OFFSHORE ENGINEERING

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PREFACE

The intensity of offshore operations concerning oil exploration, production and other related activities is increasing in many regions around the world. In this respect, developments in the Gulf of Mexico and the North Sea are very well known. A considerable amount of research has originated from engineering projects for these areas, leading to the introduction of numerous methods and techniques for the engineering analysis of the problems encountered in the design, construction, transportation, installation and operation of equipment to look for and to extract oil from the sea.

Several Latin American countries are also actively involved in offshore oil exploration and production. Venezuela, a traditional oil producer from the Maracaibo Lake and other inland regions, is now exploring its continental shelf. Mexico has found oil both in the Pacific Ocean and in the Gulf. Brazil, a country highly dependent on imported oil is making great efforts to develop its marine oil fields which are becoming more important than its continental oil fields. Chile is already installing several offshore platforms in its southern region. Lately, Argentina has also started an offshore exploration program and has already found gas, and also some oil.

The development of the offshore oil fields in Latin America will require an impressive engineering effort involving absorption of a complex technology, and the creation of methodologies well adapted to conditions in the region.

The situation outlined above was the main motivation for COPPE, The Graduate Engineering Centre of the Federal University of Rio de Janeiro, to organise a series of Symposia on Offshore Engineering. The first of these was held in 1977, with the participation of some foreign delegates, mainly from Great Britain. The second Symposium, held in 1979 immediately following the annual meeting of RILEM (The International Union of Testing and Research Laboratories for Materials and Structures) was an even greater international occasion, having participants from Africa, Asia, Europe and Latin and North America.

The present publication is the result of the contributions presented in the Third International Symposium on Offshore Engineering, held in Rio de Janeiro, on September 14-18, 1981, having the sponsorship of Petrobrás, the Brazilian State Oil Company, and CNPq, the Brazilian Council for Scientific and Technological Development.

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THE STRATEGY EMPLOYED BY BRAZIL TO MEET THE INTERNATIONAL OIL CRISIS

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ABSTRACT

A review of the part played by oil within the world energy picture, from 1945 up to December 1980, is presented, the cause of sudden and unusual rises in the price of oil and the effect thereof on the economy of developing countries, particularly BRAZIL, being covered.

Dates are furnished to show how the world reacted to the oil crisis and how BRAZIL, an importing nation in which hydrocarbons (oil and natural gas) represent about 40% of its overall consumption of energy, laid down its strategy to meet the challenge posed by such a crisis.

An appraisal of oil prospecting and production work in BRAZIL since commencement thereof up to December of last year serve to show how significant the efforts made by the state oil company PETRÓLEO BRASILEIRO S.A. (PETROBRÁS) have been during the 28 years of its existence. It is estimated that during the current year the investment in oil exploration and production development in BRAZIL should reach about US$ 2,617 million or 88% of all direct investments made by PETROBRÁS. In spite of geological difficulties, achievements have been highly rewarding. Existing reserves will provide an output of about 400,000 barrels per day in 1985.

In the "PETROBRÁS Plan of Action" for 1981/1985 it is stated that oil exploration and production development work will continue to call for the major part of the available funds of the company. An outlay of US$ 15 billion is foreseen and it is believed that the goal of 500,000 barrels per day, as set by the government, can be reached, if the present rate of work is kept up.

INTRODUCTION

After the second world war there was un unheard-of rate of growth in the economy of the capitalist world. This was largely brought about by the achievements of the highly developed countries, principally the United States, Japan, and nations of Western Europe. It is likely that the chief factors underlying such growth were the surge of technological developments, a plentiful and cheap supply of labour, and the part played by states in the raising of capital.

Since no wealth can be produced without an outlay of energy, or rather, since there is a close connection between economic growth and the consumption of energy, rising consumption and its effect upon the energy setup are matters that warrant closer study.

BACKGROUND OF THE OIL CRISIS: THE RISE IN THE USE OF OIL-DERIVED ENERGY

A breakdown of world energy sources for post-war 1945 as compared with 1973, the year the oil crisis began, points to a considerable change in the pattern of energy consumption. Thus in 1945 the world relied on coal for 62% of its energy while oil and natural gas furnished 32% thereof. By 1973, when the energy the world used was three times as much, compared with 1945, the opposite had taken place - 65% of the overall world supply of energy was being drawn from oil and natural gas, while that from coal had fallen to about 30% (Table 1)[5].

