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**The refining industry
in the arabian Gulf, Asia and Europe
Comparison et interdependance**

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SUMMARY

Although the volume of petroleum products moved between the major refining and consuming regions is much less than that of crude oil, these movements play a key role in the supply demand balance of the various products.

The Asia/Pacific region (South and South-East Asia and the Far East) is a significant importer whose dependence for oil products supplies on the Arabian/Iranian Gulf is growing.

This paper reviews the current position on products movements and the growth in products demand, and highlights the strong interdependence between the Asia/Pacific and Gulf regions in terms of refining.

RESUME

Les flux de produits pétroliers entre grandes zones de raffinage et de consommation, bien qu'inférieurs aux flux de pétrole brut jouent un rôle clé dans l'équilibre production-consommation des différents produits.

La zone Asie Pacifique (Asie du Sud, Asie du Sud-Est, Extrême-Orient) est une importante zone d'importation de produits qui dépend de manière croissante du Golfe Arabo Persique pour ses approvisionnements en produits pétroliers.

L'article analyse les échanges actuels, la croissance des besoins en produits et met en lumière la forte interdépendance entre l'Asie Pacifique et le Golfe dans le domaine du raffinage.

THE REFINING INDUSTRY IN THE ARABIAN GULF, ASIA AND EUROPE

COMPARISON AND INTERDEPENDENCE

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By converting crude oil into fuel the refining industry meets 40% of global energy requirements. The industry developed considerably in the 1960s and 1970s. For strategic and economic reasons refineries have generally been built in consumer regions within easy reach of markets. In the 1970s the oil producing countries nevertheless invested significantly in what are known as "source refineries" for export purposes. These exports have never accounted for a very large share of the consumption of industrialised countries but they play an important part in the world petroleum balance.

Although refining capacity has remained stable in the United States and Europe, it has developed rapidly east of Suez in the Arabian Gulf region and in Asia and the Pacific. The Asian countries are largely dependent on the Gulf for their crude oil supplies and also for their finished product requirements.

1 - REFINING WORLDWIDE

At the end of 1992 refining capacity (atmospheric distillation capacity) worldwide stood at 3.66 billion tons¹ per year. It peaked at 4.1 billion tons in 1980 before dropping to 3.61 in 1986 following the two oil crises. It subsequently increased slightly between 1987 and 1991.

Refining capacity reflects the demand for petroleum products. It was the strong increase in demand that caused the sharp rise in capacity up to 1980 - from 1950 to 1980 capacity doubled every ten years. It was the fall in petroleum product consumption following the rise in crude prices in the 1970s that led to refinery shutdowns and to reductions in distillation capacity.

In the early 1980s capacity was reduced chiefly in Europe (- 300 million tons/year) and in North America (- 130 million tons/year). It remained stable in other regions such as South America and Eastern Europe, or increased, particularly in the Middle East and in Asia.

Refining capacity is concentrated in North America (23% of world capacity), in Western Europe (20%), in Eastern Europe (18%) and in Asia (18% in Japan in particular, in China, Singapore, India and Korea). Capacity is growing fast in the latter region and 50% of ongoing construction is concentrated there. The strong economic growth of the newly industrialised countries, which are often lacking in energy resources, results in great demand for petroleum products. Substantial growth in capacity is also observed in the OPEC countries, particularly in the Middle East, where needs are stimulated by very low product prices. In addition, some countries, such as Iran, have to restore their capacity due to destruction of units during the recent armed conflict.

¹ 10⁹ metric tons

2 - CONVERSION

Atmospheric distillation capacity is no longer fully representative of the refining situation. In North America heavy fuel oil consumption has been low for several decades because fuel requirements are met primarily by coal and by gas. On the other hand motor gasoline demand is very high. The United States consumes 320 million tons/year of gasoline which is nearly 50% of world demand for this product. This figure represents 45% of total petroleum product consumption in the United States. Distillation of a crude oil yields a relatively small amount of gasoline and a large amount of residue of the heavy fuel oil type. Heavy products therefore have to be converted into light products by cracking processes and American refineries consequently tend to have high cracking and coking capacities. The total capacity of these units amounts to over 60% of atmospheric distillation capacity.

