difference in the shipping costs from Great Britain to Nigeria is reflected in the high price differential for North Sea crude oil.

If the destination price differential of West Africa and North Sea crude narrows to USD 50 cents/barrel against Middle East crude oil, due to the differences in crude quality such as the sulfur content or the distillate ratio of medium crude, the economic considerations of importing West African and North Sea crude oil will unconditionally occur. If a large price differential of higher than USD 50 cents/barrel occurs, the economic considerations of handling West African or North Sea crude will differ according to the petroleum product demand of the consumption site, refining facilities, quality restrictions, etc.; and the following explanation is given.

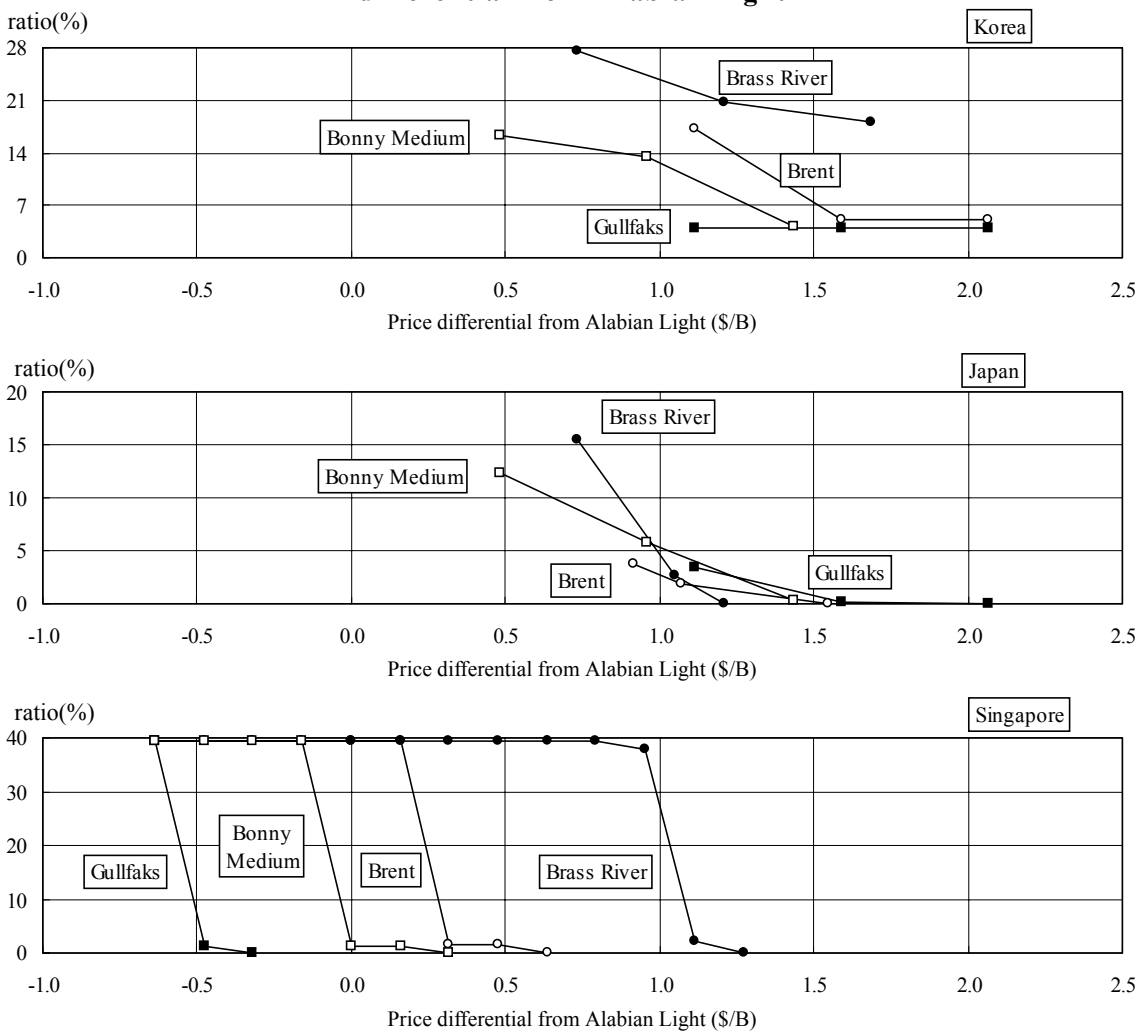
4.2 Selection of African and North Sea crude oil