TABLE 1

WORLD PRIMARY ENERGY CONSUMPTION

Unit : Million tons oil equivalent

ENERGY	1945		1973		1980	
	VOLUME	%	VOLUME	%	VOLUME	%
Petroleum	343.0	25	2775.9	46.2	3001.4	43.6
Natural gas	104.0	7	1098.8	18.3	1278.3	18.6
Coal	865.0	62	1753.1	29.1	2020.9	29.4
Hydro electricity	87.0	6	337.0	5.6	414.6	6.0
Nuclear	-	-	49.1	0.8	167.4	2.4
Total	1399	100	6013.9	100	6882.6	100

TABLE 2

OIL RESERVES BY AREA OF THE WORLD

UNIT. 10^9 barrels

COUNTRY / AREA	1945	1970
NORTH AMERICA	20,962	50,440
UNITED STATES	19,942	39,001
CANADA	0,150	8,559
MEXICO	0,870	2,880
CENTRAL AND SOUTH AMERICA	8,339	25,576
ARGENTINA	0,300	1,572
BRAZIL	0,001	0,857
COLOMBIA	0,500	1,580
EQUADOR	0,025	6,000
VENEZUELA	7,000	14,041
OTHERS	0,573	1,526
WESTERN EUROPE	0,186	6,239
WEST GERMANY	0,085	0,544
UNITED KINGDOM	0,015	2,500
NORWAY	—	2,000
OTHERS	0,086	1,195
EAST EUROPE	8,654	59,550
HUNGARY	0,075	—
RUMANIA	0,500	0,867
SOVIET UNION	8,000	58,000
OTHERS	0,075	0,683
AFRICA	0,075	46,317
ALGERIA	—	8,098
EGYPT	0,075	0,990
LYBIA	—	30,000
ANGOLA	—	0,750
GABON	—	0,485
NIGERIA	—	5,600
OTHERS	—	0,394
MIDDLE EAST	18,500	342,140
ABU DHABI	—	14,850
SAUDI ARABIA	3,000	151,473
QATAR	0,500	4,100
DUBAI	—	1,300
IRAN	6,000	60,000
IRAK	4,750	29,000
CARIBE	4,000	75,500
OTHERS	0,250	5,917
FAR EAST	1,310	33,347
CHINA	0,015	20,000
INDONESIA	1,000	10,000
OTHERS	0,295	3,347
WORLD TOTAL	58,026	563,609

The increase in the consumption of oil and natural gas sprang out of their ready availability on world markets - at dropping prices up to 1970 - when for the first time ever, the new reserves added were barely enough to meet rising demand.

In 1945 oil reserves amounted to 58 billion barrels and in spite of the swift growth in consumption referred to above, fresh discoveries pushed reserves up to 563 billion barrels by 1970 (table 2).

Thus, by the end of the 60's, 68% more energy was being used than at the beginning thereof as against a corresponding increase of 118% in world consumption of oil.

More specific figures illustrating this comparison between growing use of energy and rising consumption of oil over such years, consist of the following: Japan 214% against 550%, United States 81% and 54%, Europe 67% and 170%, Latin America 98% and 72%, and Brazil 98% against 86%.

THE OIL CRISIS AND ITS EFFECTS - 1973/1979

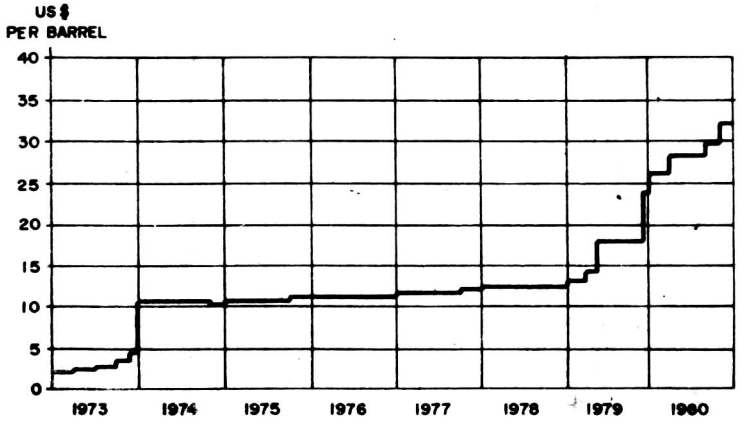
In 1970 because 67% of the world's oil reserves lay in the Middle East and in North Africa (table 2)[1,2] and because there was no doubt that oil would continue for a long time to be the world's main source of energy, the nations of OPEP set about safeguarding their interests, their aim being to earn more export revenue.