In other regions such as Europe, Asia and the Middle East (whose production is partly exported to other regions), demand for light products (motor fuels) continued to grow after 1980 whereas demand for heavy fuel oil, which faced competition from coal and gas, declined. To meet this need for a "lighter barrel", conversion facilities were built and the conversion ratio (ratio between conversion unit capacity and atmospheric distillation capacity) increased significantly, but has nevertheless not reached the level observed in the United States. It stands at 15 - 30% depending on the region.

3 - REFINING SITUATION BY REGION

The North American refining industry is the largest in both size and complexity. Atmospheric distillation capacity is 840 million tons/year. The United States possesses 184 refineries with a total capacity of 760 million tons/year (21% of world capacity). In addition to substantial conversion (i.e. catalytic cracking and coking) capacities, it also has high alkylation and isomerization capacities.

Western European distillation capacity is approximately 710 million tons/year. It was considerably reduced in the early 1980s (in 1979 it stood at over 1,000 million tons/year). A typical European refinery was relatively simple at the end of the 1970s but has become much more sophisticated in order to meet the lower demand for heavy fuel oil and then the increasing demand for unleaded gasoline.

The Asia-Pacific region extends from Pakistan to Japan and its refining capacity cannot keep pace with its growing demand for petroleum products. Its refining facilities are still relatively basic. It is clear that in the next few years its distillation capacity, which is still smaller than that of Europe (670 million tons/year), will increase but its conversion requirements will also grow rapidly.

The ex-Soviet refining industry counts 47 refineries for a capacity of around 500 million tons/year. The facilities are very often obsolete and conversion capacities are very low. Substantial capital investment is required to revamp it and to improve performance.

The other regions are less important in terms of capacity. However the Middle East which exports finished products to Asia and Europe, and South America which exports finished products to North America, play a key role in the world supply of petroleum products.

4 - REFINING BALANCE IN ASIA & THE PACIFIC

In the 17 countries in the region² distillation capacity now exceeds that of the European Community (670 million tons/year versus 620). Capacity is growing fast. Distillation capacity should exceed 800 million tons/year around 1996 and should have reached the 1000 million tons/year level by the turn of the century. The largest refining capacities are found in Japan (240 million tons/year), in China (110 million tons/year), in Korea and Singapore. The densest concentration of construction projects is found in Thailand, Malaysia, Indonesia and China.

Conversion capacities, although on the rise, are still lower than in the other two major refining regions - the USA and Europe. On average the conversion ratio is around 20% compared to 30% in Europe and over 60% in the United States.

The demand for petroleum products is increasing at an overall rate of 4 - 6% per year, whereas demand in the major industrialised countries is stable. This overall figure nevertheless masks some significant discrepancies since in some countries such as China, Korea, Malaysia, Thailand and the Philippines consumption is growing at a rate of around 10% per year.

TABLE 1

Petroleum products consumption in 10 far eastern countries
(thousand b/d)

| Country | 1992 | % change vs. 91 | % change 93 vs. 92* |
|--------------|---------------|-----------------|---------------------|
| Japan | 4,560 | +3.2 | +0.5 % - 1.5 % |
| China | 2,238 | +10.4 | +8 - 10 |
| South Korea | 1,394 | +21.9 | +10-12 |
| India | 1,152 | +4.0 | +4 - 5 |
| Indonesia | 682 | +7.7 | +6 -7 |
| Taiwan | 585 | +4.6 | +5 |
| Thailand | 460 | +8.2 | +6 - 7 |
| Philippines | 265 | +23.4 | +11 |
| Malaysia | 257 | +7.8 | +7 |
| Singapore | 199 | +0.2 | 0 |
| Total | 11,793 | +7.5 | +4.5 -5.7 |

* Forecast

² Australia, Bangladesh, Burma, Brunei, China, Korea, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan and Thailand

Out of a total consumption of 670 million tons/year in 1991, motor gasoline accounts for 20%, distillates for 35% and fuel oil for around 25%. The region therefore shows an overall deficit in products and, in view of the insufficient conversion capacity, the deficit in gasoline and distillates is particularly marked.

