The International Sugar Industry
Development and Prospects

James G. Brown
WORLD BANK STAFF COMMODITY WORKING PAPERS

1. The World Tin Economy: An Econometric Analysis (out of print)
2. International Cotton Market Prospects
3. An Econometric Model of the World Rubber Economy (out of print)
4. Industrial Processing of Natural Resources
5. The World Sugar Economy: An Econometric Analysis of Long-Term Developments
6. World Bank Commodity Models (2 volumes)
7. Analysis of the World Coffee Market
8. Analysis of the World Cocoa Market
9. The Outlook for Primary Commodities
10. World Rubber Market Structure and Stabilisation: An Econometric Study
11. The Outlook for Primary Commodities, 1984 to 1995
12. The Outlook for Thermal Coal
13. Jute Supply Response in Bangladesh
14. Prospects for the World Jute Industry
15. The World Copper Industry: Its Changing Structure and Future Prospects
16. World Demand Prospects for Jute
The International Sugar Industry

Developments and Prospects

James G. Brown

The World Bank
Washington, D.C., U.S.A.
ABSTRACT

This paper examines developments in sugar production, processing and marketing in recent years which have contributed to basic changes in the pattern of production and trade. It discusses conditions in the major preferential markets and likely developments in non-quota markets. Technological developments and prospects in allied and substitute industries are also reviewed. The paper then identifies some of the policy issues which impinge on the performance of national sugar industries and concludes with a proposed approach to the issue of determining sugar sector strategy for developing country producers and exporters.
ACKNOWLEDGEMENTS

The author wishes to acknowledge the substantial contributions to this work made by Thomas C. Earley and Donald W. Westfall (ABEL, DAFT & EARLEY) on the U.S. sugar market, Simon Harris (B.S.D. Ltd.) on the European Community sugar market, Wilfred David on diversification, F.C. Schaffer & Associates on cane production and processing, and the staff of B.S.D. Ltd on beet production and processing. Many valuable contributions were made by World Bank staff, particularly Ronald Duncan, Suan Tan, and Anthony Ody.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>vii</td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Scope and Objective of This Paper</td>
<td>3</td>
</tr>
<tr>
<td>World Bank Assistance to the Sugar Industry</td>
<td>4</td>
</tr>
<tr>
<td>II. AN OVERVIEW OF THE WORLD SUGAR INDUSTRY</td>
<td>6</td>
</tr>
<tr>
<td>III. THE UNITED STATES SUGAR MARKET</td>
<td>14</td>
</tr>
<tr>
<td>Domestic Production</td>
<td>14</td>
</tr>
<tr>
<td>Consumption</td>
<td>15</td>
</tr>
<tr>
<td>Quota System</td>
<td>17</td>
</tr>
<tr>
<td>The 1985 Farm Bill</td>
<td>19</td>
</tr>
<tr>
<td>The Gramm-Rudman-Hollings Bill</td>
<td>20</td>
</tr>
<tr>
<td>Summary</td>
<td>21</td>
</tr>
<tr>
<td>IV. THE EUROPEAN COMMUNITY SUGAR MARKET</td>
<td>22</td>
</tr>
<tr>
<td>Sugar Production</td>
<td>22</td>
</tr>
<tr>
<td>Consumption</td>
<td>23</td>
</tr>
<tr>
<td>The E.C. Sugar Regime</td>
<td>25</td>
</tr>
<tr>
<td>Summary</td>
<td>27</td>
</tr>
<tr>
<td>V. THE CUBAN SUGAR INDUSTRY</td>
<td>28</td>
</tr>
<tr>
<td>VI. STATUS AND PROSPECTS OF ETHANOL PRODUCTION</td>
<td>31</td>
</tr>
<tr>
<td>Development of the Ethanol Industry</td>
<td>31</td>
</tr>
<tr>
<td>United States</td>
<td>32</td>
</tr>
<tr>
<td>Brazil</td>
<td>34</td>
</tr>
<tr>
<td>The Viability of Ethanol Production</td>
<td>35</td>
</tr>
<tr>
<td>Other Policy Issues for Ethanol Investment</td>
<td>39</td>
</tr>
<tr>
<td>Supply Rigidities in Sugarcane Production</td>
<td>39</td>
</tr>
<tr>
<td>Energy Self-Reliance and the Energy Intensity of Development</td>
<td>40</td>
</tr>
</tbody>
</table>
SUMMARY

1. The world sugar market has historically been characterized by highly cyclical price patterns. In addition to the climatic factors which contribute to supply and price fluctuations in all commodities, the sugar sector is affected by a number of impediments to the response of production and consumption to market signals. The result of these is to amplify price swings in the decreasing share of the total market which is freely traded. Principal among these impediments are import restrictions and other means of protecting sugar producers in almost all cane and beet producing countries. Attempts to stabilize prices through an international sugar agreement have been largely unsuccessful and the prospect for an effective agreement is slim in the foreseeable future.

2. During the 1970's and early 1980's production costs increased dramatically among most sugar producers, so much so that even the higher prices paid by the heavily protected U.S. and European Community (E.C.) markets are inadequate to meet the costs of most suppliers to those markets. Business failures and private sector decisions to reduce operations have given rise to increased public sector involvement in the industry as enterprises were taken over by governments to protect the substantial employment which is generated by the typical cane sugar operation, and the anticipated flow of foreign exchange from sugar exports. Public sector operations have consistently higher production costs.

3. If it were realistic to assume that the past pattern of sugar prices
would remain essentially unchanged in the future, the major policy and operational issues would involve changes in production costs and in the structure and institutional framework of the sugar industry to improve producer response to those costs and to market conditions. However, there have been a number of fundamental developments in sugar and related industries in the past ten years which appear to have altered the pattern of sugar prices, reducing peak prices and extending the periods of low prices. These changes include: The decline or stagnation of sugar consumption in most hard currency markets; the inroads made by high fructose corn syrup sweeteners (HFCS), particularly in the U.S.; the availability of substantial raw material reserves in the form of sugarcane now devoted to ethanol production; the major gains in sugar beet productivity in several European countries which were traditionally cane sugar importers; and, the appearance of the E.C. as a major exporter of refined sugar. Those concerned with developing strategy for the sugar sector are therefore confronted with a re-examination of comparative advantage in production and a reassessment of the direction and benefits of trade for the respective country.

4. The conclusions from material presented in the present paper which are pertinent to the development of strategies for the sugar sector can be summarized as follows:

(1) Supply has consistently exceeded demand in recent years and in the aggregate this pattern is not likely to change. Demand in hard currency markets is stagnant or declining although, globally, demand may increase at about 1.5% per year through 1995.
(ii) Prices in the E.C. and U.S. markets will continue to decline in real terms; quota volumes will remain unchanged in the E.C.; barring adjustments to the support provisions of the 1985 Farm Bill, there may be slight increases in the U.S. quotas (Para 3.12); the long-term trend for world market prices is also negative in real terms.

(iii) Non-quota markets for sugar will continue to grow with population and increasing per capita incomes, probably at the rate of 2-3% per annum. Cost-reducing innovation or changes in domestic price policy could enhance this growth.

(iv) It is unlikely that production and price policies in the Soviet Union and Eastern Europe will be changed so as to materially effect current production and consumption levels, and these markets will therefore continue to take a major share of Cuban exports.

(v) Production costs among many traditional sugar exporters have risen to levels that no longer result in a satisfactory return to assets employed over the expected price cycle. The protection which has characterized policy toward this sector in temperate as well as tropical countries has contributed to widespread inefficiency, but technological innovations among temperate producers in recent years have reduced their costs relative to those of most traditional exporters. There will be a gradual concentration of tropical sugar production toward countries which presently have lower production costs or which exploit their potential to improve efficiency.
(vi) Supply reserves in the form of sugarcane now committed to the production of ethanol, and Cuban sugar which can be shifted from Centrally Planned Economies to world markets, will restrict increases in the price of sugar over the next ten years.

(vii) The supply and consumption of other sweeteners will continue to expand with technological innovations and growing grain surpluses. This will tend to put downward pressure on the world price of sugar.

(viii) A greater share of sugar production will in the future be consumed domestically and trade will evolve in non-traditional patterns among developing countries. Consumption growth will be significant in India and China, with rising incomes. However, both countries plan expanded production to serve their domestic markets.

(ix) The share of refined sugar in international trade will continue to increase while, for raw sugar, the traditional exports for refining at destination will decline in favour of direct consumption sugars; the market for specialty sugars such as demorara will remain proportionately small but could become increasingly important for individual producers.

(x) Uses of sucrose in the chemical industry will expand, but the pace will be influenced by petrolatum prices, and industrialized countries will give priority to domestic sources of sugar to satisfy this demand. Environmental concerns may lead to the introduction of sucrose in the manufacture of biodegradable detergents.
(xi) The absence of viable alternatives of the requisite scale to employ resources displaced from sugar production will require, for at least the next ten years, that attention be paid among high cost producers to maximizing the returns to a reduced sugarcane-based industry through process efficiency and byproduct utilization. Technical and market research for alternative crops should be encouraged.

(xii) Technological developments have created significant opportunities for reducing production costs and increasing byproduct surpluses.

(xiii) Changing market conditions and technological developments permit smaller mills to operate efficiently; these mills place less pressure on infrastructure and can be based on mixed cropping patterns and smaller cane areas.

(xiv) The adjustment process for resources presently committed to sugar production will be slow. Thus, whether on infant industry or sunk cost grounds, byproduct utilization schemes may warrant public sector assistance. However, in so doing, authorities must bear in mind the adverse effect that insulating producers from market forces has on supply response to market conditions.

5. The adjustment process faced by the sugar sector of export-dependent producers will be difficult for a number of reasons, including: the substantial share of agricultural and industrial resources committed to sugar production in the typical case; the social and political complexity of the sector; the fiscal and institutional implications of change; and the absence
of conspicuous alternative activities of the requisite magnitude. Adjustment will be an iterative process which in most cases should move toward a smaller, more efficient sugar industry, making greater use of the fibre and energy value of its raw material. There should be concomitant reductions in direct public sector involvement in production and marketing, with producers more exposed to demand changes and less dependent on export markets. Opportunities for the movement of resources out of sugar production will depend on concerted market and technical research efforts to develop profitable alternatives, whether in the use of sugarcane or in the production and processing of other commodities. In most cases, a number of different activities will be required to absorb the resources that can no longer be productively employed in the sugar industry.

6. Although the sequence of steps will depend on local conditions, the conclusions of this paper suggest a three-stage approach to the development of an adjustment strategy for traditional sugar-exporting sectors: Assessment of the policy framework; determination of the optimal size and structure of the sugar industry; and, finally, development of a diversification program.

7. The case of countries faced with growing domestic demand for sugar, as a result of increasing incomes and population, should be approached in a similar fashion. Structural changes may not imply a reduction in the size of the sugar sector in these cases, but the comparative advantage of sugar production in relation to other uses of domestic resources and the impact of policy on efficiency should remain the basic determinants of strategy.
I. INTRODUCTION

1.01 Declining international sugar prices between 1982 and 1986 have created very serious problems for the more than 70 developing countries which are dependent on sugar exports for a share of their foreign exchange earnings. Production costs had increased substantially among most producers in the 1970's and early 1980's, to the extent that even the higher prices paid by the heavily protected U.S. and European Community (E.C.) markets are inadequate to meet the costs of most suppliers to those markets.

1.02 The world sugar market has historically been characterized by highly cyclical price patterns, and periods of several years in which prices are below average production costs are not new. If it were realistic to assume that this pattern of sugar prices would remain essentially unchanged in the future the major policy and operational issues would surround changes in production costs and improvements in production response to those costs and to market prices. However, there have been a number of structural changes in sugar and related industries which appear to have altered that pattern in two respects: the cycle has been elongated, with more years of depressed prices between peaks; and the peaks will probably be significantly lower in the future and of shorter duration. Several factors have contributed to these developments:

- The decline or stagnation in per capita sugar consumption in most developed country markets and the inroads made by high fructose corn
syrups and other grain-based sweeteners in the sweetener market; 

- The availability of substantial raw material reserves in the form of sugarcane (mainly in Brazil) now devoted to ethanol production, which could be switched to sugar production should relative prices become favorable;

- The significant gains in beet sugar productivity that have decreased the dependence of some developed country markets, particularly in the E.C., on raw cane sugar which comprises the bulk of free market sugar trade; and

- The appearance of the E.C. as a regular exporter of refined sugar, and the growing share of refined sugar in international trade.

Sugar is an important source of employment, particularly among cane producing countries (up to six workers per 10 ha) and, based on domestic prices and revenue sharing formulae in effect in 1983, farmer returns to sugarcane production were 2-3 times as high as those for rice in countries as diverse as Brazil, Fiji, India, Indonesia, the Philippines, and Thailand. The political and economic importance of this crop is therefore substantial, and public sector intervention in recent years has grown because of pressure to

---

1/ The impact of improved low-calorie artificial sweeteners has not been a major factor as far as global sugar use is concerned. The sweetener market most affected by this development, namely the North American beverage market, has effectively switched to high fructose corn syrups (HFCS); other food applications appear to be creating new markets rather than displacing sugar. Blends of different artificial sweeteners to achieve desired taste and physical attributes are likely to become an important factor in the retail trade in the 1990's if existing U.S. Food & Drug Administration (USFDA) approvals are retained.

