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PETROLEUM AND PETROCHEMICAL INDUSTRY IN THE CARIBBEAN REGION

(A TECHNO-ECONOMIC STUDY)[1]

by

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INTRODUCTION

Up to the Second World War oil was not a major source of supply for the total world needs of energy. Coal was the main source. The petroleum industry's international trade was then chiefly from the United States and the Caribbean to Europe and chiefly in refined products like gasoline and kerosine. After the war the pattern changed. Oil became more important as a supplier of world energy and countries like Western Europe and Japan built refineries so that the nature of international trade changed. Refineries, having locations near to supplies in the Americas and the Caribbean, continued to expand but world trade in crude (for refineries with locations nearer the markets) also grew.

In the literature, Caribbean is usually taken to mean the islands neighbouring the Caribbean Sea and, because of historical associations, the territories on the mainland which are a part of the British, French or Dutch Family of Nations are also usually included - Guyana, Surinam and French Guyana. In some, and a less common, part of the literature Venezuela is also included and, in strict geographical terms, should be. Venezuela is, however, preponderantly grouped with the Latin American countries in petroleum and other matters and since Venezuela, the world's third largest producer of crude oil (exceeded only by the U.S. and the U.S.S.R.), could provide problems of consistency of treatment. Therefore, Venezuela is not discussed as a part of the Caribbean in this paper. The assumption is that Venezuela is being given a fuller treatment elsewhere in the Latin American section or, because of its importance, in its own right.

PETROLEUM RESERVES

Latin America, compared with other land masses, does not possess major known petroleum reserves: on the basis of January 1969 estimates about 7% of the world reserves. This compares with about 3% in the U.S., 8% in Africa, 10% in Europe, 10% in the Soviet Union, China and allied countries, 0.3% in Australia New Zealand. It is in Asia and the Middle East that the massive reserves occur - some 65% of the world total).

Of the known reserves in Latin America Venezuela has, substantially, the largest. In the Caribbean, Trinidad is the only territory with significant reserves (525 million barrels) and these are fifth in importance in Latin America, exceeded by Venezuela, Argentina, Mexico, Brazil (in that order).

According to the estimates, oil reserves in Trinidad at the beginning of 1969 were 5 - 6 million barrels with a reserves production ratio of about 8. With the renewed activity in marine exploration off the East Coast and a seismic survey off the North Coast there was optimism about the revision upwards of Trinidad's estimates of reserves. (See Table 1)

EXPLORATION AND OIL PRODUCTION

Trinidad

The only producer in the Caribbean for which readily available information on production of oil exists is Trinidad. Cuba is known to have some production and there is exploration elsewhere.

Trinidad and Tobago has an active programme of diversification but the economy continues to be dominated by the petroleum industry and the association between economic growth and the variation in the production of crude oil is shown in the following figures1/:

	Annual percentage rate of growth of real G.D.P.	Annual percentage rate of growth of crude oil production
1955-61	10	11
1962-65	3-3.5	nil
1966-68	6-7	9.5

1/ Draft Third Five Year Plan, 1969-73, Government of Trinidad and Tobago.

In 1968 Trinidad was the only producer of crude in the Carribean. The only other was Cuba with an output that was negligible[1]. Trinidad's output, not large by world standards, was the fourth in Latin America, 192,[illegible] b/d compared with Venezuela's 3,619,000, Mexico's 380,000, Argentina's 241,0[illegible]. (See Table 2)

Texaco Trinidad, Shell Trinidad, B.P. (until recently) together with Trinmar (concerned with the northern area and owned by Texaco, Shell and B.P.) produce practically all of Trinidad's crude oil. In 1967 production was a record (16.[illegible]% higher than in 1966). This was due in large measure to the new completions being more productive than in the past since there was in 1967 a substantial decline in footage drilled (nearly 22% from the 1966 figure). New completions made up some 11% of the total, a considerably higher proportion than in the previous year. The older wells tend to fall off in production 15 - 20% a year and increasing the level of production depends largely on the success of drilling activity.

In 1968 production passed the peak of 1967 and was three times that in 195[illegible], 60% higher than in 1960. This was in spite of the fact that there was a loss in [illegible] in both marine and land production during the early 1960's. The trend in total output from land wells has been upwards and marine's total production has increased even faster. Hence, while the proportion of total production from land wells is higher than from marine wells, there is a trend for the proportion (of total output) from marine wells to increase. (See Table 3). In 196[illegible], 37% of the total production came from marine wells but, in 1968, the proportion increased to 42%. The land areas in Trinidad have been presistently explored and the 3,60[illegible] land wells have an average production of only some 26 b/d. Since this compares with 244 barrels from offshore wells the outlook is favourable for output as well as for costs.

In attempting to make forecasts of Trinidad's oil production one must be cautious in basing estimates on the sharply rising trend in recent years since this very increase reduces the likelihood of new finds in the proximity. An opposite and pessimistic view would be to base estimates on production records. The Government, in its 1969-73 Development Plan makes a forecast of slight in-

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1/ World Petroleum Report, 1969, p. 25.

creases in production above the 1968 level of 67 million barrels, rising to a peak of 70 million in 1970 and then slowly reverting to the 1968 level of 67 million barrels in 1973.

Cuba

In 1968 Cuba claimed[1/] major successes for its petroleum industry. Production in 1968 was said to be about 2,545 b/d. Prior to the revolution production was about 1,500 b/d (in 1956). A programme in association with the U.S.S.R. and Roumania continued exploration. Roumania agreed to provide 30 million Cuban pesos, credit to be used for oil well drilling and equipment. This credit was to be liquidated over an eight year period, in fact at least on a barter basis, one of the products to be supplied by Cuba being 2,000 tons of nickel.

In the imports from the U.S.S.R., it would seem that in rounded numbers 6 tons of oil are equated with 1 ton of sugar and it is presumed that in 1967 810,000 tons of Cuban sugar were exported to the U.S.S.R. in payment for 4,860,000 tons of oil.[2/] To supplement the fuel needs research was under way to determine whether asphalt from domestic supplies could be used as a fuel in place of petroleum. Previous work had shown that, while Cuban asphalts could be a source of fuel, the high ash content increased the cost of its use as fuel. On the other hand, with the shortage of fuel in Cuba and with the advantages of foreign exchange savings, the possible use of domestic asphalt continued to receive attention.

Dominican Republic

There was drilling on a small scale in 1967. Two wells were reported to be producing in 1968.[3/]

1/ Oil and Gas, Jan. 29, 1968, p.69

2/ U.S. Department of Interior, Minerals Year Book, Vol. IV, 1967, p.876

3/ World Petroleum Report, 1969, p. 52

Natural gas production

Production of natural gas in Trinidad increased during the 1960's from 100,000 million cubic ft in 1962 to 157,000 million cubic ft in 1968 and this change might be expected in the light of the trend in oil production. The bulk of this high pressure gas was used as fuel with some also in the refinery and fertilizer plant [illegible] in smaller industrial plants which were converting their fuel oil furnaces to natural gas.

Gas vented or flared represented about 42% of the gas produced but a good deal of the gas was vented after the pneumatic energy had been used to gas-lift oil, in pumping oil to shore. Overall there has been a sharp decrease in the gas vented, expressed as a percentage of total gas production.

There is shown in table 4 production and utilization of natural gas.

The outlook for natural gas will be influenced by the results obtained from the drilling activity off Trinidad's east coast. There is much discussion, both in the public and private sector, about industrial development centred on natural gas for fuel and raw material and the chief developments are expected to be in relation to:1/

(a) generation of electricity;

(b) petrochemical manufacturing in association with petroleum intermediates;

(c) fuel for industrialists and agriculturalists;

(d) domestic utilization;

In the same report the Government indicated its resolve to intensify geological studies to increase gas reserves, to explore the more extensive use of gas storage tanks, to facilitate transportation to the main population and business centres of the country.

Because of the probable significance of the natural gas resources and their development, a separate section follows later in this paper on: "The potential for natural-gas-based petrochemical industries."

1/ 1969-73 Development Plan, Government of Trinidad & Tobago.

Refining

The Caribbean offers advantages from the point of view of location of refineries: the supply of crudes in impressive quantity from Venezuela, to lesser extent from Trinidad; convenience of shipping export products both to the Americas and to Western Europe. The three sites having this operation longest in existence - Aruba, Curacao, Trinidad - have plants among the largest in the world (See Table 5).

Netherlands Antilles

The refineries in Aruba (Lago Oil & Transport) and Curacao (Shell Curacao) are based on supplies largely from Venezuela and export almost half of their products to the U.S. In keeping with U.S. anti-air-pollution requirements Lago is investing some $ 80 million 1969 in desulphurization facilities. Shell had installed corresponding facilities at a cost of $ 13 million in 1967.