A finer analysis shows that:

- in southern Asia (Pakistan, India, Bangladesh, Sri Lanka) distillation and conversion capacities are insufficient,
- in China and the Far East distillation capacity is sufficient but cracking capacity is not high enough to meet the growing demand for gasoline and distillates,
- in South East Asia (Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand) distillation capacity is in line with overall demand but conversion capacity is inadequate.

TABLE 2

Asia/Pacific Region

**Petroleum product consumption in 1991
(million tons/year)**

| | Japan | Australasia | Other | TOTAL |
|-------------|--------------|-------------|--------------|--------------|
| Gasoline | 52.6 | 14.6 | 71.0 | 138.2 |
| Distillates | 82.0 | 12.8 | 150.6 | 245.4 |
| Fuel oil | 69.2 | 2.3 | 114.7 | 186.2 |
| Other | 43.5 | 6.1 | 51.5 | 101.1 |
| | 247.3 | 35.8 | 387.8 | 670.9 |

Source: BP Statistical Review

5 - REFINING IN THE ARABIAN GULF

The 9 Gulf states have a refining capacity of around 200 million tons/year. Saudi Arabia holds 30% of this capacity, and Iran and Kuwait (after facilities have been restored) about 20% each. Export potential is high and amounts to about 60 million tons/year of products.

Refining capacity in the Gulf was severely reduced in 1990 and 1991 due to the closure and then the partial destruction of Kuwait's refineries. By mid 1993 its capacity is well on the way to being restored and the operation should be completed by 1994.

Several refineries in the region are export oriented, for instance the Yanbu, Jubail and Rabigh refineries built by Saudi Arabia in association with foreign companies, and Kuwait's refineries whose production is in part destined for the Q8 networks in Europe.

Product demand in the region, which is often stimulated by very low prices, should grow at a rate of 3 - 4% per year. This increase in demand will curtail the growth of refining capacity available for exports. Distillation capacity should increase from 200 to 290 million tons/year between 1993 and 2000 but export capacity is only likely to increase by about 30 million tons/year over the same period.

6 - MAIN PRODUCT EXPORTING REGIONS

The main product exporting regions are located in the OPEC producing states that have developed refining capacities well in excess of their needs, thanks to their crude reserves - and in the 1970s to their abundant supply of capital.

TABLE 3

Refining capacity of main exporting regions - 1991

| | No. of refineries | Total capacity (Thousand bl/d) |
|----------------------------|-------------------|-----------------------------------|
| VENEZUELA/CARIBBEAN | | |
| Venezuela | 6 | 1,167 |
| Virgin Islands | 1 | 545 |
| Trinidad & Tobago | 2 | 246 |
| Netherlands East Indies | 1 | 470 |
| TOTAL | 10 | 2,428 |
| NORTH AFRICA | | |
| Algeria | 6 | 530 |
| Libya | 3 | 348 |
| TOTAL | 9 | 878 |
| ARABIAN GULF | | |
| Saudi Arabia | 8 | 1,557 |
| Bahrain | 1 | 250 |
| United Arab Emirates | 2 | 193 |
| Irak | 10 | 450 |
| Iran | 7 | 950 |
| Kuwait | 4 | 220 |
| Oman | 1 | 80 |
| Qatar | 2 | 62 |
| Yemen | 2 | 172 |
| TOTAL | 37 | 3,934 |

Apart from the Middle East which has already been analysed, the main product exporting countries are:

- Venezuela and the Caribbean states (Trinidad, Netherlands East Indies, Virgin Islands) which export around 40 million tons/year of products, chiefly to the United States.
- North Africa (Algeria and to a lesser extent Libya) which exports around 20 million tons/year of products, to Europe and the United States.