2/ This flexibility is diminishing as a growing share of Brazil's vehicles are designed to operate exclusively on alcohol fuels.
nationalize private enterprises which have reduced or ceased operations. Furthermore, the magnitude of resources committed to sugar production in many countries is such that viable alternatives of the requisite scale are not readily available. Additional processing, especially the production of fuel ethanol, has been undertaken in many countries but the economics of this form of diversification are generally unsatisfactory.

Scope and Objective of This Paper

1.04 This paper is intended primarily as background for the use of Bank staff working in the agricultural sector of countries which have a significant share of agricultural resources devoted to sugar production. It reviews conditions in the major preferential markets as well as allied and substitute industries and examines likely developments in non-quota markets. Technological developments are also examined because of their possible effect on production costs and comparative advantage. The findings are based partially on internal working papers commissioned by the Bank in late 1985 as well as staff analysis and interviews with authorities in the various fields of inquiry. This work was coordinated with Economic Analysis & Projections Department, Commodity Studies & Projections Division (EPDCS), and papers prepared by that Department on the Cuban sugar industry and on consumption patterns have been incorporated in this review. The Economics and Policy Division of Agriculture and Rural Development Department, (AGREP), undertook a review of the sugar industry in Latin America in 1984. While that internal working paper made special reference to the countries of the region, it also discussed policy, management, agronomic and marketing issues which have broader applicability. Portions of the summary of that study have been
incorporated in relevant sections of the present report.

1.05 After discussing the conclusions of this work, the paper proposes an approach to the extremely difficult issue of determining sugar sector strategy for the developing country producers and exporters which are most adversely affected.

1.06 Many of the basic problems faced by sugar producing economies do not originate within the sugar sector and cannot be resolved without adjustment and restructuring in the economy at large. Exchange rates, pricing policy, incentive structure, and institutional organization patterns are among these broader issues. In most cases, public sector intervention in the sugar industry has been in ways which reduce efficiency and flexibility in the sector, and more efficient means of pursuing public policy need to be introduced. The approach to a strategy for rationalization and diversification presented in the final chapter is derived from considerations within the sugar sector, and must therefore be considered in the context of the need for parallel work on broader policy issues.

World Bank Assistance to the Sugar Industry

1.07 The Bank has played a significant role in the development of sugar production in many countries. Buoyant commodity markets in the 1970's underpinned the Bank's support to expanded production in sugar as well as other commodities with a view to their role as potential foreign exchange earners and to meet growing domestic market requirements.

1.08 Most World Bank and International Development Association (IDA) support to sugar production has been in the form of irrigation, credit and rural development projects in which incremental sugar production is only one
of a range of commodity and institutional objectives. From 1974, when the average annual price of world market sugar reached an all-time high, to June 1985, 114 projects were approved which included assistance to increase sugar production. Of these, only eight were exclusively focussed on sugar, and only 18 projected production increases of 50,000 metric tons or more per year. But in the aggregate, the incremental production estimates in appraisal reports amount to more than four million tons per year at full development. While actual production is, for a variety of reasons, no doubt less than this figure, the discrepancy between these estimates and the production capacity of the assets created by these projects is likely to be considerably smaller. While this additional production capacity is not significant in relation to global sugar production of 95 million tons (1980-84 average), it amounts to an important share of traded sugar, which averaged only 20 million tons in the same period (net trade). Annex 1 presents summary information on the Bank and IDA sugar projects.

1.09 In the last several years the serious problems faced by the sugar industry in our borrowing countries has given rise to sector work, policy discussion and lending operations aimed at rehabilitation and rationalization of sugar investments. Since January 1985 sugar has been a major focus of agriculture sector work in eleven countries. In three of these cases rehabilitation projects have been approved for our support, and projects are under consideration in three others. 1/

1/ These figures do not include work done by Energy and Industry Divisions which examine ethanol and bagasse from sugarcane as energy sources or raw material for pulp and paper production.
II. AN OVERVIEW OF THE WORLD SUGAR INDUSTRY

2.01 By virtue of its derivation from two distinct raw material sources, sugar is produced under a wide range of temperate and tropical conditions. Historically, the sugarcane-based industries of the tropics have been lower-cost producers than the temperate climate beet industries, but technological advances in recent years in the beet industry have changed that relationship. While the most efficient cane industries remain the lowest cost sugar producers, the beet industries of several countries are now below international average production costs (Annex 2).

2.02 Approximately 25% of total sugar production is traded internationally, and much of that trade is governed by preferential agreements on quantity and/or price. As a result, fluctuations in supply and demand must be accommodated in a narrow free world market with consequent extreme oscillations in price. International agreements have been unsuccessful in stabilizing this market, largely because of divergent interests among the participants and the political difficulty of reducing production levels which, globally, have exceeded consumption in 20 of the last 25 years. The most recent agreement (1977-84) also suffered from two specific weaknesses: a loophole in export quotas that allowed for export expansion without regard for global consumption; and the fact that the E.C. was not a signatory and was therefore not constrained in its rapid expansion of production and exports during the period. Stocks in August 1984 were equivalent to 39% of annual

\[\text{\footnotesize{\textsuperscript{1}}\text{Several periods are used in the compilation of data on the sugar industry. For example, the International Sugar Organization (ISO) uses the calendar year, Food & Agriculture Organization (FAO) uses the national crop year, while the World Sugar Magazine adjusts year end stocks by a "pipeline" factor. Unless otherwise stated, data in this section are taken from the 1984 ISO Sugar Year Book.}}\]
consumption.

2.03 Production capacity has been maintained by investment decisions based on the fact that peak prices of the cycle have historically been more than adequate to compensate for the periods of loss. Between 1961 and 1981 centrifugal sugar production almost doubled, rising from 53.7 million metric tons raw value to 102.5 million tons. Since then it has declined slightly and the 1985 production was about 97 million tons. These overall figures conceal a shift in production which is quite dramatic at the national level in some cases and readily apparent in the following regional table:

Regional Production of Beet and Cane Sugar, 1972-84
(million metric tons, raw value)

<table>
<thead>
<tr>
<th>Region</th>
<th>1972</th>
<th>1982</th>
<th>1984</th>
<th>% Increase 72/84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle East &amp; N. Africa</td>
<td>2.5</td>
<td>4.2</td>
<td>4.0</td>
<td>60%</td>
</tr>
<tr>
<td>East Africa</td>
<td>4.2</td>
<td>5.4</td>
<td>5.8</td>
<td>38%</td>
</tr>
<tr>
<td>Latin America (incl. Cuba)</td>
<td>20.7</td>
<td>28.7</td>
<td>29.0</td>
<td>38%</td>
</tr>
<tr>
<td>North America</td>
<td>6.2</td>
<td>5.5</td>
<td>5.6</td>
<td>(10%)</td>
</tr>
<tr>
<td>Asia/Pacific</td>
<td>13.4</td>
<td>27.8</td>
<td>24.8</td>
<td>85%</td>
</tr>
<tr>
<td>USSR/Eastern Europe</td>
<td>13.8</td>
<td>14.4</td>
<td>15.0</td>
<td>9%</td>
</tr>
<tr>
<td>West Africa</td>
<td>.2</td>
<td>.5</td>
<td>.5</td>
<td>150%</td>
</tr>
<tr>
<td>Western Europe</td>
<td>10.7</td>
<td>16.1</td>
<td>14.9</td>
<td>37%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>71.7</td>
<td>102.5</td>
<td>99.4</td>
<td>39% a/</td>
</tr>
</tbody>
</table>

a/ The largest share of this expanded production was accounted for by Brazil, China and the E.C.


1/ Non-centrifugal sugar varies in importance in the domestic markets of sugar producers, but globally its production is equivalent to about 10% of centrifugal sugar production.
2.04 Global production is expected to recover to about 100 million metric tons in 1986, primarily as a result of the return of Cuba to more normal production after the hurricane and drought damage of last year. Higher output is also predicted for India, Indonesia and China. Existing stocks kept prices from responding to the 3% drop in production between 1984 and 1985 but a delayed response to the reduction of these stocks will probably lead to firmer prices in 1986 despite the projected 4% increase in production. Accordingly, the U.S. Department of Agriculture (USDA) predicts spot prices of 7¢ – 10¢ per pound through 1986 (No. 11 FOB Caribbean).

2.05 Volatility in world market prices has been exacerbated in part by slow supply response to price signals. Public sector intervention in production and marketing has been designed variously to generate revenue, to stabilize farm and processing revenues, and to support the income of significant numbers of farmers engaged in sugar production. But these arrangements have insulated producers from their market and thus diminished their response to market conditions. Access to preferential prices in the U.S. and E.C. markets also slows producer response to low world market prices by supporting the average export unit value for the countries concerned. Such insulation from market prices operates in a similar fashion on the demand side. With no change in consumer prices, consumers have no incentive to respond to external market forces. Developments in 1974 illustrate the significance of this factor: When prices increased dramatically that year, only two major consumer countries – Japan and the United States – let international prices be reflected in their domestic economies. With only this small share of traded sugar responding to market forces the price increase was greater, and its subsequent fall more precipitous, than would otherwise have been the case.
2.06 Over the last 25 years there has been a significant increase in the cost of producing sugar, particularly among cane-based industries (Para 7.01). A large percentage of cane mills are more than 20 years old and process efficiency is low by virtue of obsolescence, wear and tear, and a design bias in favor of throughput. Inadequate capital and poor management have also been factors in this poor performance. In contrast, the newer mills that have accompanied the expansion of beet production are more energy efficient, and extract a larger share of available sucrose. Producers which have maintained or improved their competitive position in sugar production have done so, at least in part, through technological innovation in both production and processing. Developments such as those identified in Chapters VII and VIII have been the result of steady and focused research and development efforts. A comparison of selected national average sugar production costs appears at Annex 2.

2.07 Another phenomenon of recent years has been the development of international trade in refined sugar which accompanied expanding beet production in temperate zones. Historically, trade has been almost exclusively in raw sugar, for refining at receiving ports. Today about 25% of international trade is in refined form, with most of these exports originating in countries which traditionally have been net importers. Improvements in processing technology may have created scope for some substitution of this trade by higher quality unrefined sugars from tropical sources, but it is likely that these direct consumption sugars will find their real potential in the domestic markets of larger cane producers and other lower income countries. The share of refined sugar in total trade will continue to grow as the processing margins are squeezed for free-standing refineries using
imported raws. Specialty raws such as demorara are enjoying growing demand in developed countries and, while they will continue to account for a small share of production and trade, these can be lucrative outlets for the individual enterprises that adopt this marketing strategy.

2.08 Substitution of grain-based sweeteners, particularly high fructose corn syrups (HFCS), will likely gain importance in grain surplus markets in future years. While the establishment of this industry benefitted from protection of the sugar industry, the cost of producing HFCS is now below that of most sugar producers, and there are, furthermore, characteristics of HFCS which make it a preferred sweetener for many industrial users. Another factor that will adversely affect producer prices for sugar is the availability of sugarcane raw materials presently devoted to ethanol production, a portion of which could revert to sugar production if relative prices of petroleum and sugar shift in favor of sugar. Most of this capacity is located in Brazil, and ability to shift products there is being reduced because a growing share of vehicles operate only on alcohol fuels. This "supply reserve" factor will probably become insignificant in the next five years, although this depends importantly on developments in the petroleum sector and on Brazil's policy towards its sugar and energy sectors.

2.09 Global sugar consumption has risen at about 2.8% per year since 1970. In some industrialized countries there has been a steady decline in per capita consumption of sugar during this period, and for the group as a whole consumption grew at only 0.4% per year. As a result, exports to hard currency markets have declined, and countries dependent on this source of foreign exchange have been particularly hard hit. Apparent consumption in the U.S. is today only 60% of 1970 levels, while in the E.C."9" countries the level is
about 83%. The growth in consumption in recent years has been mainly in developing countries which have sugar consumption at levels where demand is elastic with respect to income. Analysis of sugar demand in countries other than the U.S. and E.C. reveals the following three features:

1) For countries with comparable per capita income levels, those which are traditional sugar producers-cum-exporters tend to exhibit higher per capita consumption than countries which are not traditional suppliers;

2) For the bulk of non-traditional sugar suppliers (which hence do not have preferential access to the U.S. and E.C. quota markets), average per capita sugar consumption in the early 1980's is less than 30 kg/year. For most developing countries, however, such as the lower income countries of Sub-Saharan Africa, East and South Asia, per capita sugar consumption remains at less than 10 kg/year.

3) Preliminary analysis indicates that for the lower income countries, sugar consumption is more responsive to changes in GNP (and hence per capita incomes), than to changes in domestic consumer price. Income elasticity of demand tends to be greater than unity; price elasticity of demand tends to be less than unity, although this may be biased by regulations that affect domestic sugar consumption.

2.10 In the 1986-2000 period, developing countries are expected to be the major areas for increased sugar consumption, especially those of Africa and Asia, due to higher population growth rates and the greater elasticity of demand for sugar at the lower income levels of most of these countries. Demand growth in these regions should more than offset the decline in sugar
consumption in industrial countries (due to competition from HFCS and low-calorie sweeteners as well as changing dietary practices). The combined growth on non-quota markets will probably be about 2-3% per year, and an overall growth rate of 1.5% per year is projected for global consumption.