Both Aruba and Curacao, enjoying the privileges of overseas territories of France and the Netherlands, acquired special associate status with the European Common Market with consequent tariff advantages.

Crude supplies to these refineries come almost exclusively from Maracaibo.

The islands, already with the biggest refinery capacity in the Caribbean, were undergoing further expansion. Thus Lago Oil & Transport added 75,000 b/d capacity to the 460,000 b/d refinery.

Trinidad

Both Texaco and Shell have local refineries while B.P. (when in production) exported some of its crude and handled the remainder in Shell's refinery. These refineries in Trinidad (Texaco and Shell) have expanded substantially from about 185,000 b/d ten years ago (135,000 b/d Texaco and 50,000 b/d Shell) to about 400,000 b/d in 1968 (340,000 b/d Texaco and 60,000 b/d Shell). Shell, normally depending only on local supplies for its refinery, imported some crude in 1968. On the other hand, Texaco, one of the six largest refineries in the world, has normally looked to imports and in 1968 imported about 66% of its needs; 60% from Venezuela and the rest from the Middle East, Colombia, Gabon, Indonesia.

Overall, the crude distillation units imported 65%, 68% and 65% of the crude used in 1964, 1965 and 1966 respectively.

The throughput increased at an average rate of 10% from 1959 to 1967. There was a temporary decline in 1967, caused partly by the crisis in the Middle East but in 1968 the upward trend was continued with a throughput of 151 million barrels and a 5% increase over 1966, capacity having increased to 430,000 b/d.

In 1968, coupled with this activity in refining, imports of crude oil moved up and in December 1968 were higher than in any month since April 1966.

The biggest gains occured in primary refined products and, especially, in fuel oil which, in 1968, made up about 58% of total output. Aviation fuels also showed an increase. One notable and disppointing feature was a drop[1] in 1968 in production in petrochemical intermediates, contrary to previous trends. Refinery products continued to be export oriented and in 1968 99% of output went abroad.

Refinery products per barrel of crude oil were made up as shown in Table 6.

The Government announced that there were plans for further increases in refinery capacity to 500,000 barrels a day and stated:[2]

> "The Government considers that, after the relatively slow growth of capacity over the last four years, the time has come for another big upsurge in the extension of refinery capacity. Accordingly, the Government expects that Texaco and Shell will put into Trinidad some of the international expansion it is known must develop in the Hemisphere, not only from the throughput aspect but also from the production of special products".

In Trinidad, as elsewhere in the Caribbean (especially the Netherlands Antilles), the decision by the U.S. that fuel oils on the U.S. East Coast markets should contain not more than 1% sulphur has made it requisite that desulphurization capacity is created if exports to the U.S. are to continue.

1/ Ministry Paper

2/ Third Five Year Plan 1969-73, Government of Trinidad & Tobago, p. 230

Cuba

A few years prior to the Castro Government, three refineries were established in Cuba by Texaco, Jersey Standard and Shell. These are now operated by the Cuban Petroleum Institute. These refineries, formerly operated on supplies from Venezuela, now secure supplies exclusively from the Soviet Union. Not much is known about the internal operation except that supplies continue to come entirely from Eastern Europe. Deliveries from the Soviet Union in 1967 included:

Supplies from Soviet Union	Crude	Gasoline	Diesel Fuel	Heavy Fuel 1/
Tons 1967	3,800,000	104,000	321,000	955,000
1967:1966	same as 1966	4.2% 1966	29.4% 1966	15.7% 1966

Puerto Rico

In Puerto Rico two refineries established in 1955 have been greatly expanded. The two, Caribbean Refining Co. (a subsidiary of Gulf Oil) and Commonwealth Oil Refinery Co., import their crude from Venezuela. Sun Oil's installation of a 50,000 b/d refinery is due to be completed in 1970. There is massive petrochemicals expansion and this expansion has been in association with the refinery activities.

Jamaica

In Jamaica Esso completed in 1964 a 28,000 b/d refinery. Its crude comes from Venezuela and production is aimed at local consumption with the small surplus exported to neighbouring territories.

Dominican Republic

No reference to refining was discovered.

1/ Source: World Petroleum Report 1969, p.52

Virgin Islands

Hess Oil Virgin Islands Corp. has a 160,000 b/d refinery in the U.S. Virgin Islands. It obtains about 75% of its supplies from Venezuela and the remainder from Africa. Plans are in hand for expanding their hydrodesulphurization plant and for an aromatics unit and a vacuum still.

Antigua

The West Indies Oil Co. has an 11,000 b/d refinery in operation since 1967 in Antigua. The chief shareholders are Natomas & Amoco International (Standard of Indiana). Crude is imported from the Middle East and products are shipped to neighbouring territories.

Barbados

In Barbados Mobil's Barbados Union Oil operates the smalles refinery in the Caribbean (3,000 b/d). Crude comes from Venezuela and production thus far goes to local consumption.

Martinique

In Martinique Compagnie de Raffinage des Antilles is building a refinery which is due to be completed in 1970.

Bahamas

New England Petroleum and Standard of California (with 65% and 35% interest respectively) are installing a refinery of about [illegible]00,000 b/d capacity in the Bahamas. This is the largest new refinery in the region and the planned completion date is 1970.

Petrochemicals

Once the petroleum industry limited its concern to the production, processing and distribution of petroleum. Later production of chemicals became a major concern and today some of the companies have expanded their energy and natural resources activities into coal, shale and even nuclear fuels. One reason for this emergence into broader energy and natural resources activities is that, with the trend for primary energy to be transformed into secondary energy, the sources of primary energy have tended to be interchnageable and to be governed largely by questions of economics. Thus, whether electrical energy is to be derived from oil or coal or water power or nuclear processes tends to be determined by economic convenience.

While policy formerly planned on the basis that oil and natural gas had a secure and rising share in supplying the demand for energy, it is now clear that in the future and under certain circumstances nuclear power will be an increasingly strong competitor. Considerations such as these have been among the stimulants inducing the oil companies to diversify into petrochemicals and even into nuclear development. Petrochemical activities are summarized in Table 10.

<u>Cuba</u>1/

In 1967 the Government announced the construction of two fertilizer plants. The plans were based on: a contract with the U.S.S.R. for a plant to produce 135,000 tons of complete fertilizer annually; a contract with the United Kingdom for capacity to produce 285,000 tons of ammonium nitrate and 180,000 tons of urea annually. These were in addition to plants already under construction with goals of 400,000 tons of nitrogenous fertilizer, 220,000 tons of ammonium nitrate and 89,000 tons of urea.

It was reported that high pressure gas wells were discovered and that some of this gas was already being used to supply a thermoelectric powerplant.

There were developments in the salt works and there were plans for substantial increases in production of salt. This could, conceivably, in time have possibilities for caustic soda and chlorine production, with implications for a petrochemicals programme.

1/ Economics of International Distribution of Anydrous Ammonia, W.J. Haude, in Studies in Petrochemicals, Vol. II, UNIDO

Puerto Rico

The International Petroleum Encyclopedia[1/] states that Puerto Rico's "petrochemical facilities make it the petrochemical capital of Latin America". In the light of this importance it is proposed in this section to deal in some detail with the present situation in the island and to attempt to mention some of the factors which brought about the development: Puerto Rico's petrochemical industry has its origin in two modest petroleum refineries which went on stream in 1955, one operated by Caribbean Gulf Refinery Corporation and the other by Commonwealth Oil Refinery Company. The petrochemical plant was then attracted by feedstock from these and primarily by Corco. In 1965, Phillips Petroleum laid down a second major core facility. A third major core facility, to be operated by Sun Oil, is now in the planning stage. In 1968 the Economic Development Administration announced[2/] that 58 petrochemical operations were on stream.

Puerto Rico had 49 establishments in the chemical and allied products industry (employing 1,266 workers) in 1950, and in 1969 over 102 plants (employing 3,700 workers) with plans for establishment in the near future for 51 new plants.

The petrochemical enterprises are developing as a complex of satellite plants around core facilities that make available feedstocks for further processing. The following are some of the major projects and the companies involved:[3/]

1/ International Petroleum Encyclopedia, 1969, p.80.

2/ The Petrochemical Opportunity in Puerto Rico, The Commonwealth of Puerto Rico, 1968.

3/ The Chemical and Allied Products Industry in Puerto Rico, Economic Development Administration, Puerto Rico, Jan., 1969.

Commonwealth Oil Refining Company (Corco), in Puerto Rico for more than 10 years, operates an oil refinery (115,000 b/d) and is the largest aromatic plant in the world. It produces mostly benzene, mixed-xylenes and some ortho-xylene and toluene. This core plant, on the basis of plans now proceeding, is to be expanded by fifty per cent of existing capacity and has, on the basis of these intermediates, attracted the following satellite plants:

Shell Co. of Puerto Rico has joined with Corco to operate a $ 4 million petrochemical plant with an annual production of 30 million gallons of cyclohexane which is an important raw material for nylon. Some of this output is marketed in Western Europe by a Royal Dutch Affiliate.

