INFRASTRUCTURE REPORT

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PETROLEUM
Reserves, Production and Consumption

If coal was the fundamental and predominant source of energy for the process of industrialization during the last century, in the 20th Century petroleum has taken its place.

In reality, the share of coal in the world energy matrix still grew until 1920, when it represented 70% of all the primary energy consumed in the world. At that time, petroleum accounted for only 9%. Since then coal has progressively lost ground to petroleum, which in 1970 amounted to 62% of the total world consumption of primary energy.

Currently petroleum represents 63% of all the primary energy consumed in the world, and its importance in world terms can be evaluated by the volume of resources which circulate every year. Net operational revenues for the 31 largest petroleum groups amounted to nearly a trillion dollars in 1996 alone.

The rising of petroleum to the head of the energy sector this century was impelled by the dissemination of the internal combustion motor, which changed the technological standard of industrialization in the 20th Century. The adaptation[1] of petroleum to these new motors allowed for the progressive growth of the petroleum industry, catalyzed, above all, by the automobile industry.

Until the First World War, the petroleum industry was dominated by American companies and the European Royal Dutch Shell and British Petroleum companies. Most of these companies had the common feature of beginning operations in the refining, transport and distribution (downstream) segment. Shortly after, they also directed their investments to exploration and production (upstream) in those areas which were under the influence of their countries of origin, or where the extraction costs were low (Middle East, some countries in Africa and Asia, and Venezuela and Mexico).

The current large corporations in the sector, like Exxon, Mobil Oil, Chevron, Royal Dutch Shell, Gulf Oil, Texaco, and British Petroleum[2], have all maintained their vertical configuration until today. Vertical operation guaranteed high profit margins for this group of companies, since the cost of crude petroleum production was very low, and the price of petroleum derivatives became increasingly higher in the market.

Favored by the abundant supply and low cost of petroleum, world energy consumption went through an extraordinary growth in the post-war period. Petroleum thus became the main energy vector and maintained its primacy in the world market until the beginning of the 1970s.

This new position assumed by petroleum in the matrix of world energy consumption made the political component of business related to it increase in the same proportion. Its appreciation became clear in the influence of OPEC[3] in the controlling of oil prices. The shocks of 1973 and 1979 were clear demonstrations of the strategic content that petroleum had acquired, and its main effect was to break the price stability trajectory of energy that had been in effect in the world market until then.

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[1] Petroleum proved to be a fuel that was adaptable to the technology of the internal combustion engine because it was liquid, had high calorific power, and was easily manageable.

[2] In truth, seven western companies — the Seven Sisters — divided all petroleum negotiations until the decade of the 1970s, exploring the principal petroleum reserves of the world through very elastic concessions contracts.

[3] OPEC - the Organization of Petroleum Exporting Countries – was founded under the leadership of Venezuela and has had the following member-countries: Saudi Arabia, Iraq, Iran, Kuwait, and Venezuela (founders, 1960); Algeria (1969); Nigeria (1971); and Ecuador and Gabon (1973). The following countries have left OPEC: Ecuador (1992) ; Gabon (1996); and Iraq (Gulf War).

This new context provoked a progressive adjustment in the consumption of petroleum, and led to energy conservation programs and the search for alternative sources of energy in the world's principal consumer markets. On the other hand, high petroleum prices made the opening of new frontiers for exploration possible, especially in the ocean and in regions with higher production costs, such as the North Sea, Alaska, and other areas in developing countries. The diversification of supply sources progressively reduced dependence on supply from the OPEC member-countries. With this, the share of OPEC signatory countries in world production fell from 43% in 1980 to 29% in 1985.

RESERVES

Proven oil reserves are concentrated in a few countries around the world:

- 90.8% is concentrated in 12 countries;
- 76.1% is in OPEC countries;
- 65.0% is in the Middle East.

MAJOR PROVEN OIL RESERVES

12/31/96

	Country	Reserves (billions of tons)	% of World Reserves
1	Saudi Arabia *	35.8	25.4
2	Iraq*	15.1	10.75
3	Kuwait*	13.3	9.45
4	Iran*	12.7	9.0
5	United Arab Emirates *	12.6	8.9
6	Venezuela*	9.3	6.6
7	Ex-USSR	9.1	6.5
8	Mexico	7.0	5.0
9	Libya*	3.9	2.8
10	USA	3.7	2.6
11	China	3.3	2.3
12	Nigeria*	2.1	1.5
-	***Subtotal***	***127.9***	***90.8***
21	***Brazil***	***0.7***	***0.5***
-	***Total***	***140.9***	***100.0***

Source: BP Statistical Review of World Energy –1997.

(*) OPEC

Observe that among the 12 countries with the largest proven oil reserves, 8 are in OPEC and possess 74.4% of the world's reserves.