By 1973 when the political aspect loomed foremost because of the struggle between Arabs and Jews, the price per barrel of oil had risen from US$ 2.78 in September of that year to about US$ 5.00 by December thereof, and had got as far as US$ 11.00 per barrel at the beginning of 1974 (Table 3)[1,2]

TABLE 3

RISE IN THE PRICE OF OIL

1973/1980



Whatever the causes which led to prices fourfold greater than before, the oil crisis of 1973 marked the end of a long period of stable world prices and made the offshore exploration and other more expensive oil sites economically feasible, while ushering in enhanced oil recovery methods and also encouraging the development of alternative sources of energy.

From 1973 to 1979 a great deal of exploratory work was done, particularly by the oil importing nations, all of which led to significant new discoveries, notably those in the North Sea, in Alaska, and along the continental shelf of Mexico, which enabled extraction of a further 252 billion barrels of oil to take place in such time, not counting the USSR, China, and Eastern Europe.

One of the indications of the extent of such efforts is to be seen in the rise of the number of seismic crews operating throughout the world, the rate of which went up from 7,251 party-months of operation in 1972 to 8,416 party-months of operation in 1979,[3] even though the OPEP nations actually brought down their rates from 984 to 948 party-months over the same time.

A still more outstanding sign of such efforts, is the growth in the number of wells drilled worldwide from 36,338 in 1972 to 64,595 in 1979, not counting those in East Europe, the USSR and China - an outcome of the number of rigs (on shore and offshore) in operation, which grew from 1,651 to 4,042[3] over the said period.

The sudden and exceptionally high rises in the price of oil at the end of 1973 and in 1979, as shown under table 3,[1,2] added up to an increase a little over 1000%, and worked a considerable change within the economy of the world. This was extremely harmful to countries undergoing development, which had to bear not only the rising cost of petroleum and its products but also the effects thereof upon the price of imported manufactured goods and the consequences of the restritive practices employed by developed countries against their exports. They had to bear the full brunt of the crisis.

The steep rise in oil prices in 1973-74 moderated consumption, namely from about 56,7 million barrels per day in 1974 to about 65,2 million in 1979[3] (15%). Prices shot up even more steeply in 1979, from US$ 13.00 per barrel at beginning to US$ 24.00 per barrel FOB at the end of the year (table 3[1,2]).

EFFECTS IN 1980 OF THE NEW RISE IN PRICES. INCREASE IN THE SEARCH FOR ALTERNATIVE SOLUTIONS

The new push up in prices brought about a 5% drop in the 1980 oil consumption figure, as compared with that for the year before,

TABLE 4

WORLD OIL CONSUMPTION
(Major Consumers)

COUNTRY / AREA	VOLUME (10^3 b/d)		PROPORTION %	
	1974	1980	1974	1980
NORTH AMERICA	18 269	18 882	32,2	30,1
UNITED STATES	16 653	17 033	29,4	27,2
CANADA	1 616	1 849	2,8	7,9
LATIN AMERICA	3 625	4 638	6,4	7,4
ARGENTINA	503	560	0,9	0,9
BRAZIL	867	1 120	1,5	1,8
MEXICO	684	1 060	1,2	1,7
VENEZUELA	258	413	0,5	0,7
OTHERS	1313	1485	2,3	2,3
WESTERN EUROPE	13 815	13 509	24,4	21,6
WEST GERMANY	2 684	2 661	4,7	4,3
FRANCE	2 369	2 251	4,2	3,6
ITALY	2 095	1 903	3,7	3,0
UNITED KINGDOM	2 126	1 672	3,8	2,7
OTHERS	4 541	5022	8,0	8,0
MIDDLE EAST	1 548	1 965	2,7	3,1
IRAN	512	500	0,9	0,8
SAUDI ARABIA	391	530	0,7	0,9
OTHERS	645	935	1,1	1,4
TOTAL ASIA EXCL. MID. EAST	7 334	8 193	12,9	13,1
JAPAN	5 120	5 008	9,0	8,0
OTHERS	2 214	3 185	3,9	5,1
AUSTRALIA	602	614	1,1	1,0
NEW ZEALAND	99	89	0,2	0,1
AFRICA	1082	1390	1,9	2,2
TOTAL WORLD EXCL. CPES	46 374	49 280	81,8	78,6
CPES	10 319	13406	18,2	21,4
TOTAL WORLD	56 693	62 686	100,0	100,0

which meant that the rate of growth in world oil consumption went up by about 9% for the period 1974/1980.