Hercor Chemical Corporation, jointly with Corco, has constructed a plant with 100 million pounds of paraxylene capacity which is to be substantially expanded. The paraxylene is for export to the U.S.

Pittsburg Plate Glass Co., jointly with Corco, is constructing an ethylene plant. The bulk of production is intended to service other satellite plants which are to be established.

Styrochem, a subsidiary of Corco, operates an ethyl benzene plant and plans a styrene plant.

W.R. Grace Co., in a joint venture with Corco, is building an oxo-alcohol plant.

Carribean Gulf Refining Co. operates a refinery and plans expansion. Puerto Rico Chemical Co., a subsidiary of Hooker Chemical, produces phthalic anhydride and plans production of polyvinyl chloride. Union Carbide produces ethylene, propylene, acetylene, butadiene together with a number of other intermediates and is planning expansion. Phillips P.R. Core Inc., a subsidiary of Phillips Petroleum, operates a large core plant with facilities for producing benzene, cyclohexane, together with other intermediates and has attracted Fibers International Corporation to produce nylon. Reichhold del Caribe operates a vinyl acetate emulsion plant.

In association with the petrochemicals enterprises projects are being discussed to produce: copper from sulphide ores which are found in Puerto Rico and from which sulphur is to be recovered for the production of sulphuric acid; caustic and chlorine electrolytically.

The Puerto Rico Economic Development Administration has announced[1] that it expects the Chemical and Allied Products Industry to invest about $ 1.5 billion in Puerto Rico over the next 10 years.[2]

Dr. H.C. Barton, Director of the Office of Economic Research in Puerto Rico's Economic Development Administration in 1957 presented[3] a paper entitled Puerto Rico's Industrial Future and his discussion centred around figures which had been prepared in relation to the year 1955, i.e. some 14 years ago (See Table 7). His paper deserves attention in that, written at a time when petrochemicals showed only tentative signs of development it indicates some of the concepts that lay behind the planning. The key estimate was in the first line where reference is made in this planning review to 6 refineries. This was a major assumption since at that time there were only two refineries in operation in Puerto Rico. One was small with an outlook for expansion that was distinctly limited - "nothing in the present nature of this refinery operation that would lead one to believe that any substantial expansion of oil refining was economically feasible for Puerto Rico". The view about the other refinery was quite different because substantial expansion was already planned in order to bring the Corco refinery

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1/ The Chemical and Allied Products Industry in Puerto Rico, Economic Development Administration, Puerto Rico, July, 1969.

2/ The chief incentives offered by Puerto Rico include:
(a) Tax exemption:
A qualified chemical manufacturer can qualify for tax exemption for 10, 12 or 17 years from all Commonwealth taxes and resident stockholders are exempt from taxes on dividends during the exempt period of the operation.
(b) Industrial sites and financing
Buildings which house operations may be available on lease.
(c) Training
A special programme has been organized to help meet the need for specific skills.

3/ Puerto Rico's Industrial Future, by H.C. Barton, presented at Sixth Meeting of the Puerto Rican Economics Association, Feb., 1957.

up to a large enough size so that its output of refinery gases would be large enough for an efficient petrochemical operation. Other information which the Economic Development Administration had at that time was that Union Carbide would build a plant to use the refinery gases from Corco to manufacture ethylene glycol and that Union Carbide (or other interests) planned to build a second plant which could presumably process the ethylene glycol.

The Economic Development Administration had now come to the conclusion that purposeful and optimistic planning for expansion on the grounds that that there was a "natural" advantage for petrochemicals. The view was based on the circumstance that there was an imbalance in the complementary demand in Western Europe and in the U.S. for petroleum products. The demand in the U.S. was growing more rapidly for motor fuels (due in part to a liberal tax policy and emphasis on travel) than for fuel oils (due in part to competition from natural gas and coal). In Europe the demand was growing more rapidly for diesel and fuel oil (due in part to Europe's limited coal resources and to the post-war industrial boom) than for motor fuels (due in part to high taxes on motor fuels and to the fact the Europe's post-war prosperity had not yet been fully reflected in the upsurge in motor and other travel which was later to come).

Based on this situation, the Economic Development Administration argued that new refineries within the U.S. tax boundaries would need to sell some of their fuel oil to Europe. The cost of exporting reduced the comparative disadvantage of refining in Puerto Rico vis a vis refining on the mainland. Having assumed that the refineries could be attracted to Puerto Rico, the Economic Development Administration set out to persuade the appropriate interests that petrochemicals were a natural supplement which could and should follow.

Since the petrochemicals industry was heavily capitalized and largely financed with borrowed funds at fixed rates of interest income tax charges would intimately affect net profits. Looked at in this light, they argued, location of petrochemicals in Puerto Rico would, because of exemptions from property and income tax, hold out great attractions for the investor. In consequence, the reasoning ran, financing the petrochemicals projects could enhance these advantages still further by re-investing profits in new tax-free enterprises in Puerto Rico. It was along these lines that the argument ran and that Barton, discussing 1965 figures, when only one small and one potentially large refinery had been established, observed:

> "These findings, together with recent promotion experience, lead us to believe that ... we may get as many as 6 refineries and 6 petrochemical plants during the next 9 years .... There will be a strong incentive for the owners of the first refineries and petrochemical plants to re-invest their early profits in new tax-free enterprises ...."

It is clear that a major force in this development of petrochemicals production in Puerto Rico is the policy and influence of the first core of activities. One might make special reference to Corco which was the first core company, which was incorporated in 1953 and which was capitalized at 240,000 dollars. In 1966 the capital was 6 million dollars and par value shares increased from 2 cents to 5 dollars. The share capital further advanced in 1967 to 100 million dollars.[1] It may be noted in passing that the chairman of the Company was Mr. T. Moscoso whom many regard as one of the chief architects of Puerto Rico's modern economic development.

A further commentary on the achievement of Corco is that it signed an agreement[2] in 1967 with the Instituto Venezuelano de Petroquimica (IVP - the Government agency) for the development of a large petrochemicals complex in Venezuela. This seemed likely to give a fillip to production of petrochemicals in Venezuela.

1/ Weller Skinner's Oil & Petroleum Year Book, 1968

2/ World Petroleum, Jan. 1968, p. 25.

In summary it can be said that the Economic Development Administration based its promotional activity relating to petrochemical expansion on three main selling points:

(a) tax and related incentives in Puerto Rico;

(b) establishment in Puerto Rico of refineries in whose success depended on:

(i) sale of motor fuels in the U.S.

(ii) sale of fuel oils in Europe;

(c) encouragement to re-invest profits from refineries in petrochemical expansion.

Trinidad[1/]

Trinidad's oil production is small by world standards. Nevertheless, refining commenced in the 1920's, almost as early as the beginning of commercial production of crude. In 1968 there were 3 refineries:

(a) one 350,000 b/d operated by Texaco Limited

(b) one 5,000 b/d " " " "

(c) one 70,000 b/d " " Shell Trinidad.

There was in addition one batch still (50 b/d) operated by B.P. (Trinidad) Limited.

In the early stages the first petrochemicals evolved simply as by-products of the refinery. The first were crude naphthenic acids recovered from the lye liquor, used for treating gas oils. In order of appearance sulphur was next and came to be produced in quantity from refining operations when one refinery decided to help meet its need for sulphuric acids by constructing a Claus Kiln and recovering sulphur from hydrogen sulphide in the refinery gases. Capacity for other processes followed including: catalytic cracking, reforming, alkylation, isomerisation, polymerisation. The petrochemical products include: norenes, dodecenes, benzene, tolene, xylenes, aromatic solvents, normal paraffins, di-isobutylene and cyclo-hexane.

1/ Sources of much of this information are: The Petrochemical Industry of Trinidad & Tobago by D.H.N. Alleyne, E.L. Bertrand and revised by L. Lister.

Natural gas began to be used for the production of ammonia in Trinidad in 1959. The enterprise deserves special mention because of its initiating in Trinidad a petrochemical industry as distinct from refining activities, a distinction which, admittedly, is one with less and less difference.

Nitrogen:

At the beginning of this decade both the consumption and the production of nitrogeneous fertilizers were largely concentrated in the more highly developed economies. There were, however, indications that, with the spread of information, the sharpest rising trends in consumption would be in those areas of the world with large populations and low yields in agriculture. Two thirds of the world's population in the developing countries consume under 15 % of the chemical fertilizers; the other third of the world's population in the more industrialized countries consume 85 %. The nitrogeneous fertilizers have been showing a faster growth rate than the other two chemical fertilizers - phosphate and potassium.