African and North Sea crude oil, as an optional substitute for Middle East crude oil, was analyzed in terms of the degree to which they are assessed in Western Europe and Asia in comparison to Arabian Light crude oil, using a simulated petroleum-refining model. The African crude oil of Brass River (light crude; API 41.5, sulfur content 0.09%) and Bonny Medium (medium crude; API 26.5, sulfur content 0.22%), and the North Sea crude oil of Brent (light crude; API 38.3, sulfur content 0.37%) and Gullfaks (medium crude; API 29.9, sulfur content 0.41%) were selected as the substitute crude oil. Based on the transitions in the price differential of crude oil for 1995 (generally at a standstill), 1996 (rising trend), and 1997 (declining trend), a comparison of the changes in the price differential between Arabian Light and the substitute oil companies was examined.

The preference for African or North Sea crude oil, in lieu of Middle East crude, was reviewed against factors such as petroleum product demand, the availability of refining facilities, quality restrictions of petroleum products, etc. of Japan, Korea and Singapore, which differ. The degree to which the preference for Middle East and African crude oil affected the changes in the price differential of Brent crude oil was studied with regard to the petroleum demand, refining facilities, and quality restrictions of North and Western Europe using the Rotterdam market. In addition, the degree to which the preference for African and North Sea crude oil is affected by changes in petroleum product quality, due to increased environmental controls in 2002 was also analyzed.

The price differential between the substitute crude oil companies and Arabian Light was changed using the destination price at the consumption site in Japan, Korea, and Singapore and the shift from Arabian Light crude oil to African or North Sea crude oil was analyzed using the simulated petroleum refining model explained above. The findings are shown in **Fig. 4-2**. What is immediately observed from this data, is that despite the price differential in the destination price of about USD 2.00/barrel between the substitute crude oil and Arabian Light crude, Korea has continued to purchase African or North Sea crude oil. This is due to Korea's increased restrictions on the sulfur content of gas oil and residual oil in its

Fig.4-2 Preference for African and North Sea crude oils caused by the price differential from Arabian Light



(Source) Prepared by IEEJ from this survey results.

attempt to address environmental issues such as air pollution. African and North Sea crude oil, which is low in sulfur content, is preferred due to a shortage of desulfurization facilities in Korea. The shortage of cracking facilities has also contributed to this preference.

Although the shift to African or North Sea crude oil has been minimal in the case of Japan, there has been a gradual move toward African and North Sea crude oil, in conjunction with the narrowing price differential between Arabian Light crude oil and the substitute crude oil to USD 1.00/barrel in the destination price. If the price differential were to drop even further to about USD 50 cents/barrel, there will be a notable shift to African crude oil. However, the ratio of desulfurization and cracking facilities is high in Japan, which is a major difference between the two countries, and unless the price differential between Middle East and African crude narrows considerably, the shift to African crude by Japan will not occur easily. This is especially true in the case of North Sea crude oil, where higher shipping costs are generated.

Singapore is even less likely than Japan to shift to African or North Sea crude oil unless there is a

reduced price differential in the destination price. When the price differential between Brass River and Arabian Light dropped to USD 1.00/barrel in 1997, there was a dynamic shift to African and North Sea crude oil by Singapore. Additionally, there was also a shift when the price differential of Brent crude oil fell to USD 20 to 30 cents/barrel. Similarly, unless the price differential of Bonny Medium and Gullfaks, which are crude oils with slightly heavier properties, narrows considerably against Arabian Light, a shift to these crude oils will not occur. The demand for African or North Sea crude oil in Singapore is not high, in terms of product demand patterns, required quality, and ratio of cracking facilities. Among the substitute crude oils, there is a preference for Brass River, which is a lighter and sweeter crude that is relatively close to refinery.

The findings given in **Fig. 4-2** show an economic advantage to switching to African or North Sea crude oil when the price differential between Arabian Light falls below USD 1.00/barrel. When the price differential ranges between USD 1.00 to 2.00/barrel, it is advantageous for Korea to shift to African or North Sea crude oil due to its shortage of secondary facilities (desulfurization, cracking facilities), but it is not an incentive for Japan and Singapore.