2.11 The political importance of sugar in most producing countries derives from its traditional role as a major foreign exchange earner, as well as from the relatively high levels of employment it generates. (Para 1.03). Direct participation of the public sector in production and marketing has increased in many countries over the past twenty years, as governments endeavored to increase their share of the foreign exchange proceeds of sugar exports. Some also responded to populist appeals to nationalize enterprises to stop what was perceived as producer exploitation. In other cases, government takeover was seen as essential to preserve employment and foreign exchange earnings in the face of private sector decisions to reduce operations or close down. Whatever the genesis, higher production and marketing costs are a general phenomenon of publicly operated enterprises. In countries where both public and private mills are in operation direct comparisons consistently reveal this difference.1/ Elsewhere, the costs of non-financial objectives of public enterprises such as unproductive employment generation 2/, the lack of technical and managerial expertise, cumbersome decision processes and failure

---

1/ For example, in two Central American countries, production costs in publicly operated mills were found to be 70% to 100% higher than in private mills. In two East African countries the difference is about 60%.

2/ In an extreme case, one mill in East Africa presently employs 2,300 people, including 1,100 in administration, whereas a private mill in Louisiana of the same size and similar technology employs a total of 270 people during the peak crushing season.
to take advantage of cost-saving measures in areas such as shipping contracts are consistently larger factors in government run operations.

2.12 It should also be noted that in some countries, notably the Philippines, large cane estates are owned by a few prominent families which also have a monopolistic hold over the processing facilities. All such monopolies are, at best, slow to change or respond to the market signals, and there is a strong tendency to use political clout as a substitute for painful but necessary adjustments.
III. THE UNITED STATES SUGAR MARKET

Domestic Production

3.01 In the aftermath of the abolition of the Cuban sugar quota there was a steady rise in U.S. sugar production from 4.0 million short tons in 1960 to 5.6 million tons in 1965, primarily through the expansion of Florida cane production. With several intermittent declines, production continued to rise to an all-time high of 7.8 million tons in 1976. Following declines in seven of the ensuing nine years production stood at 6.8 million tons in 1985.1/ The rising costs of production, particularly energy costs, together with the steady product substitution by HFCS and a conscious effort by consumers to reduce sugar intake, have all contributed to this downturn. The combined effect has been to force the closure of high cost operations and the consolidation of refining capacity by larger firms. In 1985 there were only 16 refineries in operation, owned by eight companies, in contrast to the 24 refineries operated by 15 companies in 1970. While the total areas planted to beet and cane have not changed significantly, except in Puerto Rico, there has been a shift away from the higher cost beet areas of the Great Plains and California and the higher cost cane areas of Hawaii and Louisiana. This shift has coincided with a concentration of the ownership of processing capacity. For example, three firms now control two-thirds of total refining capacity and 27% of total beet processing capacity.

3.02 In addition to the concentration of ownership, rationalization of the U.S. beet and cane processing industry is based on two elements: increased

1/ Most of this decline has been in Puerto Rico where only four factories operated in 1985, in contrast to more than 50 in the 1970's.
energy efficiency, and improved process efficiency. These are being pursued with minimum capital investment through rehabilitation of used equipment, installation of improved ancillary systems, and phasing of investment to limit debt financing. While the adjustment process has gone a long way in the past five years, it is not complete, and with the fixing of the Commodity Credit Corporation Loan Rate in current terms under the 1985 Farm Bill, real support levels will decline through 1991. Some further contraction of total production can be expected, although two developments will delay this adjustment probably for several years. First, the relative support level for sugar is better than that for the main alternative crops, and loss-minimizing strategies will keep some growers in sugar in the short term. Second, a European-based firm has acquired substantial interests in beet production and processing in the U.S., and is introducing improved technology which will probably significantly reduce some Western beet sugar costs.  

Consumption  

3.03 In the past 25 years total sweetener consumption per capita has risen gradually from 113 lbs per year to 138 lbs per year. However, sugar consumption, after holding at about 100 lbs per year through 1973, began to drop rapidly and was only 60 lbs in 1985. Consumption of corn sweeteners, essentially HFCS, was also 60 lbs per person last year, in contrast to the

1/ Cane and beet acreage are both up this year from 1985 (1-3% for cane, 5.5% for beet.)

2/ Disappearance, or apparent consumption, of food commodities is invariably higher than actual human intake. In the case of sugar in the U.S., the ratio of these figures is 2.9:1, the difference being accounted for by, inter alia, waste and loss, miscellaneous uses, and reporting errors. However, since the concern of this paper is the sugar industry rather than nutrition, disappearance data are of primary importance and, unless otherwise stated, references to consumption are apparent rather than actual human intake.
10:1 ratio of these sweeteners in favor of sugar in 1960. Non-caloric sweetener consumption rose in the same period from 2 lb per person to 13 lb. Overall, the share of sugar in the U.S. sweetener market dropped from 87% in 1960 to 46% last year. With the complete domination by HFCS of beverage and industrial food markets that can use liquid sweeteners, the displacement of sugar by HFCS now appears to be nearing completion. Although dietary preferences and health concerns may further retard per capita consumption, it appears likely that increased purchasing power in low income groups, as well as population growth, will combine to sustain a growth of caloric sweetener consumption (both sugar and HFCS) of about 1% per year through 1995.

3.04 Two technological developments may alter this pattern beyond the next ten years, or earlier if commercial development is induced by higher prices of caloric sweeteners. The first is the introduction of crystallized HFCS, now technically feasible but not financially viable. The second is the progressive introduction of new low-calorie sweeteners with physical and taste properties closer to those of sugar. A number of these new sweeteners are at various stages of FDA evaluation or have already been approved.

3.05 The dominant feature of the U.S. sweetener industry in the past ten years has been the rapid expansion of HFCS production and its displacement of sugar in the relatively steady total consumption of sweeteners. While protection of the domestic sugar industry was a major factor in this development, its effect appears to have been in terms of accelerating a change which was brought about through technological development. \(^1\)\(^{\text{1/}}\) HFCS production costs in the U.S. in the early 1980's were 12-16\(^{1/4}\)/lb. Declining raw material and capital costs have further reduced these levels in 1985 and 1986.

\(^{1/}\) Annex 3 presents a brief discussion of the development of HFCS production.
Allowing 2¢/lb for the shipping and refining of raw sugar from Caribbean port, HFCS costs (42% concentration) are competitive in the U.S. with sugar at world prices as low as 6¢/lb. In relation to U.S. domestic sugar prices, 42% HFCS prices have been consistently lower, ranging from 50% to 85% of contemporary refined sugar prices since 1977. Expansion in the 1980's has been primarily in 55% HFCS, a product which is 10% sweeter than sugar, is superior in industrial use, and has been marketed at 71% to 84% of contemporary sugar prices.

Quota System

3.06 The first sugar import quotas were introduced by the U.S. in 1934. At that time, domestic production was set at 3.5 million short tons (raw equivalent) and import quotas were 2.9 million tons, consisting almost entirely of allocations to the Philippines and Cuba. Fifty years later, in 1984, domestic production was 5.8 million tons, and the import quotas were 2.2 million tons, shared by 40 countries. Despite the resulting economic inefficiency, the system worked well until 1960 in its dual role of protecting the domestic industry and supporting two countries of important geopolitical interest. In that year, the Cuban quota, amounting to 1/3 of total imports, was reduced, and completely rescinded in 1961. The major beneficiary of this change was the Florida cane industry, but import quotas were introduced or dramatically increased for 30 countries. These quotas were allocated annually thereafter directly by Congress, a system which gave rise to widespread lobbying and favoritism, and the Sugar Act lapsed in 1974, "the victim of its
own unsavory reputation”.1/

3.07 The 1977 Farm Bill attempted to support the domestic sugar industry through a guaranteed loan program and dependence on a system of fees and tariffs. However, there are statutory limits on the level of tariffs which can be imposed by the U.S. Administration, and when world market prices fell below 8¢/lb in 1978, large amounts of sugar began to be forfeited to the Commodity Credit Corporation by domestic processors in lieu of loan repayment. Budgetary losses on the sale of that sugar were avoided by the fortuitous rise of prices to a cyclical peak in early 1980, but the threat of such losses figured prominently in the drafting of sugar provisions for the 1981 Farm Bill. The concept of a Market Stabilization Price (MSP) was introduced, essentially as an early warning device. The MSP is set sufficiently above the loan rate to ensure that, as long as prices are at or above that level, forfeitures will not occur. However, once again in May 1982, world market prices fell to a level at which tariffs could no longer control supply so as to sustain the MSP in the market, and the President proclaimed an emergency quota system which has been in effect since that time.

3.08 Unlike the European Community quotas for Lome Convention countries, which do not fluctuate over time, quotas in the U.S. market are adjusted frequently by the USDA in response to projected domestic supply and demand changes, to ensure that market prices remain at or above the MSP. In recent years the adjustment has taken the form of lengthening (or shortening) the

---

period of time in which the specified quota volumes can be delivered. For example, a three month extension of the quota year effectively reduces the annual quota by 20%.

3.09 While there is general consensus among all interested parties in the U.S. that the quota system is inefficient, and administratively complex, it is likely that past failures of the tariff system as an alternative, and the prognosis of continued difficulties in the domestic sugar industry, will result in the system remaining in place in the foreseeable future essentially as it is now.1/ Imports from developing countries have steadily declined with the expansion of alternative sweeteners, and the sugar quotas for calendar 1986 currently stand at only about 1.8 million tons.

The 1985 Farm Bill

3.10 The 1985 Farm Bill was seen by the Administration as an opportunity to reduce support levels to American agriculture and by agroindustrial complexes as a vehicle to effect reduced raw material prices. Proposals by the Administration and by a consortium of refiners, industrial users and consumers would have dropped effective support prices by about one third (for example, a loan rate of 12¢/lb instead of the current 18 cents). However, the farm crisis gained widespread attention during the period the Bill was under consideration, and the corn millers who were concerned to prevent greater competition for HFCS by lower priced sugar joined forces once again with

1/ There are three bills before Congress at present which, independently, include provisions to alter the distribution of quotas among countries as part of anti-drug and anti-Apartheid measures. Changes may result by Spring 1987.
producer groups and succeeded in securing less radical reductions. Nevertheless, real support levels are projected to decline, and price levels will continue to be protected through an aggressive quota policy. The four basic provisions of the Bill pertaining to sugar are as follows:

- The loan rate for raw sugar is frozen at 18¢/lb for the 1986 through 1990 crops.
- The 1985/86 quota year must be extended to December 31, 1986 or the program must be administered in a way that will result in the equivalent reduction in forfeitures (this is interpreted as meaning a cut in the quota.) The quota year was extended on February 27, 1986.
- Beginning with the quota year that follows 1985/86 (presumably January 1, 1987), the program shall be operated at no cost to the Federal Government; and
- After the 1985/86 quota year, sugar imports will be prohibited from any country that is a net importer of sugar, unless it can be verified that the country does not import sugar from Cuba for re-export to the U.S.

The Gramm-Rudman-Hollings Bill

While certain features of this Bill have been challenged on constitutional grounds, Congressional Committees have agreed on measures that would compensate for any adverse Supreme Court ruling, and the basic formula for budget reduction is likely to prevail. Commodity programs account for 75% of the $23 billion Agriculture budget which is subject to across-the-board cuts under the Bill if negotiated reductions are not adequate. In this event,
the effective loan rate (i.e. amount actually disbursed) would be cut by 4.3% to 17.2¢/lb, probably beginning with the 86/87 crop year. The effect could be to reduce domestic market prices for sugar, reduce production and lead to some increased import requirements, albeit at the lower prices.

Summary

3.12 The consumption of sugar in the U.S. appears to have reached the bottom of the ten-year decline triggered by product substitution and changes in eating habits. At the national level consumption is not significantly responsive to any probable range of changes in price or income and it is likely that demand for sugar and HFCS will grow in line with population over the next 10 years. Import quotas are determined as a residual between estimates of demand and domestic supply, and the process of adjustment to higher costs and somewhat lower real price support levels under the 1985 Farm Bill may induce further declines in domestic production. While there may be further declines in quotas as a result of short-term domestic producer strategies, the net effect of these trends could be a gradual increase in import quotas, perhaps beginning in 1988, on the order of 100,000 tons per year through 1990. Any such growth would be curtailed in 1990 if, by the next Farm Bill, the domestic support prices were to be indexed. U.S. sugar policy is a highly political issue and these projections are based on the assumption that successive administrations during the covered period, and their allied interests, sustain the current attitude toward budget deficits and farm prices.
IV. THE EUROPEAN COMMUNITY SUGAR MARKET

Sugar Production

4.01 Sugar production rose steadily through the 1970's among the countries of the E.C. "10", to reach a peak of 15 million metric tons white sugar equivalent (wse) in 1981/82. Despite the subsequent drop in world prices, production since that time has stabilized at about 12-1/2 million tons. Ninety percent of that production is covered by the "A" and "B" quotas (see Paras 4.07-4.11). There continues to be a gradual reduction in real prices under the sugar regime, but this is offset by productivity gains so that returns per hectare have remained about the same. A significant number of technological innovations have yet to emerge in commercial practice and it is therefore likely that these gains in productivity will continue for at least another ten years. With the accession of Spain and Portugal, production of the E.C. "12" will probably be 13.7 million tons by 1990.

4.02 Technological innovations have had a dramatic effect on beet yields in E.C. "10" countries (Para 8.02). For example, the three year average beet yield during 1968-70 was 42.9 metric tons per ha., and by 1982-84 this figure had risen to 50.2 tons. Despite a fractional decline in sucrose content over the period (15.7% to 15.4%), sugar yield per ton rose by 0.5% per year as a result of improved processing efficiency. The combination of these factors resulted in a rise in white sugar per ha. from 5.7 tons in 1968-70 to 7.0 tons in 1982-84, a compound growth rate of 1-1/2% per year.