Up to the 1930's processes based on coal provided about 90 % of the world's ammonia and electrolytic hydrogen most of the rest. Because of advantages of cost, hydrogen is increasingly derived from natural gas and petroleum so that by the early 1960's about one third of the production of world ammonia was based on coal and the trend is for only about 10 % to come from that source by the 1970's. Some of the chief factors increasing dependence on natural gas and petroleum are: improvements in technology, (e.g. more efficient catalysts), improvements in transportation and storage (including sea-going refrigeration tankers), economies of scale achieved in larger plants. Nitrogen production calls for capital intensive processes and fixed charges (including depreciation of 10 % plant investment costs and 10 % for interest on capital, insurance, taxes) account for about 40 % total manufacturing costs.

In this context Grace began expansion in nitrogen , announced plans for an ammonia and urea plant in Tennessee, to be followed by nitrogen ventures in West Texas, North Caroline, the Mid-West, Trinidad and Puerto Rico. The Trinidad project came about after a market research and development team of engineers and economists made surveys in the Caribbean. A subsidiary was established, Federation Chemicals with Grace owning 49% of the equity, the rest owned by institutional investors.

Some of the attractions offered by Trinidad were known reserves of "hundreds of billions of cubic feet"[1/] of natural gas with new explorations disclosing new supplies; the low price of natural gas made it possible to produce ammonia at $ 10 to $ 20 cheaper than on site production in Carolina and cheaper than in the Middle East (See Table 8); Trinidad, with other units in the Caribbean, being heavy consumers of nitrogen fertilizers (particularly for cane) provided a basic domestic demand; the petroleum industry and its processing plants, long established in the island, made available a labour force having pertinent skills; Government incentive legislation[2/] included pioneer status. Construction on a plant (at Point Lisas, Trinidad) began in 1958.

1/ The Grace Log Fall Issue 1962

2/ Trinidad recognizes that it lacks one of the main stimuli for a growing petrochemical industry -- an appreciable home market for the products. In the circumstances the Government has introduced various institutional measures to help the expansion of the still only burgeoning activities and these measures include:

(1) extension of the date on which the income tax holiday commences to 4 years after the construction of the factory;

(2) exemption for 10 years from customs duty on material used for constructing or equipping the factory;

(3) a 10-year income tax holiday;

(4) exemption from export duty on the petrochemicals manufactured

(5) exemption from customs duties on supplies not manufactured locally;

(6) exemption from income tax of interest received on certain loans to petrochemical manufacturers;

(7) the right to compulsory acquisition of a "right of user" of land, relating to the manufacture of an approved chemical.

In the third year of operation Grace decided to exploit Trinidad's location in relation to world markets, constructed what was then the largest single train ammonia plant in the world (235,000 t/y), brought into use the world's first sea-going ammonia refrigeration tanker and embarked on what was now primarily an export oriented programme. To complement the Trinidad operation a major terminal, storage and conversion facility was built at Wilmington (North Carolina) to receive imports of ammonia to be sold directly, converted to ammonium nitrate, calcium ammonium nitrate and other nitrogenous compounds.

In 1967 the project increased its natural gas consumption by 40% over 1966 and in 1968 by 14% over 1967 and the output of anhydrous ammonia from 209,000 short tons in 1965 to 501,000 tons in 1968. The plant now has a rated capacity of 540,000 tons of anhydrous ammonia.

The cost of producing anhydrous ammonia is closely associated with size of plant. Thus, a steam reforming natural gas plant with gas costing $ 0.20 per MCF and producing 100 t/d (equivalent to about 33,000 t/y) had a production cost (not including depreciation and interest on capital) of under $ 35 per ton. The corresponding cost in a 200 - 250,000 t/y plant was reduced to something like $ 10. This explains how it is that the cost of production of anhydrous ammonia in Trinidad's 500,000 t/y plant "can be regarded as one of the world's lowest".1/

The production and export data on nitrogenous products for 1966 - 1967 are shown (See Table 9).

1/ Economics of International Distribution of Anhydrous Ammonia, W.J. Haude, in Studies in Petrochemicals, Vol. II, UNIDO

The potential for natural gas-based petrochemical industries

In this section of the paper a strategy for the further development of natural gas-based industries is outlined. At the present time most of the oil fields under development in Trinidad are petroleum reservoirs of the solution gas drive type so that the total production of natural gas is largely dependent upon the level of crude oil production. The production of gas now stands at 410 million S.C.F. per day and this is utilised in the following ways:

	Per cent
Petrochemical manufacture	13.5
Power generation	6.5
Refinery and oilfield fuel	25.2
Re-injection into reservoirs	14.4
Flared, vented or otherwise wasted	40.4
	100.0

Over the past six years there has been a steady increase in the quantity of gas produced although there have been signs within recent months that this trend is likely to be reversed. The amounts used for the manufacture of petrochemicals, as fuel and for secondary recovery purposes have, however, remained substantially constant. As a result, increasing quantities of gas remain unutilised. It is felt that, taking into account the problem of pressures and geographical location of sources, some 80 million cubic feet per day of the gas at present being wasted could be made available for industrial use.

The average composition of the natural gas produced in Trinidad is

	Volume, per cent
Methane	87.7
Ethane	5.6
Propane	4.5
Iso-Butane	1.1
N-Butane	0.3
Carbon dioxide	0.8
	100.0

Hydrogen, nitrogen and hydrogen sulphide are present in negligible quantities and the gross calorific value of the gas is 1150 Btu/cu.ft. It will be seen that the gas consists predominantly of methane and would therefore appear to be of limited use for the production of olefins and more complex hydrocarbons. Only 13.5% of the available gas is at present being consumed in the manufacture of petrochemicals and this supports the following plants:

Ammonia	1465 tons/day
Ammonium sulphate	275 tons/day
Urea	220 tons/day

The production of these units is dedicated almost exclusively to the export market.

Future prospects

The prospects for further development in the petrochemical sector have been greatly enhanced by recent discoveries of substantial quantities of gas, condensate and oil off the South East coast of Trinidad by a major international oil company. This company has been engaged in exploration activities over the last [illegible] years within an area bounded by the 3-mile limit and the continental shelf. Several wells have still to be drilled prior to any meaningful estimation of oil, natural gas or condensate reserves in this new field but the present evidence appears to indicate a potential daily production of at least 600 MMSCF of gas and [illegible]000 barrels of condensate by 1972. This is in addition to black oil production which would itself result in additional supplies of associated gas. Most of the gas discovered is found in condensate reservoirs and the estimates assume that 50% of the gas produced would be recycled and returned to the formation in order to improve the efficiency of recovery of the valuable condensate liquids.

Because of the limited insular and regional markets, any petrochemical development based on these new gas reserves must, of necessity, be oriented towards extra-regional export markets. This factor has dominated and will continue to dominate the development of the local petrochemical industry.

Possible strategy for utilisation of gas

The optimal strategy for the utilisation of East Coast gas is to have it brought ashore in sufficiently large quantities for

(a) Use as a fuel and, in particular, for generation of low-cost electricity (of the order of 3-4 U.S. mills/kwh) for aluminium smelting, caustic soda manufacture and a petrochemical industry;

(b) Manufacture of methane-based chemicals such as ammonia, nitric acid, ammonium nitrate, urea, methanol, formaldehyde and resins, and

(c) Liquefied Natural Gas (LNG) manufacture.

All gas produced should be stripped of its ethane and propane content for use as cracker feedstock. Based on this strategy, the core plant would be a cracker and other key units would be an aluminium smelter, an electrolytic caustic soda plant and a polyvinyl chloride (PVC) unit.

The cracker should have a capacity of at least 1.2 million tons/annum. Such a large unit is required in order to achieve maximum economies of scale and surmount the high tariff barriers which exist in the major export markets. The plant must, of necessity, be a low cost producer and would form the basis for the manufacture of PVC, polyethylene and polystyrene from ethylene, acrylonitrile from propylene and polyisoprene and polybutadiene rubbers from butylene and butadiene.

Present and estimated future prices of a selected number of relevant products are given below:

	Prices, U.S. cents/lb	
	1969	1975-80
Ethylene	3.5	3
Low density polyethylene	12.5	8
High density polyethylene	16.5	12
Polyvinyl chloride	10.5	9
Styrene	7.75	7
Polystyrene	14.5	13
Polypropylene	20.5	15

This emphasises both the sharp downward trend in prices as well as the need for maximum economies of scale. Only a very large cracker should produce ethylene sufficiently cheaply to meet such prices.

Feedstock for the cracker would be

(a) ethane and propane stripped from natural gas,
(b) condensate and
(c) naphtha from existing refineries.