In 1980 the world consumption of oil was 62.7 million barrels per day, breakdown thereof by major consumers being as shown under tabl 43.

Except for the United States and the Soviet Union which are two of the three biggest oil producers of the world, as well as being the two countries where consumption is heaviest, major producing and consuming areas do not match, an instance of this being the nations of the Middle-East and North Africa which accounted for 34% world production in 1980, such production having been 62 million barrels per day, very much the same as the figure for world consumption (table 5)3.

TABLE 5

WORLD OIL PRODUCTION 1980

COUNTRY / AREA	PRODUCTION	%
OPEP COUNTRIES	26 927	43
MIDDLE EAST	18 134	29
NORTH AFRICA	2 894	5
OTHERS	5 899	9
MEXICO	2 154	3
NORTH SEA	2 141	3
UNITED STATES	10 216	17
SOVIET UNION	12 109	20
PEOPLE'S REP. OF CHINA	2 143	3
OTHERS	6 399	11
WORLD TOTAL	62 089	100
	Unit : 10^3 b/d	

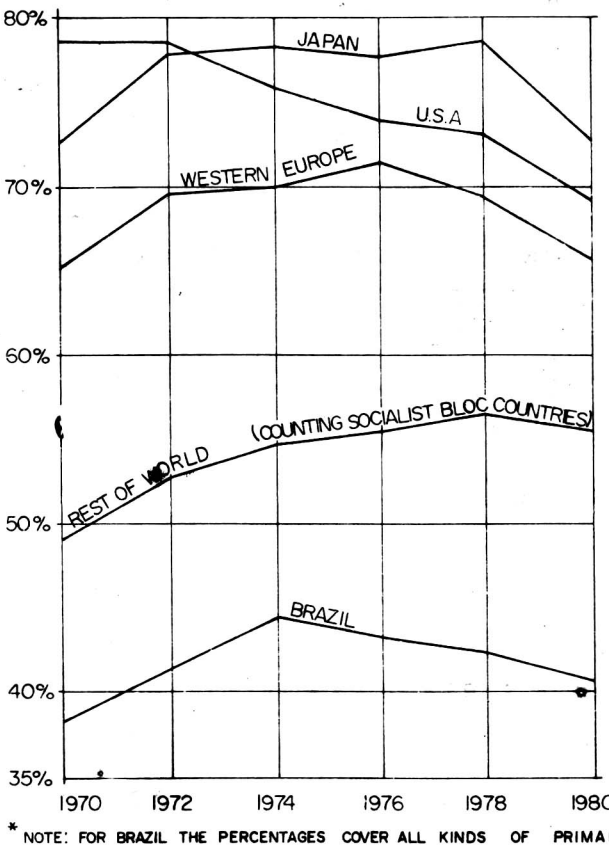
Nowadays 43,6% of the energy used in the world is derived from oil, while 18,6% comes from natural gas, as shown under table 1. Among the obstacles any importing nation, including Brazil, would have to contend with, if it attempted to cut down on oil and natural gas, there is the existing framework which is geared to use energy from such sources and which cannot easily be switched over to energy derived from other sources.

The hydrocarbon rate within the overall energy pattern (table 6)1,4 serves to show up trends in the more economically

developed parts of the world (U.S.A., Japan, and Western Europe), as well as in Brazil and the rest of the world, including those countries belonging to the socialist bloc (Russia, Eastern Europe, and China). In the case of Brazil, for instance, a gradual decline in the rate of hydrocarbons has been taking place since 1974 as a result of government policy aimed at rationalizing the consumption of energy.