Regionally, world reserves are distributed as follows:

- North America (without Mexico) 3.2%
- Latin America 13.0%
- Europe 1.9%
- Ex-USSR 6.5%
- Middle East 65.0%
- Africa 6.4%
- Asia and the Pacific 4.0%

An analysis of the regional distribution of oil reserves shows that the industrialized countries have few reserves relative to their respective levels of consumption. Worldwide supply for these countries (the USA, Japan, and Western Europe) depends on the use of oil reserves located in less-developed regions – the Middle East and Latin America – , which jointly own 78% of the world's proven reserves. In Latin America, the main sources of reserves are in Mexico and Venezuela.

In considering "estimated" reserves, a change in the map of world petroleum resource distribution can be verified, with some areas noted for their great potential for future development. In Venezuela, for example, the Orinoco region has oil reserves estimated to be on the order of 164 billion tons, of which 37 million are commercially recoverable using currently available technology. The Caspian Sea region

(Azerbaijan, Kazakhstan Turkmenistan, Uzbekistan, Iran, and Russia) is also an area which represents great production potential over the medium and long term, with reserves estimated at about 26.2 billion tons.

In relation to Brazil, even though the country has only modest reserves in the world context (0.7 billion tons), it has a diversified energy matrix that is not completely dependent on petroleum, making it not so vulnerable as those economies which have petroleum as their main source. Another aspect which differentiates the situation of Brazil in relation to the world average is the fact that whereas proven world reserves over the past eight years have stabilized at about 135 billion tons, or 1 trillion barrels, the size of Brazil's proven reserves has grown 72% over the same perios. This growth was the result of heavy investments in Research and Exploration (R&E) undertaken by Petrobrás, which reached an average level of US$ 2 billion a year between 1980 and 1996.

Until the 1980s, Brazil did not retain significant oil reserves. In 1975, its dependence on imported oil was 79.8% of total consumption (imports = 692,000 barrels per day). Currently the country imports 703,000, or, in other words, 46.5% of all petroleum consumed. The effort to reduce its level of dependence on oil imports, motivated by the raising of oil prices after the shocks of 1973 and 1979, produced results like the discovery of petroleum in the ocean by Petrobrás, and the development of national technology for oil exploration in deep waters[4], both of which have definitively transformed the petroleum production panorama of the country.

PRODUCTION

In order to best characterize the complex of major petroleum producers, they can be divided into two subgroups, namely: (i) large producers/exporters; and (ii), large producers/consumers. In the first of these groups appear those countries which retain large world reserves, but which have restricted internal markets. These countries generate exportable surpluses, and their reserves can guarantee world supply at current production levels for approximately 42 years.

In the second group are the United States of America and China, which, even though large producers, do not generate surpluses sufficient for exportation. To the contrary, they depend on substantial imports in order to provide full supply for their internal markets. The domestic production of the United States currently supplies only 46% of its market and its dependence on imports has been rising at the same time that, over the past 20 years, proven domestic reserves levels have been steadily declining.

In world terms, the Reserves/Production (R/P) index has been progressively declining. This is because the growth in global oil production over the past decade has not been accompanied by a proportional increase in reserves, which, as already mentioned, have been relatively stable for the past 8 years.

MAJOR PRODUCERS - 1996

	Country	**Production** (millions of tons)	**% of World Production**	**Reserves/ Production (years)**
1	Saudi Arabia	428.8	12.8	83.5
2	USA	382.9	11.4	9.7
3	Ex-USSR	352.6	10.5	25.8
4	Iran	183.8	5.5	69.1
5	Mexico	163.6	4.9	42.8
6	Venezuela	162.4	4.8	57.3
7	China	158.5	4.7	20.8
8	Norway	155.5	4.6	9.6
9	United Kingdom	129.9	3.9	4.6
10	United Arab Emirates	117.3	3.5	107.4
	Subtotal	**2,235.3**	**66.5%**	**-**
20	***Brazil***	***40.3***	***1.2%***	***17.4***
	Total	**3,361.6**	**100.0%**	**41.9**

Source: BP Statistical Review of World Energy –1997.

[4] Efforts by Petrobrás to explore for oil in deep waters had their first big success in 1984 with the discovery of the Albacora oilfield in the Campos-RJ basin, the first of the Brazilian giant deep offshore fields with more than 1 billion barrels in reserves.

MAJOR EXPORTERS - 1996

Country	Exports (millions of tons)	% of World Exports
Middle East	852.8	44.6
Ex-USSR	159.6	8.4
West Africa	145.5	7.6
North Africa	136.3	7.1
Mexico	82.5	4.3
Canada	73.4	3.8

Source: BP Statistical Review of World Energy –1997.

CONSUMPTION

The Energy Crisis of 1979, which provoked a jump in the average price of oil[5] from 13.03 US$/barrel in 1978 to 29.75 US$/barrel in 1979, brought a contraction in world demand that lasted until 1983. After then, consumption returned to growing at annual rates much lower than those experienced before 1973 (less than 3%). The level of consumption recorded in 1979 was only attained again ten years later. Petroleum consumption in 1996 grew 2.4% in relation to 1995, reaching 3,312.8 million tons (an average of 69.545 million barrels a day).