The caustic soda plant should have a minimum capacity of 300,000 tons/annum. Estimated annual CARIFTA demands for caustic soda are

1969	100,000 tons
1972	310,000 tons
1975	410,000 tons

Almost the entire production of caustic soda would be used in alumina manufacture while the by-product chlorine (in conjunction with ethylene from the cracker) could be reacted to produce ethylene dichloride and hence PVC.

Electrochemical industries - Use of natural gas as an energy source

The most economically significant use of the natural gas lies in the generation of low-cost electricity for reduction of alumina and the production of electrolytic caustic soda. An electrochemical industry - and particularly the manufacture of caustic soda, chlorine and aluminium - is largely dependent upon the availability of low cost power, a product of cheap natural gas.

Caustic soda plant

A large and growing market for caustic soda exists in the CARIFTA region because increasingly the bauxite companies in Jamaica and Guyana are processing their bauxite into alumina. This operation requires large quantities of caustic soda (0.08 tons per ton of alumina for the trihydrate type bauxite available) which are at present being imported. For every ton of caustic produced by the electrolytic process, 0.88 tons of chlorine and 0.025 tons of hydrogen are produced.

Contrary to trends in the industrialised countries, the demand for chlorine in the developing countries is much less dynamic than that for caustic soda. In the CARIFTA region this problem is aggravated even further by the potentially large captive market for caustic in the processing of bauxite to alumina. An insular market must therefore be found for large quantities of chlorine if a plant designed to supply the regional requirements for caustic soda is to be economically viable. As suggested earlier, a unit utilising chlorine for the manufacture of PVC would satisfy this need as well as consume ethylene produced by the cracker.

The present total annual production of alumina in Jamaica and Guyana is 1.2 million tons and the caustic requirement for this output is [illegible],000 tons. Allowing for imports into Trinidad and other territories, the present CARIFTA demand for caustic soda is estimated to be 100,000 tons per year. Significant progress has been made in the planning and construction of three new alumina plants (with a total additional capacity of 2.[illegible] million tons/year) in Jamaica. On this basis and assuming that no additional alumina capacity is constructed in Guyana, the CARIFTA demand for caustic soda in 1972 is expected to be 210,000 tons/year. If all the bauxite produced at present in Jamaica and Guyana (10 million tons/year) were to be converted into alumina, there would be a regional demand for caustic soda of 410,000 tons/year.

The economic viability of a caustic/chlorine plant is also dependent upon the availability of cheap electricity. The existence of a cheap and abundant source of natural gas can result in extremely low electricity rates.

Aluminium Smelter

One of the major deterrents to the installation of aluminium smelting capacity in the region is the unavailability of low cost electric power. More than is the case with any other widely used metal, the production of aluminium is highly intensive in its consumption of electricity. Present typical operating practice requires some 17,000 kilowatt hours to smelt a ton of metal, so that a difference in the price of electricity of only one mill per kilowatt hour is equivalent to about $ 17 per ton of aluminium.

Under best practice figures as low as 14,000 - 15,000 kwh per ton of metal have been achieved. Allowing for conversion and step-down losses of 5%, normal scheduled maintenance and unscheduled outages, it will be seen that a about [illegible] of generating capacity is needed to support a ton of smelter capacity.

While, in general, conventional thermal power cannot attain the low costs of the cheapest hydroelectric power, advantages of location may offset the higher energy costs. Moreover, inexpensive fuel sources could be used to generate thermal power at prices attractive to the aluminium industry.

Economics of power generation

The power requirement of a 300,000 tons/annum electrolytic caustic soda plant is 130 MW while that of a 200,000 tons/annum aluminium smelter (converting only 8% of the present regional production of bauxite) is 400 MW. The power requirement for additional petrochemical units can also be conservatively estimated at 70MW. It will be seen, therefore, that the total complex would require the entire output of a generating plant of 600 MW. Efficient generating plants now tend to run to this size or larger. Present trends indicate that conventional natural gas-burning steam generating plants of this capacity can be built for about $ 89 per kw in the early 1970's.

The two principal components of cost of generation - fixed charges and operating costs - may be summed together as follows: (1) fixed charges of 15 per cent, (2) capital cost of $ 89 per kw, and (3) 90 per cent plant factor, which combination implies 1.7 mills per kwh fixed charge, and (1) existing fuel costs of 9.8 cents per million Btu, (2) 8,000 Btu per kwh heat rate (this combination equal to fuel costs of 0.8 mills per kwh), and (3) other operating costs of 0.3 mills for 1.1 mills per kwh operating costs or a total cost of 2.8 mills per kwh. The table below shows the relation between fuel costs and thermal efficiency.

Cost of Fuel →		Thermal Efficiency in Btu per [illegible]			
Cents per 1000 cu. ft.	Cents per million Btu	10,000	9,000	8,000	7,000
		Fuel Cost in Mills per kwh			
1	0.87	0.09	0.08	0.07	0.06
5	4.35	0.44	0.39	0.35	0.30
7.5	6.52	0.65	0.59	0.52	0.46
10	8.70	0.87	0.78	0.70	0.61
12.5	10.87	1.09	0.98	0.87	0.76
15	13.04	1.30	1.17	1.04	0.91
20	17.39	1.74	1.56	1.39	1.22
25	21.74	2.17	1.96	1.74	1.52
30	26.09	2.61	2.35	2.09	1.83

It is clear, therefore, that even with prices of gas as high as 28 cents/MCF the cost of power is likely to be less than 4 mills/kwh. In this context it is almost certain that the existing gas price of 11.25 cents/MCF will fall considerably as a result of the exploitation of the new reserves. A 600 MW generating plant operating at a thermal efficiency of 9,000 Btu/kwh will require 100 million cubic feet of gas per day.

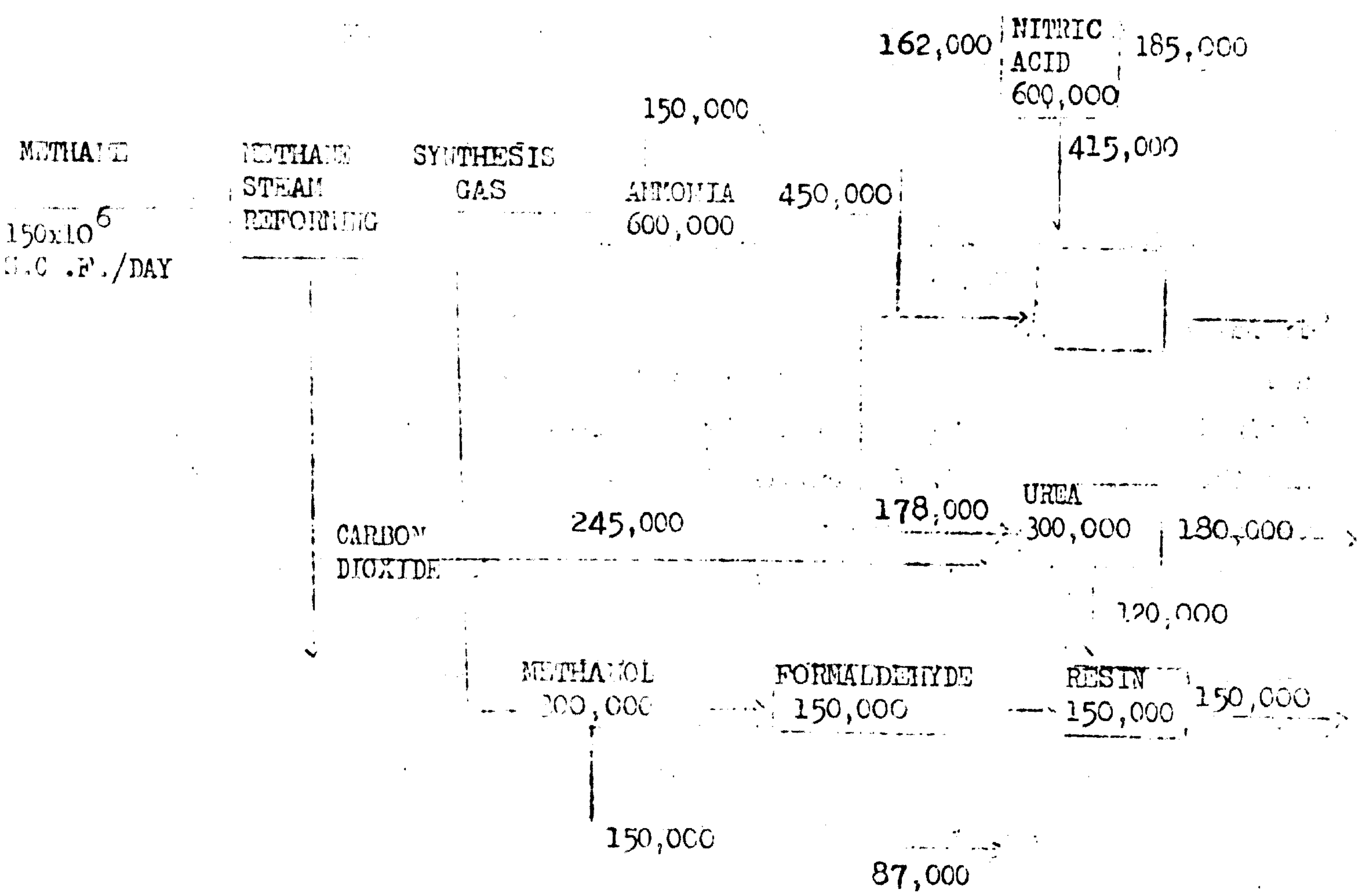
Manufacture of Natural Gas-based Petrochemicals

The high proportion of methane (nearly [illegible] per cent in this case) in natural gas normally restricts its use for the supply of energy as a fuel or as a raw material for a limited number of petrochemicals (principally the derivatives of synthesis gas-notably ammonia, methanol and their end products). The current disfavour towards acetylene eliminates an important outlet for natural gas.