4.03 The structure of the sugar industry in the E.C. is changing, with fewer farmers cultivating larger areas, and fewer mills processing larger tonnage. For example, between 1970 and 1977 the number of growers dropped
22%, from 425,000 to 334,000 in the E.C. "9" and this trend continues. The number of growers with more than 10 ha almost doubled in that time, and the capital intensity of cultivation suggests that the concentration of beet production in fewer large farms will continue. One-third of the factories in operation at the start of the sugar regime have now closed and employment in processing has declined by 26,500 (30%). The average capacity of remaining mills has increased by 106% and total capacity now stands at 1.2 million tons of beet per day, about 50% greater than in 1968. (Processing figures are for the E.C. "10".)

4.04 There is a wide variation of production costs among E.C. sugar producers. France is the lowest-cost producer, at about 73% of the weighted average cost of major producers worldwide (Annex 2). The Federal Republic of Germany is also very competitive at 92% while, at the opposite extreme, Italy is the highest cost member, at 155%. In fact, Italian producers have consistently lost money in recent years despite the price support system, and there is likely to be some realignment of "B" quotas among member countries in the foreseeable future.

Consumption 1/

4.05 Among the original six members of the E.C., sugar consumption rose with incomes from 30.5 kg (67.1 lb) per capita in 1960 to about 38.2 kg (84 lb) prior to the shortage in 1974. Since then, consumption in these countries has declined slightly (est. 35 kg or 77.0 lb per capita in 1985) as

1/ As in the discussion of the U.S. market, the following comments relate to apparent consumption (see footnote on page 15.)
a result of price and diet factors, but the preference for "natural" foods has prevented any significant substitution by artificial sweeteners. Furthermore, HFCS (isoglucose) is controlled in terms of quotas and prices as part of the sugar regime, and there has not therefore been the dramatic growth in its use through substitution which characterized the U.S. market over the same period. Countries that joined the E.C. since 1960 have displayed consumption patterns consistent with the profile of initial increases with rising income and subsequent declines with the shift to lower carbohydrate levels in the diet. The average per capita consumption among the ten members in 1985 was estimated to be 36.8 kg (81.0 lb). Greece is the only member of the E.C. 10" in which consumption is continuing to rise, standing presently at a level equal to about 80% of the average of other members. Consumption is also increasing in Spain and Portugal.

4.06 Were it not for pending changes in the E.C. starch regime, it is likely that modest continued growth in Greece, Spain and Portugal would offset most of the declines in other member countries and result in only slight continued erosion of overall consumption by the expanded Community. However, there is growing pressure to reduce raw material costs for non-food starch users. Budgetary funds to support this reduction would be secured by eliminating the refund presently paid on starch for food use, beginning with the '86/87 cereal marketing year in August 1986. There are indications that this initiative will succeed and that sugar consumption would increase by about 200,000 metric tons as a result of substitution for glucose with the change in relative prices. A recent amendment also provides for the sale of up to 450,000 tons of sugar per year through June 1988 to the chemical industry at a price equivalent to the world sugar market or the supply price for
glucose for which it would substitute in the manufacture of biodegradable chemicals. The net effect of these factors is that current E.C. member consumption of 9.5 million metric tons of sugar per year will probably remain stable. Adjusting for consumption in Spain and Portugal the total would be about 10.7 million metric tons per year in 1990 and beyond.

The E.C. Sugar Regime

4.07 To support producers, internal Common Market prices for sugar are kept at levels normally higher than world market prices, and producers and consumers are insulated from world markets. These objectives are realized through three mechanisms: intervention buying of domestic sugar; open-ended variable import levies; and export refunds (restitutions), to clear surplus from the internal market. There are four important features of the E.C.'s sugar regime:

- Intervention buying is restricted to output within production quotas.
- Under the co-responsibility system, producers are required to bear the full cost of surplus disposal (Para 4.11).
- There is guaranteed access for 1.3 million metric tons (wse) of ACP sugar under the Lome Convention, at E.C. prices, which are currently much higher than world prices.
- Support prices apply to processed products - white and raw - thereby creating a common lobby between growers and processors.

4.08 The production quota system consists of three elements: the "A" quota, which is based on estimated consumption and presently stands at 9.5 million tons; the "B" quota, which was once set as 27-1/2% of the "A" quota but is now
a fixed quantity, 2.2 million tons; and "C" sugar, which falls outside the regime, is not subject to any public assistance, and must be sold outside the E.C. The allocation of quotas among members is the subject of intense debate at the regular Commission and Council of Ministers reviews and there are frequent minor adjustments both in "B" quotas and in compensation procedures. However, the "A" quotas have come to be viewed as a matter of national sovereignty and are likely to remain unchanged.

4.09 To meet the cost of the support program, including any refunds necessary as a result of quota sugar exports below the internal support price, a system of producer levies is in effect. A Basic Producer Levy is charged on all "A" and "B" sugar at the rate of 2% of the Basic Beet Price. A Supplementary Producer Levy of 37-1/2% is charged on all "B" sugar, bringing the effective rate on "B" sugar to 39 1/2%. There are no levies on C sugar since it is not supported by the Community.

4.10 The total cost of support to sugar in 1985 was about US$1,180 million or 8% of the total agriculture market support of the E.C. About 30% of this consisted of export refunds against shipments equivalent to the ACP preferential imports and was charged to the general E.C. budget. Almost all of the balance has been financed by producer levies, and the net cost of the program has been less than one percent of the agriculture support budget since 1982.

4.11 One important element was introduced to the regime in 1981. Other producers had argued that export refunds amounted to a subsidy and Australia and Brazil had appealed under the rules of the General Agreement on Tariffs and Trade (GATT) for relief. The principle of co-responsibility, referred to earlier, was adopted in 1981 whereby producers would bear the cost of any
support not paid by consumers. Consistent with this principle, the small
deficit that remains at the end of the third production quintennium (1985/86)
est. $320 million) is to be removed by an additional Elimination Levy of 1.3%
over the next five years. This will not have a significant effect on
production levels.

Summary

4.12 There has been significant technological innovation among E.C. sugar producers over the past 20 years. After an initial period of expanding production, the sugar regime of the Common Agricultural Policy (CAP) has, through a combination of producer levies and reduced quotas, encouraged a rationalization of the industry in the direction of larger, more efficient producers and processors. By controlling the volume of exports eligible for export refunds, as well as varying the level of stocks, the E.C. can smooth out exports from year to year in response to world market prices and there is evidence in the last several years that this policy is in effect. Net exports have been between 4.2 and 4.8 million tons, equivalent to 22-25% of free market trade, and it appears that the Community will maintain this share. E.C. sugar policy will thus continue to cause world prices to be lower than they otherwise would be. Total demand in the Community will remain steady, with declines in consumption in most member countries being offset by continued growth in Greece, Spain and Portugal, as well as new demand in the chemical industry.
V. THE CUBAN SUGAR INDUSTRY

5.01 Cuba is the largest sugar exporter in the international market, and sugar accounts for 70-80% of that country's foreign exchange earnings. Prior to the 1959 Revolution, 60% of its exports went to the U.S. and over the past 25 years about the same share has gone to Centrally Planned Economies (CPE's), with the balance being sold to market economies at world prices. Cuban sugar typically accounts for 20-30% of total world exports and about 50% of world free market exports.1/ Changes in these shares as a result of increased Cuban production or reduced shipments to CPE's could affect world sugar prices dramatically. A recent EPDCS study on the Cuban sugar industry and trade is the basis of the summary comments offered in the following paragraphs. 2/

5.02 At the time of the Revolution, Cuba had 161 mills which produced 5.8 million tons of sugar, the largest share of which originated in large privately-owned estate-mill complexes. In 1982 there were 154 mills with a combined crushing capacity of 610,000 'tons per day; total production was 8.0 million tons. Eighty-five percent of the cane area and more than 85% of the milling capacity is state-owned, the balance being operated by state-controlled co-operatives. Production is heavily mechanized and employment in the sugar industry is only about one-half of the level of the 1960's. Annual production varies a great deal as a result of Cuba's exposure to adverse weather in the form of hurricanes. For example, production in 1978 and 1984 were 7.7 and 7.8 million tons respectively, but fluctuations in the intervening years were −12% and +4% of the 1978 level. It is not the purpose

1/ In this case, the free market means sales other than those under either quota or multi-year contract.

of this paper to comment on the efficacy of the strategy adopted for the sugar industry in Cuba, but it appears that institutional and capital constraints that characterize the sector to date would probably have kept the total production below 8.5 million tons into the 1990's were it not for two factors: A particularly destructive hurricane in 1985, which will probably keep production to about 6.5 - 6.9 million tons in 1986; and a major investment and restructuring program which is expected to increase output thereafter to levels in excess of 9 million tons.

5.03 Exports consistently account for 90-95% of total Cuban sugar production. USSR purchases range between 25% and 60% of exports, although since 1975 this share has not been below 44%. Shipments to CPE's have grown in recent years with the result that only one-third of exports are sold to market economies. However, these sales vary considerably on an annual basis and CPE contractual arrangements are such that Cuba can adjust its shipments to the two groups of markets in response to price changes and its balance of payments position with respect to each, as well as in response to the Soviet domestic sugar supply deficit.

5.04 The EPDCS study found that the world sugar price has an elasticity of 0.7 with respect to Cuba's share of free market sugar trade. The study examined several possible determinants of changes in export volumes, and three factors were found to be significant: (i) The level of Cuba's production, and hence exports; (ii) Cuba's balance of trade position with CPE's and market economies; and (iii) Soviet domestic supply deficit relative to Soviet domestic consumption. For any level of production, exports to CPE's and market economies were found to be strongly complementary if not of equal importance. Since no significant increase over past levels is expected in the
next five to ten years in Soviet production, the poor outlook for world sugar prices and continued Cuban dependence on Soviet aid and technology are likely to result in a continuation of the past pattern of export shares to CPE and free markets. A figure of 37% is projected by the EPDCS study for 1995 compared with the 1985 actual of 35%. It is possible, however, that free market price fluctuations will induce short-term shifts in these shares. In the event of a major shift in the relationship of free market sugar prices and petroleum prices in favor of sugar, this share could rise significantly.

5.05 In summary, the flexibility of the sugar trade relationship between Cuba and the CPE's is such that Cuba can adjust its market strategy to best serve its balance of trade and debt service needs. This has had a slightly stabilizing effect on free market prices in recent years and is likely to have a dampening effect on sugar prices during the next cycle peak, if recovery from the effects of Hurricane Kate can be achieved in the next one to two years.
VI. STATUS AND PROSPECTS OF ETHANOL PRODUCTION

6.01 There are two important relationships between sugar and ethanol as far as the sugar industry is concerned:

- The potential for ethanol production from sugarcane, thereby diversifying the output of resources committed to sugarcane production and reducing the dependence of that industry on sugar sales.

- The extent to which sugarcane committed to ethanol production could be diverted to sugar production in the event of a price shift in favor of sugar, thereby constituting a damper on the upper end of the sugar price cycle.

Development of the Ethanol Industry

6.02 Between 1977 and 1984, there was a seven-fold increase in world production of ethanol, primarily for fuel purposes. This has resulted from the most part from the shift in relative prices of petroleum and sugar, although

Summary of Ethanol Production Capacity

<table>
<thead>
<tr>
<th></th>
<th>1977</th>
<th>1984</th>
<th>In Progress</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed Countries</td>
<td>N/A</td>
<td>2,750</td>
<td>368</td>
<td>417</td>
</tr>
<tr>
<td>Of which - USA</td>
<td>38</td>
<td>1,643</td>
<td>360</td>
<td>367</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>N/A</td>
<td>10,850</td>
<td>574</td>
<td>2,449</td>
</tr>
<tr>
<td>Of which - Brazil</td>
<td>1,210</td>
<td>10,000</td>
<td>508</td>
<td>688</td>
</tr>
<tr>
<td>- Other S. American</td>
<td>-</td>
<td>309</td>
<td>40</td>
<td>880</td>
</tr>
<tr>
<td>- Central Amer./Car.</td>
<td>-</td>
<td>137</td>
<td>18</td>
<td>239</td>
</tr>
<tr>
<td>- Africa</td>
<td>-</td>
<td>88</td>
<td>-</td>
<td>128</td>
</tr>
<tr>
<td>- Asia</td>
<td>-</td>
<td>470</td>
<td>8</td>
<td>516</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,850</td>
<td>13,600</td>
<td>942</td>
<td>2,866</td>
</tr>
</tbody>
</table>

Source: Compiled from World Bank Working Papers.
in the U.S., the E.C. and Canada, environmental and health concerns have led to widespread substitution of ethanol for tetraethyl lead as an octane booster in fuels. New projects at various stages of development will further increase production capacity by 28%.

6.03 Ethanol production in developed countries is based primarily on grain and other crop residues, whereas installations in developing countries use sugarcane products as the feedstock in almost all cases. The two major markets for ethanol, the United States and Brazil, are briefly described below.