The former USSR and the former countries of the Eastern bloc are also large exporters, not only of crude oil but also of petroleum products (around 50 million tons/year, mainly to Europe).

With the exception of the Middle East whose exports doubled between 1985 and 1989, exports from the main source countries have changed little over the last few years.

Lastly, mention may be made of South East Asia and Western Europe, which are both large importers and large exporters.

TABLE 4

**Main exporting regions
(million tons per year)**

| | 1985 | 1989 | 1990 |
|---------------------|------|------|------|
| Middle East | 37 | 78 | 66 |
| USSR/Eastern Europe | 49 | 50 | 46 |
| Caribbean | 43 | 42 | 42 |
| South Est Asia | 16 | 23 | 25 |
| North Africa | 15 | 17 | 21 |
| Western Europe | 24 | 27 | 25 |
| Other | 58 | 53 | 58 |

Source: Drewry Shipping Consultants

TABLE 5

**Main importing regions
(million tons per year)**

| | 1985 | 1989 | 1990 |
|----------------|------|------|------|
| Western Europe | 82 | 82 | 77 |
| North America | 82 | 93 | 88 |
| Japan | 23 | 35 | 32 |
| South Est Asia | 19 | 34 | 32 |
| Other | 36 | 46 | 54 |

Source: Drewry Shipping Consultants

7 - PETROLEUM PRODUCT FLOWS

The three main refining regions - the United States, Western Europe and Asia/Pacific - are also the main petroleum product consuming regions. These three regions have a deficit.

TABLE 6

Petroleum product imports - 1990

| | |
|-------------------------------|----|
| UNITED STATES | |
| from the Caribbean | 27 |
| from North Africa | 6 |
| from Europe | 5 |
| EUROPE | |
| from Eastern Europe countries | 36 |
| from North Africa | 13 |
| from the Middle East | 10 |
| ASIA PACIFIC | |
| from the Gulf | 48 |

Remark. Only the main flows are mentioned. The "intra-region" flows are not covered. Each of the 3 regions also exports a certain amount of products.

The United States imports products mainly from the Caribbean (Venezuela, Netherlands East Indies, Trinidad) and to a lesser extent from Europe and North Africa. In the latter case the products concerned are chiefly gasoline.

Europe imports petroleum products from the Eastern European countries (mainly Russia), North Africa and the Middle East.

The Asia/Pacific region imports mostly from the Gulf.

8 - PRICE SENSITIVITY TO FLUCTUATIONS IN SUPPLY- EXAMPLE OF THE GULF WAR

In 1989 the Kuwaiti refineries had exported over 20 million tons of products and accounted for 40% of the Gulf's export product potential. In August 1990 exports from these refineries ceased. They suffered great damage in 1991 and exports did not resume until 1992.

This meant a fall in exports from the Gulf in 1991 of around 20 million tons/year, which affected all regions. Fewer products were exported to the United States (-2 million tons/year), to Europe (-5 million tons/year) and to Asia (-13 million tons/year). The consequences were minor where the United States were concerned but Europe and especially Asia were greatly affected. In Europe the reduction in imports was offset by increased imports from North Africa and the former Eastern bloc, especially Russia. Asia and in particular southern Asia (Pakistan, India, Bangladesh) which traditionally imports large quantities of products, had to find new sources. Refineries in the Mediterranean temporarily sent cargoes to this region.

This increased demand for products in the Mediterranean region resulted in a rise in prices. The price of gasoline had usually been lower in the Mediterranean than in Rotterdam, but the situation was reversed at the end of 1990.

9 - PETROLEUM OUTLOOK IN THE GULF AND IN THE ASIA/PACIFIC REGION

Links between the two regions will become closer and closer. The Asia/Pacific region depended on the Middle East for 70% of its crude supplies in 1990 and this figure will reach 90% by the year 2000. Furthermore, petroleum product demand is likely to continue its rapid increase due to sustained economic growth in this region. In spite of considerable construction of new refining facilities, the region will probably have to resort to increased imports of petroleum products.