As previously indicated, the optimum strategy for the utilisation of East Coast gas calls for the separation of ethane and propane for the production of ethylene by pyrolysis. Under these circumstances there are two possible alternatives for the utilisation of the residual methane:

(a) Extending the production capacity of the existing range of natural gas-based petrochemicals or

(b) Implementing the following gas-based complex
(figures are given in tons/annum



The plant capacities indicated allow for maximum economies of scale using existing technology and the total gas consumption would be approximately 150 million SCF/day. All the products have good market potential. An important consequence of the maximization of economies of scale is that the contribution to unit production cost of raw materials - on which Trinidad can claim a comparative advantage - is high.

<u>Manufacture of Liquefied Natural Gas (LNG)</u>

For obvious reasons the manufacture of LNG has the lowest priority. However, this operation will utilize surplus gas produced after the requirements as an energy source and for petrochemical manufacture have been fulfilled. The capacity of the liquefaction plant would therefore be approximately 300 million SCF/day.

Reserves of natural gas within the U.S.A. are estimated to be of the order of 7 years and an attractive future can be predicted for imports of LNG in the context of short supplies of sulphur-free fuels and the anti-pollution regulations. The expected production of gas from the East Coast is so large that an export oriented LNG plant offers the only other major possibility of sufficiently sizeable consumption. In particular, the Eastern seaboard of the U.S.A. appears to offer a good market for Trinidad produced LNG. One of the major competitive advantages over traditional suppliers would, of course, be lower transport costs. Estimates of value added in LNG manufacture are:

Gas to plant site	10 cents/MCF
Cost of liquefaction	15 cents/MCF
Transport	13 cents/MCF

<u>Cracking Unit</u>

Ethylene can be regarded as the key building block for petrochemical manufacture. In general, it is not available in sufficient quantity from waste refinery gases so that it has to be produced by operations specifically designed for its synthesis - i.e. cracking. The usual starting points for ethylene are ethane, propane and liquid hydrocarbons.

In a situation such as exists in Trinidad - i.e. where considerable quantities of natural gas exist in excess of the local demand for fuel - it becomes an economic proposition to recover ethane and propane from natural gas for use as cracker feedstock for the production of ethylene. This hardly affects the usage or value of the stripped gas and the cost is therefore the equivalent of methane plus the cost of extraction. The gas volumes involved are sufficient to justify the manufacture of ethylene and its derivatives. For example, vinyl chloride manufacture from ethylene obtained from such cracking is more attractive than the acetylene route.

Additional ethylene production could come from the cracking of surplus naphtha and the East coast production of condensate. This condensate has a boiling range and composition which makes it an excellent feedstock for cracking.

THE NATIONAL COMPANY AND PARTICIPATION

The industry in the Caribbean is a part of the Latin American scene, certainly geographically. Political attitudes and philosophies cross national boundaries. Many of the Latin American countries, independent for over a hundred years, have for periods longer than in the case of any of the newly developing countries adopted nationally oriented policies to the industry and to the international companies involved. As early as the years immediately following the First World War some of the Latin American countries (e.g., Argentina, Bolivia) were introducing controls on the industry relating to supply and distribution. In the late 1930's Mexico expropriated the assets of its international firms. In the 1940's Venezuela negotiated its concessions along lines which became a pattern for many other major producers in the late 1950's and 1960's.

While many parts of the world have looked to coal and other sources of energy in their present and/or past, oil has always been the chief fuel in Latin America. Thus consumption, while in the 1960's about the same as in the 1930's in the case of coal, has increased tenfold in the case of oil. With oil so intermingled with the course of economic development in countries influenced in much of their political thinking by the socialist movements in Western Europe, political policies, in many instances, continued to urge modification of the maintenance of oil activities in the private sector. There has, therefore, been and continues to be general agreement over a wide spectrum of political opinion as to the need for more control of the companies' activities. Different countries, at different times, have implemented these attitudes in different ways. The developments most relevant to this issue, as far as the present paper is concerned, are those which have recently taken place in Trinidad.

In mid-1968 BP announced that it would curtail its operations in Trinidad, attributing this decision mainly to declining reserves and high production costs. Presumably, one of the reasons for higher costs was that, unlike Texaco and Shell, BP operated no marine wells.

As pointed out earlier, marine yields are much higher (about 250 b/d compared with 30 b/d for the land wells). BP, while continuing in production, drilled no new wells after early 1967. It attempted, without success at first, to sell its onshore properties. After some negotiation the Government agreed to purchase BP's assets (45 % in cash, 55 % by deferred payment in crude). The Government then set up a state oil company to be operated in conjunction with the Texas Petroleum Corporation (Texas). The two, on a basis of 50 : 50 ownership agreed on plans for development operations, both in petroleum and petrochemicals.

A question which, therefore, is receiving attention, not only in the Carribean, is: if some modification of relationships is requisite and if one innovation is to be a national company, what kind of policy should host Governments try to implement in order to secure optimum returns in the long and short run? A contribution to this discussion has been, among others, the paper[a] "Participation versus Nationalization, a better means to survive" by Mr. Yamani and the discussions which followed at the Beirut Seminar (May 1969) and at OPEC's eighteenth Converence[b] in Vienna (July 1969).

In the Yamani submission participation is taken to mean participation by the national oil companies (of the host countries) in the operation of the major international oil companies: upstream in the producing operation and downstreams in the market. His thesis is that participation is a better and preferable alternative to nationalization. Nationalization adversely affects the exporting countries in the sense that the major international companies have in the past and present succeeded in maintaining crude prices in the consumer market. With the spreading of nationalization there would be little incentive to fight for the maintenance of crude prices. On the contrary,

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a Middle East Economic Survey, Vol. XII, No. 33, 13 June, 1969, pp., et seq

b Petroleum Press Service, August 1969 pp 282 et seq the interests of the oil companies would then be identical with those of the importing countries, i.e. to pay as low prices as possible for crude. The [illegible] points in this argument are:

(1) The producing countries, in the interest of orderly marketing need to support the general framework of the world price structure. The production end is the chief source of profit of the oil companies. Since the taxable profits of the companies are calculated on posted prices and since, due to conditions negotiated over time by the host Governments, the companies cannot easily reduce posted prices, the cost of discounts on the market has to be met by the companies, not by the producer countries. The companies, therefore, have an interest in maintaining the stability of world crude prices.

(2) The purpose of participation is not to increase prices at the present time because if this were the purpose there would be other and less complicated methods. The purpose is to endeavour to maintain stability in the future of prices of the products marketed by the national companies. Since the existence as well as growth in number of national oil companies is a reality, participation downstream is desirable if the growth of the national oil companies is not to be hurt, both themselves and the industry as a whole.

(3) An alternative to participation is nationalization. The more nationalization there is, the more the international companies would lose incentives to maintain prices for the national producers. The national companies would, progressively, have interests identical with those of the consumers: to purchase the industry's products from the producer countries at as low a figure as possible. The producer countries, as far as world markets are concerned, would be driven to price cutting and price wars.

(4) Participation with the national companies upstream is also desirable since participation by the international companies in exploration and producer operations discourages them from efforts to depress crude prices.

The international oil companies seem to view these proposals with reservation.[a] They question whether there is much which the national company has to offer in this arrangement. One possible contribution might be capital but this is not a commodity with which the producer countries are generously supplied. The state partner, even if able to supply capital, could help little with the expansion of the downstream operations because it is the problem of markets that have prompted proposals for participation. Participation could provide problems of logistics for the international company which is endeavouring to minimize its refining costs by using crudes of different types to meet the specific demands of its different markets.[b] Another comment from the point of view of the international companies is that, if the advantages of downstream participation prove unattractive and if non-acceptance involved a loss of their producing interests, then one compensation would be lower prices for crude.