United States

6.04 Growth in ethanol use in the U.S. is primarily the result of environmental concerns over lead-based ingredients in automotive fuel, which can be replaced by ethanol. Consumption over the past four years, and projected through 1995, is summarized below:

<table>
<thead>
<tr>
<th></th>
<th>1982</th>
<th>1983</th>
<th>1984</th>
<th>Projected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1985</td>
</tr>
<tr>
<td>Grain Based</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>210</td>
<td>370</td>
<td>440</td>
<td>565</td>
</tr>
<tr>
<td>Beverage &amp;</td>
<td>95</td>
<td>90</td>
<td>95</td>
<td>85</td>
</tr>
<tr>
<td>Industrial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>305</td>
<td>460</td>
<td>535</td>
<td>650</td>
</tr>
<tr>
<td>Fuel Ethanol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From domestic grain</td>
<td>210</td>
<td>370</td>
<td>440</td>
<td>565</td>
</tr>
<tr>
<td>Imported</td>
<td>25</td>
<td>80</td>
<td>125</td>
<td>195</td>
</tr>
<tr>
<td>Total</td>
<td>235</td>
<td>450</td>
<td>565</td>
<td>760</td>
</tr>
</tbody>
</table>

6.05 Two features of this summary are important. First, it was prepared before the recent drop of petroleum prices and therefore probably overstates the future use of ethanol as opposed to petroleum derivatives as an octane booster. Second, the ethanol industry in the U.S. is almost entirely based on grain and is not therefore a competing user of sugar raw material. It is nevertheless important to the sweetener industry in that HFCS and ethanol are both products of corn wet milling. Grain producer and processor groups will continue to advocate programs to reduce ethanol imports as well as increase the degree of self-sufficiency in sweeteners. The domestic cost of ethanol production exceeds its commercial value in automotive fuel and is sustained with substantial state subsidies and federal excise tax waivers.

6.06 The scope for increased imports of lower cost foreign ethanol is constrained by a strong political lobby basing its arguments on the vulnerability that the U.S. would experience if a major share of its energy ingredients were to be subject to crop failure or political measures in a foreign country. Lower petroleum prices are likely to reinforce pressure to expand the use of petroleum-based or artificial octane boosters that can be domestically produced. Furthermore, ethanol has been discredited among users in certain areas of the U.S. as a result of alleged damage to engines. While there is no inherent problem in the use of "gasohol", any significant consumer resistance is likely to influence the choice of additive by the gasoline industry. While ethanol use will continue to grow over the next several years as plants under construction come on stream, it appears at the present time that ethanol is unlikely to provide more than about 25% of the four billion gallon "octane gap" that will result from the full implementation of environmental regulations in the early 1990's.
Brazil

6.07 The case of Brazil is of particular interest because it has the largest and most comprehensive scheme for ethanol production and because its production costs are the lowest in the world, therefore constituting a "best case" analysis for substitution.

6.08 Brazil adopted its national alcohol fuels program, PROALCOOL, in 1975 in response to rapidly increasing petroleum import costs, as well as to dropping sugar prices and the sugar export restrictions imposed on the country under the International Sugar Agreement. Under the program, subsidized loans were provided for autonomous distilleries as well as distilleries annexed to sugar mills. (Capital costs have been found to be about 30% less in annexed facilities than in autonomous ones, and operating costs 23% less.) In addition, the program featured substantial research and development grants. While emphasis was initially on the production of anhydrous alcohol to mix with gasoline in a 20:80 blend, investment since 1980 has concentrated on hydrous alcohol production for use as straight or "neat" alcohol fuel. Fuel and vehicle price incentives have encouraged consumers to switch to straight alcohol vehicles, and about 95% of passenger vehicles manufactured in Brazil since 1984 have been of this type.

6.09 Today, there are about 400 autonomous and 200 annexed distilleries in Brazil. It is estimated that the PROALCOOL program has created 600,000 new jobs (direct). Although this employment resulted from expanded sugar cultivation and more intensive production and processing, some labour displacement almost certainly occurred, and this figure is not adjusted for those losses. The area under sugarcane is 60% greater than that of 1974-75 and 47% of all sugarcane is devoted to ethanol production. Current production is
equivalent to 140,000 barrels of oil per day. All gasoline in Brazil is blended and 17% of all cars now operate on neat alcohol. Research and development efforts have led to a 10% increase in alcohol yield on an area basis and 15-20% increases in distillery efficiency. As a leader in ethanol technology, Brazil's exports of technical assistance and capital goods may continue to increase. At one stage, Brazil had developed significant exports of fuel alcohol. More recently, however, exporting has ceased to be profitable due to lower prices (reflecting competition with gasoline) and imposition of import duties in the U.S. (formerly the main importer). In addition, the pressure of rising domestic demand on production capacity has essentially eliminated surpluses available for export.

6.10 Brazil's remarkable technological success is not without its drawbacks. The basic issue remains the economic cost of alcohol in relation to petroleum-based fuels. While it is not feasible to identify a single petroleum price to be used in economic analysis, it appears that the production of hydrous alcohol is not at the present time economically viable, and the case for anhydrous product for use in gasohol is marginal (Annex 4). Another factor of concern is the displacement of food and other export crops which has shifted the dependency of large pockets of population toward the wellbeing of the domestic fuel market and reliance on the local cash market for foodstuffs formerly produced on land now devoted to sugarcane. Such shifts in employment and purchasing patterns, together with the concomitant change in local staple prices, can have serious welfare repercussions for the rural community.

The Viability of Ethanol Production

6.11 The production of ethanol can be seen both as a substitute for
petroleum imports and a substitute for sugar exports.\footnote{Where non-sugarcane alternatives appear ex ante to be feasible, their potential should also be compared to the production of ethanol.} In both cases the analysis begins with an assessment of ethanol production costs, the major elements of which are:

- **Total fermentable carbohydrates (TFC) per ton of cane.**

  In addition to the sucrose content on which sugar production is based, reducing sugars such as glucose and fructose are also available for fermentation. TFC typically ranges between 10% and 18% of cane weight.

- **Cost of sugarcane production.**

  This is a function of land, capital and labour costs as well as agronomic efficiency. A rough proxy for costs may be commercial yield per unit area which typically ranges between 50 and 90 tons per ha.

- **Conversion Efficiency.**

  This is expressed as a percent of the potential alcohol production from a unit of raw material which is actually captured as a final product, and plants in operation today perform in the range of 60 to 85%.

- **Conversion Cost.**

  Investment and operating costs between raw material and finished product. In addition to conversion efficiency and factor prices, this varies between annexed and autonomous distilleries and between types of raw material (raw juice, first or second massequite, molasses, effluent).
Energy Efficiency and Byproduct Utilization.

While some distilleries must purchase fuel, operations associated with efficient sugar mills can typically derive their power needs from the surplus of bagasse generated by the milling operations.

6.12 While the above list illustrates the wide range of costs that may be experienced under different conditions, some indicative costs have emerged from recent studies. In Brazil, investment costs have declined with technological improvements over the past ten years from U.S. 41¢/liter of annual capacity to about 30¢. These figures equate to 5.7¢/liter and 4.2¢/liter of output, respectively, and are based on plants of the most common capacity, 120,000-150,000 liters/day. Cane costs are highly variable, but a 1983 study in Brazil used an average of 16 cents per liter of hydrous ethanol. Processing costs averaged about 3.6¢/liter. Using these figures, the average cost of hydrous ethanol production was 24¢/liter in Brazil in 1983. This was higher than contemporary gasoline cost in Brazil and the price of gasoline has since decreased. The average price was 20¢/liter in 1985, before the precipitous declines of recent months. 1/ Under these

---

1/ The relationship between crude oil and gasoline costs varies but the following figures calculated by the Industry Department in 1985 are indicative:

<table>
<thead>
<tr>
<th>Crude Oil ($/barrel)</th>
<th>Gasoline (US cents/liter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>12.2</td>
</tr>
<tr>
<td>20</td>
<td>15.9</td>
</tr>
<tr>
<td>25</td>
<td>19.5</td>
</tr>
<tr>
<td>30</td>
<td>23.1</td>
</tr>
<tr>
<td>35</td>
<td>26.8</td>
</tr>
</tbody>
</table>
circumstances, Brazil's substitution program is not economically viable. Another Bank study (Second Brazil Alcohol and Energy Project, 1984) found that investments would only be viable with long-term crude oil costs of $30/barrel or higher. With ethanol production costs as much as 100% higher than Brazil in other countries, the viability of ethanol investments elsewhere, based entirely on gasoline import substitution, are highly suspect.

6.13 The "overhang" effect of sugarcane grown for ethanol on the sugar market depends on the feasibility of conversion and the relative values of ethanol and sugar which would trigger conversion. Conversion is possible to the extent that the use of existing milling capacity can be intensified by processing larger volumes of cane for sugar rather than ethanol. There is significant idle sugar milling capacity in Brazil, but the growing distillery investment creates the parallel problem of idle capacity in that industry, if such diversion were to occur, and consequent unit cost increases. Furthermore, a growing share of Brazil's transport fleet uses neat alcohol and cannot use gasoline-based fuel. The extent of feasible conversion to sugar production is therefore declining, although in 1985 it is estimated that an additional one and one half to two million tons of sugar could have been produced for export had relative prices made conversion attractive. Bank analysis done in 1984 indicates that crude oil would have to have been at $9-12/barrel to result in an equal return to sugar and ethanol. However, were sugar prices to rise to 15¢/lb, petroleum would have to be about $58.50/barrel to generate equivalent returns to ethanol production. To take the more realistic case of crude oil at $18-19/barrel in 1986, indications are that conversion to sugar production would begin as sugar prices exceed 7.5¢/lb.
6.14 Countries that enjoy the Caribbean Basin Initiative (CBI) benefits of duty free access to the U.S. market can incur higher production costs for their ethanol and still be financially viable. Nevertheless, sugar remains an attractive alternative for these producers at prices above 8 - 11¢/lb depending on the country. Their quantities, with the exception of the Dominican Republic, are not likely to have a noticeable effect on world market prices. However, the CBI provisions extend only to 1992 and feasibility studies recently conducted in several countries of Central America indicate that cost recovery and adequate returns would require about 15 years at present costs and prices. Private investors are not likely to participate in new projects without price or tariff waiver assurances beyond the present CBI period.

Other Policy Issues for Ethanol Investment

6.15 The basic economic criteria for ethanol investment analysis pertain to production costs and gasoline and sugar prices as outlined above. Proper application of this methodology involves adjustment for exchange rate distortions, but also, in the case of small economies, adjustment for the actual CIF cost of gasoline, which is typically higher than that for countries which buy crude oil at world prices and produce gasoline at or near standard conversion costs. Two other factors should also be taken into account.

(a) Supply Rigidities in Sugarcane Production. Whether at the national or regional level, sugarcane is a major activity, to which significant shares of land, labour and capital are committed. In the 50 to
100 years during which this pattern has developed a complex political and social framework has evolved which is a major force in the domestic policy of many countries. The absence of viable alternatives on the requisite scale gives rise to a reasonable sunk-cost or opportunity cost argument in which the value of a significant share of resources engaged in sugarcane production can be set well below market prices or book value, at least in the assessment of short and medium term alternatives.

(b) Energy Self-Reliance and the Energy Intensity of Development. If the rationing of energy based on imported fuels were achieved through an open price mechanism, the level and distribution of energy consumption could be assumed to reflect its marginal productivity. However, the distortions that accompany the typical monopoly import patterns and the public sector control of foreign exchange expenditures have not permitted a market-based distribution of energy. In addition, energy infrastructure in the form of electricity generation and distribution tends to discriminate spatially or by type of user. A domestic energy source which is not vulnerable to foreign exchange rationing and which is produced by more suppliers in the economy, could be the basis for broader energy distribution and more intensive energy use. Rural electrification schemes for example could give rise to indirect employment and production benefits to the use of sugarcane as an energy source. On the other hand, the development of fleets of vehicles that operate only on neat alcohol, or other technologically constrained energy uses, creates rigidities and limits the potential of a country to capitalize on international trade opportunities as the relative prices of petroleum and export products for the country at risk change over time.
VII. TECHNOLOGICAL DEVELOPMENTS AND OPERATING EFFICIENCY

7.01 Average production costs among cane-based sugar producing countries have tripled in current U.S. dollar terms since the mid 1970's and now stand at 15-16¢/lb. This weighted average is depressed by several large, low-cost producers such as South Africa, Brazil, Dominican Republic, Fiji and Australia and the cost among typical smaller producers is much higher. To varying degrees this increase reflects changes in exchange rates. In dollar terms, costs may actually have declined in some cases with the recent devaluations of the dollar, the value of which now stands at early 1982 levels vis-a-vis the SDR. However, overvaluation of domestic currencies in relation to the dollar remains a widespread problem. Adjusting for these factors must be done on a country- and time-specific basis. In most cane producing areas there have also been significant increases in real costs, the most common causes of which are: low capacity utilization; increased energy costs; operating inefficiencies in the field and in the mill; marketing inefficiencies; and increased fixed charges as a result of greater capital intensity of investment.

7.02 Any rationalization program must include an emphasis on cost reduction and recovery efficiency. Technological developments have been made in cane sampling, handling and preparation as well as in the mill itself which can contribute to this objective, but there is also a need to re-evaluate the roles of labour and capital in the industry, the appropriate size of mill for new market conditions, and the nature of the product to be produced. The design and operation of mills in the last 20 years have reflected an emphasis on throughput rather than efficiency. Overall recovery rates (sucrose in
sugar as % of sucrose in cane) of 60-85% are common, whereas rates of 85-90% could be achieved in the same mills with minor investment and improved operating techniques. (Moving from 70% to 85% overall recovery would reduce sugar costs by 20% to 30% depending on additional investment requirements).

There have also been significant advances on the agricultural side which need to be taken into account (para 8.01 - 8.03).