Between regions, consumption has followed a distinct pattern. While lower growth rates can be verified in the industrialized economies, consumption in other countries has increased at a rate faster than the world average. The exception to this picture is the ex-USSR, whose consumption, as a consequence of the political and economic transformations of the 1980s and 1990s, fell from 420 million tons in 1987 to 196.5 million tons in 1996, or, in other words, 53.2% less.

From the point of view of consumed volume, it can be noted that thirteen countries are responsible for 70% of all the volume consumed in the world, with Brazil being part of this group (12th largest market).

MAJOR CONSUMERS - 1996

	Country	Consumption (millions of tons)	% of World Consumption	Consumption per capita (toe/inhabitant)
1	USA	833.0	25.2	3.14
2	Japan	269.9	8.2	2.14
3	Ex-USSR	196.5	5.9	0.67
4	China	172.5	5.2	0.14
5	Germany	137.4	4.2	1.67
6	South Korea	101.4	3.1	2.24
7	Italy	94.1	2.8	1.64
8	France	91.0	2.7	1.56
9	United Kingdom	83.7	2.5	1.42
10	Canada	79.5	2.4	2.65
11	India	78.7	2.4	0.08
12	***Brazil***	***74.2***	***2.2***	***0.45***
13	Mexico	73.8	2.2	0.46
	Subtotal	***2,285.7***	***69.0%***	**-**
	Total	***3,312.8***	***100.0%***	**-**

Source: BP Statistical Review of World Energy – 1997.

[5] Prices refer to Arabian Light/Dubia type oil.

The United States alone consumes one quarter of the world's petroleum production, representing a volume greater than all the other countries of the Americas, Africa, the Middle East and the ex-USSR combined.

As for per capita consumption, it can be verified that the industrialized countries and large consumers have high indices, although significantly less than those characterized at the end of the decade of the 1970s.

Some countries, however, although pertaining to the group of large consumers, present low per capita consumption indices. This is the case with Brazil, China, India, and Mexico. These countries, still in the process of industrialization, have large populations (they contain 42% of the world's total population). Part of their populations have consumption levels lower than the average, and therefore represent strong potential for consumption growth.

In observing the Reserves/Consumption indices for the world's wealthiest countries, the level of their dependency on imported petroleum is evident. The USA, for example, can fulfill domestic demand with its own reserves for only 4.4 years. Italy has reserves for only about a year, and France and Germany have reserve levels that are not even sufficient for one year of consumption. Due to its total dependency, Japan has been searching for the possibility of petroleum occurring in its own territory.

RESERVES versus CONSUMPTION - 1996

Country	Reserves/ Consumption (years)
Mexico	94.9
Ex-USSR	46.3
China	19.1
Brazil (**)	***13.2***
Canada	10.1
Brazil (***)	***9.4***
India	7.6
United Kingdom	7.2
USA	4.4
Italy	1.1
Germany	*
South Korea	*
France	*
Japan	-
Subtotal	**-**
Total	***42.5***

(*) Index ≤ 1 year; (**) SPE criteria and (***) Petrobrás criteria.

When considering proven reserves, calculated according to Petrobrás's own criteria – more conservative than the internationally adopted standard – , Brazil will exhaust its deposits in 9.4 years at current levels of consumption. Nevertheless, when adopting the calculation standards used by most international entities, such as the Society of Petroleum Engineering (SPE), this level rises to 13.2 years[6], a period closer to that level considered strategic for maintaining the security of internal supply (15 years).

When analyzing the petroleum foreign trade matrix, some relevant aspects can be observed:

- The world's great oil consumers, excluding China and the ex-USSR, are large importers. The USA, Western Europe, and Japan are responsible for 64% of the world's petroleum imports;

- The USA imports 56% of its petroleum consumption; Western Europe imports about 70%, and Japan, 100%.

[6] According to SPE criteria, proven Brazilian reserves totaled 977.6 million tons at the end of 1996.

- The import strategy of these three grand blocs of consumers can be defined by political-regional influences: the USA has a strong source of sustenance for its oil purchases in the axis of the Americas (56% - Canada, Mexico, and Venezuela, basically); the supply region for Western Europe covers the Middle East (37%) and Africa (32%), areas involving former European colonies; and Japan is dependent essentially on the Middle East (74%).

MAJOR IMPORTERS - 1996

Regions	Imports (millions of tons)	% of Total Imports
Western Europe	472.9	24.8
USA	465.6	24.4
Japan	281.6	14.7
Rest of the World	690.5	36.1
Total	***1,910.6***	***100.0***

Source: BP Statistical Review of World Energy –1997.

Brazil, in addition to the realization of investments for increasing its reserves both within and outside the country, has been reinforcing the safety of its stock with a policy aimed at diversifying its sources of supply. While in 1980, 83% of Brazil's imports came from the Middle East, by 1996 this number had fallen to 46%. This was made possible with a substantial increase in the purchasing of oil from Argentina, Venezuela, and Nigeria.

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