This dialogue has much relevance to the future policy of national companies such as the one established by the Government of Trinidad and Tobago.

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a Petroleum Press Service, Aug. 1969 , p.2[illegible].

b "The Role of OPEC in Changing Circumstances" by Prof. Edith Penrose, Eighteenth Conference of OPEC, Vienna, July 1969.

S U M M A R Y

In this survey paper, information is given on the petroleum and petrochemical industry in the Caribbean. Caribbean is taken to encompass the island territories and not Venezuela. Data are included in relation to reserves, production of crude, natural gas, location and size of refining plants, petrochemicals.

Three points which, each in its way, have special relevance to the development of the petroleum and petrochemical industry in the Caribbean are discussed briefly but separately:

(1) Petrochemicals in Puerto Rico.

The International Petroleum Encyclopedia states that Puerto Rico's petrochemical facilities make it the petrochemical capital of Latin America. A description is given in some detail of the background of the petrochemicals enterprises in Puerto Rico and reference is made to the type of planning and philosophy which contributed to the development.

(2) Potential for natural-gas-based petrochemical enterprises.

This section bears special relation to Trinidad where, it is announced, there have been finds of large natural gas reserves. The potential for developing natural gas resources is discussed and some of the chemical engineering considerations are examined.

(3) The National Oil Company.

The National Oil Company has made its appearance in several oil producing countries. One has recently been established in Trinidad. The policy of these national companies is receiving much thought from both the host countries and the international companies. The proposal that the national and international companies should endeavour to "participate" in downstream and upstream operations as a better alternative to nationalization has has recently been made. The sponsors of the proposal are members of OPEC. Both there and elsewhere the subject is receiving lively attention. Because of the possible implications for policy of the

national oil company in the Caribbean and elsewhere reference to the subject was included in the present paper. The question of policy in the national company should repay a fuller and more comprehensive examination especially in regard to the policy and achievement of some relevant national oil companies.

Table 1

Petroleum Reserves and Crude Oil Production, Latin America[a]

Latin America and Caribbean	Estimated Petroleum Reserves Jan., 1968 (000 bls.)	Crude Production 1968 (000 bls.)	Reserves: Production Ratio
Argentina	2,950,000	123,075	24
Bolivia	500,000	14,550	34
Brazil	1,100,000	59,818	18
Chile	150,000	13,696	11
Colombia	2,000,000	65,251	31
Cuba	1,000	146	7
Ecuador	310,000	2,049	151
Mexico	2,708,000	141,960	19
Peru	500,000	27,668	18
Trinidad	525,000	66,905	8
Venezuela	15,955,000	1,311,050	12

[a] See Twentieth Century Petroleum Statistics, June 15, 1969 Degolyer and Mac Naughton, Texas.

T A B L E 2

Crude Oil Production in Latin America

Crude Oil Production in Latin America and Trinidad, 1940–
Annual Production (million tons)

	1940	1950	1955	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Argentina	2.3	3.2	4.2	[illegible]	6.6	[illegible]	[illegible]	13.4	13.3	13.7	13.5	14.3	16.4	
Bolivia		0.1	0.4	0.5	0.4	0.5	0.4	0.4	0.5	0.4	0.5	0.8	1.3	
Brazil		0.1	2.3	2.6	3.2	4.0	4.8	4.6	4.9	4.5	4.7	5.0	7.3	
Chile		0.1	0.4	0.8	0.9	1.0	1.3	[illegible]	1.8	1.9	1.7	1.7	1.8	
Colombia	3.5	4.6	5.5	6.4	7.2	7.6	7.3	7.1	8.3	8.6	[illegible]	9.8	9.8	
Cuba														
Ecuador	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	
Mexico	6.0	9.9	12.5	13.8	13.2	13.5	14.6	15.3	15.7	15.8	16.1	16.6	18.4	
Peru	1.7	2.0	2.3	2.5	2.4	2.1	2.6	2.6	2.9	3.1	3.1	3.1	3.4	
Trinidad	3.0	2.8	3.4	5.1	6.0	5.8	[illegible]	6.7	6.6	6.8	6.7	7.6	9.3	
Venezuela	25.4	74.9	107.9	[illegible]	138.6	142.3	146.0	[illegible]	162.4	169.6	173.0	168.5	173.4	
Total	42.7	98.1	139.9	167.3	179.0	185.7	195.1	212.3	216.8	224.8	230.3	228.6	241.9	

TABLE 3

Trinidad's production of crude oil, land and marine output shown seperately[a]

	Production (million bls.)	% Total	Daily Average per Well
1965			
Land	29.5	60	28
Marine	18.1	37	216
Marine deviated from Land	1.3	3	41
1966			
Land	34.2	60	31
Marine	20.2	38	215
Marine deviated from Land	1.3	2	39
1967			
Land	39.7	61	36
Marine	24.1	37	229
Marine deviated from Land	1.2	2	36
1968			
Land	38.1	57	36
Marine	27.9	42	244
Marine deviated from Land	1.0	1	31

[a] Annual Review of Petroleum Development in 1967 in Trinidad & Tobago, Ministry of Petroleum and Mines, Government of Trinidad & Tobago.

TABLE 4

Natural Gas Production and Utilization, Trinidad and Tobago [a]

	1964 Millions Standard Cubic feet	1964 % total	1965 Millions Standard Cubic feet	1966 Millions Standard Cubic feet	1966 % total	1967 Millions Standard Cubic feet	1967 % total	1968 Millions Standard Cubic feet	1968 % total
Production	110,732	100.0	111,503	118,927	100.0	140,339	100.0	151,445	100.0
G.O.R. (scf/bbl)	2,227		2,282	2,138		2,159		2,264	
A. Used as fuel									
in refineries	20,499	18.5	22,714	25,257	21.2	28,304	20.2	29,257	19.3
in fields	5,979	5.4	6,677	8,208	6.9	7,783	5.6	7,848	5.2
in other industries	11,414	10.3	12,126	15,227	12.8	17,759	12.7	19,294	12.8
Sub total	37,892	34.2	41,517	48,692	40.9	53,846	33.5	56,399	37.3
B. Other complete utilization									
Used as process gas	4,222	3.8	4,502	6,714	5.7	9,309	6.6	10,603	7.0
Injected into formation	14,688	13.3	13,866	19,841	16.7	22,625	16.1	21,323	14.1
Converted into C.H.P.S.	210	0.2	206	219	0.2	204	0.1	173	0.1
Sub total	19,120	17.3	18,574	26,774	22.6	32,138	22.3	32,099	21.2
C. Vented									
After use of pneumatic energy	22,781	20.6	24,078	23,224	19.5	30,877	22.0	31,257	20.6
Without use	30,939	27.9	27,334	20,237	17.0	23,478	16.7	31,690	20.9
Sub total	53,720	48.5	51,412	43,461	36.5	54,355	38.7	62,947	41.5

a Developments in the Trinidad and Tobago Petroleum Industry - 1968. Ministry of Petroleum and Mines, Trinidad and Tobago

TABLE 5

Refining Plants and Capacity in the Caribbean, 1969 [a]

	Company	Type of Refinery	Capacity b/d Distillation	Cracking	Reforming	Crude Throughput (1968)
Antigua	West Indies Oil Co. owned by Natomas & Standard Oil (Ind.)	Distillation, Reforming, Bitumen	11,000		1,800	6,900
Bahamas	Bahamas Oil Refineries Co. owned by New England Petrol.(65%) California Standard (35%)	Distillation	200,000			To be completed, 1970
Barbados	Barbados Union Oil Co. & Mobil Oil Barbados	Distillation, Bitumen	3,000			2,400
Cuba	Shell da Cuba ECP Havana Santiago	Distillation Reforming	27,000 60,600 23,500		5,000	Not available 57,800 23,500
Dominican Repuplic	no refining recorded					No refining recorded
Jamaica	Esso West Indies Ltd.	Distillation Reforming Bitumen	28,000		2,800 C	28,000
Martinique (proposed)	Compagnie de Raffinage des Antilles	Distillation, Reforming Hydrocracker	10,000			To be completed 1970
Netherlands Antilles	Lago Oil & Transport Co., Aruba	Distillation, Visbreaking, Cracking	460,000	300,000 T 44,000 C		440,000
	Shell Curacao	Distillation, Cracking, Reforming, Lubricating Oils, Bitumen	300,000	114,000 V 35,000 C		
	Shell Curacao (proposed)	Distillation, Hydrocracker	74,000			To be completed 1970
Puerto Rico	Caribbean Gulf Refining Corp.	Distillation, Cracking, Reforming, Bitumen	40,000	8,500 C	6,000 C	38,000
	Commonwealth Oil Refining Co.	Distillation, Cracking, Reforming, Visbreaking	115,000	36,000 C	7,500 C	95,000
Trinidad	Shell Trinidad Ltd.	Distillation, Reforming, Bitumen	60,000		6,000 C	80,000
	Texaco Trinidad, Pointe a Pierre	Distillation, Cracking, Reforming, Visbreaking, Lubricating Oils	350,000	28,000 C	25,000 C	350,000
	" " , Brighton	Distillation	6,000			5,000
Virgin Islands	Hess Oil, Virgin Islands Corp.	Reforming	160,000	15,000		1[illegible],000