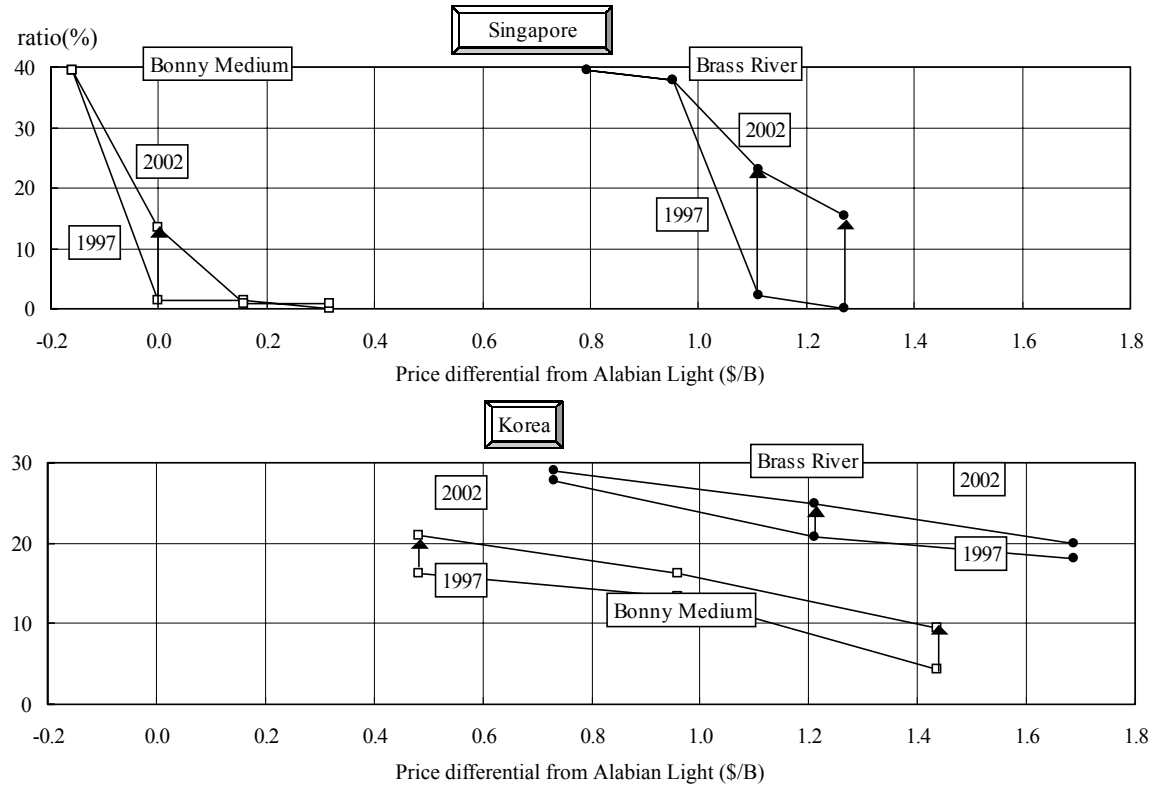
4.3 Changes in preferred crude oil due to increased environmental controls

A shift in preference to African and North Sea crude oil, due to increased environmental controls that are expected to be implemented by 2002, was simulated using the petroleum refining model. A major change did not occur in the case of Japan. Therefore, the switch to African crude oil by Korea and Singapore with the onset of increased environmental controls was analyzed and the findings are shown in **Fig. 4-3**.

In the case of Singapore, if the sulfur content of gas oil is subject to strengthened environmental controls, a large shift in volume from Arabian Light to Brass River crude oil will occur at a price differential of USD 1.30/barrel. The switch to Bonny Medium crude oil will not occur unless there is a relatively large reduction in the price differential between Arabian Light and this crude, but a similar phenomenon will occur. For Korea, the shift to a substitute crude oil will not be as drastic in volume as Singapore. However, with increased environmental controls, the preference for African crude oil will rise. Therefore, strengthened environmental control is a major key factor to increasing the supply of African and North Sea crude oil to Asia.