Capital/Labor Balance in Field Operations

7.03 The steady flow of fresh cane to the mill is a prerequisite for efficient operation. Mechanization of field operations has been seen as a solution to this problem and a number of harvesting machines were introduced in the 1960's and 70's. But high investment and operating costs, as well as foreign exchange and operating skill requirements, have proven to be serious disadvantages of mechanized harvesting. Furthermore, cane quality is adversely affected in terms of sucrose content as well as trash and dirt content. A combination of hand cutting and mechanized loading and transport has been found best in terms of cost and quality in settings as different as Florida and the Sudan. A good incentive pay structure for cutters and proper knife design and care are critical. Hand cutting costs can be as much as 50% less than mechanized harvesting, and 75% of hand cutting costs are typically in local currency, whereas 70% of mechanized harvesting costs are typically in hard currency. While the best harvest/transport system will depend on local conditions, reduced capital intensity and greater simplicity are proving to be the best approaches to steady cane supply.

1/ Where mechanization of field operations has been extensive, as in Brazil, it is often based on highly subsidized credit to obtain the machinery.
Energy Efficiency

7.04 Historically, the disposal of bagasse has been a problem for sugar mills, and steam generation and mechanical systems were designed to consume as much of the bagasse produced as possible.\footnote{Furfural production from bagasse was a factor favoring efficiency in a few cases where market links were established. Furfural is an aldehyde derived by hydrolysis from complex carbohydrates in the cellulose of many plants. The principal commercial sources are bagasse, corn cobs, oat husks and wood chips. Furfural is used as a solvent in the refining of lubricating oils, and is itself the raw material for resins used in foundaries and tetrahydrofuran used in the production of nylon.} Modifications to these systems, including more efficient boilers, higher pressure steam, steam recycling through multiple effect and bleeding techniques, and vapour recompression can result in savings of 30-40% in fuel requirements. The cope for re-generation of electricity for sale to other users is therefore significant as is the potential for other uses of surplus of bagasse (para 8.06 and Annex 5).

Size of Operation

7.05 Two factors have given rise to the need to re-assess the appropriate size of sugar mills: capacity utilization and market location. Aside from the conscious decision to reduce production as a response to low prices, low capacity utilization is a widespread problem resulting from one or more of the following: poor cane supply, inadequate transport and utility infrastructure, management and killed labor constraints, domestic currency and foreign exchange limitations, and equipment breakdowns. The problems of a mill in respect of these issues increase disproportionately with size, whereas the theoretical economies of scale of larger mills can only be realized with adequate capacity utilization. Smaller mills do not offer the design potential
for least cost operations but, being more compatible with the resources and services of the environment in which they function, they can often operate at higher levels of capacity utilization. Furthermore, technological improvements in the past ten years in the generation and use of energy and in clarification and crystalization processes have reduced the gap in design efficiency between large and small mills.

7.06 Another factor contributing to capacity decisions has been market location. Production for export encouraged large centralized units for more efficient use of product transport systems as well as institutional arrangements for assembly and marketing. With the shift in emphasis from export to domestic markets which is accompanying changes in world trade patterns and rising domestic incomes, this factor is no longer as important as it once was. Smaller mills are in many cases more compatible with the marketing channels and consumption patterns of the domestic market and are certainly more readily integrated into a mixed food and cash crop pattern of agriculture. Mills to process 20 - 80 tons of cane per hour are now an attractive alternative in many cases to the 160 - 800 tons cane/hour mills that have been constructed in the past 20 years.

**Nature of the Product**

7.07 The norms for sucrose content as well as colour, ash, etc. for refined sugar have risen with technological development to levels which in some cases exceed the requirements of even the most particular processing application such as the soft drink industry. Specifications have become a marketing tool among competing refineries in industrialized countries and have had spillover effects into preferences in international trade. At the same time as there
has been this differentiation in refined sugar, the distinction between raw and refined sugars has also changed. Improved techniques for juice clarification and crystal separation have permitted the production of direct consumption sugar that can resemble the refined product in appearance and taste to the unskilled eye but is much less expensive to produce.1/ Promoting a change in product mix for the domestic market of producing countries is a means of reducing production costs without significantly altering the apparent quality of the product offered to the consumer. Nutritional quality would not be adversely affected. In export trade, the trend toward white (refined) sugar will continue as the margins for import refiners are squeezed and their numbers decline. Small producers of raw sugar who cannot operate viable refineries may still find lucrative hard currency markets for specialty sugars, but these are relatively small markets.

1/ Refining costs in established U.S. port refineries are about 5¢/lb.
VIII. SUGAR PRODUCTION AND AGRICULTURAL DIVERSIFICATION

Agricultural Developments

8.01 Crop yields, whether in beet or cane, can only be sustained and increased through a continuous program of varietal development and agronomic research. Although tissue culture and genetic engineering techniques will gradually reduce the development cycle, the breeding, selection and commercialization of a new variety presently takes 10-15 years. Variety importation and trials is the faster, low-cost approach to research suited to small producing countries. In beet, the greatest advances in recent years have been in Western Europe where the combined effect of breeding and improved cultivation and pesticides led to an average E.C. increase between 1974/75 and 1984/85 of 31% in white sugar equivalent per hectare. Increases in cane sugar yields have been much more modest and, in fact, research and development efforts have been badly neglected in all but a few of the larger producing countries (United States, Australia, Argentina, Brazil, Colombia, Mexico, India, and South Africa).

8.02 In beet cultivation the most significant developments have been in monogerm seed (to reduce labour requirements for plant thinning), seed pelletization (anchoring the disc-like seed in peat for more accurate placement), and in a range of practices and machinery developments intended to reduce soil compaction. In cane cultivation, the development of efficient billet planters has led to germination and plant population performance equivalent to that of good quality hand planting. Dessicants are now used to facilitate burning; chemical sprays are also common in commercial practice for growth regulation, maturity induction and flowering control. In both crops
there have been advances in the composition, form, timing, quantity and application techniques of fertilizers and pesticides.

8.03 While the cost effectiveness of applying these developments will vary with local conditions, their impact on productivity can be very significant. Although soil and climate are also critical factors, differences in quality of planting material and cultivation practices account for much of the differences that currently exist in cane yields of three to 12 tons white sugar per hectare and beet yields of two to nine tons.

The Scope of Diversification

8.04 Discussion of diversification in the context of poor performance of the sugar industry tends to lack clarity with respect to both objectives and strategy. Objectives, often only implicit, include reduced dependency of the economy on sugar revenues, transfer of productive resources to other activities, and greater use of sugarcane raw material. The basic strategies, which may be adopted in combination, are: downstream processing of sugar; byproduct utilization; the cultivation of different crops; or, the use of sugar lands for non-agricultural purposes. Ethanol is the major focus of downstream processing at the present time. It has been separately discussed, and the issue of appropriate degree of refining has also been raised. Another use of sugar which is technically feasible but is as yet financially unattractive is as a feedstock for the production of biodegradable detergents. Environmental concerns may eventually create the regulatory and price factors which would lead to the adoption of these phosphate-free substitutes for industrial and domestic uses. The balance of this section discusses byproduct utilization and diversification out of sugar.
Byproducts of Sugarcane 1/.

8.05 Sugarcane can produce several times more energy and fibre per hectare than any other crop. For example, a good variety on good soils can yield 100 tons of cane per hectare.2/ This cane contains 40-45 tons of food and fiber on a bone dry basis, of which sugar, historically of primary concern, is only about 10 tons. The technology for utilizing the other available materials, including the 30% or more of bagasse which is surplus in an efficient mill, is well established but the traditional emphasis on sugar has led to inadequate attention to these other areas and the alternative uses of sucrose. Annex 5 presents a partial list of byproducts, including 19 types of products which can be produced from bagasse, 16 from molasses, four from sugar and cane juice, four from filter press mud, and five from cane and cane waste.

8.06 One use of bagasse which could have particularly good economic and social benefit is as a domestic and industrial energy source. The following comparison of heat values illustrates the basis for this assertion:

<table>
<thead>
<tr>
<th>(BTU) per pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bagasse (field moisture)</td>
</tr>
<tr>
<td>Bagasse (bone dry)</td>
</tr>
<tr>
<td>Peat</td>
</tr>
<tr>
<td>Wood (air dried)</td>
</tr>
<tr>
<td>Lignite coal</td>
</tr>
<tr>
<td>Charcoal</td>
</tr>
<tr>
<td>Bituminous coal</td>
</tr>
<tr>
<td>Anthracite coal</td>
</tr>
</tbody>
</table>

1/ Sugarcane is of greater interest than beet in the context of diversification, since more areas of concern to the Bank produce cane than beet, and the range of under-exploited byproduct uses is greater. Beet pulp is widely used as livestock feed, but there is scope for expansion and more efficient use.

2/ Sugarcane takes more than 12 months to reach this level of output the first year after planting. Subsequent ration crops reach maturity more rapidly, but for strict comparison with other crops, the figures should be adjusted for the delay in the first year.
As a rough indicator, bagasse briquettes (depithed to reduce smoking) could be produced in some regions at about $30 per ton whereas firewood in many cane growing countries sells at $35-70 per ton. Charcoal could be produced at $55 per ton under the same assumptions and commonly sells for between $75 and $100 per ton.

8.07 Some of the byproducts listed in Annex 5 have small or saturated markets (e.g. waxes and furfural); others require substantial investment and are subject to significant economies of scale (e.g. pulp and paper.) However, the important issue at this stage is that byproduct opportunities have not been adequately explored in many countries, and any evaluation of sugar sector prospects should take into account the current domestic food, feed and energy markets which could be served by diversified production in the sugar industry. Animal feed/litter, building materials, charcoal, fuel briquettes, electricity co-generation and potable and fuel ethanols appear to be the most interesting prospects for further investigation.

Alternatives to Sugarcane Cultivation

8.08 Despite widespread rhetoric on the subject, experience with diversification out of sugarcane cultivation is very limited. Diversification has been constrained in part by the higher returns to land under cane than under other crops in the context of support programs in both producing and importing countries. This highlights the importance of harmonizing agricultural and macro-economic policies to induce alternative use of resources, particularly land and labor. Even where returns are cyclically less attractive than in other crops, there is resistance among sugar interest groups to giving up on the return of sugar to its lucrative state. Another
fundamental issue is the absence of obvious alternatives that can absorb resources at the required level out of sugar production were policies to be adjusted to induce alternative uses of land and labour. Although there are some agronomic problems in shifting crops, such as rainfall patterns in upland areas and water management in irrigation schemes, the most serious and widespread constraint is again markets. Diversification that has been undertaken is generally of three types: inter-cropping between rows and rotations; crop substitution; and, shifting land out of agriculture.

8.09 Small traditional sugar exporters have been the hardest hit by changes in the international sugar industry. Antigua, Barbados, Costa Rica, Guyana, Jamaica, Panama, Peru, Puerto Rico, and Trinidad and Tobago have all experienced major increases in costs and are now well above average production costs. Although currency overvaluation has been a factor in some cases, real cost increases have been very large. The general pattern in recent years has been to neglect planted cane, leave land idle, and otherwise avoid additional expenditure on sugar production. Jamaica has the most organized program of diversification, based on joint venture and public enterprise production of other agricultural crops, primarily for export. Antigua has launched a large maize/sorghum scheme, and Trinidad and Tobago have committed 1500 acres of former sugarcane lands to housing. Agronomically, the best alternatives appear to be tree crops, including citrus, annual fruits and vegetables for processing or fresh export, feed grains, cotton, and groundnuts.

8.10 These economies have small domestic markets and the focus thus has to be on exports. The most critical factor in offsetting the market constraints that face most of these commodities will be contractual arrangements for the supply of technology, management and market links. Most substituted crops are
perishable, and even the off-season North American market is highly competitive. The issues of production control and market access are politically sensitive, but without product standardization and a formal link to the market structure, new suppliers have little chance of tapping into established markets beyond the level of occasional ad hoc shipments. Favorable transportation arrangements are a fundamental component of the marketing plan.

8.11 Most African and Asian countries produce sugar primarily for their own growing consumption. Such economies are not dependent on sugar exports for a significant share of their foreign exchange earnings. Joint production with other crops has been widespread, whether in rotation or by inter-cropping. Short duration crops for intercropping are the subject of ongoing research at the Mauritius Sugar Industry Research Institute and crops as diverse as tomatoes, potatoes, maize, beans and groundnuts can be used in this manner. The use of sugarcane land to increase the livestock feedbase is also being investigated, but other constraints to livestock development such as breed improvement, herd management practices, and market infrastructure must also be alleviated if this is to become a viable alternative.

8.12 In the case of large diversified sugarcane producers such as the Philippines and Brazil, which are also major exporters, the problem of sugarcane monoculture is regional, and the possibility exists for the production of other agricultural commodities for the large domestic market or for new export markets. Feed grains and tree crops are being proposed in the Philippines and food crops and citrus are expanding in Brazil, although ethanol has been the dominant factor in diversification to date.
Summary

8.13 In general, the greatest potential for reduced reliance on sugar in the near future lies in byproduct utilization, cogeneration of electricity, and ethanol production for petroleum import substitution, although the economic rationale for these must be examined in each case. While the technical and market constraints vary among countries, there is a great need for research into diversification alternatives and for more consistency in this work among countries.
9.01 The conclusions of this paper suggest that, for the foreseeable future, border prices for sugar will remain below the production costs of all but the most efficient producers, and it is unlikely therefore that investments in new production capacity would prove economically viable. Domestic markets with significant natural protection, or the substitution of lower-cost direct consumption sugars may justify expansion, but in most cases the focus of strategy in the sugar sector should be on improved technical and economic efficiency within the context of present or reduced production levels. In the development of an adjustment strategy for traditional sugar exporting sectors, a three-stage approach should be adopted. Analysis of the policy issues which impinge on sector performance; determination of an optimal size and structure for the sugar industry; and, development of a research and investment program to absorb resources that can no longer be efficiently employed in sugar production.