TABLE 6

PROPORTION OF HYDROCARBONS
IN OVERALL CONSUMPTION OF ENERGY *



* NOTE: FOR BRAZIL THE PERCENTAGES COVER ALL KINDS OF PRIMARY ENERGY; FOR OTHER COUNTRIES ONLY THE FOLLOWING: OIL, NATURAL GAS, COAL, NUCLEAR, AND HYDRAULIC.

As interesting point is that this trend towards such a drop in the consumption of energy is discernible in figures for the United States, Japan, the West European Community and, to a lesser degree, the rest of the world.

We believe that at present there is a worldwide shortage of 1 million barrels per day (oil consumption estimated at 57.6 million barrels per day as against production estimated at 56.6 million

barrels per day) which is being met by drawing on stocks reckoned to be about 5 to 6 billion barrels[5].

Heavy stocks, the high cost of upkeep thereof and their consequent fall, plus the high Saudi Arabian output and present low rate of consumption, are factors which lead to an undersupplied market becoming, paradoxically, a buyers market, at least until December next when a regular meeting of OPEP is scheduled to be held at Abu Dhabi.

BRAZILIAN STRATEGY AGAINST THE ENERGY THREAT

The steep rise in oil prices on world markets as well as the unstable political scene in the Middle East have caused pressure to be brought to bear on the need to take multiple action, not only towards speeding up oil prospecting work but also towards seeking out other sources of energy and re-examining former plans.

Brazil also strives to have to rely less on foreign sources of energy, for ever since its post-war surge of industrial development oil has played an outstanding role in its energy requirements. By 1968 it was the source of 38% of all primary energy used and by 1973 this rate had become 44% [4]. During this time while the average rate of growth in the use of primary energy was about 8.5% the consumption of oil was going up at the rate of 11% per year.

This was due to the economic growth which took place in the country at exceptionally high rates then, favourable world conditions having helped. The GNP of Brazil grew at an average rate of over 11% per year, a figure which few countries in the world could equal, this having brought about the use of twice the quantity of petroleum products, such quantity having gone up from 138.4 million barrels in 1967 to more than 276.8 million in 1973. In 1973 consumption went up at the record rate of 20% (Table 7).

Suddenly foreign exchange was thrown off balance in October 1973 when world prices of oil shot up. Brazil which was the twelfth largest consumer of oil and the eighth biggest importer thereof in the world could hardly get by scatheless; indeed, net outlay for crude oil and its products went up threefold, having risen from US$ 1 billion in 1973 to US$ 3 billion in 1974 when an adverse balance of trade of US$ 4.7 billion was recorded (Table 8) [6].

However, economic growth had to be kept up, and this could still be done, at a rate which though less than that of the years prior to the crisis, would yet match the need to provide job opportunities on the home market in keeping with the national purpose of bridging the gap which prevents us from joining the ranks of the more advanced nations.

Thus, effort was directed towards overcoming foreign exchange difficulties while trying to safeguard business at home from the slump brought on by the state of world affairs, some of the action undertaken having been directly aimed at the energy question.

TABLE 7

PERCENTAGE RATE OF GROWTH OF GNP AND OF CONSUMPTION OF OIL PRODUCTS

YEARS	GNP		CONSUMPTION OF PETROLEUM PRODUCTS	
	GROWTH PER YEAR	AVERAGE RATE OF GROWTH	GROWTH PER YEAR	AVERAGE RATE OF GROWTH
1968	11.2		15.4	
1969	10.0		7.7	
1970	8.8		6.7	
1971	13.3		11.8	
1972	11.7		12.1	
1973	14.0		19.8	
1967/1973	-	11.5	-	12.2
1974	9.8		7.5	
1975	5.6		5.4	
1976	9.0		8.9	
1977	4.7		2.3	
1978	6.0		9.9	
1979	6.4		6.3	
1980	8.0		-1.4	
1973/1980		7.1		5.5

TABLE 8

BRAZIL - BALANCE OF TRADE

US$ milhoes FOB

YEARS	EXPORTS	IMPORTS	BALANCE
1968	1881	- 1855	26
1969	2311	- 1993	318
1970	2739	- 2507	232
1971	2904	- 3245	- 341
1972	3991	- 4235	- 244
1973	6199	- 6192	7
1974	7951	-12641	-4690
1975	8670	-12210	-3540
1976	10128	-12383	-2255
1977	12120	-12023	97
1978	12659	-13683	-1024
1979	15244	-18084	-2840
1980	20132	-22961	-2829