The petroleum refining model was also used to analyze the petroleum demand in North and Western Europe; and it was concluded that West African oil will be unable to compete with the local North Sea crude oil as long as the surplus supply continues and the current level of price differential exists. Middle East crude oil also faces severe competition from North Sea crude oil, despite having adopted various formula prices to compete with destination prices. In particular, if stringent environmental restrictions are adopted as countermeasures against air pollution and global warming in 2000 and 2005, Middle East sour crude oil, high in sulfur content, will face even stiffer competition. In this respect, North Sea, North Africa, and West Africa crude oil, which is low in sulfur content, will gain a strong advantage over

Fig.4-3 Shift in preference to African crude oils by Korea and Singapore with the onset of increased environmental controls



(Source) Prepared by IEEJ from this survey results.

Middle East crude.

5. Future issues for review

As explained earlier, a price differential of about USD 1.00/barrel occurred in the formula price of Middle East crude oil exported to Asia and Western Europe since the 1990s. Recently, this price differential has risen even further to USD 1.50/barrel. A price differential of USD 1.00/barrel is unavoidable due to inherent structural problems that exist when Dubai crude is used as the benchmark oil price for Asia. However, the price differential is clearly problematic in terms of international competition. The recent rise in the price differential to USD 1.50/barrel signifies that there is a problem in the spot pricing formation of Dubai crude, that does not necessarily reflect the netback value stemming from spot market conditions for petroleum products. In order to clarify these problems further and to examine specific countermeasures, the following three issues are discussed.

The first issue is to determine whether Dubai crude oil is appropriate as a benchmark crude for Asia. The production volume of Dubai crude oil has rapidly declined since the mid-90s and the number of spot cargoes departing every month has also decreased. If this situation continues, there is the possibility that changes in the benchmark crude similar to what occurred to Alaskan North Slope (ANS) will develop, which was unable to provide reliable pricing information due to a sudden drop in the shipment volume to the United States Gulf in 1993. In particular, spot prices of petroleum products have weakened recently

due to a decline in petroleum demand in Asia; and the netback value of Dubai crude oil has been assessed at a lower value in the Rotterdam market. Despite this fact, there was a reversal in the price differential of the spot price of Dubai and Brent crude oil.

In reviewing the various issues related to the benchmark crude oil price for Asia, the following points should be examined; 1) study the possibility of designating local crude oil as the benchmark crude for Asia, 2) designate a crude oil price index that reflects the supply and demand of petroleum in Asia, as the benchmark price, 3) select Middle East crude oil, which has global destinations, as the benchmark crude, 4) ascertain whether regional differences in petroleum demand will produce a distortion if the benchmark price of crude oil west of the Suez Canal such as Brent crude oil is utilized.

The second issue is that, as seen between 1997 and 1998, the spot price of Dubai crude has deviated from price levels that signify netback value and has been at high and abnormal levels. If Middle East oil-producing countries continue to utilize the spot price of Dubai crude as the formula price for term contracts, the selection of a substitute crude oil other than Middle East crude oil should be actively reviewed. West African and North Sea crude oil are realistic candidates as substitute crude oil. The half year average of price differential between Bonny Light, Forcados, and other West African crude oil stayed under USD 1.00/barrel between 1995 and 1998, sometimes dropping to around 50 cents/barrel. The half year average of price differential of North Sea crude oil also narrowed to USD 1.00/barrel.

The third issue is the lack of an international spot market for petroleum products that represent Japan, Korea, Taiwan, and the coastal area of China, East Asia's largest consumption region. As a result, the oil-producing countries have not accurately grasped the competitive conditions of the region. Although the Singapore market represents Asia's spot market for petroleum products, it is only a halfway point from the perspective of Asia's consumption region. The shipping cost from the Middle East gulf to Singapore has been deducted, but the transport cost from Singapore to East Asia has not been taken into account. Consequently, it is reflected in the price of Dubai crude oil, which has ranged at the high end of the spectrum. A spot market for petroleum products that reflect supply and demand should be created in East Asia that will allow the netback value to be reflected in the price of Middle East crude oil. The issue of creating a spot market for petroleum products needs to be addressed in future.

If a spot market for petroleum products is created and sufficiently matures, the next step is to create a futures market. A futures market would introduce arbitrated trading that would create a uniform system of price linkage among the three large consumption regions of Western Europe, the United States, and East Asia. Although the first priority is to create a spot market for petroleum products, the long-term goal is to establish a futures market that would lead to global price linkage.

As a consumption region equivalent in scope to Western Europe and the United States, the East Asian petroleum market must strengthen the bargaining power of Asia against the oil-producing countries by reviewing and implementing appropriate measures on the three issues delineated above.