TABLE 7

Petroleum products prices (\$ per ton)

| | Premium | Jet fuel | Diesel oil | HS fuel oil |
|---------------------|----------------|-----------------|-------------------|--------------------|
| Rotterdam 01.89 | 175,69 | 190,29 | 156,00 | 74,62 |
| Mediterranean 01.89 | 167,43 | 179,81 | 158,60 | 74,29 |
| Rotterdam 06.89 | 216,80 | 163,68 | 143,80 | 87,89 |
| Mediterranean 06.89 | 216,20 | 157,11 | 139,70 | 85,45 |
| Rotterdam 01.90 | 216,25 | 218,11 | 187,86 | 91,20 |
| Mediterranean 01.90 | 197,55 | 213,32 | 196,50 | 96,48 |
| Rotterdam 07.90 | 245,68 | 176,41 | 162,20 | 67,80 |
| Mediterranean 07.90 | 226,89 | 166,18 | 154,59 | 67,36 |
| Rotterdam 01.91 | 255,11 | 300,30 | 274,48 | 131,20 |
| Mediterranean 01.91 | 248,48 | 299,05 | 269,86 | 130,64 |
| Rotterdam 03.91 | 240,95 | 200,80 | 178,88 | 68,55 |
| Mediterranean 03.91 | 247,45 | 182,38 | 177,80 | 71,83 |
| Rotterdam 06.91 | 240,08 | 194,30 | 174,80 | 67,53 |
| Mediterranean 06.91 | 245,05 | 183,88 | 174,50 | 66,85 |

TABLE 8

Petroleum product production vs. consumption - estimated balance

Asia/Pacific region - year 2000

(million tons/year)

| | |
|---------------------|-----------|
| Refining capacity | 900-1,000 |
| Refinery production | 800-900 |
| Product demand | 900-1,000 |
| Net product imports | 100 |

Net imports of products of around 100 million tons/year (2 million b/d) could therefore be required. Are these imports feasible? They are in fact equivalent to the maximum export potential of the Arabian Gulf, assuming that the planned projects are completed in time.

TABLE 9

Petroleum product production vs. consumption - estimated balance

ARABIAN GULF - year 2000

(million tons/year)

| | |
|---------------------|-----|
| Refining capacity | 290 |
| Refinery production | 260 |
| Local demand | 170 |
| Net exports | 90 |

Consequently, other sources of products are likely to be called upon, primarily the Mediterranean.

In addition, these overall balances may conceal differences in situations if balances are based on individual products. The product deficit in the Asia/Pacific region will increasingly become a motor fuel (gasoline and diesel fuel) deficit. In order to produce larger quantities of motor fuels the Gulf states will have to develop their distillation capacity and also to build a number of conversion, desulfurization and gasoline production units.

10 - CAPITAL INVESTMENT, MARGINS AND PRICES

Substantial capital expenditure is required in both these regions in order to meet product demand. The new refineries that are built will have to concentrate on the production of light products and will have to include a number of cracking, hydrotreating, alkylation, isomerization, MTBE, etc. units. Further, product standards will be increasingly strict, although obviously the same constraints will apply to the refineries located in Asia and those projected in the Gulf.

Saudi Arabia is already planning to invest considerable sums in developing and modernizing its refining industry (e.g. \$4 billion for the Ras Tanura complex). Although some countries (Saudi Arabia, Kuwait, Korea, Taiwan) may be able to make these investments without too much difficulty, the outlook is not so clear for countries where the economic situation is less favourable.