Assessing the Policy Environment

9.02 Even if an industry is technically efficient and productive, its performance can be undermined by the price, marketing and economic incentive system. Furthermore, this impact can occur very rapidly. Nowhere does this emerge with more force than in the sugar industry. Countries which once were among the most efficient and competitive producers in the world are now among the least efficient; Peru is a striking example. In other countries, incentives have been eroded despite the fact that the country once had an inherent comparative advantage; a number of Commonwealth Caribbean countries
are excellent examples. Among the problems which have been noted in Bank reports and elsewhere are:

(i) subsidized consumer prices which stimulate excessive consumption, or, conversely, artificially high prices to suppress demand;
(ii) low producer prices which discourage production, often brought about by explicit export taxes;
(iii) unrealistically low exchange rates which result in the underpricing of tradeable goods relative to labor and other costs, higher production costs in terms of other currencies, and reduced returns to producers;
(iv) further disincentives against export crops by a restrictive trade regime that provides excessive protection to import substitution, inflating exporter costs;
(v) excessively high wages and uneconomic labor laws that increase non-wage labor costs;
(vi) subsidized capital which, together with (v), distorts choices in the use of capital and labor;
(vii) producer compensation formulae which are not related to sugar yield; and
(viii) taxation policies and other financial controls which divert funds during surplus periods and discourage sound reinvestment decisions.

9.03 An evaluation of the extent of these and other distortions in the sugar industry is an important first stage in the development of a sector strategy. If work is ongoing in broader policy areas, or if effects of present policy are significant, alternative strategies may need to be
developed as scenarios linked to changes in particular policies. 1/

Determining the Optimal Size and Structure of the Sugar Industry

9.04 The following elements should be included in the process of determining appropriate size and structure:

(i) Cost of Production: A review of current production costs, separately for field and factory operations. Assessment of the technical and economic scope for cost reduction.

[NB: The foreign exchange component of costs should be separately identified as it is typically quite large for modern sugar operations in developing countries. (In one study in Tanzania, 64% of total costs required foreign exchange).]

1/ The AGREP sugar study identified three main areas for more detailed multi-country analysis:

(i) Country and regional comparative advantage -- an analysis geared to defining appropriate "rationalization" and "diversification" programs for the sector;

(ii) the structure of domestic pricing policies and the resulting effects of these policies on incentives and resource allocation decisions; and

(iii) the organizational structure of the institutions involved in the production and marketing of sugar.
(ii) **Structure:** Identification of the least-cost cultivation areas and factories as well as those with the least attractive production alternatives. A review of ownership and income patterns, and an assessment of the impact of regulatory and marketing structures on revenue distribution and economic efficiency.

(iii) **Markets:** Assessment of quota and domestic market conditions, the latter under different price assumptions.

(iv) **Alternatives:** A survey and analysis of potentially viable alternatives for resources taken out of sugar production.

(v) **Impact:** Assessment of the employment, income and fiscal impact of a reduced sugar sector.

**Developing a Diversification Program**

9.05 An underlying factor in planning for diversification is the disruption of customs, financial relationships and capital structure that accompanies change. To facilitate adjustment, existing relationships and capital assets should be incorporated in the diversification programs to the maximum extent consistent with economic objectives.

(i) **Sugarcane Byproducts:** Examination of import and energy consumption patterns, including fuelwood, as the principal basis of identifying potential byproduct investments.

(ii) **Alternative Activities:** Examination of domestic and foreign market conditions and competitive position to identify agricultural investments. Also examine alternatives outside agriculture.

(iii) **Impact:** Assessment of the employment, income and fiscal potential of diversification proposals.
9.06 For reasons alluded to elsewhere, adjustment in the sugar industry will be a long-term process. The cost of adjustment to participants may be high, and a pragmatic approach to phasing and coordination will be essential. In assessing the capital implications of the proposed strategy, care should be taken to examine the extent and the means of disinvestment as well as any new investment requirements. Assistance in respect of both dimensions could facilitate the desired adjustment. During the process, investment in sugar should be limited to assets with a relatively short economic life, except those made in the context of an agreed optimal industry structure. Additional investments in byproduct and alternative crop research and in market development for diversification should be encouraged.

9.07 In conclusion, there is significant scope in terms of policy, technology and organization to adjust national sugar industries toward a structure which is more responsive to the present and projected conditions in the sector. However, the degree to which rationalization can occur is constrained by the macro-economic framework within which that industry functions as well as limits to international trade imposed by the distortions in the U.S. and E.C. sugar sectors and the prevailing imbalance between global production and consumption. Efforts to improve the efficiency of resources presently committed to sugar production must proceed in concert with work on overall resource efficiency issues.
### ANNEX 1
**IBRD AND IDA PROJECTS WITH SUGAR COMPONENTS**
**(FY74 - FY85)**

<table>
<thead>
<tr>
<th>Projects Completed</th>
<th>No. of Countries</th>
<th>No. of Projects</th>
<th>Annual Sugar Production At Full Development (1,000 tons Raw Equiv.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Africa</td>
<td>1</td>
<td>1</td>
<td>44.0</td>
</tr>
<tr>
<td>West Africa</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EMENA</td>
<td>4</td>
<td>7</td>
<td>512.8</td>
</tr>
<tr>
<td>LAC</td>
<td>5</td>
<td>7</td>
<td>234.7</td>
</tr>
<tr>
<td>E. Asia/Pacific</td>
<td>1</td>
<td>1</td>
<td>97.0</td>
</tr>
<tr>
<td>South Asia</td>
<td>2</td>
<td>7</td>
<td>386.8</td>
</tr>
<tr>
<td>Sub-total</td>
<td>13</td>
<td>23</td>
<td>1,275.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projects Under Implementation</th>
<th>No. of Countries</th>
<th>No. of Projects</th>
<th>Annual Sugar Production At Full Development (1,000 tons Raw Equiv.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Africa</td>
<td>4</td>
<td>5</td>
<td>367.5</td>
</tr>
<tr>
<td>West Africa</td>
<td>1</td>
<td>1</td>
<td>19.2</td>
</tr>
<tr>
<td>EMENA</td>
<td>10</td>
<td>26</td>
<td>510.9</td>
</tr>
<tr>
<td>LAC</td>
<td>11</td>
<td>20</td>
<td>329.2</td>
</tr>
<tr>
<td>E. Asia/Pacific</td>
<td>5</td>
<td>7</td>
<td>159.2</td>
</tr>
<tr>
<td>South Asia</td>
<td>4</td>
<td>32</td>
<td>1,381.3</td>
</tr>
<tr>
<td>Sub-total</td>
<td>35</td>
<td>91</td>
<td>2,767.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>-</td>
<td>114</td>
<td>4,042.6</td>
</tr>
</tbody>
</table>

**Source:** World Bank Data.
ANNEX 2
COMPARISON OF SUGAR PRODUCTION COSTS

The range in world sugar total production 1979/80 - 1982/83
(weighted world average = 100)

<table>
<thead>
<tr>
<th>Country</th>
<th>Sugar Plant</th>
<th>Index Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan cane</td>
<td>229</td>
<td></td>
</tr>
<tr>
<td>Japan beet</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>Trinidad c/ cane</td>
<td>158</td>
<td></td>
</tr>
<tr>
<td>Italy b/ beet</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>Poland beetle</td>
<td>141</td>
<td></td>
</tr>
<tr>
<td>Guyana c/ cane</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>Barbados c/ cane</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>U.S. beet</td>
<td>111</td>
<td></td>
</tr>
<tr>
<td>U.S. mainland cane</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>U.K. b/ beet</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Jamaica c/ cane</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Germany, Fed. Rep. b/ beet</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Belize c/ cane</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>India cane</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Thailand cane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argentina cane</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Brazil (N/NE) cane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philippines cane</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Mauritius c/ cane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France b/ beet</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Cuba cane</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Dominican Republic cane</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>St. Kitts c/ cane</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Australia cane</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Fiji c/ cane</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Brazil (Central/South) cane</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>South Africa cane</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a/ Average 1979/80 - 1982/83 exchange rates and base years for data; constant prices; ex-mill costs in terms of raw sugar (96 pol). Costs derived by a synthetic cost engineering approach.

b/ E.C. Member State

c/ Has E.C. sugar quota

ANNEX 3
DEVELOPMENT OF HIGH FRUCTOSE CORN SYRUP SWEETENERS

Background 1/

1. Sweeteners from corn are not new products. Dextrose was produced commercially in the United States in the 1860's. Enzymatic conversion of D-glucose to D-fructose (HFCS) was also practiced at that time, but the degree of process control was not adequate to prevent discoloration and off-flavors. In the early 1950's, medical research on metabolization led to discoveries in isomerization 2/ which were picked up by the food industries at the research level. However, commercial production of fructose from glucose was not viable because of the cost of producing the enzymes that would ensure consistent quality of the converted product.

2. The Japanese identified a bacterium in the early 1960's that produced the desired glucose isomerase and patented a process for production of this enzyme in 1966. Also in the mid-1960's a technique was developed to immobilize enzymes so they could be recovered and re-used indefinitely. Commercial production of HFCS began in the U.S. in 1967. By 1972 a continuous HFCS process had been introduced. As a consequence of these technological developments, the cost of enzymes, which was prohibitive in the 1960's, amounted to about 5% of production costs in the U.S. by the early

1/ This annex is derived primarily from Clive Y. Thomas Sugar, Threat Or Challenge, (IDRC, Ottawa, 1985).

2/ Changing the structure of a molecule such that, while it possesses the same number of atoms of the same elements as the original, it exhibits different properties.
1980's. The extremely high sugar prices of 1974 created great interest in alternative sweeteners but patent protection prevented widespread investment in HFCS production until 1975 when drawn-out legal battles finally led to removal of the basic patent coverage. The convergence of these legal and market developments resulted in a rapid expansion of HFCS production.

4. Production of HFCS grew in the late 1970's despite the failure of the sugar protection mechanism during part of that time to keep imported sugar from dropping below the support prices for domestic sugar. In the year of lowest sugar prices, HFCS was sold on average at 85% of the price of refined sugar. By 1980 U.S. production capacity for 42% HFCS was over two million tons, exceeding demand by 38%. Capacity for 55% HFCS was 780,000 tons, 12% over demand. By 1983, capacity stood at 2.24 million tons for 42% HFCS and 2.5 million tons for 55% HFCS. Expansion of demand for 55% HFCS has kept pace with increased capacity but there remains a surplus of about 20% in 42% HFCS capacity in the U.S.

<table>
<thead>
<tr>
<th></th>
<th>42%</th>
<th>55%</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>2,240</td>
<td>2,530</td>
</tr>
<tr>
<td>Japan</td>
<td>600</td>
<td>495</td>
</tr>
<tr>
<td>E.C.</td>
<td>288</td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>264</td>
<td>206</td>
</tr>
<tr>
<td>Other</td>
<td>610</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,002</strong></td>
<td><strong>3,231</strong></td>
</tr>
</tbody>
</table>

1/ Percent HFCS unspecified but probably all 42%; countries include Yugoslavia; Hungary; Argentina; Peru; Brazil; Indonesia; Taiwan, People's Republic of China, Republic of Korea; and Egypt.
The Product

5. HFCS is a liquid mixture of D-glucose and D-fructose. Early production of HFCS in 1967 contained 15% fructose and later this rose to 30%. The 42% version, which has the same sweetness as sucrose, was introduced in 1968. By 1978 a 55% fructose sweetener was introduced that is 10% sweeter than sucrose. A 90% product is also produced but is used primarily in health foods and other specialty applications. (The 55% product is produced by blending 42% and 90% syrups).

6. Unlike sucrose from sugarcane or beet, the byproducts of HFCS are commercially important. Credits on raw material costs through the sale of oil, meal and feed byproducts normally range between 40 and 60 percent of corn prices.

Costs and Prices - U.S.A.

7. Fixed capital charges and raw material costs are typically the largest items of expense in HFCS production (35% for capital; raw material, 25-30%). This cost structure, together with questions of transfer pricing and ancillary business aspects, make cost comparisons difficult. However, a range of 12¢/lb to 16¢/lb for 42% HFCS probably includes most U.S. producers (+15% for 55% HFCS). For a cost comparison with sugar at world prices, an adjustment for refining and transport is required since sugar is normally quoted 96 degree raw FOB Caribbean port. If these costs are taken as 5¢/lb and 1¢/lb respectively, the U.S. producer of HFCS whose cost is 12¢/lb could compete

1/ Assuming 90% capacity for 330 days per year, and average corn prices early 1980's.
with world market sugar at 6¢/lb.