[a] World Petroleum Report '69, pp. 52 *et seq*

Petroleum Times, Jan. 3, 1969, pp. 70 *et seq*

Papers of Ministry of Petroleum and Mines, Trinidad & Tobago

Table 6

Products per Barrel of Crude in Trinidad, 1963 and 1967[a]

Product	1963 per cent	1967 per cent
Liquified Petroleum Gases (Butane and Propane)	0.09	0.23
Motor Gasolines	15.29	14.13
Aviation Gasolines	0.82	1.15
Aviation Turbine Fuels	6.39	8.38
Kerosines	1.59	2.81
Gas/Diesel Oils	16.76	14.01
Fuel Oils	55.37	54.00
Lube Oil/Greases	nil	0.90
Bitumen	0.25	0.20
Petrochemicals	0.21	0.20
Other Products	0.05	0.03
Gas and Loss	3.18	3.04
Total	100.00	100.00

a Third Five-Year Plan, 1969 - 1973, Government of Trinidad and Tobago

Table 7

Puerto Rico's Economic Development Administration's Forecast in 1965 of Refineries which would, in turn, beget Petrochemical Projects[a]

	Net Income ($ millions)	Capital ($ millions)	Employment (thousands)
6 large refineries	144	600	6
6 directly related Petrochemical or Power Plants	144	600	6
3 related Fibre or Plastic Plants	32	100	3

[a]Puerto Rico's Industrial Future by H.C. Barton, Jr., presented at the Sixth Annual Meeting of the Puerto Rico Economics Association, Feb., 1957.

Table 8

200,000 [illegible] Ammonia Production by Natural Gas Steam-Reforming

	Plant erected in		
	Trinidad	Middle East	
Investment ($ million)[a]	23.5[b]	28.0[c]	
Variable charges[d]	1,500 10^6 $	1,500 10^6 $	
Fixed charges[e]	5,400 10^6 $	7,150 10^6 $	
Manufacturing cost	6,900 10^6 $	8,650 10^6 $	
Mean ex-factory price	$ 34.5/ton		
Selling price			$ 43.2/ton
		Case 1[h]	Case 2[i]
Net cash flow at 20%[f] of total investment	4,700		
Net cash flow at 20%[g] of equity			
Depreciation provides	2,940	1,850	1,850
Net income after taxes		1,150	1,150
Net income before taxes at 50%			700
	1,760[h]	700	1,400
Manufacturing cost	6,900	8,650	8,650
Ammonia sales	8,660	9,350	10,050
Ammonia selling price	$ 43.3/ton	$ 46.7/ton	$ 50/ton

[a] Including [illegible] units, off-sites and start-up expenses.

[b] Quoted as non-financed plant, taking only into account additional investment owing to distance from suppliers of materials and equipment and shortage of skilled labour.

[c] Quoted as financed plant.

[d] Based on natural gas priced at $ 2/$10^3 m^3$.

[e] Based on depreciation at 12.5 per cent, interest at 3.5 per cent, maintenance at 4 per cent, general plant overhead at 2 per cent, taxes and insurance at 1 per cent.

[f] Return required for a five-year payout on total investment.

[g] Return required for a five-year payout on equity capital only.

[h] Not taxes on benefits are included.

[i] Including taxes on benefits.

Table 9

Natural Gas Consumption in the Fertilizer Industry Production and Exports of Nitrogenous Fertilizers

Trinidad and Tobago [a]

	1967		1966	
Natural gas Consumption (million cf)				
Feedstock	9,309		6,714	
Fuel	7,839		5,579	
Total	17,148		12,293	
Product manufactured (Short tons)	Production	Exports	Production	Exports
Ammonia	426,133	399,485	270,271	232,336
Ammonium Sulphate	82,755	63,302	82,206	74,804
Urea	75,230	74,165	65,897	64,277

[a] Annual Review of Petroleum Development in 1967 in Trinidad and Tobago, Ministry of Petroleum and Mines, Government of Trinidad and Tobago.

T A B L E 10

Petrochemical Plants in the Caribbean, Aug., 1968 [a]

Company	Product	Capacity	Stage reached
Jamaica			
[illegible] S.A.	Nitrogenous Fertilizer	60,000 t/y	planned
Netherlands Antilles			
Aruba [illegible] Industries N.V.	Ammonia	325 t/cd	in operation
	Urea	250 t/cd	" "
	Complex Fertilizers	500 t/cd	" "
Puerto Rico			
Caribe Nitrogen Corp.	Ammonia	41,000 t/y	in operation
	Sulphuric Acid	115,000 t/y	" "
	Ammonium Sulphate	145,000 t/y	" "
Commonwealth Oil Refining and W.R.Grace	Oxo Alcohols	125,000 t/y	completion 1970
	Phthalic Anhydride	35,000 t/y	" "
Commonwealth Oil Refining and Foster Grant Inc.	Styrene	200 000 t/y	completion 1970
	Ethyl Benzene	n.a.	" "
Commonwealth Petrochemicals Inc.	Benzene	104 million gal/y	in operation
	Toluene	10 " "	" " "
	Xylene	43 " "	" " "
	Orthoxylene	10 " "	" " "
	Aromatic solvents	10 " "	" " "
	Aromatic solvents	10 " "	" " completion 1969
Phillips Petroleum Co. and Rhone-Poulenc S.A.	Nylon 66		completion 196[illegible]
Hercor Chemical Corp. (owned by Hercules Powder Co. and Commonwealth Oil Refining Co.)	Paraxylene	70,000 t/y	in operation
	Paraxylene	50,000 t/y	completion 1969
Phillips Puerto Rico Core Inc.	Benzene	3,000 b/d	in operation
	Cyclohexane	3,000 b/d	" "
	Ethylbenzene	800 b/d	" "
	Paraffinic Fractions	9,500 b/d	" "
	Paraxylene	600 b/d	" "
	Orthoxylene	n.a.	

a/Source: World Petroleum, Aug. 15, 1968, p.67.

TABLE 10 (continued)

Petrochemical Plants in the Caribbean, Aug., 1968[a]

Company	Product	Capacity	Stage reached
Puerto Rico (contd.) P.P.G. - Corco (joint venture of P.P.G. Industries and Commonwealth Oil Ref. Co.)	Ethylene	500,000 t/y	1970
	Propylene	300,000 t/y	1970
	Butadiene	825,000 t/y	1970
Puerto Rico Chemical Co.	Phthalic Anhydride	24,000 t/y	in operation
	Phthalic Anhydride	24,000 t/y	completion 1968
Reichhold Chemical del Caribe	Polyester Resins		in operation
Shell and Commonwealth Chemicals	Cyclohexanol	30 million g/y	
Styrochem Corp. (subsidiary of Commonwealth	Ethylbenzene	48,000 t/y	in operation
Union Carbide Caribe	Ethylene Glycol	n.a.	in operation
	Alcohol Intermediates	n.a.	" "
	Ethylene	600,000 t/y	completion 1970
	Butadiene	78,000 t/y	" "
	Cumene	380,000 t/y	" "
	Ethylbenzene	73,000 t/y	" "
	Benzenes and Xylenes	313,000 t/y	" "
	Ethanol	480,000 t/y	" "
	Polyethylene	125,000 t/y	" "
	Oxo Alcohols	68,000 t/y	" "
Trinidad			
Federation Chemicals	Anhydrous Ammonia	485,000 t/y	in operation
	Urea	75,000 t/y	" "
	Ammonium Sulphate	90,000 t/y	" "
Texaco Trinidad	Cyclohexane	240,000 b/y	in operation
	Di-isobutylene	45,000 b/y	" "
	Propylene trimer	90,000 b/y	" "
	Propylene tetramer	30,000 b/y	" "
	Benzene	50,000 b/y	" "
	Toluene	75,000 b/y	" "
	Naphthenic Acids	20,000 b/y	" "
	Normal Paraffins	75,000 b/y	" "

a/ Source: World Petroleum, Aug.15, 1968, page 87.

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