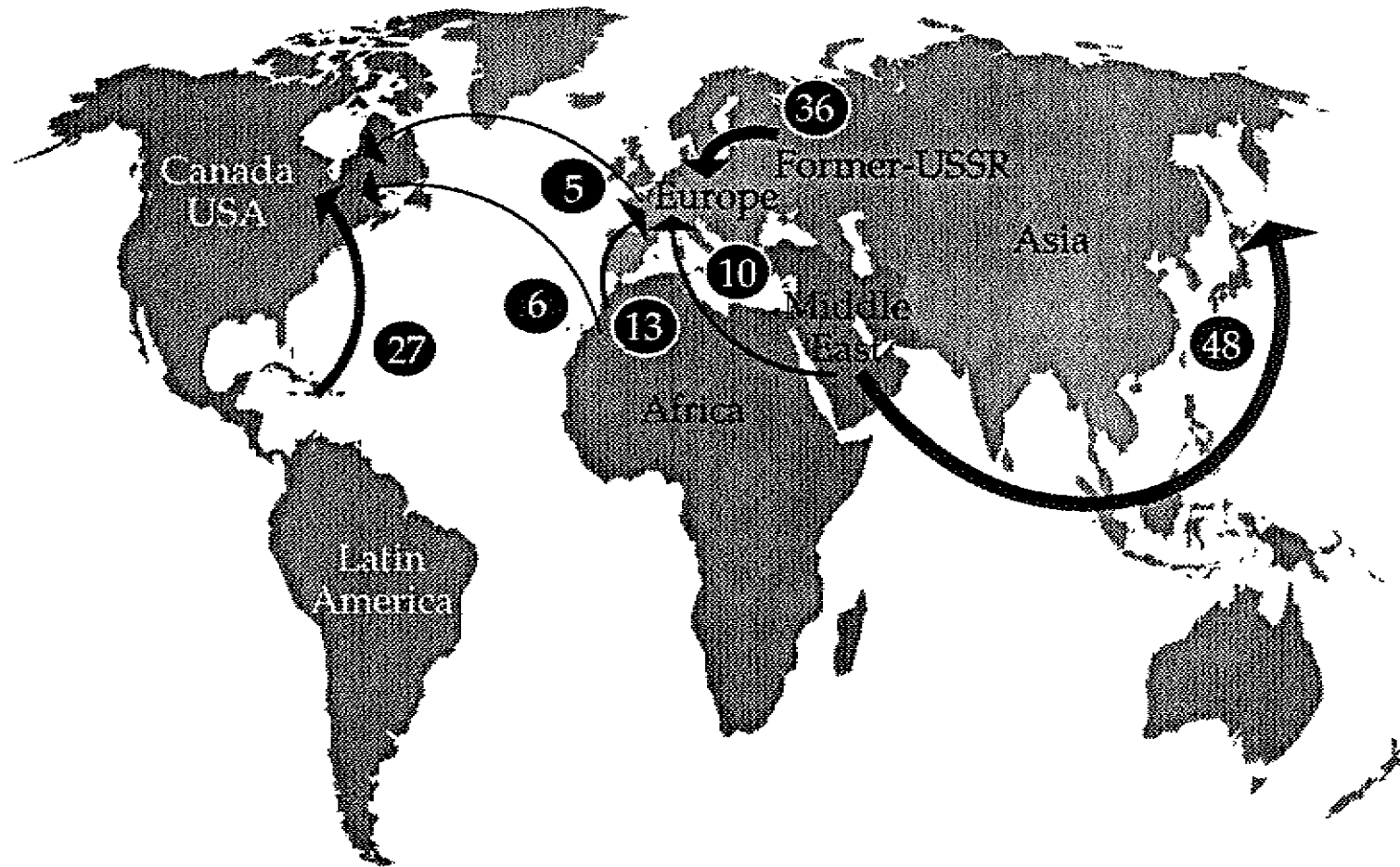
Furthermore, investments of this nature obviously have had - and will continue to have - repercussions on the price of products. Refining costs, for refineries which have mostly been paid off, are close to \$20/ton (\$3/bbl), whereas the repayment cost alone for a new refinery designed to produce a maximum amount of high quality motor fuel is of the same order of magnitude.

Refining margins are currently low in Europe and higher in Asia due to tension regarding supply, and to a controlled refining industry in some countries. However are the refining margins of \$40- 50/ton required to pay off current investments feasible in the short term? The construction of new refineries in this region will no doubt depend on the answer to this question.

International trade in petroleum products

(million tons)

1990



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