8. The following table presents HFCS and sugar prices in the U.S.:

<table>
<thead>
<tr>
<th>Year</th>
<th>HFCS 42%</th>
<th>HFCS 55%</th>
<th>Sugar a/ 42%</th>
<th>Sugar a/ 55%</th>
<th>Ratio: HFCS/Sugar Price 42%</th>
<th>Ratio: HFCS/Sugar Price 55%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>12.4</td>
<td>-</td>
<td>14.6</td>
<td>84.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1978</td>
<td>12.1</td>
<td>-</td>
<td>17.1</td>
<td>70.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1979</td>
<td>13.1</td>
<td>-</td>
<td>18.4</td>
<td>71.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1980</td>
<td>23.6</td>
<td>-</td>
<td>30.8</td>
<td>76.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1981</td>
<td>21.4</td>
<td>23.9</td>
<td>28.3</td>
<td>75.6</td>
<td>84.3</td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>14.3</td>
<td>20.0</td>
<td>28.1</td>
<td>50.9</td>
<td>71.2</td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>17.7</td>
<td>21.8</td>
<td>29.9</td>
<td>59.1</td>
<td>73.3</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>19.7</td>
<td>22.8</td>
<td>31.1</td>
<td>63.2</td>
<td>73.3</td>
<td></td>
</tr>
</tbody>
</table>

a/ Bulk, dry beet FOB refinery.


9. In addition to the price advantage, industrial users prefer HFCS to sugar because it is shipped in liquid form and is therefore less expensive to handle. Its uniformity and ease of blending are also greater. Although it has not been a factor domestically in the past five years, price volatility in sugar is also a consideration which strongly influences the choice of sweetener by industrial users.
The economic justification of Brazil's PROALCOOL program and its financial implication for the public sector have become increasingly problematic. Fundamentally, these problems can be traced to the fact that world prices of oil and gasoline, rather than continuing to rise in real terms as earlier anticipated, first stagnated and then, more recently, have fallen sharply. On the economic side, it is not possible to quote a single price of petroleum required to justify ethanol production. This is a reflection of the following factors:

a) Regional costs of production differ widely, with Sao Paulo and similar areas much more competitive than the Northeast (and new areas apparently intermediate);

b) The price needed to justify investing in a new distillery is higher than that needed to warrant continued operation of an existing unit;

c) Some producers have further scope to improve productivity through learning effects;

d) Anhydrous ethanol in gasoline has a higher fuel value than pure hydrous ethanol; and

e) At the margin, domestically refined gasoline displaced by ethanol has had to be exported, thus yielding a lower benefit than gasoline import substitution.

---

a/ This annex is extracted from the work done in early 1986 by Anthony Ody (IBRD).
2. With these caveats, the table below indicates World Bank estimates of the approximate minimum real crude oil prices needed to justify economically the different levels of ethanol development. The ranges quoted reflect differences in production costs within each region.

<table>
<thead>
<tr>
<th>Region</th>
<th>Anhydrous in Gasoline</th>
<th>Hydrous Import Substitution</th>
<th>Hydrous Export</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sao Paulo</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Build New Distillery</td>
<td>23-38</td>
<td>29-36</td>
<td>33-40</td>
</tr>
<tr>
<td>b) Operate Existing Distillery</td>
<td>17-23</td>
<td>22-29</td>
<td>26-33</td>
</tr>
<tr>
<td><strong>Northeast</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Build New Distillery</td>
<td>24-34</td>
<td>31-43</td>
<td>35-47</td>
</tr>
<tr>
<td>b) Operate Existing Distillery</td>
<td>20-28</td>
<td>26-36</td>
<td>30-40</td>
</tr>
</tbody>
</table>

3. The above estimates make it unlikely that a strict economic justification could be provided for widespread production and use of hydrous alcohol at the crude oil prices generally expected in the near future. In addition, this economic problem has been translated in recent months into a substantial financial deficit for the public sector, which purchases and sells
fuel ethanol. As recently as 1984, revenues from fuel ethanol sales were adequate to cover the weighted cost of ethanol purchase and distribution. However, with the retail price of ethanol still pegged at 65% of that of gasohol, the real consumer price of ethanol has declined proportionately with falling gasoline prices, and it now no longer covers ethanol acquisition and distribution costs. The deficit has recently been running at an annual rate of several hundred million dollars, and responsibility for financing this gap has been transferred explicitly from PETROBRAS to the government. It is estimated that the average cost of purchasing and distributing hydrous alcohol to retail level is approximately US$0.28 per liter (comprising 22 cents for acquisition and 6 cents for distribution). By contrast, the retail price as of the introduction of the price freeze is estimated to have been about US$0.22 per liter. If this level of real consumer price is maintained, the public sector can expect to lose about six cents per liter of hydrous ethanol sold. On expected 1986 hydrous ethanol sales of about 7-8 billion liters per annum, a deficit of US$420-480 million per annum can be expected.
ANNEX 5
PARTIAL LIST OF SUGARCANE BYPRODUCTS a/

From Bagasse:
- Cogeneration of steam and electricity
- Pulp and paper
- Synthetic lumber; corrugated/fiber/particle boards
- Plastics and resins (from lignins)
- Door cores; acoustical wall and ceiling tiles
- Fuel/charcoal briquettes
- Methane and producer gas
- Furfural
- Xyliton
- Alpha Cellulose
- Absorbant for explosives (pith or light fraction)
- Cattle feed (with or without addition of molasses)
- Poultry litter and cattle bedding
- Mulch and soil conditioners
- Single cell protein for animal consumption
- Carbon from fly ash
- CO2 from stack gasses
- Heat and/or steam from stack gasses
- Flyash and ash as a component on non-shrink concrete and concrete grout.

From Molasses
- Animal feed
- Industrial and anhydrous ethyl alcohol
- CO2 and dry ice
- Rum and other potable alcohols
- Acetic acid and vinegar
- Citric acid
- Yeast
- Butanol
- Glycerol and other chemicals
- Dextran
- Other organic chemicals
- Aconitic acid, other acids, and salts of these acids
- Monosodium glutamate
- Fertilizer
- Edible molasses
- Edible syrups

a/ There are more than 100 known products of sugarcane in addition to sucrose which can be derived from cane or from various stages of sugar production. Beet byproducts are not as diverse, with pulp for animal feed being the most important at the present time. A Swedish firm has developed a process to use beet pulp in the food industry.
From Filter Press Mud and Miscellaneous
Cane wax
Animal feed
A mulch, soil conditioner and fertilizer
Possible fuel

From Sugar/Cane Juice
All products that can be produced from molasses
Bio-degradable detergents and soaps
Alcohols
Fructose

From Cane and Cane Waste
Whole green cane fed direct to animals
Whole green cane converted to ensilage
Whole green cane converted to animal feeds by disintegration, drying
and pelletizing, either alone or mixed with molasses, grain or other
products.
Cane leaves and tops used in the same manner as any of the three uses
mentioned above.
Cane trash (leaves, tops and scrap cane) ploughed back as mulch or
partially air-dried and collected for use as fibre or fuel.
Distributors of World Bank Publications

Algeria: Office des Publications Universitaires, 1, place centrale de Ben-Aznoun, Alger
Argentina: Carlos Hirsch, SRL, Galeria Guemes, Florida 165, 4th Floor-465, 1333 Buenos Aires
Australia, Papua New Guinea, Fiji, Solomon Islands, Vanuatu: Info-Line, Overseas Document Delivery, Box 556, GPO, Sydney, NSW 2001
Austria: Gerald and Co., A-1011 Wien, Graben 31, Austria
Bahamas: Middle East Marketing Research Bureau, Branch Office: Bahrain Research and Consultancy Associates W.L.L., P.O. Box 2750, Manama Town 317
Bangladesh: Micro Industries Development Assistance

Belgium: Publications des Nations Unies, Av. du Roi 202, 1050 Brussels
Brazil: Publicacoes Tecnicas Internacionais Ltda., Rua Northern Ireland. See United Kingdom

Bahrain: Middle East Marketing Research Bureau, Branch Office, 2, rue Moliere, Casablanca

Argentina: Carlos Hirsch, SRL, Galeria Guemes, Florida Limited, P.O. Box 1127, Jalan Pantai Baru, Kuala Lumpur

Egypt, Arab Republic of: Al Ahram, Galaa Street, Cairo

Singapore, India, Burma: Information Publications, DomInkan
Denmark: Samfundslitteratur, Rosenørns Alle 11, DK-1970 Frederiksberg C.

Dominican Republic: Editora Taller, C. por A., Isabel la Catolica esq. Restauracion, Apdo. postal 2190, Santo Domingo

Egypt, Arab Republic of: Al Abram, Galaa Street, Cairo

Fiji. See Australia

Finland: Akateeminen Kirjakauppa, P.O. Box 128, SF-00101, Helsinki 10

France: World Bank Publications, 66, avenue d'Iena, 75116 Paris

Germany, Federal Republic of: UNO-Verlag, D-5300 Bonn 1, Simrockstrasse 22

Greece: EMBR Information Services, Branch Office, 24, Ippodamou Street, Athens-11635

Hong Kong, Macao: Asia 2000 Ltd., 6 Fl., 146 Prince Sri Lanka: Lake House Bookshop, P.O. Box 244, Colombo 2

Hungary: Kultura, P.O. Box 149, 1389 Budapest 62


Indonesia; Pt. Indira Limited, Jl. Sam Ratulangi 37, Jakarta

Ireland: TDC Publishers, 12 North Frederick Street, Dublin 1

Israel: Jerusalem Post, Jerusalem Post Building, P.O. Box 81, Romema Jerusalem 91000

Italy: Libreria Commissionaria, Samoni S.P.A., Via L.ammerw 45, Castella Postale 552, 52015 Florence

Ivory Coast: Centre d’Edition et de Diffusion Africaines (CEDA), 4 B.P. 541, Abidjan 4 Plateau

Japan: Eastern Book Service (text), 37-3, Hongo 3-Chome, Bunkyo-ku 113, Tokyo

Jordan, EMBR Information Services, Branch Office, P.O. Box 3143, Ibadan

Kenya: Africa Book Service (E.A.) Ltd., P.O. Box 42452, Nairobi

Korea, Republic of: Pan Korea Book Corporation, 134, 1-Ka, Shumun-RO, Jongro-Ku. P.O. Box 101, Kwangwahsan, Seoul

Kuwait, EMBR Information Services, Branch Office, P.O. Box 5465, Kuwait

Macao. See Hong Kong

Malaysia: University of Malaya, Cooperative Bookshop, Limited, P.O. Box 1127, Jalan Pantai Baru, Kuala Lumpur 59200

Maldives. See Sri Lanka

Mexico: INFOTEC, San Fernando No. 37, Col. Toreiello Guerra, Tlahual

Morocco: Societe d’Etudes Marketing Marocaine, Branch Office, 2, rue Moliere, Casablanca

Netherlands: Medical Books Europe, BV (MBE), Noorderwal 38, 7241 BL Lochem

New Zealand: B. Hill and Son Ltd., Private Bag, New Market, Auckland

Nigeria: University Press Limited, Three Crowns Building Jericho, Private Mail Bag 5095, Ibadan

Northern Ireland. See United Kingdom

Norway: For single titles: Tanum-Karl Johan, A.S., Boks Box 1177 Sentrum, 0107, Oslo 1

Pakistan: Mira Book Agency, 65, Shahrah-e-Qauid-e-Azam, P.O. Box No. 729, Lahore 3

Panama: Libreria Cultural Panamena, S.A. (LCP), Via Espana 16, Panama Zone 1

Papua New Guinea. See Australia

Peru: Editorial Desarrollo SA, Aparado Postal 3824, Ica 242, O.E. 106, Lima 1

Philippines: National Book Store, P.O. Box 1934, Manila

Portugal: Livraria Portugala, Rua Do Campo 70-74, 1200 Lisbon

Saudi Arabia: Jarir Book Store, P.O. Box 3196, Riyadh—11471

Singapore, Taiwan, Burma: Information Publications, Private, Ltd., 02-06 First Floor, Feo-Industrial Bldg., 24 New Industrial Road, Singapore 1953

Solomon Islands. See Australia

South Africa: For single titles: Oxford University Press, Southern Africa, Academic Division, P.O. Box 1141, Cape Town 8000. For subscription series: International Subscription Serv., P.O. Box 41095, Craighill, Johannesburg

Spain: Mundial-Frensa Libros, S.A., Castello 37, 28001 Madrid

Sri Lanka, Maldives: Lake House Bookshop, P.O. Box 244, 100, Sir Chittampalal A. Gardner Mawatha, Colombo 2

Sweden: For single titles: ABCB Fritz Kung. Hovbolghandel, Regeringsplan 12, Box 16356, S-103 27 Stockholm. For subscription orders: Wennergren-Williams AB, Box 30004, S-104 25 Stockholm

Switzerland: Libraria Payot, 6 Rue Grenus, Case postal 381, CH 1211 Geneva 11

Taiwan, China. See Singapore

Tanzania: Oxford University Press, P.O. Box 5299, Dar es Salaam

Trinidad & Tobago: Systematics Studies Unit, 35 Eastern Main Road, Curepe, Trinidad

Tunisia: Societe Tunisienne de Diffusion, 5 Avenue de Cartaghe, Tunis

Turkey: Hasek Kitabevi A.S., 469, Istikli Caddesi, Beyoglu-Istanbul

Uganda: Shipping' Services, Head Office, P.O. Box 106, Limuru, Kenya

United Arab Emirates: Middle East Marketing Research Bureau, Branch Office, P.O. Box 6097, Sharjah

United Kingdom and Northern Ireland: Microinfo Ltd., P.O. Box 3, Alton, Hampshire GU 34 2PG

Venezuela: See Australia

Venezuela: Libreria del Este, Aptdo. 603337, Caracas 2422

Western Samoa: Wesley Bookshop, P.O. Box 207, Apia

Yugoslavia: Jugoslavenska Knjiga, YU-11000 Belgrade/Dig Republike, B8 1

Zimbabwe: The Booksellers Pvt. Ltd., Box 3799, Harare